

To net or not to net

3rd edition

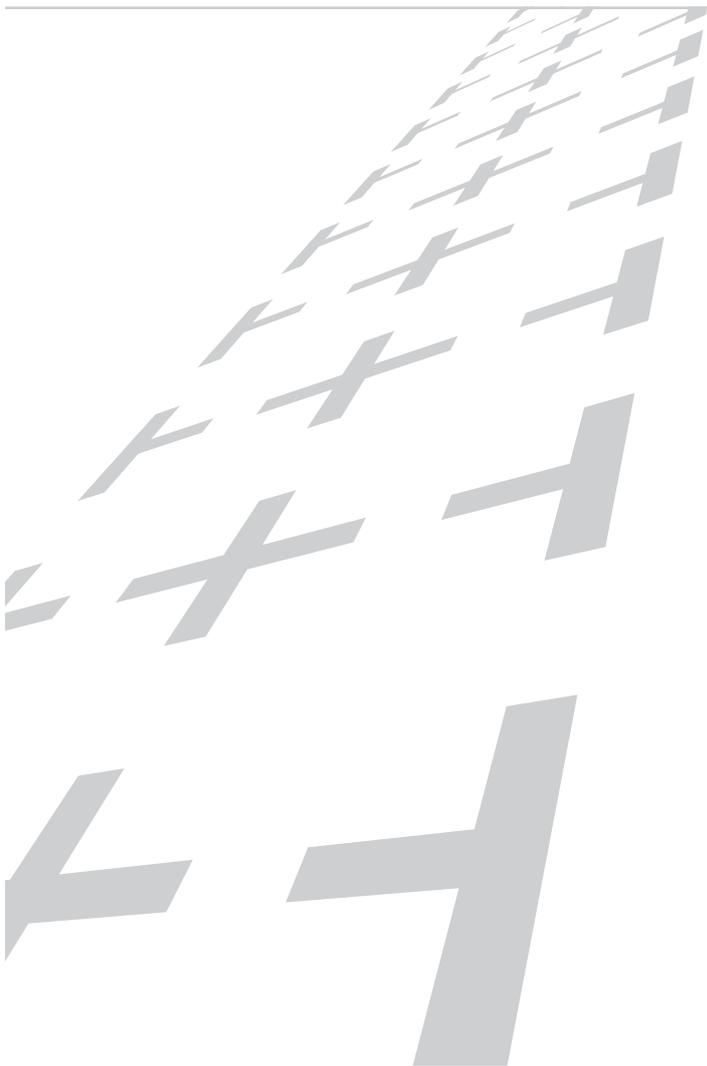
By Peter Rigden



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Summary

Orchard netting is a method of controlling vertebrate pests and some insect pests. Netting is reliable because it places a physical barrier between the pest and the crop. Growers can use a range of netting options to protect orchard crops from damage by flying foxes, birds and some insect pests.

The decision to net an orchard is not a simple one. Netting involves a high capital cost and, in some situations (with some crops), returns may not justify the expenditure. The aim of this report is to provide enough information to help growers gain a better understanding of whether or not orchard netting is an appropriate option in their situation. In this report you will find:

- information about the pests that can be controlled by orchard netting
- a description of the netting options available to growers
- an outline of some of the effects of netting on the orchard environment
- discussion of some of the consequences of netting on orchard management and crop growth
- a brief outline of some deterrent methods for controlling vertebrate orchard pests
- an outline of the financial implications of orchard netting
- a number of case studies describing a range of netting options that have been used in commercial orchards
- examples of costs for several different types of orchard netting
- some contact details of businesses involved in manufacturing, supplying and installing orchard netting.



Introduction

The native winged vertebrates collectively known as ‘flying foxes’ or ‘fruit bats’ damage fruit crops in Queensland on an annual basis and have been a significant pest of fruit orchards for many years.

Crops most affected are low-chill stone fruit, lychee, longan and rambutan and other crops often damaged include persimmons, bananas, pawpaws and mangoes. Most crops damaged by flying foxes are also susceptible to damage by birds.

Orchard netting provides a physical barrier to exclude flying foxes and protect crops under all conditions. While sound and light systems can be used to deter animals from feeding in an orchard, these systems can be ineffective in some situations (e.g. when animals are starving).

Pests that can be controlled by netting

Orchard netting can be used to control a number of vertebrate and insect pests. Information about these pests and the type of net needed to control them follows.

Flying foxes

‘Bats’ is the common name given to a group of mammals that belong to the scientific order Chiroptera, which includes all the species commonly referred to as flying foxes, fruit or blossom bats.

Within the order Chiroptera are two suborders:

- **Microchiroptera** (microbats) are generally small bats with wingspans up to 30 cm. Microbats use echolocation to hunt their prey and most eat insects.
- **Megachiroptera** (megabats) includes the family Pteropodidae, to which the flying foxes belong. Flying foxes are much larger than the Microchiroptera and have wingspans up to 1.6 m. Flying foxes live on a diet of fruit, blossoms and nectar and use their well-developed senses of smell and sight to find food. Megabats, including flying foxes do not echolocate.

Flying foxes have adapted to take advantage of introduced species found in urban areas and commercial orchards that—combined with native species—gives a year-round food supply (Hall 1994). Flying foxes are intelligent creatures with communal habits. They are good food foragers and range 60–100 km per night from their roost site. These characteristics make flying foxes hard to predict and control.

Flying foxes play an important environmental role as flower pollinators and seed dispersers. Because they feed on a wide range of forest species, flying foxes have a major influence on the evolution and reproduction of many different forest types (Eby 1995).

Six species of flying fox are found in Australia, but the following four are most common:

Little red flying fox, *Pteropus scapulatus* (Figure 1). This is Australia’s most widely distributed flying fox species and is found in all states and territories except Tasmania. The wing membranes are distinctly brown and are transparent when spread in flight. Little red flying foxes are distinctly smaller than grey-headed and black flying foxes.

Little red flying foxes feed predominantly on nectar. They are seasonally nomadic, following the mass flowering of native hardwoods, and their unpredictable movements depend on the flowering of these trees. They live in large camps—often near water—which they return to each year (the camps usually last 4–6 weeks while native trees in the area blossom). Unlike Australia’s other flying fox species, little red flying foxes cluster together on branches when roosting.

This species is migratory and is not regarded as a persistent orchard pest; however, when native blossoms fail, little red flying foxes can cause severe damage to orchard crops.



Figure 1. Little red flying fox



Figure 2. Grey-headed flying fox



Figure 3. Black flying fox



Figure 4. Spectacled flying fox

Grey-headed flying fox, *Pteropus poliocephalus* (Figure 2). This species is found from Victoria through New South Wales and north to Rockhampton in Queensland. The body and head fur is light grey. An orange or russet-coloured collar encircles the neck. Leg fur extends to the ankle.

The grey-headed flying fox is primarily a nectar feeder and is the largest flying fox species in Australia—a fully grown male can weigh up to 1 kg and has a wingspan more than 1 m. They can range long distances in search of food and are unpredictable in their movements. They are not regarded as migratory, moving only in response to food availability (and not on a seasonal basis).

The grey-headed flying fox is regarded as an orchard pest over its entire distribution area particularly in northern New South Wales and south-eastern Queensland. The Australian Government has listed this species as ‘vulnerable’ under the *Environment Protection and Biodiversity Conservation Act 1999*.

Black flying fox, *Pteropus alecto* (Figure 3). This species is found throughout the northern half of Australia, from Carnarvon in Western Australia to the Queensland–New South Wales border on the east coast. Typically they have a jet-black head and body fur, though sometimes the fur can be dark brown. There can be a deep russet shoulder mantle similar to the grey-headed flying fox but the mantle does not completely encircle the neck. Unlike the grey-headed flying fox, leg fur does not extend below the knee. Black flying foxes prefer to feed on the nectar and blossoms of eucalypts, paperbarks and other native trees.

Spectacled flying fox, *Pteropus conspicillatus* (Figure 4). The range of this species is restricted to the coastal Queensland north of Bowen. The fur is almost all black, though often pale yellow fur is found on the shoulders and the back of the neck. As its name suggests, the spectacled flying fox has prominent, pale, straw-coloured fur surrounding the eyes (sometimes on the muzzle), which clearly distinguishes it from the black flying fox.

The spectacled flying fox is a more versatile feeder than other flying fox species. Among its natural food sources are the fruits of North Queensland’s rainforest trees. The Australian Government has listed this species as ‘vulnerable’ under the *Environment Protection and Biodiversity Conservation Act 1999*.

Distribution

Generally flying foxes are mainly found along the northern and eastern seaboard of Australia, though some species can range inland for several hundred kilometres wherever there are permanent or semi-permanent rivers. Figure 5 shows the distribution of Australia’s four main flying fox species.

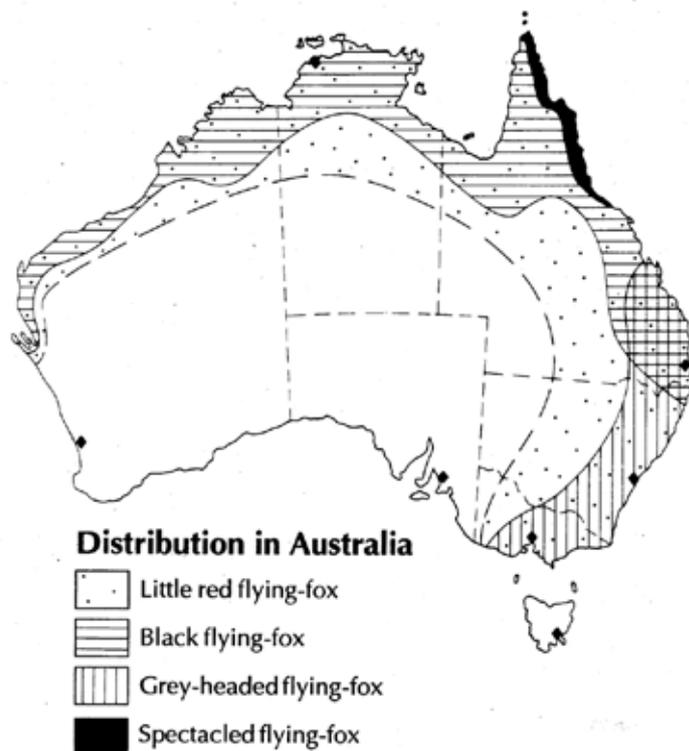


Figure 5. Distribution of four main flying fox species in Australia (Tidemann 1997)

Breeding

Grey-headed, spectacled and black flying foxes give birth from October to December. Little red flying foxes give birth in May. The following breeding characteristics apply to all species:

- The breeding cycle is annual, with only one young born per year. Females bear young from two years of age. Rapid increases or decreases in local populations reflect the movement of flying foxes (entering or exiting an area) more so than breeding.
- The high mortality rate of flying foxes in their first two years of life is due to misadventure (electrocution on power lines, trapped on barbed wire fences etc.).
- Mass spontaneous abortions can occur from time to time; almost all females in a camp can lose their young.
- The flying fox's usual lifespan in the wild is five years or less; 10 years is exceptional (C Tidemann 2000, pers. comm.).

Diseases

Flying foxes are associated the following diseases:

- **Australian bat lyssavirus (ABLV)**—This rabies-like virus has been found in all of the common Australian flying fox species. The virus infects the central nervous system. Once animals are ill, the disease is invariably fatal. This virus survives only a short time outside its host, and humans are not infected through handling or eating damaged or soiled fruit. People can be infected with ABLV through contact with an infected bat when the animal's saliva comes into direct contact with exposed tissue through a bite, scratch or a mucous membrane (such as the eye).
- **Hendra virus (HeV)**—Flying foxes are the natural hosts for Hendra virus. Humans do not get Hendra virus from bats. The few cases of Hendra virus infection in humans have been the result of close contact with infected horses. More information on Hendra virus can be found on the DPI&F website at www.dpi.qld.gov.au
- **Leptospirosis**—This disease occurs in humans and animals worldwide. It affects the blood, renal and central nervous system. Leptospirosis antibodies have been found in flying foxes but it is not clear if they can transmit the disease to other animals or humans. Further research is needed to determine the relationship of flying foxes and leptospirosis (Smythe 1999).

IMPORTANT: Do not handle sick or injured flying foxes. If you are bitten or scratched, wash the wound carefully with soap and water for five minutes and seek urgent medical advice. Do not scrub the wound. If possible, keep the bat for testing but do not attempt to handle bats yourself (for example, try to put a box over the bat).

Research

Scientists are researching the behaviour of flying foxes so that damage to cultivated fruit can be predicted and controlled. One method of doing this is to attach metal or plastic bands onto one or both of the flying fox's 'thumbs' (Figure 6).



Figure 6. Flying fox with identification band attached

By collecting information from banded animals (such as where and when they are found), it will be possible to resolve the following questions:

- **Camps**—Where are they? Which species use them? When are they occupied?
- **Orchard damage**—Which species are involved? Which crops are affected? In which areas and at what times of the year are orchards likely to be damaged?
- **Movements**—Where do flying foxes go and how long do they live?

A number and a return address is stamped on each band. Any banded animals found should be reported to the contact shown (Tidemann 1997).

Flying foxes and orchard netting

All flying fox species are relatively large animals but are capable, when their wings are folded, of squeezing through small apertures. Cases of flying foxes crawling through 50 mm mesh netting have been reported. Use nets with a mesh size no larger than 40 mm for orchard exclusion netting.

Orchard netting may trap flying foxes, either underneath the netted enclosure or by entanglement. The Queensland Environmental Protection Agency has developed detailed guidelines for growers who need to deal with animals in this situation—*Euthanasia of flying foxes trapped in orchard netting*. This document can be found using the search engine at www.epa.qld.gov.au

Birds

Many bird species eat orchard fruit and damage by birds can exceed damage by flying foxes. When suitable netting is used, the control of birds is a significant benefit of exclusion netting. A net with a 40 mm mesh size will exclude larger birds (such as lorikeets, parrots, rosellas crows, currawongs and ducks), but smaller species (such as silver-eyes) will only be excluded by nets with a mesh size of 20 mm or less.

Orchard netting excludes both beneficial and pest bird species. In the off-season, some growers leave net doors open or roll up the sides of canopy netting to allow birds to enter the orchard and feed on insects. However, birds are non-discriminatory feeders and it is likely that both beneficial and pest insects will be eaten.

Fruitpiercing moth

There are three different species of fruitpiercing moth—*Othreis fullonia*, *Othreis maternal* and *Eudocima salaminia*—and all three are large, stout-bodied and colourful (Figure 7). The forewings are mainly brown, green or cream. The hindwings are yellow and black. Adult fruitpiercing moths can have a wingspan of 100 mm; however, when their wings are folded they can squeeze through holes 10 mm in diameter.

The larvae are velvety black and have two large spots, white with black centres on either side of body segments six and seven (Smith et al. 1997). Larvae feed on native vines found in rainforests.

Fruitpiercing moths are found in most of the coastal fruit-growing areas of Queensland and northern New South Wales and feed on a number of different orchard crops. Adult moths rest outside orchards during the day (often in surrounding scrub or forest) and attack orchards at night using a long proboscis (mouthpart) to suck juice from fruit. A feeding fruitpiercing moth typically leaves a hole 2 mm in diameter in the fruit. Decay and premature colouring sets in around the damaged tissue and causes premature fruit drop or renders the fruit unsaleable (Smith et al. 1997).

There is no established chemical control method for this pest.

This moth can be excluded from an orchard using netting. Some growers have reported reasonable control of fruitpiercing moth with 13 mm and 15 mm vine netting but to be confident of completely excluding the moth a net with a mesh size of 10 mm or less is recommended. No fruitpiercing moth damage was recorded under quad netted (5 mm mesh) lychee trees (Lloyd et al. 2003).

Macadamia nutborer

The macadamia nutborer (*Cryptophlebia ombrodelta*) is a major pest of lychees and is common throughout eastern Queensland. The adult female has a wingspan of around 25 mm and is reddish-brown with a distinctive black triangular mark on the hind margin of each forewing. Adult males are smaller and lighter coloured (Figure 8).

The female lays its eggs, which are oval and about 1 mm in size, on the surface of the fruit and the larvae (Figure 9) tunnel into the flesh and through to the seed (Ironsides 1981). Green lychee fruit will either split or fall prematurely when damaged. Macadamia nutborers can be controlled in lychee orchards using chemicals.

A trial to test the effectiveness of using tunnel netting to exclude macadamia nutborers from lychee orchards was conducted at the Maroochy Research Station in South East Queensland. A 12 mm quad net, with a 5 mm mesh size, was used to cover Kwai Mai Pink and Salathiel lychee trees in November 2001 and again in October 2002. In both years the nets were left on trees until fruit had been harvested (Lloyd et al. 2003). Fruit under the 12 mm quad net was less damaged than fruit under the bird netting (which offered free access to adult moths). The results are summarised in Table 1.

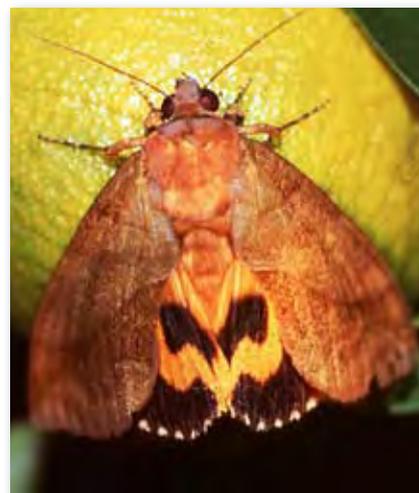


Figure 7. Three species of fruitpiercing moth, from left to right, *Othreis fullonia*, *Othreis materna*, *Eudocima salaminia*



Figure 8. Female and male adult macadamia nutborer



Figure 9. Macadamia nutborer larvae in an immature lychee fruit

Table 1. Results of bird/quad net trials to exclude macadamia nutborers in lychee

Net type	Lychee variety	% fruit damaged at harvest by MNB	
		2001–02	2002–03
12 mm quad net (5 mm mesh)	Kwai Mai Pink	12	5.6
	Salathiel	2	5.1*
Bird net (15 mm mesh)	Kwai Mai Pink	36	26
	Salathiel	15	12

* Most of the damaged fruit was recovered from two rogue Wai Chi trees in the row. The Salathiel fruit was not damaged.

Protection was not 100%. Some females alighting on the net were able to squeeze through the 5 mm hole and lay their eggs on the fruit; however, most were excluded and there was a significant reduction in the damage to fruit of both varieties under the 12 mm quad net. The poorer result in Kwai May Pink reflects this variety’s higher susceptibility to macadamia nutborer damage than Salathiel (as evidenced by the difference in damage between these two varieties in unprotected bird netted rows).

Queensland fruit fly



Figure 10. Female Queensland fruit fly

Queensland fruit fly (*Bactrocera tryoni*) is a major pest of many orchard crops in eastern Australia. The adult fly is about 7 mm long and is reddish-brown with yellow markings on the thorax (Figure 10). Larvae are creamy white maggots, tapering towards the front end, which grow to a maximum size of 9 mm.

The adult female fly lays her eggs in batches of 10–12 into fruit rind, the eggs are banana-shaped and only 1 mm long. The eggs hatch after 2–3 days and the maggots burrow into the fruit pulp (Figure 11). After about 10 days the maggots drop to the ground and pupate in the soil for around nine days. This short life cycle means that as many as six generations a year can occur in the warmer parts of North Queensland (Smith et al. 1997).

Chemical control of Queensland fruit fly using cover and bait sprays is possible but expensive; often protection is incomplete unless frequent spraying is carried out. Interstate quarantine requirements often require post-harvest control dipping or spraying for a number of fruit crops.

Fruit fly exclusion netting has been tested in a low-chill stone fruit orchard and complete exclusion was achieved using a 2 mm mesh net (Lloyd et al. 2003). The exclusion net enclosure was constructed with no gaps around the seams or posts. The bottom edges of the net fabric were held down by a slurry of concrete, or buried in the ground. A double entrance door was used to minimise fruit fly access during normal orchard management practice. Over two harvests in 2001 and 2002 no fruit fly larvae were found in a total of 1517 fruit harvested from within the enclosure.

The complete report, *Exclusion canopy netting of fruit crops for economically and environmentally sustainable production and non-chemical interstate/export market access protocols* (project number HG00018), is available from Horticulture Australia Limited at www.horticulture.com.au/



Figure 11. Queensland fruit fly larvae in stone fruit

Fruitspotting bug

Fruitspotting bugs are serious pests on a wide range of subtropical and tropical fruit crops. There are two species—*Amblypelta nitida* (fruitspotting bug), which is common in New South Wales and South East Queensland, and *Amblypelta lutescens lutescens* (banana spotting bug), which is found throughout coastal Queensland but not New South Wales.

Adult bugs are 12–15 mm long and range in colour from green, yellow-green to brownish-green. They are easily disturbed, and either fly away, move to lower branches, or quickly hide behind fruit or under leaves. The fruitspotting bug adult is usually a brighter green than the banana spotting bug (Figure 12).

An adult female lays only a few eggs each day, but during its life may lay more than 150 eggs. The eggs hatch in 6–7 days and development from egg to adult takes about 42 days in summer. The bugs pass through five nymphal stages (instars) before becoming adults. The first instar is green and black, and has an ant-like appearance. Later instars are orange-brown or green (fruitspotting bug) and pinkish (banana spotting bug). They have prominent antennae and two scent gland openings on the upper surface of the abdomen. The scent gland openings on the abdomen of the banana spotting bug are highlighted with white circles. Adults tend to infest groups of trees, forming ‘hot spots’ in orchards.

Both adults and nymphs feed by piercing fruit, inserting their long mouthparts and sucking the juice from the tissue. Losses result when fruit drops because the bugs have fed on the developing fruit.

A 12 mm quad net with 5 mm mesh successfully excluded fruitspotting bug in the macadamia nutborer exclusion trial carried out on lychees (Lloyd et al. 2003).

Possible pest problems under nets

In some cases, insect pest problems have increased in severity as a result of growers using orchard netting. Two examples are:

- A build up of oriental tip moth (*Grapholita molesta*) (Figure 13) occurred under fruit fly exclusion nets at Maroochy Research Station. About 70% of shoot tips were affected under the exclusion net compared to a nil incidence in bird and bat net enclosures (Lloyd et al. 2003). It is thought that either the natural predators of this pest had been excluded and/or the life cycle of the pest had been shortened due to the warmer conditions under the exclusion nets leading to a population explosion. Registered chemicals have been used to control this pest (A George 2008, pers. comm.).
- Successful control of the macadamia nut borer was achieved in lychees grown under permanent quad netting with a 5 mm mesh size on a farm in New South Wales. However, longicorn beetles (*Strongylurus* sp.)—a native branch borer—became established inside the enclosed orchard and these have been responsible for the loss of large numbers of branches over several seasons. (Lloyd et al. 2003). In 2007 a three-year research project began



Figure 12. Adults and nymphs of fruitspotting bug (left) banana spotting bug (right)



Figure 13. Tipborer in stone fruit

to investigate the problem and develop a management strategy (R Hewer 2008, pers. comm.). A report on the project can be found on the Australian Lychee Growers Association’s website at: www.australianlychee.com.au/items/54/Longicorn%20Beetle.pdf

Orchard netting

Two types of netting systems are commonly used by growers:

1. **Full canopy netting**—The net is held permanently by a rigid structure of poles and tensioned cables over the entire orchard.
2. **Tunnel netting**—A series of light frames connected by wires are erected at intervals along the row to support the net and hold it away from the tree. The nets are placed over the frame only when the fruit approaches maturity and are taken down after harvest.

Some points to note are:

- Orchard netting provides a physical barrier between the pest and the crop, giving a high level of protection that is reliable from season to season at all levels of pest pressure.
- Provided a suitable mesh size is chosen, the net can protect against a wide range of potential problem animals (such as flying foxes, birds, fruitpiercing moths, fruitspotting bugs, macadamia nut borers, fruit flies, wallabies, hares and possums). Appropriate netting can also protect orchards from wind and hail damage.
- Cost is the major hurdle with netting. Netting an orchard can cost from \$17 000 to \$72 000 per hectare depending on the system and type of net used.
- Difficulties associated with topography, orchard layout and tree size can make orchard netting construction impractical or lead to higher construction costs that make it uneconomical.
- There is a risk of storm or fire damage to the nets.
- Depending on crop, location and management netting can beneficially change the orchard microclimate resulting in higher quality fruit production from the netted orchard. There is also a possibility that microclimate changes under a netted orchard will result in production of poorer quality, less valuable fruit.
- Netting is generally regarded as an environmentally friendly and socially responsible approach to the problem of vertebrate pest control.

The different characteristics of tunnel and full canopy netting are compared in Table 2. This information may help you to identify the most suitable system for your situation.

Table 2. A comparison of tunnel and canopy netting systems

Factor	Full canopy netting	Tunnel netting
Capital cost	High cost, \$23 000–72 000 per hectare.	Moderate cost, from \$17 000 per hectare.
Support structure	Needs to be strong and durable and is therefore relatively expensive.	Can be made from lightweight and relatively low-cost materials.
Net quality and cost	Nets are permanently exposed to the elements so good quality, more expensive nets need to be used.	Nets are on the trees for only +/- 2 months per year, so cheap light weight nets can be used.
Quantity of net	Nets cover only the top and sides of the whole orchard, reducing the area of net needed per tree.	Nets cover the top and the two sides of each tree row, increasing the area of net needed per tree.
Recurrent costs	No recurrent costs putting out and recovering the nets.	The cost of putting out and recovering the nets each season is significant over the life of the orchard.
Maintenance	Repairs to net and structure will be required from time to time, depending on quality of materials used and weather events.	Frames need to be smooth to minimise net damage during application and removal. Store nets in vermin-proof containers.

Table 2. (cont.)

Factor	Full canopy netting	Tunnel netting
Portability and multi-use	Nets are permanent and cannot be moved.	Nets can be moved between varieties or crops that ripen at different times.
Planting distances	Suitable for orchards where trees are planted close together (within and between rows). This minimises the unproductive area under the net canopy.	Suitable for orchards where there is a wide distance between rows to allow passage of machinery when the nets are out.
Net lifespan	Nets are exposed to sunlight and other elements all year round. Good quality nets will last at least 10 years and structures last up to 40 years.	Nets are only used for +/- 2 months per year, limiting exposure to the elements. Even lower quality cheap nets can be reused for many years.
Tree growth and pruning	Prune regularly to control tree height and to prevent branches growing through the net canopy.	Prune trees to maintain the canopy within the frames. Put out nets as late as possible and take them in straight after harvest to minimise damage by branches growing through them.
Orchard microclimate changes	Extent of changes (both beneficial and detrimental) will vary depending upon net type used and the climate.	Any change to the microclimate has a minimal effect because of the short time the tree is covered.
Pollination	Bee hives are needed in the enclosure if mesh size is too small for bees to pass through easily. Sheltered conditions reduce wind pollination.	No effect on pollination as the nets are put out after pollination takes place.
Pest predators	Nets may exclude non-pest bird species. This can be minimised by rolling up side netting and opening the doors in the off-season.	Nets are out for a short period, minimising changes to the ecology of the orchard.
Effectiveness	Where an appropriate net type is used complete protection against flying foxes, birds and some insects can be achieved.	Fruit touching the net can be damaged by pests on the outside of the net. Nets need to reach ground level and be pegged down to prevent pests getting underneath them.
Machinery use	Position poles in the tree rows to minimise problems when using machinery such as slashers and sprayers. Care must be taken using pruning machinery.	Care needs to be taken not to damage nets with machinery moving between the rows. Poles and frames can interfere with some orchard operations such as pruning.
Harvest operations	Labour efficiency normally improves after netting an orchard when yields increase due to lower losses to vertebrate pests.	The need to lift nets prior to picking can slow harvesting.

Full canopy netting

Note: *The following notes are adapted from the Low chill stonefruit information kit and Protect your stonefruit (both published by the Department of Primary Industries and Fisheries, Queensland).*

The type of netting referred to here is flat canopy, consisting of a net canopy held in place by a grid of wires or steel cables supported and tensioned at the perimeter by poles and anchors. There are many possible variations of net type, structure materials and design and the following notes are meant as a general guide only.

Professional assistance

The netting structure needs to be designed to withstand wind loads, the weight of the net when wet and (possibly) the extra weight of hail.

Netting contractors provide a complete design and construction service. If you undertake full canopy net construction yourself, without the use of experienced contractors, we advise you to obtain professional advice prior to construction. Some netting contractors provide design services and advice to growers.

Pole size and quality

As the structure will be subject to storms (and possibly cyclones), use good quality poles. Poles that are CCA-treated to H5 standard are preferred; these have a life of 40 years. Galvanised steel poles are also suitable.

The general practice is to imbed perimeter poles and anchors in the ground and use lighter internal poles, which are often not imbedded. Internal poles are generally placed under every second grid wire junction (Figure 14). Where the soil is soft, use anti-sink pads to prevent poles sinking into the soil. Perimeter poles should have a small end diameter (SED) of 200 mm. Internal poles should have a SED of 150 mm.

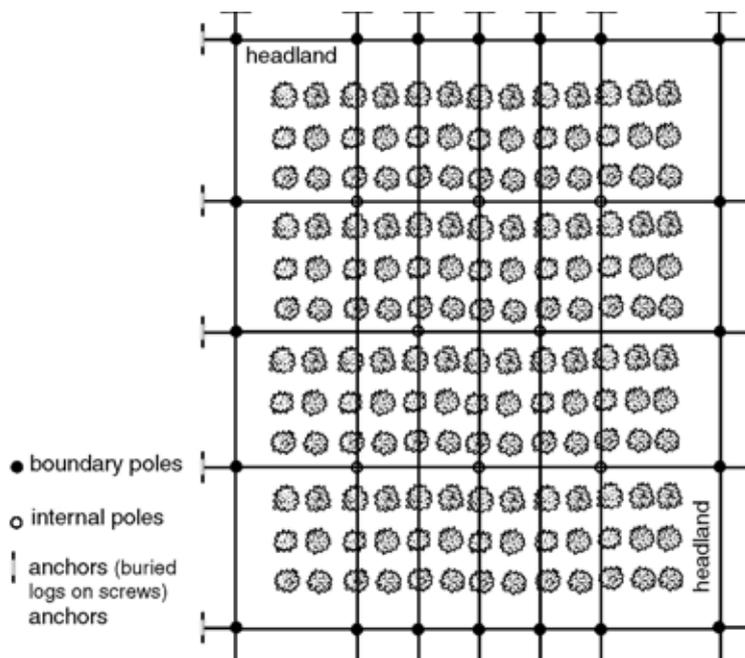


Figure 14. Overall plan of a typical netting structure (adapted from *Guidelines for netting orchards and backyard fruit trees*, courtesy John Gough)

Anchor type and position

There are five possible anchor types:

- simple end post
- compression-braced end stay
- tension-braced end post
- boxed end stay
- buried log or deadman.

These are illustrated in Figure 15. Although the boxed end stay is the best, it is rarely used because of cost. The most common and practicable are the tension-braced end post and the buried log or deadman stay.

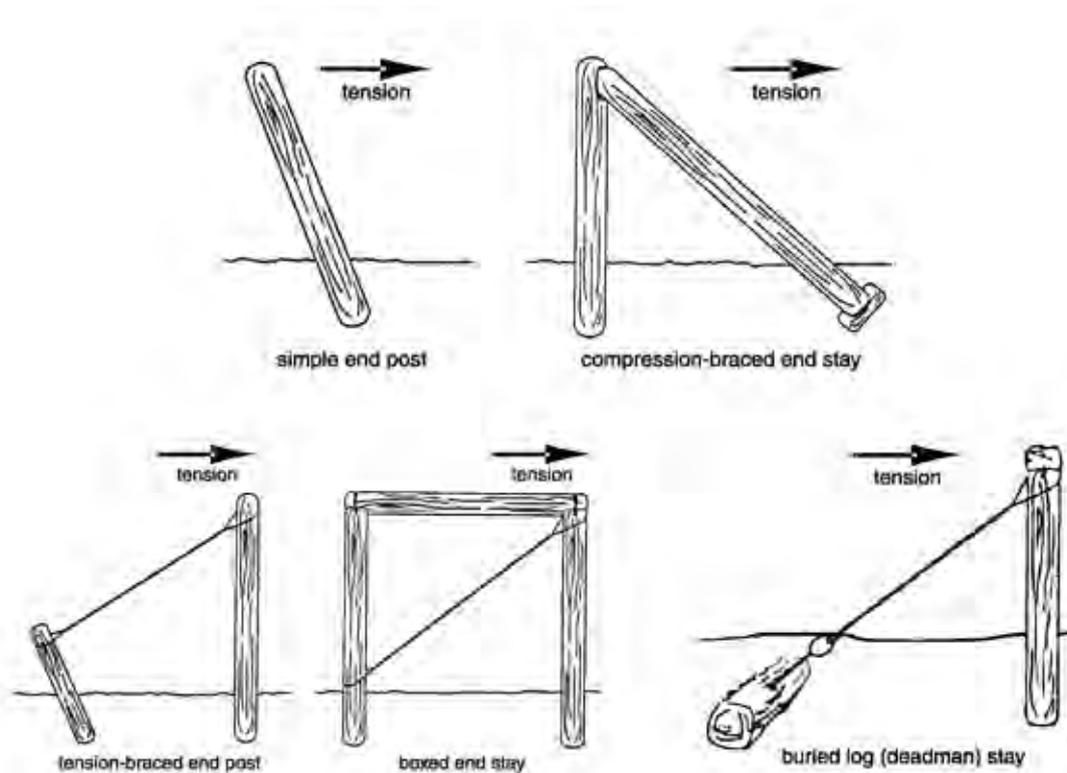


Figure 15. Types of anchors

The buried log or deadman stay should have an SED of 225 mm with the tensioning wire attached by a screw anchor. Position the anchors at a maximum of 45° from the pole top. An example of this position is shown in Figure 16. This is the most commonly used option because it is easy to install, cheap and works well.

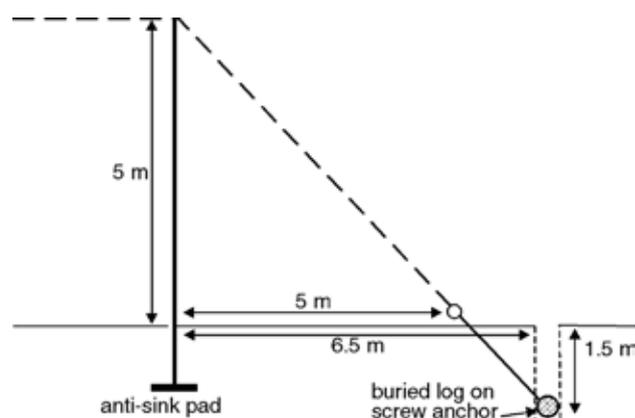


Figure 16. Positioning of anchors for a 5 m high structure; other heights would have dimensions proportional to these (adapted from *Guidelines for netting orchards and backyard fruit trees*, courtesy John Gough).

Wires and cables

Use only high-tensile wire. High-tensile wire maintains tension better than plain wire (hence fewer posts are needed). High-tensile wire usually has a galvanised coat and heavy or double-galvanised wire is recommended. Minimum requirement is 3.15 mm high-tensile wire.

The best option is to use a 6.1 mm or 7.5 mm cable (consisting of multiple strands of wire) for the main grid between poles and guy wires with single-strand, high-tensile wire to support runs of net within the main grid. Where cable is used, span widths and lengths can be increased and this offsets the higher cost of the cable compared to wire. The size chosen is dependent on the carrying load. Load weights include initial tension plus net weight as well as any load created by hail, wind or rain and contraction associated with temperature changes.

Guy wires that run from perimeter posts to anchors should be a double strand of the wire or cable used for the grid. Always exercise care when handling wire to ensure the galvanised coating is not scratched or removed. Avoid dragging wires across the ground during construction. Use only galvanised nails and fasteners.

Tension requirements

Correct tensioning of wire and cables is essential to hold the structure firmly and to prevent movement of the net (which causes wear). The exact tension of the wires and cables in the structure depends upon the situation and overall design.

Contraction during cold weather must be considered when straining wire. Longer runs of wire perform better where cold contraction occurs as they are more capable of absorbing changes in temperature. To ensure the correct tensions, use wire strainers that incorporate a tension gauge. The limiting factor in wire tension is usually the ability of the soil to transfer the load to the anchors.

In practice, few growers tension wire or nets correctly; often lower than desirable tensions are used. We strongly recommend you seek advice from experienced netting consultants to ensure that the correct tensions are used for your design and situation.

Orientation of wire/cable and net

Where possible, run the net in the same direction as the rows.

Headland room

Keep at least 10 m between the outer edge of the orchard trees and any boundaries, windbreak trees, buildings etc. This allows plenty of room for machinery access and turning on headlands within the net enclosure, as well as for the netting structure itself (including stays and anchors).

Height of structure

This depends on intended tree height, clearance required and the amount of sag in the net. Where cable is used, net sag is minimised. A sag of 10 cm per 17 m is acceptable.

You can reduce capital costs by keeping the net canopy as low as possible; however, these savings are relatively minor as the extra expense of a higher canopy is only that associated with the purchase of longer posts and the larger area of side netting needed. In the long term a lower net canopy may prove expensive because of the extra costs incurred managing the orchard (arising from such factors as less flexibility in the timing of pruning). Also, good clearance of the net above the trees can help minimise the impact of the net on the orchard microclimate. Structure heights range from as little as 3.6 m (for open vase-pruned stone fruit) up to 8 m (in lychee orchards).

Net characteristics

There are several features to consider.

Mesh size

Bird and flying fox nets can have a square, diamond or hexagonal-shaped mesh. For a square or diamond-shaped mesh, the size is the distance in millimetres (when the net is correctly hung and tensioned) along one of the sides. For hexagonal-shaped nets, the size is the distance between two opposite sides.

Choice of mesh size usually depends on three factors:

- The type of pest, or pests, you wish to control (see notes on individual pests).
- Your ability to manage any changes to orchard microclimate that may occur after netting the orchard (nets with smaller mesh sizes have a greater impact on the orchard microclimate than nets with larger mesh sizes).

- Financial factors. Nets with a small mesh size are more expensive than large mesh nets. In addition, they are heavier and can hold hail (and therefore need stronger, more expensive structures to support them).

Some nets have a main mesh plus strands of monofilament that stretch across the apertures of the main mesh and reduce the hole size. These strands of monofilament are known as cross-stitches. Double and quadruple cross-stitched nets (with two or four cross-stiches respectively) are commonly available. Cross-stitched nets have a major advantage—the hole size of a large mesh net can be reduced without adding too much weight or excessively reducing light transmission through the net. Nets with quadruple cross-stitches are usually known as ‘quad nets’.

A wide range of mesh sizes are available, from 10 mm to 37 mm. Cross-stitched nets come in mesh sizes of 8 mm, 12 mm, 16 mm and 21 mm.

Hail nets come in a number of different designs which all have a small mesh, these are suited to different canopy structures and different climates.

In areas where heavy hail is a regular occurrence, it is best to use a pitched roof net canopy (Figure 17), which deflects hail safely into ‘valleys’ located over the inter-row space between tree rows. Netting with a zigzag weave of monofilament held in place by parallel runs of knitted monofilaments is designed for use in this situation (Figure 18).

In areas where hail storms are less regular, flat canopy netting is used (Figures 19). The net catches the hail and stops it damaging the crop. With this design the net gives under the weight of the hail and stretches (usually returning to tension after the hail has melted). The cables holding the nets are positioned over the tree rows and the nets sag into the inter-row space between tree rows, thus minimising damage to the trees. Diamond mesh net with quadruple cross-stitch (Figure 20) is mostly used on this type of canopy.

Net manufacturers change their ranges of products from time to time (as grower needs are identified and advances in net design are made), so it is advisable to discuss what is available with manufacturers and/or retailers before determining which net suits your situation.

Net type

Modern knitted or woven nets may have a square, hexagonal or diamond-shaped mesh and are all made from woven monofilament strands without knots. The most common nets are made from high-density polyethylene (HDPE) and these have good durability and these nets should last at least 10 years. Use nets with woven selvedged edges, which give extra strength and ensure the net material will not unravel. The selvedging normally forms an eyelet that a wire can be threaded through for easy attachment to the support wires or cables.

Where nets are made from woven monofilaments, the tightness of the stitching can be varied. This is called the ‘stitch density’ and a net with a tight stitch density is stronger and heavier but less elastic than a net with a loose stitch density. Some net manufacturers recommend nets with a heavier stitch density for areas where large



Figure 17. Pitched roof hail netting



Figure 18. Net suitable for pitched roof hail netting



Figures 19. Flat canopy hail net



Figure 20. 12 mm quad hail net

hail is possible. The tighter the stitch density, the more expensive the net and the structure required to support it.

One indicator of the strength of a net is the weight per square metre (remember to compare nets of the same mesh size). Another is the thickness of the monofilament fibres, which is measured in ‘denier’. More light is intercepted by heavier, stronger nets and they have a greater impact on the orchard microclimate than lighter nets made from thinner monofilaments; however, lighter nets probably will not last as long as heavier nets. Lightweight vine net may have a weight of around 30 g/m², while a 12 mm quad net typically weighs about 90 g/m².

In the past, other types of net have been used to protect orchards. These nets may still be available, but they are not as suitable as knitted nets for orchard netting. Extruded nets consist of a grid of extruded plastic. Extruded nets are cheap, but not as strong as knitted nets, and do not last as long. Knotted nets are made from monofilaments twisted together to form multifilament strands (rope), which are knotted together to form a square mesh net with a knot at each corner. Knotted nets are heavy and relatively expensive. Knotted nets are better than extruded nets but not as good as knitted nets.

Net colour

Traditionally, white nets were cheaper than black nets but had a life expectancy about two-thirds of black nets, which used carbon black as a UV stabiliser and had the best durability. However, modern white nets incorporate chemical UV stabilisers that do not colour the material and have comparable life spans to black nets.

Prices are now the same or very similar for either black or white nets. White nets tend to ‘bounce’ light through the mesh and reduce light levels less than black nets with equivalent mesh size. Grey nets with properties intermediate to white and black nets are also available from some suppliers.

Net width

Net panel widths should coincide, if at all possible, with tree row widths or multiples of these. Panels are usually 10–15 m wide but can be specially manufactured to any width up to 50 m. Wider nets are generally favoured where available as they reduce installation costs because there is less joining; however, very wide nets can be difficult to handle when erecting.

Generally speaking, a good way to determine a net’s optimum width for handling is to convert the mesh size in millimetres (not including any cross-stitch) to metres (e.g. a quad net with 12 mm mesh is best hung using 12 m wide net). With flat canopy designs, panel widths greater than 10 m may require a support wire down the centre of the panel to reduce sag.

Doors

Plan the position of doors carefully for efficient access. Doors can be as simple as a curtain drop of net with a pipe weight at the bottom. A more elaborate hinged-gate design, consisting of a metal frame covered with the net material, can also be used.

An illustration of a typical netting structure is shown in Figure 21.

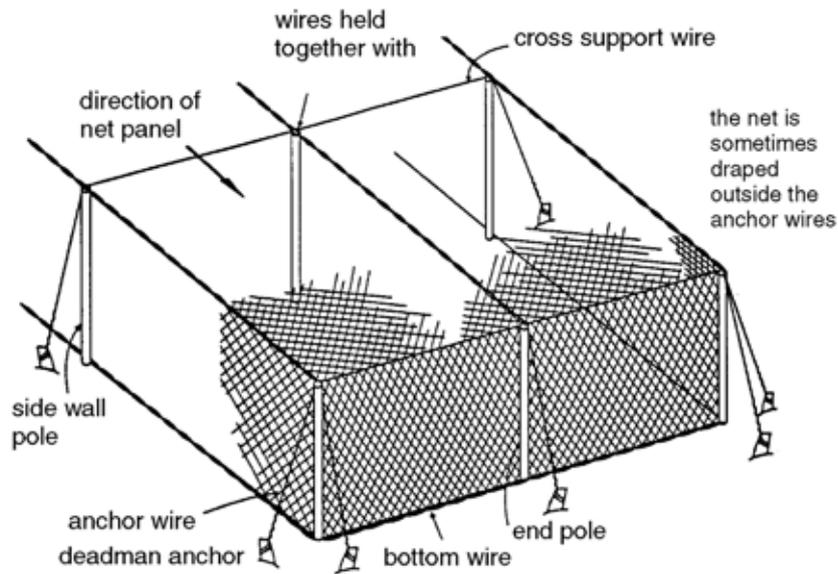


Figure 21. A typical netting structure

Basic construction procedure

1. Erect poles and anchors. Imbed corner and perimeter poles 1–1.5 m in the ground and anchors 1.5 m. In sandy soils, poles may need anti-sink pads in the bottom of the holes.
2. Erect wire grid and tension to firm only.
3. Thread a net wire through the net selvaging. The net does not have to be expanded to do this. In many instances, the net manufacturer will have threaded a polytube through the net selvaging to make the job of threading the wire easy.
4. Place the bunched panels of net up onto the wire grid.
5. Attach the net wire to the perimeter wires at both ends but do not tension them. Expand the net out to its full length (Figure 22).

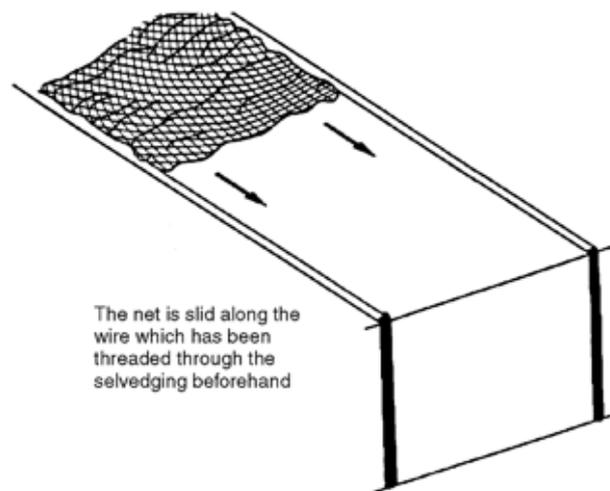


Figure 22. Erecting nets

6. Use C-hooks or some other type of fastener to hold the support wires of the grid close to the net wires (Figure 23).

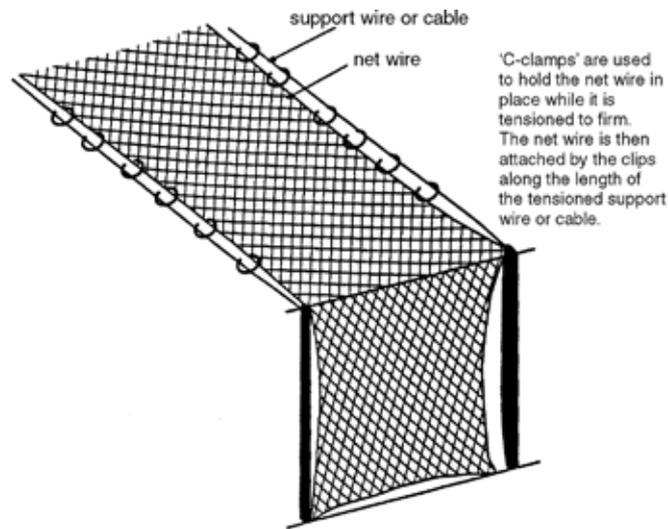


Figure 23. Securing net with C-hooks

7. Tension the net wires to firm only.
8. Clip net wires permanently to the support wires. Use Duralink clips or galvanised wool bale fasteners.
9. Put sidewall net panels in place.
10. Tension net and support wires to their correct tension. Use a tension gauge.
11. Lace net to right angle grid wires for extra strength. This transfers some of the wind load along the right angle grid wires to the side anchors, thus reducing the load on the anchors on the windward edge.



Figure 24. A sequence of photos showing contractors erecting hail net at Maroochy Research Station

Tunnel netting

Three types of frames are commonly used to support the net away from the tree from the tree:

- **The hoop frame** (Figure 25)—50 mm diameter black polypipe hoops are slotted over star pickets driven into the ground either side of each tree. Wires are strung between the hoops to stop the net sagging onto the tree canopies. Because the polypipe hoops are smooth, the net can move around on them in wind without being damaged.
- **The coathanger system** (Figure 26)—About every 20 m along the row a lightweight metal frame in the basic shape of a coathanger is held above the canopy on a single wooden or metal pole. Wires are strung between the frames to hold the net away from the tree canopies. It is essential to make sure that any corners on the frames that touch the net are rounded off or covered with something smooth (e.g. old inner-tube rubber) to prevent them catching on the net as it moves in the wind. The main advantage of this system is that there are no posts each side of the trees to get in the way of machinery when slashing or spraying.
- **The single pole and wire frame** (Figure 27)—A single line of poles in the tree row supporting a single wire above the canopy can be used to hold the net away from the top of the tree canopy. A drawback with this simple structure is that it allows the nets to fall against the sides of the trees and any fruit touching the sides of the net can be damaged by pests. Some growers tie the nets together overhead between the rows of trees to prevent this happening.

Hoop frame construction procedure

- Drive a 2 m star picket firmly into the ground on each side of each tree (or every second or third tree, depending on spacing).
- Cut 50 mm diameter polypipe irrigation pipe into 9 m lengths (to be used to form the hoops).
- Drill three holes big enough to take fencing wire through the pipe (one in the centre and 3 m from each end).
- Thread fencing wire through the holes. The fencing wire will hold the net away from the trees and also stabilise the hoops.
- Slide the polypipe over the star pickets.
- As the trees grow and increase in height, the height of the hoop can be increased by lifting the polypipe on the picket and securing with a wire pin through one of the holes in the picket.
- At the end of each row, tie the wires running through the hoops to a firm anchor post (to stabilise the hoops and allow the wire to be tensioned). To make tensioning easier, brace the hoops at each end of a row with wooden cross-frames.
- Use tie wire to attach each hoop to the wires running through them (this prevents the hoops sliding on the wires and keeps them in the vertical position). Make sure you fasten the tie wire against the inside of the hoop so it does not catch on the nets later.



Figure 25. Polypipe hoops over lychee trees



Figure 26. Coathanger frame tunnel netting over lychee



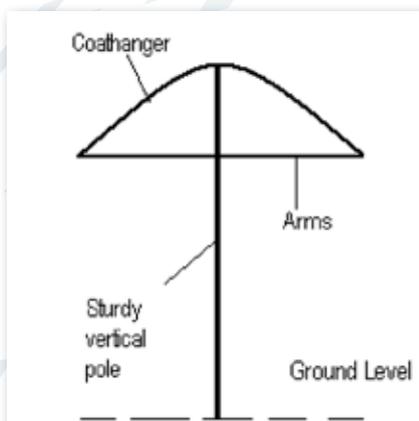
Figure 27. Single pole and wire frame for tunnel netting over lychee



Figure 28. Nets pulled up under a wire running along the ground and hooked back onto themselves



Figure 29. Nets can be rolled up and run onto the next row instead of being cut at the end of a row



This structure can be created using wood or metal. It is very important to choose a material that is smooth to reduce net tear

Figure 30. Cross-section of a typical coathanger tunnel net

- Slide the net over the hoops with a couple of long sticks. As this is being done it is necessary to tie the net to the pickets at the base of the hoops with soft twine to stop the wind blowing it back off. Alternatively, wire can be run along each line of star pickets and fastened at ground level. Pull the net under the wire and either tie it to the wires or hook the net back on itself (Figure 28).
- If possible do not cut nets at end of rows. Roll the net together and run it around to the next row (Figure 29)—you avoid having to sort out different lengths of net every year when you put them out. Alternatively, if you cut nets at the end of rows, be sure to number nets when you recover them (so they can be placed on the same row the following season).
- Finally, where necessary close the net from top to bottom at the end of the row. Either close the net with clips or sew with a net needle and soft twine.

Coathanger construction procedure

- Choose material (either wood or steel) for the coat hanger frame keeping in mind that it needs to be smooth to prevent tearing;
- The size of the frame will depend on tree height and width. The distance between each coathanger frame should be no more than 25 m.
- Construct a frame to create a structure like that illustrated in Figure 30. Wrap the ends of any rough or sharp surfaces that will touch the net with rubber strips made from old inner tubes (Figure 31).
- Erect the frames in the tree row and position the poles in line with the tree trunks. Place each pole in a 1 m deep hole in the ground and backfill with either concrete or firmly rammed soil.
- Run strands of fencing wire between the frames to support the net and stop it sagging onto the trees. One wire on the apex of the frame and one at the end of each arm, plus two along the ground either side of the tree row directly below the ends of the arms, are usually sufficient. Drill holes through the frame to take the wires. Tie the two wires on the ground (running either side of the trees) to stakes knocked firmly into the ground at suitable intervals.
- At the end of each row, tie back the wires running through the hoops to a firm anchor post (to stabilise the frames and allow you to tension the fencing wire).
- Slide nets over the top of the coathanger and wires joining the frames using long sticks or a net applicator (Figure 34). Pull the net under the wires on the ground on either side of the row and either tie the net to the wires (Figure 28) or hook the net back onto itself.
- Finally, where necessary close the net from top to bottom at the end of the row. Either close the net with clips or sew with a net needle and soft twine.

Application and recovery of tunnel nets

Relatively inexpensive 12 mm to 16 mm white vine netting (Figure 32) is normally used for tunnel netting.

Tunnel nets are put out over the frames when the crop is approaching maturity and are removed as soon as possible after harvest. The net is fastened to the wire runner along the ground on either side of the trees to prevent any birds getting under the edges of the net (Figures 28 and 33). Importantly, this also tensions the net, which helps prevent birds and flying foxes pushing the net down against the canopy to reach fruit.

A number of growers have developed homemade equipment to make the application and recovery of nets easier. A simple but effective system is to use a frame or pole with a hoop on top through which the net is threaded. This guides the net to a point above the tree row from which it can be pulled down manually either side of the tree (Figure 34). Alternatively, a person on a cherry picker can guide the net onto the trees from above in a similar way.

Net application machinery specifically designed and manufactured to apply and recover orchard nets quickly and efficiently is available. The masts on some versions of this equipment can be hydraulically extended up to 7 m.

Sometimes the lengths of net are tied together temporarily overhead between tree rows. This significantly reduces the quantity of net needed to cover the trees because only the tops of trees are covered. Nets can be secured to the ground around the perimeter of the orchard to prevent pests entering from the sides.

Tunnel nets can be joined together using the side wires on the shoulder of the frames. The nets are pulled across from one tunnel to the next and fastened to the wires on the 'shoulder' of the neighbouring tunnel using zip cable ties every metre (Figure 35). An advantage of this arrangement is that nets do not need to be lifted during picking. Following harvest, the zip cable ties are cut and the nets recovered in the normal way.



Figure 31. Sharp corners of the frames should be wrapped with old inner tube rubber to stop them tearing the net

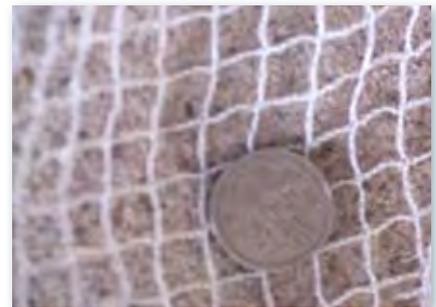


Figure 32. Vine net suitable for use over tunnel frames



Figure 33. Net fastened to the wire runner along the ground on either side of trees



Figure 34. Netting being run-out over frames using a simple hoop applicator.



Figure 35. Nets over a polypipe hoop tunnel that have been lifted and joined to the wires on the shoulder of the adjacent row of hoops

To make joining the lengths of nets quicker, the net can be pulled between double wires and clipped on to the wires at ± 1 m to intervals using cable clips. A pole and spreader arm arrangement can be constructed in a similar way to the coathanger tunnel netting frame (Figure 36).



Figure 36. A schematic representation of a system of poles and spreader arms to hold temporary nets above the canopy (drawing courtesy Oblimov Trading Company)

Microclimate, tree growth and management

Changes to microclimate

Permanent canopy netting changes the microclimate and environment under the net. Changes to the orchard microclimate will be significantly greater where nets with small mesh sizes (such as a 12 mm quad hail net) are used than where nets with large mesh sizes (such as a 37 mm or 20 mm mesh flying fox exclusion net) are used. Net colour also influences the changes that occur.

Two research projects have provided some data on the effect of orchard netting on the environment under the net.

Project 1—Research on hail-netted apple orchards in Queensland, New South Wales and Victoria (Middleton & McWaters 1996, 2000) studied the changes to the under-net microclimate. It was found that:

- Light levels, assessed by measuring photosynthetically active radiation, were reduced by 20–27% under black net, 18% under grey net and by 12–15% under white net.
- Humidity was consistently increased by up to 10%. After rainfall the humidity under the net remains high and takes longer to fall than under non-netted trees.
- Hail net had a minimal effect on air, grass or soil temperature. On warm to hot days air temperatures under the net, measured in a Stevenson screen, were reduced by 1 °C to 3 °C when compared to recordings in a Stevenson screen outside the net. The Stevenson screen excludes radiation and restricts wind, permitting a ‘true’ measure of air temperature. The temperature under black hail net may ‘feel’ cooler because light levels are reduced. The temperature under white net may ‘feel’ higher on hot days because of reflected light off the net.
- Wind speed is reduced by up to 50% within the netting.
- Hail net has little effect on night time temperatures and does not offer frost protection.

Project 2—Research on insect exclusion netting at the Maroochy Research Station near Nambour in Queensland included measurement of the environmental conditions under the nets (Lloyd et al. 2003). The research involved using nets to exclude Queensland fruit fly and macadamia nut borer from stone fruit and lychee trees respectively. Tables 3, 4 and 5 summarise the changes to the microclimate under the different types of net used. Pictures of the types of net referred to are shown in Figures 37 to 42.

The final report *Exclusion canopy netting of fruit crops for economically and environmentally sustainable production and non-chemical interstate/export market access protocols* (project number HG00018) is available from Horticulture Australia Limited at www.horticulture.com.au/



Figure 37. Black bird and bat diamond mesh net (15 mm)



Figure 38. White bird and bat diamond mesh net (25 mm)



Figure 39. White bird and bat diamond mesh net (15 mm)



Figure 40. 12 mm diamond mesh hail net with quadruple cross stitch (5 mm)



Figure 41. Translucent monofilament fibre exclusion netting with light-weave (2 mm)



Figure 42. Translucent monofilament fibre exclusion netting with heavy weave (2 mm)

Table 3. Orchard microclimate changes under two types of canopy net over stone fruit in relation to externally located Stevenson screen data

Factor	Exclusion net*			Bird net**	
	Oct 2001	Jan 2002	June 2002	Jan–Feb 2002	July 2002
Daily maximum temperatures	+4.9 °C	+5.3 °C	+4.21 °C	–2.2 °C	–2.4 °C
Daily minimum temperatures	–0.23 °C	–0.33 °C	–0.19 °C	–0.3 °C	–0.62 °C
Average daily temperatures	+2.13 °C	+2.56 °C	+1.52 °C	n/a	n/a

* Full canopy white Queensland fruit fly light weave exclusion net, hole size of 2 mm.

** Full canopy black diamond mesh bird net, hole size of 15 mm.

Table 4. Orchard microclimate changes under three types of tunnel net over lychees in relation to externally located Stevenson screen data

Factor	Exclusion net*	Hail net**	Bird net***
	Nov–Dec 2002	Nov–Dec 2002	Nov–Dec 2002
Daily maximum temperatures	+ 6.1 °C	+4.0 °C	+2.59 °C
Daily minimum temperatures	–0.8 °C	–0.79 °C	–0.3 °C

* Tunnel netting using white Queensland fruit fly light weave exclusion net, hole size of 2 mm.

** Tunnel netting using white 12mm hail net with a quadruple cross-stitch, hole size of 5 mm.

*** Tunnel netting using diamond mesh black bird net, hole size of 15 mm.

Table 5. Light level measurements taken in direct sunlight over 2 m square frames of each net type (similar reductions in light levels were found when measurements were taken under these nets in netted orchards)

Net type	Light reduction*
Translucent heavy weave exclusion net (2 mm)	–31.04%
Hail net 12 mm diamond mesh with quadruple cross-stitch (5 mm)	–21.9%
Translucent light weave exclusion net (2 mm)	–19.81%
Black bird and bat net diamond mesh net (15 mm)	–18.16%
White bird and bat net diamond mesh net (15 mm)	–15.39%
White bird and bat net diamond mesh (25 mm)	–3.87%

* Photosynthetic photon flux density reduction compared to direct sun.

Light levels within the canopy of peach trees under both translucent light weave exclusion net and black bird and bat net were measured. It was found that the levels were higher than the critical levels at which photosynthesis activity is reduced, even at the base of the canopy.

Relative humidity was increased and wind speed was reduced under the fruit fly exclusion nets.

At a Bryon Bay lychee orchard the relative humidity was generally higher under permanent canopy nets used to exclude macadamia nut borer, birds and flying foxes than outside the net. Readings below 50% relative humidity were rarely recorded under the net, while outside they were recorded on most days. Readings of 100% relative humidity were recorded almost daily both inside and outside the nets. Temperatures under the net were generally 1 °C or 2 °C cooler than the external temperature.

Changes to tree growth

Changes to tree growth under nets are a result of the interaction of many variables including the type of net used, the prevailing climate, the varieties grown and how the orchard was managed both prior to and after netting. Information from research on netted orchards can provide an insight into potential changes.

Observations and comments regarding the growth of apple trees under hail nets in the Stanthorpe region of Queensland (Middleton & McWaters 1996, 2000) include:

- Tree response to hail netting is largely determined by vigour. Netting most noticeably affects tree growth, yield, fruit size and colour on vigorous trees that would have shading problems without artificial protection.
- Although hail net reduces light levels by 12–27%, the leaf and canopy structure of the trees themselves can reduce light levels by up to 95% (regardless of the presence of netting). Daily cloud cover plus the time of day and the season (all of which affect the angle of incidence of sunlight to the net surface) also significantly influences the light levels reaching the tree.
- Differences in natural vigour between different varieties are important in managing the effects of netting. Increased shoot growth, larger leaves and reduced fruit set are classic ‘shading response’ symptoms that occur on vigorous apple varieties grown under black hail net in southern states; however, these symptoms did not occur with dwarf and semi-dwarf apple varieties grown on the Granite Belt in Queensland.
- Hail netting had little effect on yields per tree but fruit size was affected (though not always reduced). It was noted that vigorous apple varieties produced smaller fruit than comparable non-netted trees but dwarf and semi-dwarf apple varieties produced similar or larger sized fruit than on comparable trees outside the net.
- The effect of hail netting on the colour development in red apples is variable and colour is affected more by tree vigour and fruit position in the canopy. Similarly, the sugar content of apples was found to be strongly influenced by fruit size and location within the canopy and any direct effects of netting were masked.
- Wind rub and sunburn damage to fruit is reduced under hail netting.
- Other research has found that, under hail netting, pan evaporation levels are reduced by 1 mm per day. With reduced evaporative water losses, an improvement in tree water-use efficiency would be expected under hail netting. Trees under hail netting would be less stressed in hot, dry weather and irrigation water can be used more efficiently.
- Netted orchards help to ensure consistent lines of supply for market development.
- Bees are active in the sheltered environment under nets—both along the rows and across alleyways between adjacent rows—provided they are not blocked by trees growing too close to the underneath of the hail net. When hives are first introduced into a fully enclosed orchard, some bees may fly against the net and become trapped. Trapped bees soon die and are replaced by younger bees that have acclimatised to conditions under the net.
- Although hail netting has relatively little influence on apple yields, there is a significant improvement in pack-out through reductions in sunburn and russet, improvements in colour and the reduction or elimination of bird damage to fruit.
- Higher humidity under the net increases the length of time leaves remain wet after rain or spraying. No difference in disease incidence between non-netted and netted trees was noted in the experiment.
- Chemical efficacy under nets is greater due to higher humidity and reduced wind, resulting in slower drying times and more timely applications because wind does not disrupt spraying programs as much. This applied to chemicals used for fruit thinning (which caused over-thinning) and would also apply to pesticides.



Figure 43. The fruit fly (LHS) and bat (RHS) exclusion netting trial at Maroochy Research Station

Research on insect exclusion netting at the Maroochy Research Station (Figure 43) compared the growth of stone fruit under fruit fly exclusion nets to those grown under black bird and bat exclusion nets (Lloyd et al. 2003). The following observations were made:

- Vegetative growth rates and photosynthesis was variable. Some varieties exhibited reduced height and increased girth under exclusion nets and for others there was very little change.
- Reduced shoot extension growth of between 15–20% occurred on trees under the fruit fly exclusion netting and this was reflected in reduced pruning weights. Reduced shoot extension up to stone hardening may be a contributing factor to the increase in fruit size under exclusion netting (due to less competition between the shoot and the fruitlets at the time of cell division).
- The higher daytime temperatures under exclusion nets did not appear to alter flowering dates significantly. Only slight differences were observed between the trees under the two net types on defoliation, flowering and fruit set dates. Flordaprince defoliated and flowered about a week earlier under the fruit fly exclusion nets; however, for UF Gold, Sunwright and White Satin there were little or no differences.
- Due to the greater heat units under the exclusion nets, fruit maturity and harvest dates were advanced by 7–10 days for all varieties grown.
- Under the fruit fly exclusion netting, pollination and fruit set was affected in the first year of the trial due to lack of bees at flowering. In the second year, bee hives were placed in the netted enclosure at flowering and trees on straw mulch had less than 10% of unpollinated nubbin fruit (compared to about 3% under bird and bat nets and 2% on non-netted trees). Under the fruit fly exclusion netting, bees tended to avoid visiting flowers on trees on two types of reflective mulch—possibly due to the reflected light and the percentage of nubbin fruit on these trees (32% and 41%)—about five times greater than for those on the straw mulch. Under the black bird and bat nets, poorly pollinated fruit was less than 3% on all types of mulch, including the reflective mulches.
- For trees grown on straw mulch under the fruit fly exclusion netting, fruit yield per tree was 15–29% higher (mainly due to 10–20% greater average fruit weights).
- Sugar concentration in fruit was increased under the exclusion net by 20–30% (depending on variety), while improvements in skin colour were also significant. No clear effects on firmness were noted.
- A trend for higher rates of carbon dioxide assimilation was noted for trees under the fruit fly exclusion netting, which is reflected in the increased productivity of these trees.

Lychee fruit harvested under a fruit fly exclusion tunnel net, which covered the trees for 10 weeks prior to harvest, were on average 27% larger than fruit harvested from under bird and bat net exclusion net. The fruit also appeared cleaner, with better colour development possibly due to the enhanced dispersion of sunlight (Lloyd et al. 2003).

Management of netted orchards

Nets change the orchard environment. Some of these changes may be beneficial and others may be detrimental. This information outlines some of the changes that may occur, possible consequences and strategies to manage them.

Advantages of orchard netting identified by growers include:

The harvesting season begins earlier than it did before netting—Much of the early maturing fruit that is normally lost to birds and flying foxes before growers netted their orchard is now harvested. In practice, this more than offsets any delay in maturity to individual fruit brought about by microclimate changes caused by netting.

The larger fruit in the top of the canopy normally taken by birds and flying foxes is saved—Overall fruit size and pack-out improved after netting because the larger pieces of fruit are harvested and packed.

Fruit quality is improved—Yields are higher because netted fruit is not lost to birds and flying foxes. There is also less sorting and rejection of damaged fruit, which speeds up the harvesting and packing.

Management improves—During the harvest season there is no need for nightly patrols of the orchard to control birds and flying foxes. Consequently, the grower is able to concentrate on harvesting, packing and marketing.

Hail-netted stone fruit trees are easier to manage regarding practices such as defoliation and disease control—The crop and trees are healthier and of better quality because shelter provided by the nets reduces wind rub damage to fruit and wood.

Netting can provide chemical-free control of some orchard pests—The QFF exclusion netting trial at Maroochy Research Station demonstrated that a 2 mm mesh net, erected and maintained in a manner to minimise fruit fly entry, resulted in zero infestation in stone fruit—a crop that is highly susceptible to this pest (Lloyd et al. 2003).

The work also showed significant reduction in fruit damaged by macadamia nutborer in lychees under 12 mm quad nets.

Orchard netting is effective in eliminating or reducing insect pest damage in crops to the extent that it could be used as a stand-alone system for Interstate Certification Assurance or even to meet phytosanitary requirements for export.

Improved water use—Shading provided by nets, increased humidity and reduced wind speed in netted orchards may improve water-use efficiency through lower evapo-transpiration rates from leaves.

Financial certainty is improved—Netting ensures growers can be confident that all of the crop developing on the tree will be marketed and can budget accordingly. In seasons when fruit set is poor, or other producers are suffering high losses from birds and flying foxes, growers with netted crops have protection and can expect higher prices.

Concerns raised by growers regarding the use of orchard netting include:

Chemical use—Concerns that slow pesticide breakdown under netting can result in maximum residue limits being exceeded (and therefore create a workplace health and safety hazard) can be discounted because:

- Chemical residues on nets would be exposed to high levels of sunlight, either direct or reflected. Since sunlight is the main agent causing chemical breakdown, any residual chemical on the net would pose no greater threat to anyone working under the nets than residual chemical on shaded foliage. In non-netted orchards, chemical residues that are shaded by leaves or heavy cloud conditions are not regarded as a cause for concern.
- There are no label constraints regarding the use of registered chemicals under netting.

Pollination—Nets with small holes can limit access or exclude bees and other pollinators. Bees are able to pass through holes as small as 12 mm diameter and bird and flying fox exclusion nets (which have mesh sizes greater than 12 mm) are unlikely to limit bee movement in and out of the orchard. Bees usually fly up and down through the canopy net when entering or leaving an orchard, rather than going through the side netting (P Warhurst 1998, pers. comm.).

In orchards enclosed by nets with a mesh size smaller than 12 mm, bee hives can be successfully introduced during the flowering period. Apiarists in the Stanthorpe area of Queensland have noted problems in hail-netted orchards whereby bees cannot orientate themselves to return to their hives in the

evening (becoming trapped against the net canopy and dying from the evening cold). Sometimes marker paint sprayed onto the net above the hive helps guide bees back to hives that have been placed inside hail-netted orchards (P Warhurst 1998, pers. comm.).

The following points regarding the management of bees under hail nets have been noted (Middleton & McWaters 1996, 2000):

- Weak hives contribute nothing to the pollination of the crop.
- Adequate space between the top of the trees and the hail net is essential for optimum bee flight and even distribution of bees in the block.
- Bees naturally tend to work along tree rows rather than between rows; however, the more protected environment under netting (compared to uncovered trees) can encourage increased bee foraging between adjacent tree rows.
- It is essential to place hives under hail netting to achieve good pollination. It is best to distribute hives throughout the netted orchard.
- Bees must be introduced once flowering has commenced, usually at 3–5% bloom.
- Temporary removal of some netting sections during flowering is one means of assisting pollination. Bees are able to fly upward out of one part of the orchard and back down to trees in other parts of the orchard.
- Disorientation of bees can be minimised by ensuring that the tops of trees do not grow close to the height of the netting.

Strategies that may help to alleviate pollination problems associated with nets include:

- Use nets with a large mesh size, which allow movement of bees and other insects into the orchard.
- Where wind pollination is important, nets with a large mesh size would be appropriate. They will not reduce wind speeds in the orchard as much as nets with a small mesh size.
- Use air blast sprayers (often needed at flowering to spray for pests like flower caterpillar) to create artificial wind that may assist pollination.
- Roll up side netting during flowering to help bee and other insect movement into the orchard. This will also improve air movement through the orchard if wind pollination is a factor.
- Where appropriate, tunnel netting can be used so that the nets are not over the trees during flowering.

If you are planning to net an orchard, discuss your plans with an apiarist. An apiarist can offer advice on how to make the netting more ‘bee friendly’ and how to manage bees in the netted orchard.

Pruning—Canopy management of trees under netting does not normally require major changes for crops such as stone fruit and persimmons, which are normally managed under stringent pruning regimes. However, where net canopy heights are 5 m or less, growers have found that timeliness for pruning become much more important than in a non-netted orchard.

In lychee orchards in South East Queensland (where tree growth is not particularly vigorous), a minimum 6 m high net canopy is recommended. In North Queensland (where growth is much more vigorous), net canopies up to 8 m in height (both canopy and tunnel netting) have been successfully used. Timeliness of pruning is important to prevent ‘growth flushes’ pushing through the net.

In netted orchards, pruning to maximise light distribution through the canopy is important. After installing nets, growers should progressively review and amend their pruning practice to meet the requirements of their own situation.

Cyclone and storm damage—Netting capable of withstanding cyclonic conditions is very expensive and growers need to consider carefully whether or not the expense of this type of netting is justifiable for their business. Some strategies that may help avoid or minimise damage to nets by wind include:

- Construct full canopy netting to professionally designed wind-resistant specifications using quality materials both for the structure and nets.

- Do not grow tree species such as *Cadagi torrelliana* that readily shed branches in windbreaks near full canopy netted orchards. Netting itself offers significant wind protection (where appropriate designs are used) and windbreaks may not be necessary.
- Use of tunnel netting, where the nets are only out for a limited time prior to harvest, can reduce the risk of damage by seasonal cyclonic winds.

Other control methods

Other methods of preventing flying fox and bird damage in orchards include:

- **Scaring devices**—Kites to simulate the presence of birds of prey, silver paper, streamers, smoke and recordings of animal alarm calls have all be used to deter animal pests from entering an orchard, with varying degrees of success.
- **Smell and taste deterrents**—Substances that are offensive in taste or smell to animal pests are sprayed onto the crop to deter pests from taking fruit. Such odours and tastes are a potential hazard to market confidence unless they can be reliably removed from fruit before sale. Any chemicals used as taste or smell deterrents need to be registered for that use.
- **Acoustic and light equipment**—Electronic systems and other equipment such as gas cannons and ‘Bird Fright’ shotgun cartridges can be used to emit loud noises and/or bright lights to deter animal pests. Unfortunately birds and flying foxes often become familiar with the lights and noises, which reduces their effectiveness. To prevent this, some systems use sophisticated sensing methods to activate sound and/or lights only when the animals are present. Manufacturers and suppliers of the equipment can advise on the most effective layouts of speakers and lights. The loud noises or bright lights emitted by these systems mean that growers with close neighbours may rule out this option.

Growers may need to patrol orchards and scare pests away to reinforce these methods at times when pest pressure is high (e.g. after periods of heavy rain). Some growers report that these systems are more effective when used to deter pest animals from becoming familiar with an orchard before the fruit ripens, thus reducing the likelihood that they will subsequently return (alone or with other animals) when the fruit is ripe.

Pest pressure varies considerably both from season to season and property to property, making the success of any of these control methods very difficult to predict. A few animals that are not very hungry may be controlled effectively by one or a combination of these methods, but when there are large numbers of very hungry animals control may breakdown.

Weather variability, the availability of alternative food sources and the degree of hunger of the animals can all affect the performance of these control methods. This makes it extremely difficult to conduct scientific research on these control methods and statistically valid data regarding the effectiveness of these methods is not available.

Financial aspects of netting

Many variables affect the financial viability of using orchard netting. Individual growers need to consider their particular circumstances, deciding which netting system best suits them and carefully assessing the financial implications.

Cost of orchard netting

The capital cost of netting an orchard can range from \$17 000 per hectare up to \$72 000 per hectare. The main factors that affect the cost of orchard netting are:

- **The netting system used, tunnel or full canopy**—Capital investment for tunnel netting is less than for full canopy netting but there are recurrent costs of putting out and taking in the nets each year for tunnel systems.

- **The mesh size and quality of the net**—Hail net with a quadruple cross-stitch will cost at least \$1.25 per square metre, 16mm diamond mesh bird and flying fox exclusion net costs around \$0.55 per square metre and a 15 mm vine net suitable for throw over or tunnel netting may cost from as little as \$0.30 per square metre.
- **The quality of structural materials (poles and cables) used in construction**—Large mesh bird or flying fox exclusion net is light and does not capture hail, so a relatively lightweight inexpensive structure can be used to support it. Hail net on the other hand is heavy and can hold hail, so a strong expensive structure is needed to support both the weight of the net and any hail it may capture. In areas where extreme winds rarely occur relatively light and inexpensive structures made of cheap materials can be used but where strong structures are needed to withstand strong winds costs are much higher.
- **The use of contractors or farm labour to erect structures and install the nets**—Tunnel netting structures are usually fabricated on farm and erected using farm labour. Whilst canopy netting structures and nets can be erected using farm labour, it may be more efficient to use an experienced contractor to do the job. There is also a possibility that inexperienced labour may not complete the work to the correct specifications, resulting in high maintenance expenses later. A combination of farm labour and contractors can reduce cost, for example farm labour can be used to erect poles to contractor's design and then the contractor's team installs the cables and nets.
- **The area to be netted**—Full canopy netting over a small orchard costs more on a per hectare basis than a large orchard because the small orchard needs a higher proportion of side netting and more perimeter posts per hectare than the large orchard.
- **Shape of the orchard**—Irregular shaped orchards that have a longer perimeter are more expensive to full canopy net than square or rectangular blocks of the same size.
- **Unproductive area under the net**—Minimise any unproductive areas under full canopy nets. Unnecessarily wide row spacings, roads and headlands result in a lower financial return per hectare of net.
- **Terrain**—Steep land is more difficult and expensive to net than flat or gently sloping land.
- **Height of the net canopy**—A high net canopy will cost more to construct than a low one because extra side netting and longer posts are needed. However, in the long run the initial extra cost may be offset by the comparative ease of management and likely better performance of trees under the higher net canopy.
- **Location of the orchard**—If a contractor is used relocation costs for equipment and work crews can be a significant cost. Where contractors are able to relocate crews to work on several contracts in one area relocation costs can be minimised for the individual growers. It is an advantage for growers in one area to call for tenders jointly, wherever possible.

Low initial costs may not work out cheaper over the life of the orchard than higher cost options. For example, cheap vine net used as canopy netting over a low cost lightweight structure is likely to need considerable maintenance and need early replacement, whereas a more expensive net on a professionally designed and constructed structure will last many more years and have a much lower maintenance cost.

Where it is not clear that netting is viable one option it may be best to trial net a small part of the orchard with low cost tunnel netting and compare subsequent returns from the netted area with those from the rest of the orchard. The whole orchard can be netted if increased returns are found to justify the expense.

Costings for netting

Example costings for four types of full canopy netting and tunnel netting follow.

Canopy netting

These costings and plans have been kindly provided, in September 2008, by **NetPro Protective Canopies** of Stanthorpe, Queensland.

Table 6 gives example costings for four different canopy nets, providing a range of protection options, over both 1 and 4 hectare orchards. In these costings all the labour, materials and specialised equipment are provided by **NetPro Protective Canopies**. These examples illustrate the higher unit cost for canopy

netting small areas compared to large areas, a reflection of the higher proportion of side netting, perimeter posts and cables used when netting a smaller orchard.

Note the following points regarding this information:

- All costings are for a flat structure with 4 angled sides (see plans)
- These are generic examples and should be regarded as indications only and will not apply to any unsighted block.
- These costings are based on the project being carried out in the Stanthorpe region. Should the contract be located outside this region travel, meals and accommodation costs for work crews and relocation costs of equipment would be an additional charge.
- Cost of backhoe is included and based on standard soil types, not 'rocky' or wet ground.
- Does not include engineering certification, if required.
- Does not include council permits etc, blasting, drilling or additional excavation costs due to rocky' ground.
- Price includes entranceways but not gates (gates are charged at \$60.00/hour plus GST and materials).
- Does not include cost of unloading of poles, net and other materials.
- Due to high transport costs, a tractor (in safe, working order) must be available for use, for dispatching poles, cable and net cloth, when necessary.
- A secure area must be available for storage of materials, tools and equipment.
- Location of irrigation and underground services is the responsibility of the customer.
- If power lines are over the proposed structure, safe working clearance is required.

Table 6. Example costings for four different canopy nets over 1 and 4 hectare orchards

Net type	*Installation cost (inclusive of GST)		
	100 m x 100 m area (1 ha)	200 m x 200 m area (4 ha)	(cost per ha)
Black or white Birdtex ¹ (15 mm hole)	\$51 535	\$136 070	(\$34 018)
Black or white Batnet ² (37 mm hole)	\$40 865	\$89 320	(\$22 330)
Black or white quad 12 mm ³ (5 mm hole)	\$71 500	\$207 680	(\$51 920)
Translucent Fruit Fly Net ⁴ (2 mm hole)	\$71 940	\$195 745	(\$ 48 937)

* Including costs of materials, labour and equipment as at 19 September 2008 and based on the work being carried out in the Stanthorpe region.

¹ Birdtex is a structural knitted net distributed in Australia by Netpro Pty Ltd. Manufactured from quality HDPE yarn, Birdtex is used for small bird protection structures and is covered by a 10-year prorated UV degradation warranty.

² Batnet is a structural knitted net distributed exclusively in Australia by Netpro Pty Ltd. Manufactured from quality HDPE yarn, Batnet is used for flat-roofed structures to protect against fruit losses to bats/flying foxes and is covered by a 10-year prorated UV degradation warranty.

³ Quad 12 is a structural knitted net distributed in Australia by Netpro Pty Ltd. Manufactured from quality HDPE yarn, Quad 12 is used for flat-roofed hail structures and is covered by a 10-year prorated UV degradation warranty.

⁴ Fruit Fly Net is a structural knitted net, distributed in Australia by Netpro Pty Ltd. Manufactured from quality HDPE yarn, Fruit Fly Net is used for maximum protection and is covered by a five-year prorated UV degradation warranty.

The following materials have been used in these costings:

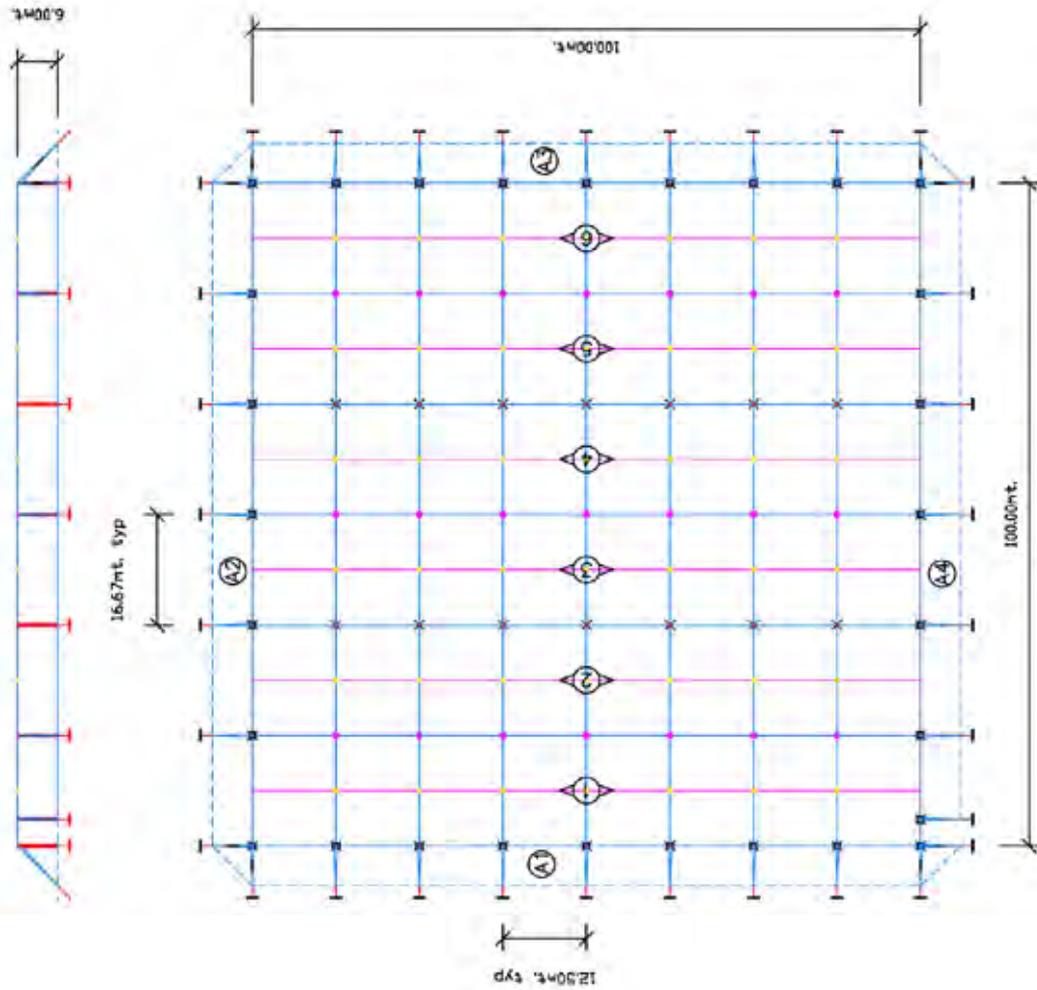
- spring steel wire (3.15 mm HT, Galv)
- dome T-connector (UV Stabilised)
- galvanised Prosplices 3.15 mm
- galvanised Prosplices 7.5 mm

- cable (7.5 mm, 1570Mpa, W15 Galv)
- polyester wire
- hail links (UV stabilised)
- PVC Prosleeve 7.5 mm (UV stabilised)
- PVC Prosleeve 12.0 mm (UV stabilised)
- galvanised thimbles 16 mm heavy
- galvanised pins 2.4 x 20 mm
- side cloth mini anchor (duck bill)
- miscellaneous (tape, nails, staples, pole caps, etc.)
- poles, 7.0 m x 175SED, hardwood
- poles, 7.0 m x 200SED, hardwood
- buried logs, 1.8 m x 200SED, hardwood.

The following plans (Figures 44 to 51) have been supplied by **NetPro Protective Canopies** of Stanthorpe, Queensland. These show the layout of posts, cables wires and anchors for each of the eight examples given in Table 6. Please note that the plans are copyright to NetPro Pty Ltd, in whole or in part.



A



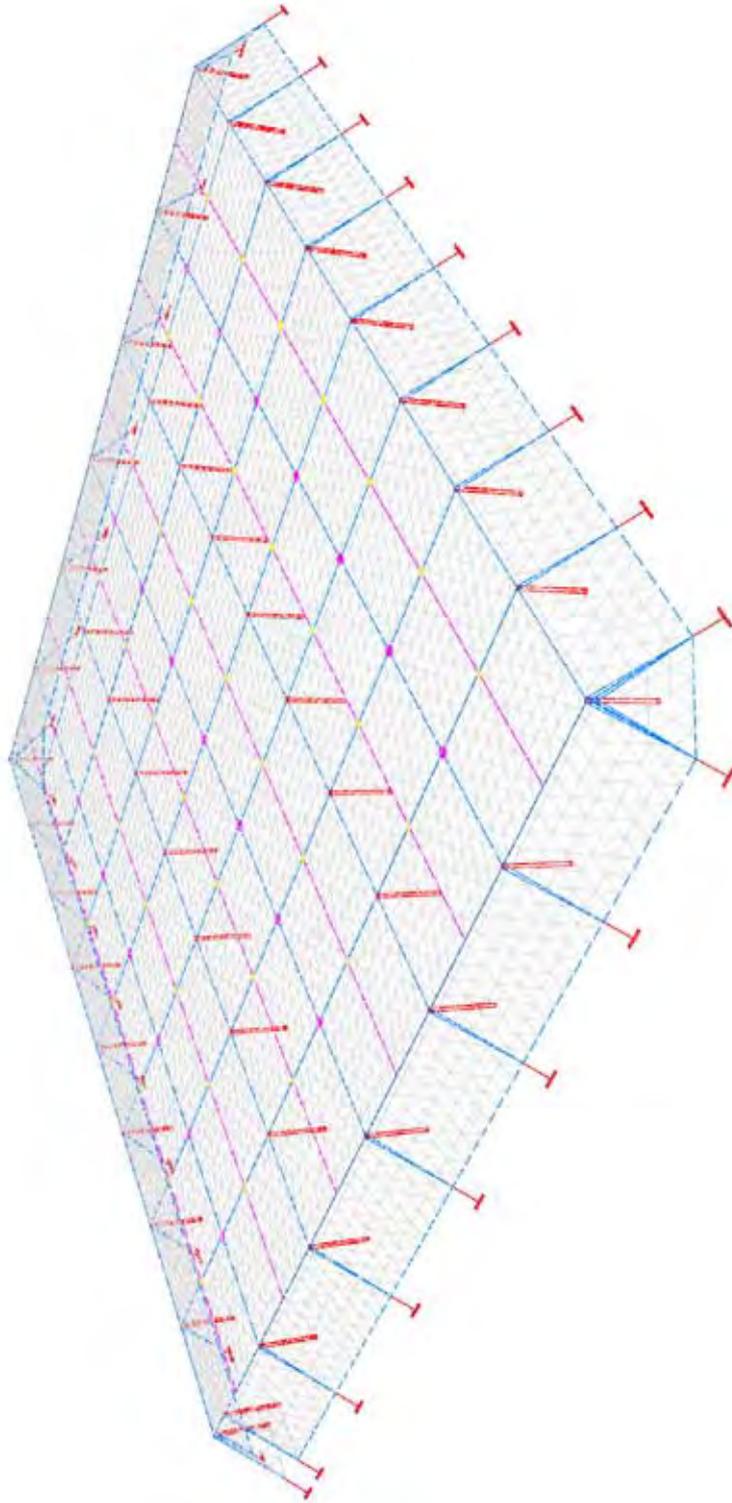
LEGEND

- X Internal Post
- X Corner Post
- Tie Backs - Doubles
- Tie Backs - Singles
- f Blurred Log Anchor
- T-Connectors - Poly/Tie
- T-Connectors
- Cable - Galv.
- Polyester Wire
- Sole Cloth Cable - Only
- ① Reel Cloth Run Number
- ⓐ Wall Cloth Run Number / Angled

<p>NetPro PROTECTIVE CANOPIES</p>	<p>Typical Nelpro Protective Canopy BirdNet Structure (Dual) 100mt x 100mt x 6mt high</p>		<p>PLAN & ELEVATION</p>		<p>DWG NO. Typical_BirdNet_100x100</p>	<p>DATE 10/09/2008</p>
	<p>NetPro Pty. Ltd. - A.C.N 054 642 036 200 South Street, Scarborough, QLD P.O. Box 337, Scarborough, QLD 4159 Phone: (07) 4681 6666 Fax: (07) 4681 6620</p>		<p>PLAN NO. None</p>	<p>DRAWN RMH</p>	<p>SHEET 01 OF 02</p>	<p>© 2008 COPYRIGHT Nelpro Pty Ltd. All Rights Reserved. CONFIDENTIAL/PROPRIETARY NELPRO PTY LTD</p>

Figure 44 A. Plan for black or white Birdtex 100 m x100 m

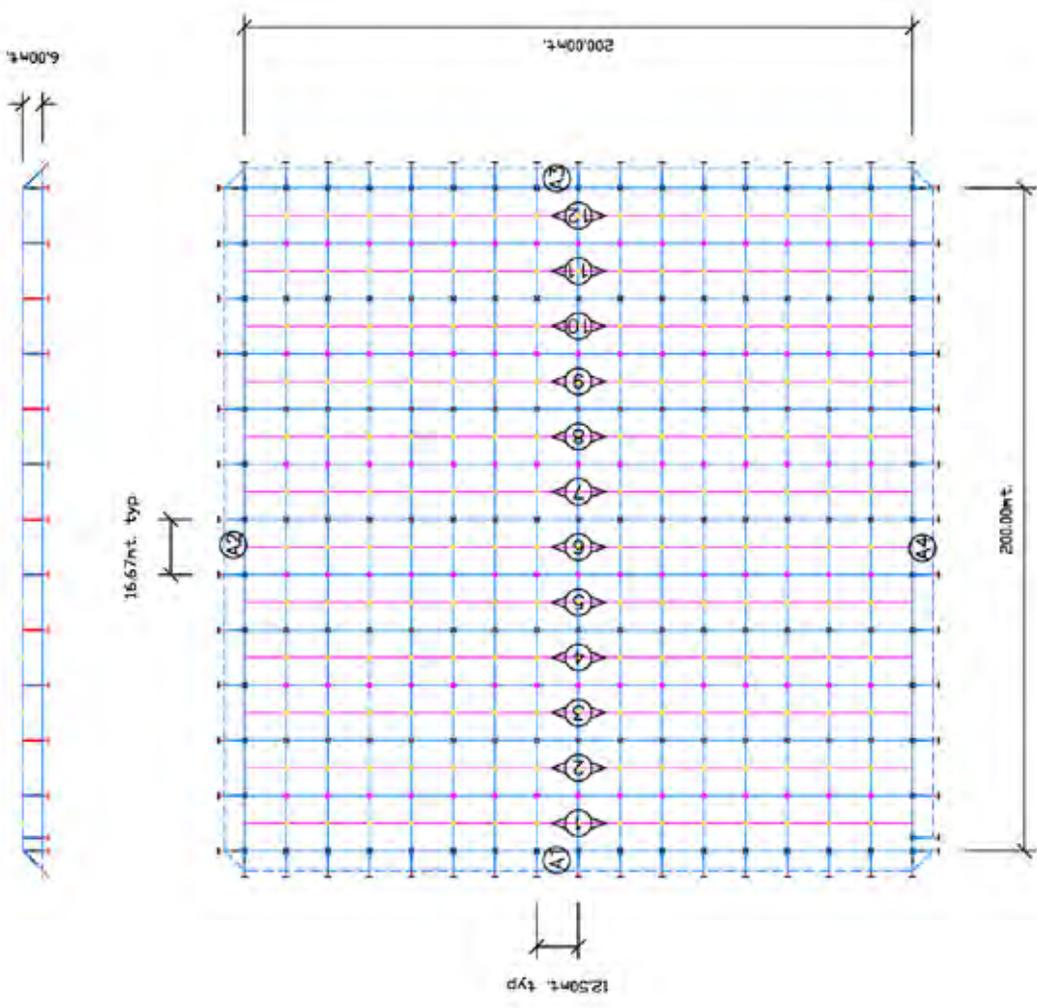
B



	Typical Netpro Protective Canopy BirdNet Structure (Dual) 100mt x 100mt x 6mt high	PERSPECTIVE VIEW		DWG NO.	10/09/2008
		NetPro Pty. Ltd. - A.C.N 054 642 036 1st Floor, 337 Stirling Street, Perth, WA 6000 Phone: (07) 4681 6666 Fax: (07) 4681 6600		Typical_BirdNetD_100x100	DATE
				PLAN NO.	None
				DRAWN	RMH
				SHEET 02 OF 02	
				© 2008 COPYRIGHT NetPro Pty Ltd. All Rights Reserved. CONFIDENTIAL/PROPRIETARY NETPRO PTY LTD	

Figure 44 B

A



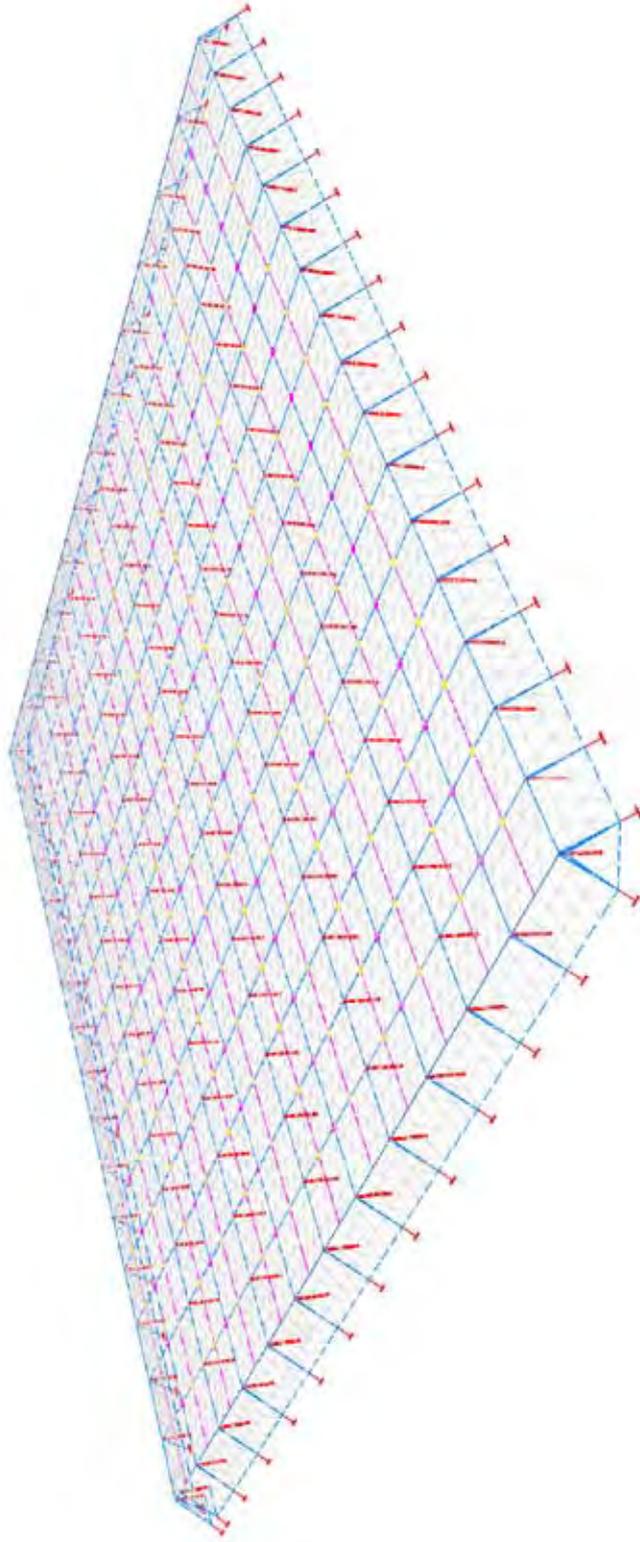
LEGEND

- X Internal Post
- X Corner Post
- - - Tie Backs - Doubles
- - - Tie Backs - Singles
- - - Blurred Log Anchor
- - - T-Connectors - Poly/Tie
- - - T-Connectors
- - - Cable - Galv.
- - - Polyester Wire
- - - Side Cloth Cable - Galv.
- ① Roof Cloth Run Number
- Ⓐ Wall Cloth Run Number
- Angled

<p>NetPro PROTECTIVE CANOPIES</p>	<p>Typical Nelpro Protective Canopy BirdNet Structure (Dual) 200mt x 200mt x 6mt high</p>	<p>PLAN & ELEVATION</p>	<p>DWG NO. Typical_BirdNet_200x200 PLAN NO. None</p>	<p>DATE 10/09/2008 DRAWN RMH SHEET 01 OF 02</p>
	<p>Nelpro Pty. Ltd. - A.C.N. 054 642 036 107 South Street, Scarborough, QLD 4159, Australia Phone: (07) 4681 6666 Fax: (07) 4681 6600</p> <p>© 2008 COPYRIGHT Nelpro Pty Ltd. All Rights Reserved. CONFIDENTIAL/PROPRIETARY NELPRO PTY LTD</p>			

Figure 45 A. Plan for black or white Birdtex 200 m x 200 m

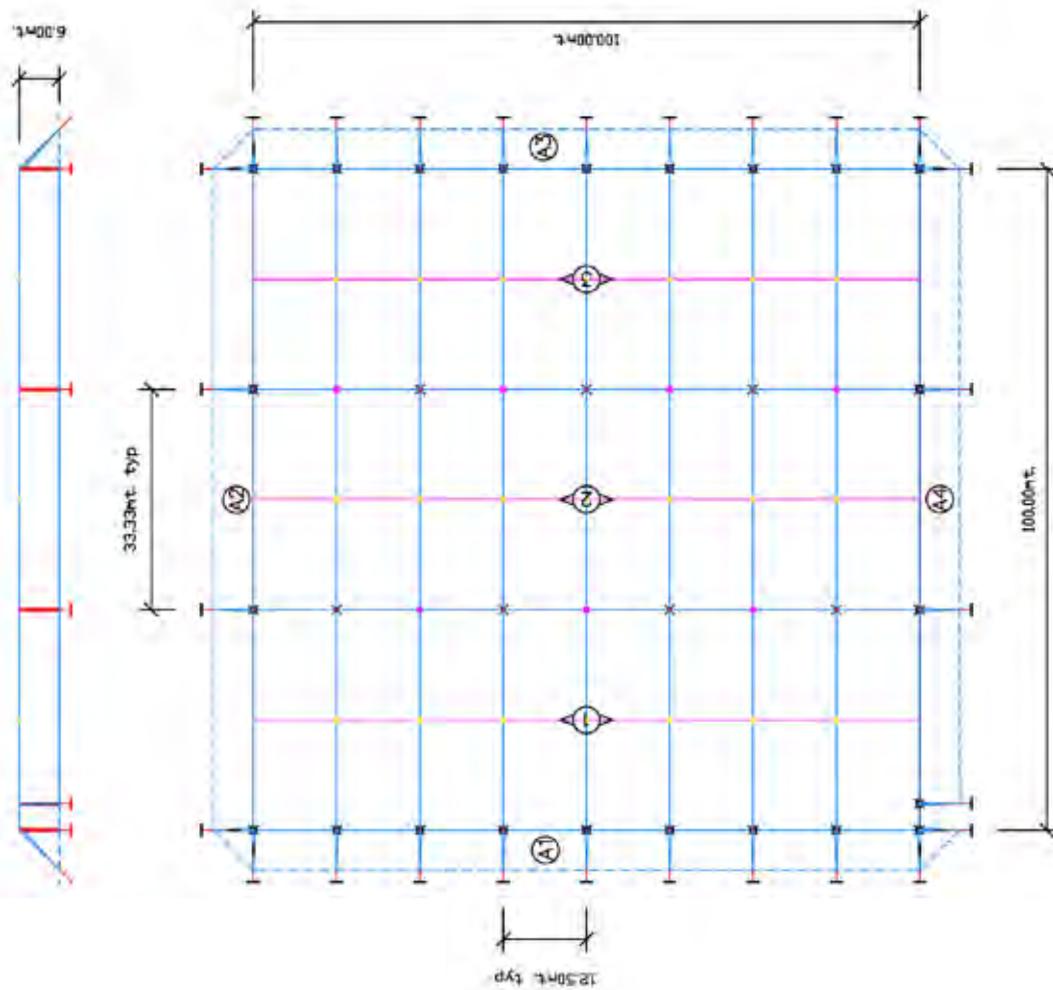
B



	Typical Netpro Protective Canopy BirdNet Structure (Dual) 200mt x 200mt x 6mt high	PERSPECTIVE VIEW		DWG NO.	DATE
		NetPro Pty. Ltd. - A.C.N 054 642 036 Lot 1 Saxon Drive, Stanthorpe, QLD P.O. Box 337, Stanthorpe QLD 4350 Phone: (07) 4681 6606 Fax: (07) 4681 6609		Typical_BirdNetD_200x200	10/09/2008
		PLAN NO.	None	DRAWN	RMH
				SHEET 02 OF 02	
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Figure 45 B

A



LEGEND:

- X Internal Post
- X Corner Post
- T-Backs - Double
- T-Backs - Single
- Buried Lug Anchor
- T-Connector - Poly/Tie
- T-Connectors
- Cable - Galv.
- Polymer Wire
- Side Cloth Color - Galv.
- ① Roof C/With Run Number
- Ⓐ Wall C/With Run Number - Angled

DWG NO.	Typical_BatNet_100x100	DATE	10/09/2008
PLAN NO.	None	DRAWN	RMH
		SHEET 01 OF	02

PLAN & ELEVATION

NetPro Pty. Ltd. - A.C.N. 054 845 038
 NetPro Sales Pty. - A.C.N. 438 430
 P.O. Box 337, Stonehouse Qld. 4350
 Phone: (07) 4681 6666 Fax: (07) 4681 6600

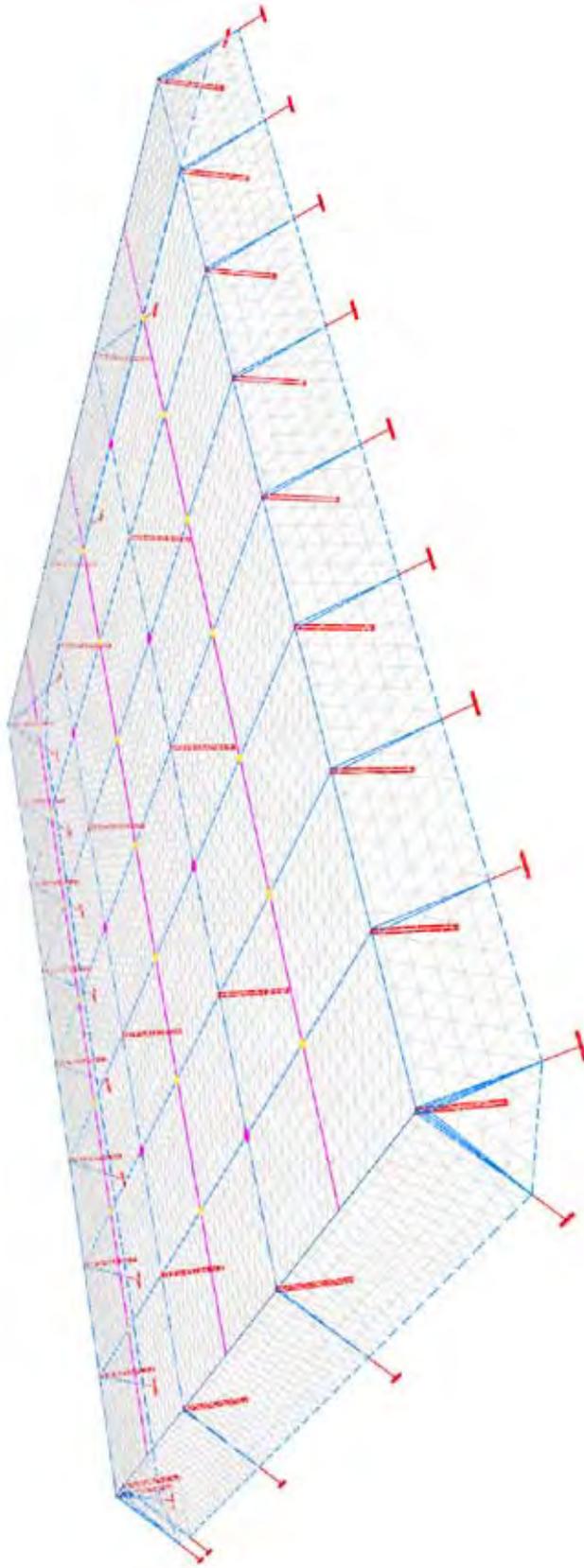
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Typical Netpro Protective Canopy
 BatNet Structure
 100mt x 100mt x 6mt high

NetPro
 PROTECTIVE CANOPIES

Figure 46 A. Plan for black or white Batnet 100 m x 100 m

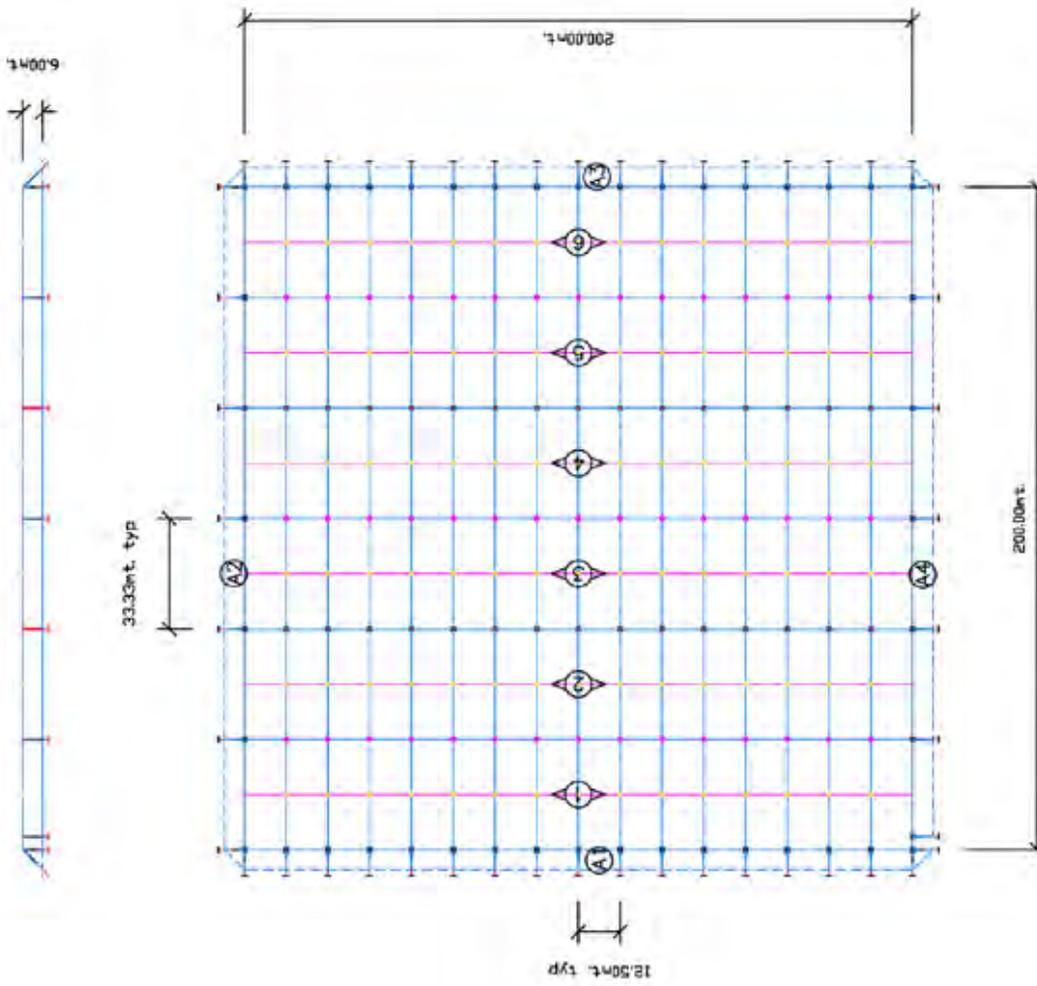
B



	Typical Netpro Protective Canopy BatNet Structure 100mt x 100mt x 6mt high	PERSPECTIVE VIEW		DWG NO.	Typical_BatNet_100x100	DATE	10/09/2008
		NetPro Pty. Ltd. - A.C.N 054 642 036 of Sully Drive, Stoney Creek, NSW P.O. Box 337, Stoney Creek, NSW Phone: (07) 4681 6666 Fax: (07) 4681 6600		PLAN NO.	None	DRAWN	RUH
						SHEET	02 OF 02
				© 2008 COPYRIGHT NetPro Pty Ltd. All Rights Reserved. CONFIDENTIAL/PROPRIETARY NETPRO PTY LTD			

Figure 46 B

A



1400'9

200.00'±

33.33m± typ

200.00m±

12.50m± typ

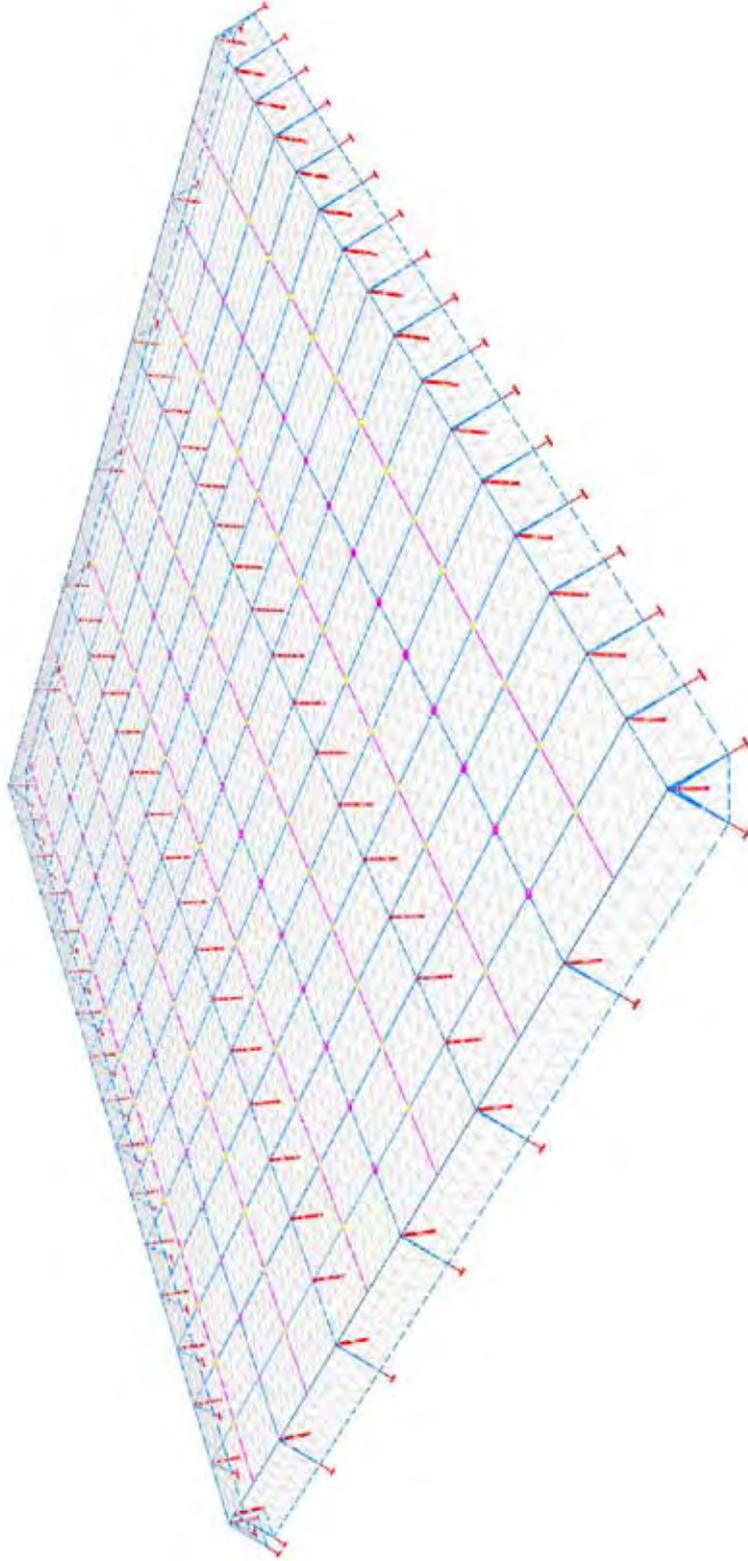
LEGEND

- X Internal Post
- K Corner Post
- Tie Backs - Doubles
- Tie Backs - Singles
- f Blurred Log Anchor
- T-Connectors - Poly/Tie
- T-Connectors
- Cable - Galv.
- Polyester Wrm
- Side Cloth Cable - Only
- ① Roof Cloth Run Number
- Ⓐ Wall Cloth Run Number - Angled

<p>NetPro PROTECTIVE CANOPIES</p>	<p>Typical Netpro Protective Canopy BatNet Structure 200mt x 200mt x 6mt high</p>	<p>PLAN & ELEVATION</p>	<p>DWG NO. Typical_BatNet_200x200</p>	<p>DATE 10/09/2008</p>
	<p>NetPro Pty. Ltd. - A.C.N (54 642 036) 107 Salford Drive, Stoney Creek NSW 1530 Phone (07) 4981 6666 Fax (07) 4681 6600</p>	<p>PLAN NO. None</p>	<p>DRAWN RUH</p>	<p>SHEET 01 OF 02</p>

Figure 47 A. Plan for black or white Batnet 200 m x 200 m

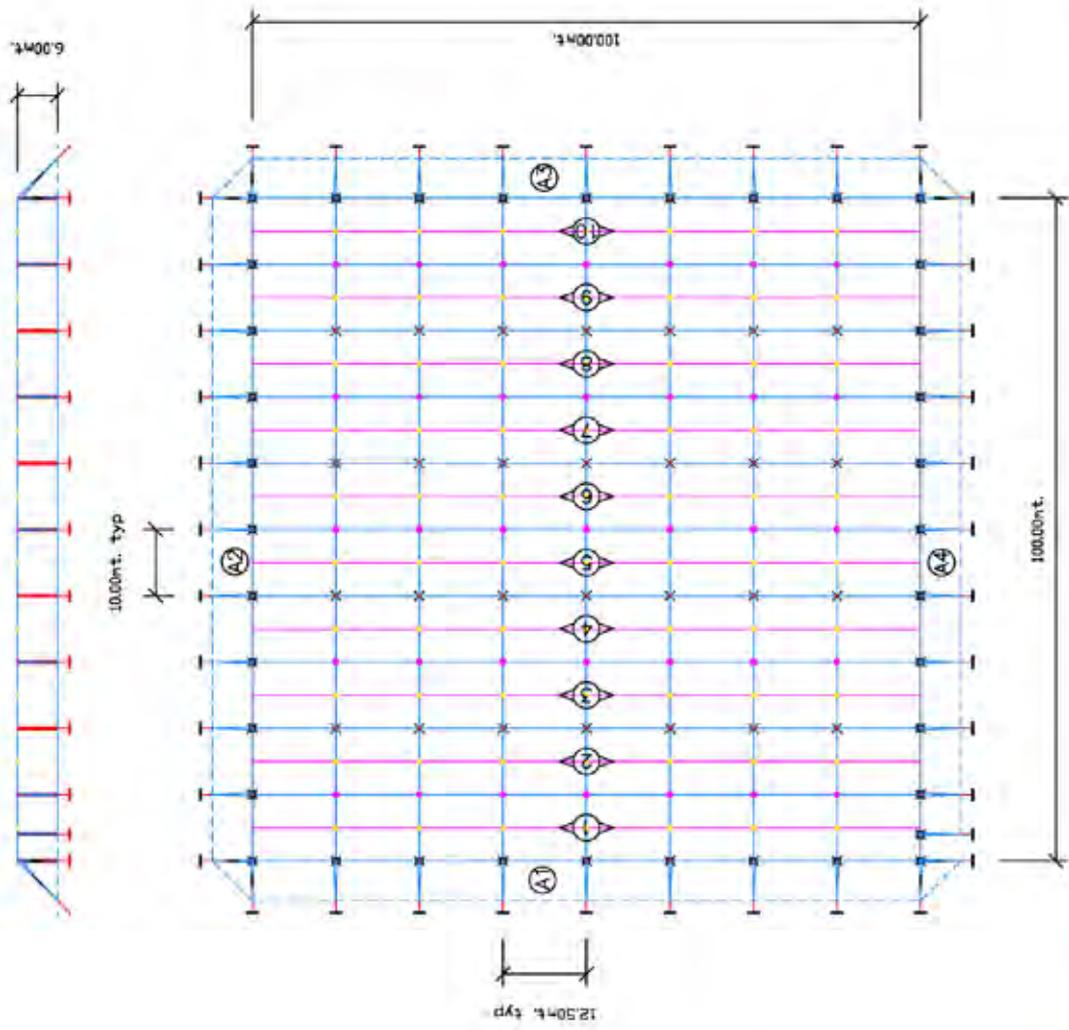
B



	Typical Netpro Protective Canopy BatNet Structure 200mt x 200mt x 6mt high	PERSPECTIVE VIEW		DWG NO.	DATE
		NetPro Pty. Ltd. - A.C.N 054 642 036 107 Sully Drive, Stange, NSW 2880 Phone: (07) 4681 6666 Fax: (07) 4681 6600		Typical_BatNet_200x200	10/09/2008
		PLAN NO.	None	DRAWN	RMH
				SHEET 02 OF 02	
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Figure 47 B

A



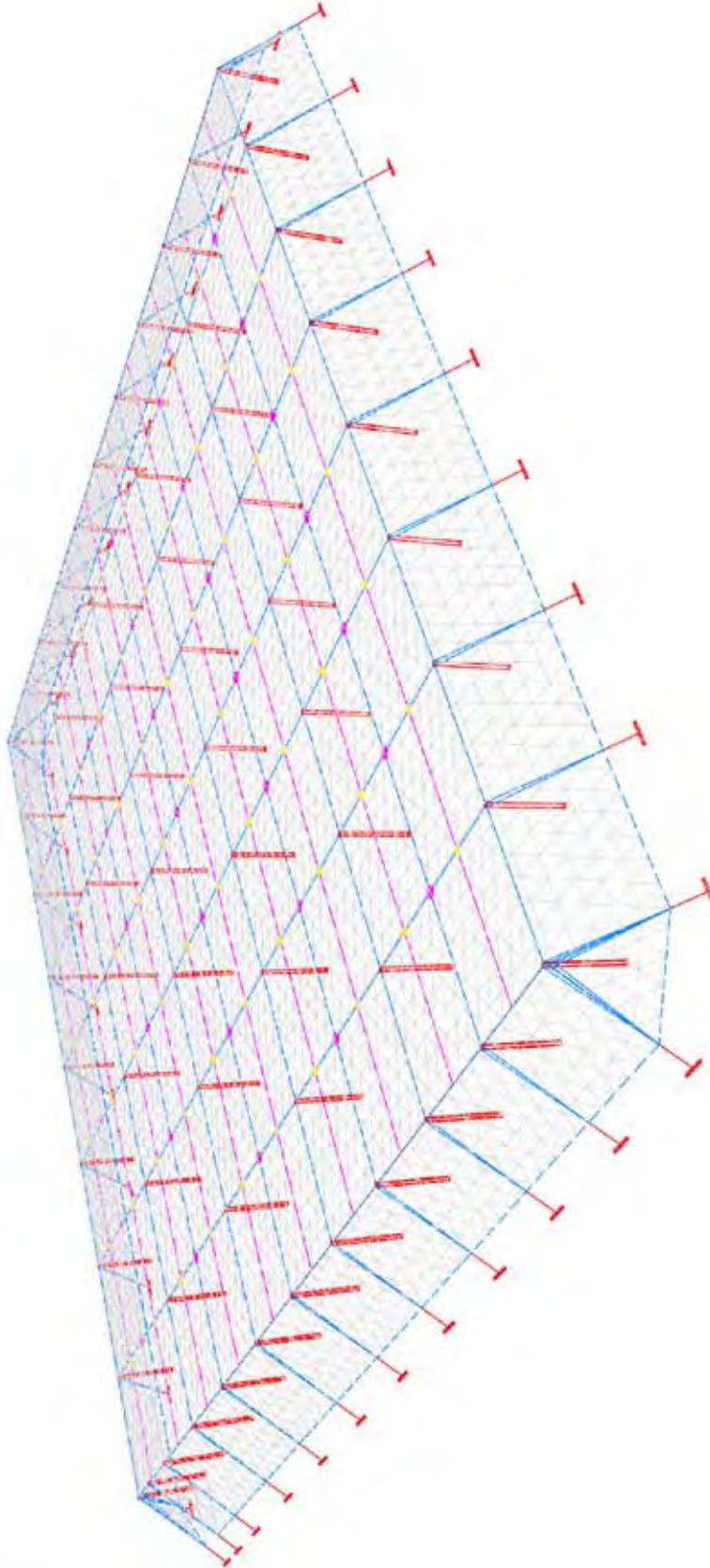
LEGEND

- X: Internal Post
- X: Corner Post
- - - Tie Backs - Doubles
- - - Tie Backs - Singles
- - - Blurred Log Anchor
- T-Connectors - Poly/Tie
- T-Connectors
- Cable - Galv.
- Polyester W/m
- Side Cable - Only
- ① Rood Code Run Number
- Ⓐ Wall Code Run Number
- Angled

<p>NetPro PROTECTIVE CANOPIES</p>	<p>Typical Netpro Protective Canopy HailNet Structure 100mt x 100mt x 6mt high</p>	<p>PLAN & ELEVATION</p> <p>NetPro Pty. Ltd. - A.C.N (54 642 036) 100 S. Hill Drive, Stomoxys, QLD 4307 Phone: (07) 4681 6666 Fax: (07) 4681 6600</p>	<p>DWG NO. Typical_HailNet_100x100</p>	<p>DATE 10/09/2008</p>
	<p>None</p>	<p>PLAN NO.</p>	<p>DRAWN RUH</p>	<p>SHEET 01 OF 02</p>

Figure 48 A. Plan for black or white Quad 12 mm 100 m x 100 m

B



	Typical Netpro Protective Canopy HailNet Structure 100mt x 100mt x 6mt high	PERSPECTIVE VIEW		DWG NO.	10/09/2008
		NetPro Pty. Ltd. - A.C.N 054 642 036 107 Sully Drive, Stange, NSW 2880 Phone: (07) 4681 6666 Fax: (07) 4681 6600		Typical_HailNet_100x100	DATE
		PLAN NO.	None	DRAWN	RUH
				SHEET 02 OF 02	
		© 2008 COPYRIGHT NetPro Pty Ltd. All Rights Reserved. CONFIDENTIAL/PROPRIETARY/NETPRO PTY LTD			

Figure 48 B

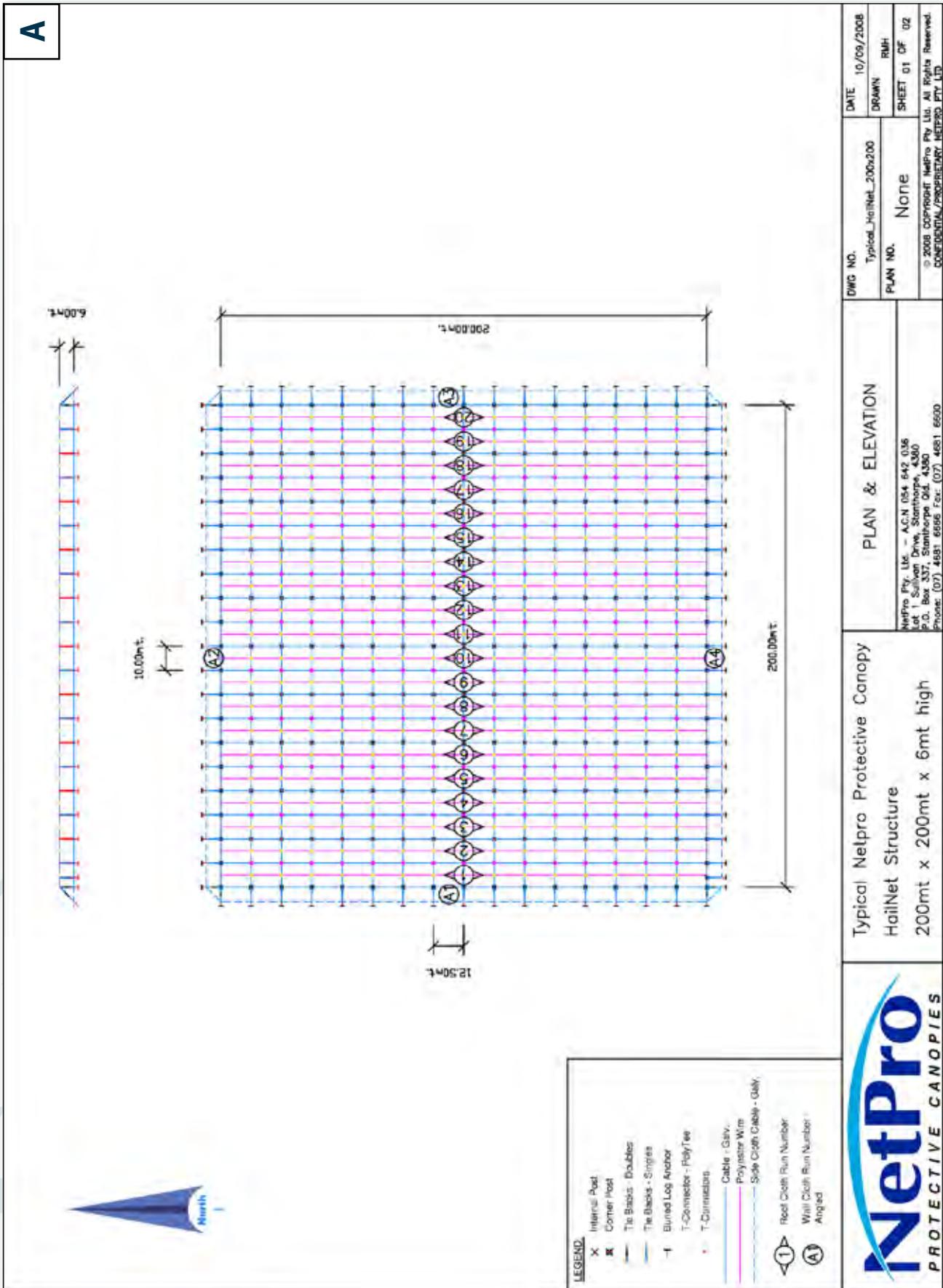
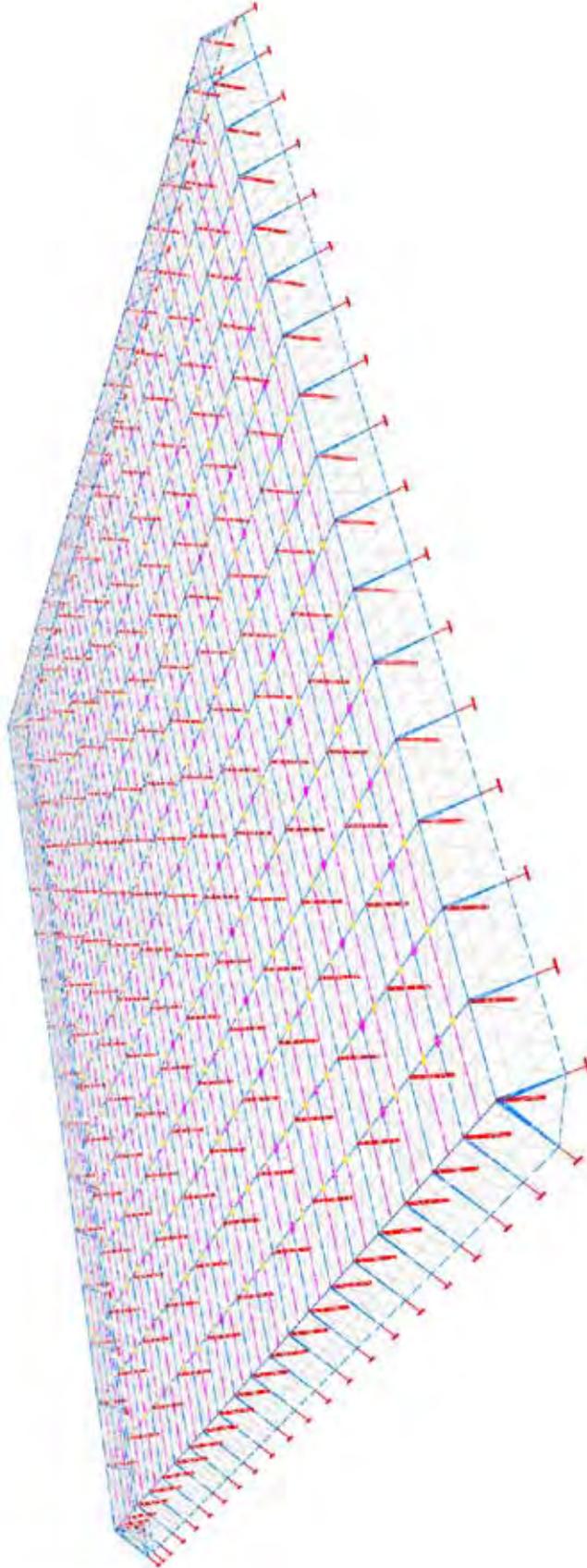


Figure 49. Plan for black or white Quad 12 mm 200 m x 200 m

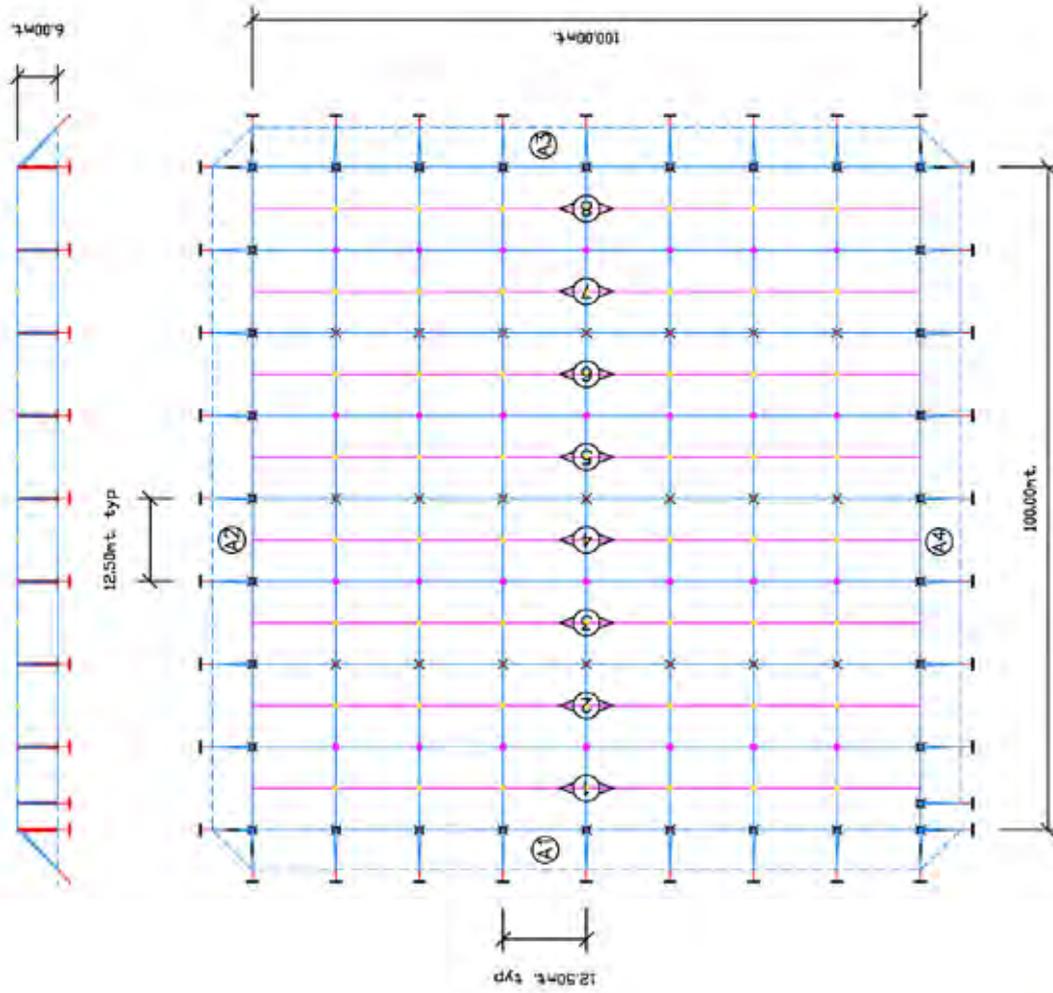
B



	Typical Netpro Protective Canopy HailNet Structure 200mt x 200mt x 6mt high	PERSPECTIVE VIEW		DWG NO.	DATE
		NetPro Pty. Ltd. - A.C.N 054 642 036 1st Floor, 337 Stirling Street, Perth, WA 6000 Phone: (07) 4681 6666 Fax: (07) 4681 6600		Typical_HailNet_200x200	10/09/2008
		PLAN NO.	None	DRAWN	RMH
				SHEET 02 OF 02	
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Figure 49 B

A



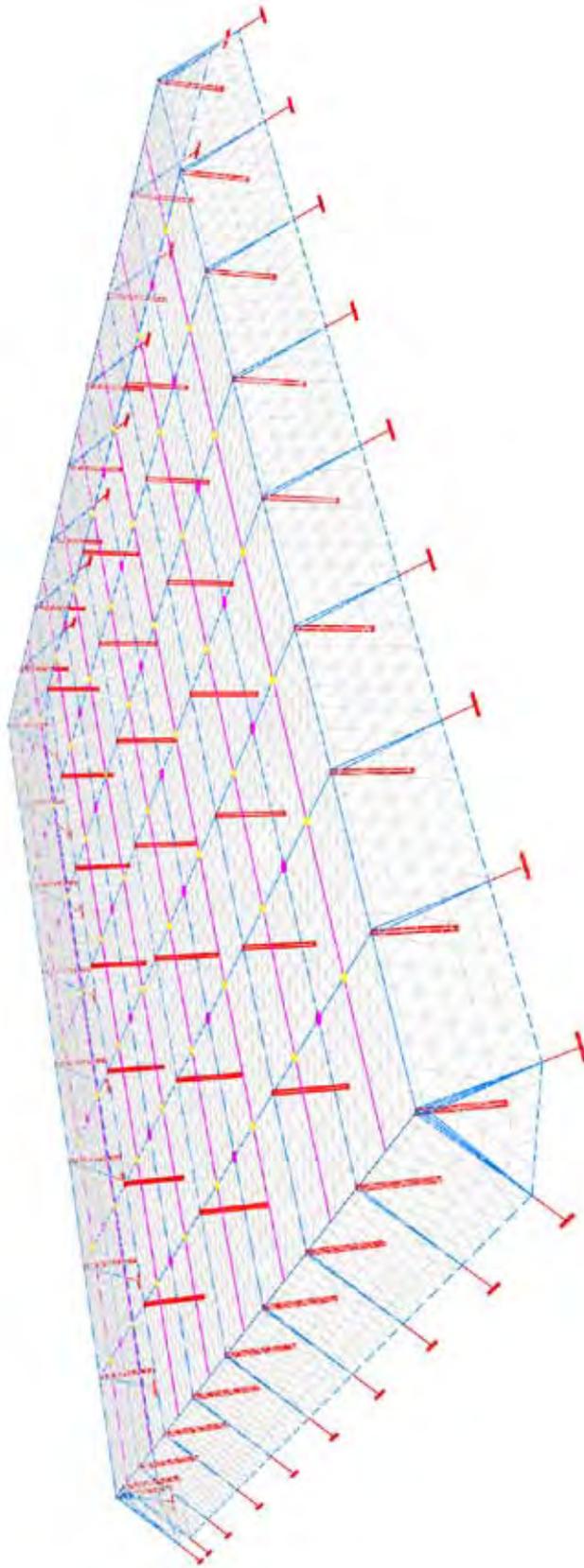
LEGEND

- X Internal Post
- X Corner Post
- Tie Backs - Doubles
- Tie Backs - Singles
- f Blurred Log Anchor
- T-Connectors - Poly/Tie
- T-Connectors
- Cable - Galv.
- Polyester Wire
- Side Cable - Only
- ① Rool Code Run Number
- ⓐ Wall Code Run Number
- Angled

<p>NetPro PROTECTIVE CANOPIES</p>		<p>Typical Netpro Protective Canopy Fruitfly Structure 100mt x 100mt x 6mt high</p>		<p>PLAN & ELEVATION</p>		<p>DWG NO. Typical_Fruitfly_100x100 PLAN NO. None</p>		<p>DATE 10/09/2008 DRAWN RUH SHEET 01 OF 02</p>	
		<p>NetPro Pty. Ltd. - A.C.N (54 642 036) 100 S. St. Drive, Stomoxys, QLD 4300 Phone: (07) 4681 6666 Fax: (07) 4681 6600</p> <p>© 2008 COPYRIGHT NetPro Pty Ltd. All Rights Reserved. CONFIDENTIAL/PROPRIETARY - NETPRO PTY LTD</p>							

Figure 50 A. Plan for translucent fruit fly net 100 m x 100 m

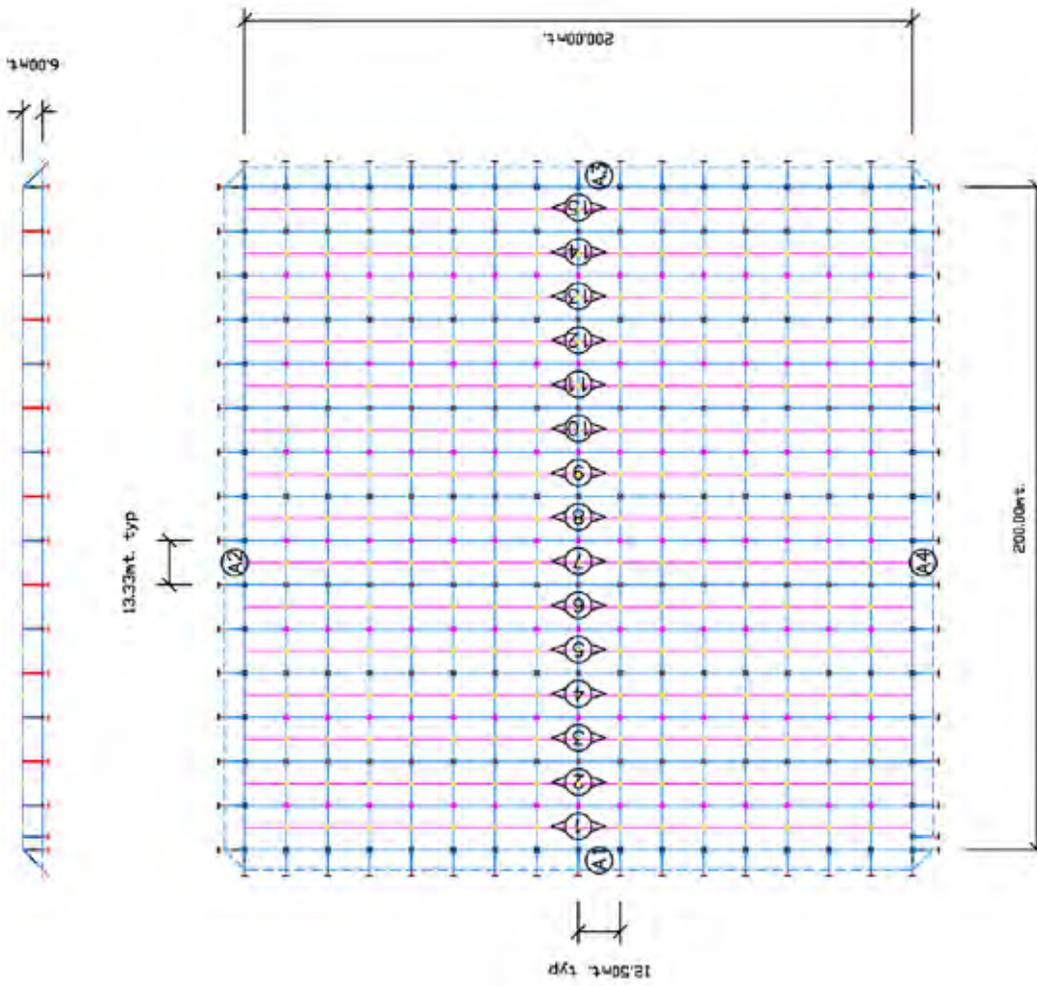
B



	Typical Netpro Protective Canopy Fruitfly Structure 100mt x 100mt x 6mt high	PERSPECTIVE VIEW		DWG NO.	DATE
		NetPro Pty. Ltd. - A.C.N 054 642 036 107 Sully Drive, Staines, VIC 3045 P.O. Box 337, Staines VIC 3045 Phone: (07) 4681 6666 Fax: (07) 4681 6600		Typical_Fruitfly_100x100	10/09/2008
		PLAN NO.	None	DRAWN	ABH
				SHEET	02 OF 02
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Figure 50 B

A



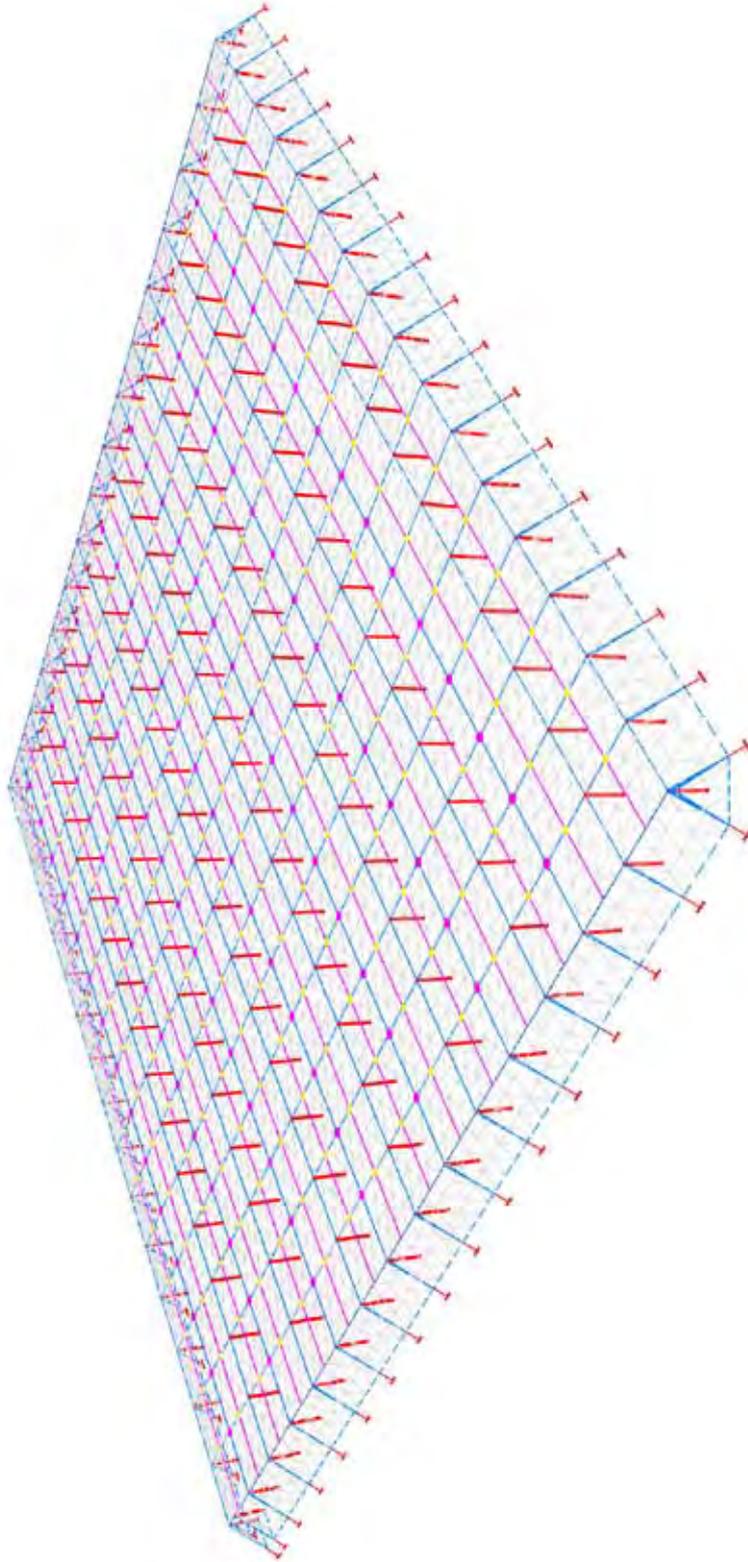
LEGEND

- X Internal Post
- X Corner Post
- - - Tie Backs - Doubles
- - - Tie Backs - Singles
- f Blurred Log Anchor
- T-Connectors - Poly/Tie
- T-Connectors
- Cable - Galv.
- Polyester Wrm
- Side Cloth Cable - Galv.
- ① Post Cloth Run Number
- Ⓐ Wall Cloth Run Number - Angled

<p>NetPro PROTECTIVE CANOPIES</p>	<p>Typical Netpro Protective Canopy Fruitfly Structure 200mt x 200mt x 6mt high</p>	<p>PLAN & ELEVATION</p> <p>NetPro Pty. Ltd. - A.C.N (54 642 036) 107 Sturt Drive, Sturt, SA 5000 P.O. Box 337, Adelaide, SA 5000 Phone: (07) 4691 6666 Fax: (07) 4681 6600</p>	<p>DWG NO. Typical_Fruitfly_200x200</p>	<p>DATE 10/09/2008</p>
	<p>None</p>	<p>PLAN NO.</p>	<p>DRAWN RUH</p>	<p>SHEET 01 OF 02</p>

Figure 51. Plan for translucent fruit fly net 200 m x 200 m

B



	Typical Netpro Protective Canopy Fruitfly Structure 200mt x 200mt x 6mt high	PERSPECTIVE VIEW		DWG NO.	DATE
		NetPro Pty. Ltd. - A.C.N 054 642 036 100 Sully Drive, Stange, NSW 2330 Phone: (07) 4681 6666 Fax: (07) 4681 6600		Typical_Fruitfly_200x200	10/09/2008
		PLAN NO.	None	DRAWN	RUH
				SHEET 02 OF 02	
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Figure 51 B

Tunnel netting

Note: The costing in Table 7 for polypipe hoop tunnel netting has been developed by the author from unit costs and information supplied by growers and suppliers. It is an indicative guide only.

Table 7. Example costing for polypipe hoop tunnel netting

	\$ Cost/100 row metres
Labour	
Install star pickets (3 hours @ \$20/h)	\$60
Install polypipe (3 hours @ \$20/h)	\$60
Thread Wires (8 hours @ \$20/h)	\$160
End posts install (4 hours @ \$20/h)	\$80
Materials	
Star pickets (1 picket every 5 m @ \$10.00 per picket)	\$200
Polypipe (10 m x 12 m hoops @ \$2.50/m)	\$300
Wire (700 m of fencing wire @ \$0.30/m)	\$210
End post timbers	\$50
Net (120 m long x 15 m wide @ \$0.30/m ²)	\$540
Total cost per 100 m	\$1660*

* Equivalent to \$16 600 per hectare if rows are 10 m apart or \$20 000 per hectare if rows are 8 m apart.

Financial returns from orchard netting

The financial return from netting is the income that is attributable to the presence of the netting minus the costs of installing and maintaining nets.

Income from orchard netting includes:

- Income from the sale of fruit normally lost to pests or hail. Some growers have estimated crop losses average 60% in non-netted orchards.
- The harvest and sale of earlier fruit from the top of the canopy, which is often lost to birds and flying foxes in non-netted orchards. Early harvest fruit generally has a high value.
- Overall the quality and value of fruit harvested from netted orchards may be higher than fruit harvested from non-netted orchards because of reduced pest damage.
- Higher yields can improve picking speed and reduce harvest labour costs.
- Reduced levels of pest damage and improved quality mean less sorting is required, which reduces the cost of picking and packing.
- Netting removes one of the elements of uncertainty in orchard management, allowing more reliable crop forecasting and budgeting. This may allow access to more lucrative markets.
- In seasons when fruit set is poor, or when non-netted orchards are suffering heavy losses from animal pests, income from netted orchards is more assured. Growers will normally receive higher prices for fruit they deliver to the market in seasons when fruit supply is limited.
- Growers and employees do not need to carry out night patrols in the orchard to check on flying fox activity. The efficiency of harvesting and packing operations is likely to improve, thus reducing costs.

- In addition to the primary target pests of birds and flying foxes, appropriate orchard netting may control some insect pests (such as fruit fly, fruitpiercing moth and macadamia nutborer), thus reducing or eliminating costs associated with insecticide use.

Costs of orchard netting can include:

- Capital costs for the net, structures and installation. This is the major cost and it can vary greatly depending on the netting system chosen, the quality of materials used and the construction standards.
- Recurrent costs of putting out and taking in the nets each year for tunnel systems.
- The cost of any finance needed for the capital investment.
- Routine repair and maintenance costs for the net and structure. These are largely dependant on the quality of materials originally used.
- Repair costs arising from hail, cyclones and storm damage to netting and structures.
- Yield loss, if the impact of the netting on the orchard environment reduces pollination and fruit set.
- Reduced income, should orchard netting change the crop cycle and harvest dates, resulting in produce reaching the market at times of low prices.
- Extra orchard maintenance costs (e.g. extra spraying of pesticides and fungicides may be needed if nets increase pest and disease problems).
- Low prices may be received for poorer quality fruit if nets lead to a higher incidence of pest and disease damage.
- Tunnel netting may slow harvesters and increase harvest costs.

It is likely to be uneconomical to net an immature orchard. Limited returns from low-yielding young trees and the high capital cost of orchard netting may mean that deferring the installation of nets until the orchard is more mature is the best financial option.

We strongly recommend that growers seek professional financial advice regarding the financial viability of orchard netting in their situation. The DPI&F has a Farm Financial Counselling Service, which may be able to help you:

- Understand your own financial position.
- Identify and assess the financial impact of options.
- Negotiate with financial institutions.
- Develop strategies and plans for implementing your preferred option for improvement.
- Prepare applications for loans and government assistance schemes through QRAA.

More information about this service and how to make contact can be found at www.dpi.qld.gov.au (follow the links from 'Business and trade' > 'Business and trade services' > 'Farm Financial Counselling Service').

Finance

Some banks and financial institutions provide loans for orchard netting. Regarding eligibility, much depends on the individual situation of the grower. Some general points to note are:

- Equipment finance is often easier to obtain than an overdraft or loan. This can take the form of leasing, hire purchase or chattel finance.
- Some net suppliers and installation contractors are able to assist with organising lease arrangements.
- Some types of finance may have taxation benefits.
- Banks will normally only extend finance on the security of mortgaged land if they are the mortgagee. This is because nets are regarded as a fixture, not a portable chattel.
- Finance may be easier to obtain for nets that have been professionally designed and installed.

IMPORTANT: This information is meant as general information only. Individuals must check carefully the terms and conditions of any agreement that they enter into with a financial institution.

Queensland rural adjustment authority

Concessional loans through the Queensland Rural Adjustment Authority's (QRAA) Primary Industry Productivity Enhancement Scheme (PIPES) Development Program are available for orchard netting to growers who meet the eligibility criteria. Interested growers can visit the QRAA website at www.qraa.qld.gov.au/ or contact their local QRAA client liaison officer (follow the links from 'About QRAA' > 'Contact us').

Insurance

After a series of major storm damage payouts between 2002 and 2007, insurance cover for orchard netting was withdrawn and is not currently available. This situation may change in the future. Check with your insurance provider, netting contractor, bank or financial organisation.

Case studies—a review of growers experiences using various netting options

The case studies that follow summarise information gathered in 1999 from a survey of 18 fruit growers in Queensland and northern New South Wales who had been using nets to protect their orchards for several years.

IMPORTANT: These notes reflect the views and comments of the orchardist and may not be consistent with some of the recommendations and information given in other parts of this report. They are included here to help readers gain a practical perspective of netting.

Case study 1—full canopy netting on lychee

A North Queensland orchard, mainly Tai So and Fay Zee Siu with some Souey Tong, Sar Keng and Salathiel.

White 13 mm square mesh high-density polyethylene vine net was used on both the sides and on top of the canopy. The net has been used for five years now and is beginning to get brittle. After another two years it will probably need replacement. It has been repaired extensively after cyclones but is still functional.

The structure is 8 m high and made from Duragal steel box section poles of varying sizes. A 3 m long base section is concreted 1.5 m into the ground (a bobcat post-hole borer was used to make a 60 cm diameter hole for the concrete) and an 8 m long post with smaller dimensions slots into the base section (Figure 52). In some places these inner sections have been pulled out of the base section and pegged into place to raise the net height by half a metre where tree size warrants.

Layout of support posts and cables is on a modular system, using a 60 m x 60 m square. The module's corner posts are 125 mm square section base posts with a 100 mm square section slotted into them. The non-corner perimeter poles, every 20 m on two facing sides and every 15 m on the other two sides, are 100 mm square bases with a 75 mm square section slotted into them. Internal posts of the module are a 50 mm square section slotted into a 75 mm base spaced at 20 m x 15 m. These modules are repeated to cover the entire 2.2 ha of orchard.

Perimeter poles are stayed back to anchor poles sunk 1.5 m into ground with 60 cm diameter metal plates welded to the bottom. The perimeter wire around each module is 6 mm stainless steel wire. Eight-gauge fencing wire is used to form the internal grid to support the net on the same distances as the internal poles. The structure is expected to last at least 20 years.



Figure 52. The upper part of the pole slots into the base section, which is concreted into the ground

The 2.2 ha was netted in two and a half months using four people, giving an estimated labour cost of around \$10 000/ha. The total cost of materials and equipment was \$10 500/ha. After cyclone Justin, net repairs took the equivalent of one person six months, but only one post was bent. In a normal year repair and maintenance work on the net can be completed in two weeks by one person.



Figure 53. Full canopy nets over lychee



Figure 54. A 13 mm net with a double cross-stitch

- Before the orchard was netted, 40% losses to flying fox and birds were normal. After netting, there was no loss of early fruit and no delay to harvesting noted.
- Fruit quality is improved because the grower is able to pick mature fruit and does not have to rush harvesting to beat the flying foxes to the fruit.
- Early fruit in the top of tree is not lost and this fruit gets the best prices.
- The net also prevents damage by fruitpiercing moths and rhinoceros beetles, so there are no sticky or sap-stained fruit.
- It would be best to use six-gauge (6 mm diameter) wire throughout, the eight-gauge (4 mm diameter) fencing wire stretches too much.
- A system to make netting either removable or roll up in the off-season would be good.
- A better quality, heavier, net would be used next time.
- The grower has to do the pruning himself because contractors are worried about hitting poles and work too slowly.
- Not all the poles are in line with the tree rows because of uneven tree spacing in the orchard. Care is needed when slashing and spraying because some poles get in the way.
- After netting the neighbours were no longer disturbed by night time shooting.
- There have been no problems with steel poles in lightening storms (they just crackle a bit!)
- Cattle barge through net and people cut it to steal fruit.
- There is less drift when spraying.

Case study 2—full canopy netting on lychee

A Kwai May Pink and Wai Chee orchard in South East Queensland (Figure 53).

The side nets are black knitted HDPE with a 13 mm square mesh with double cross-stitch (Figure 54) and the canopy is black knitted HDPE with a 25 mm hexagonal mesh with double cross-stitch. Expected lifespan of the net is 10 years.

The structure is 6–6.5 m high and CCA-treated pine logs are used. The outside poles have a small end diameter (SED) of at least 200 mm and the internal poles have a SED of at least 120 mm. Perimeter posts have a buried log deadman to steady them. The supporting wire grids for the nets are high-tensile steel, seven-strand, 6.1 mm cable throughout. The internal poles are spaced on offset 18 m x 40 m square, which forms a diamond shape pattern allowing the cable grid to be 9 m x 20 m. The internal poles do not have to be exactly on the wire cross over points as long as they support at least one wire. The expected lifespan of the structure is 50 years.

The grower installed the net himself with the help of a local contractor. It took two people a month to complete the installation over an area of 1.2 ha. A Bobcat post hole borer was used to dig post holes and a 12 tonne excavator was used for 1.5 days to erect the poles. The grower's cherry picker was used to put out and fit the nets. The grower's estimate of the cost including the nets and hired labour but excluding his own labour is \$15 000/ha.

- Birds, flying foxes and fruitpiercing moths are completely controlled. Macadamia nutborers are not.
- The pruning policy is to hedgerow with the height of trees kept at least 50 cm below net canopy.
- More discipline is required regarding the timing of pruning but no extra pruning is needed above what was done before netting the orchard.
- No significant changes in pest and disease problems were noted after netting.
- Flowering and maturity times did not change after netting.
- No impact on bee activity or pollination by wind. Bees fly in and out of the orchard through the overhead netting with no problem.
- The fruit is not threatened by flying foxes and birds so there is no premature harvesting. After netting, fruit has been better quality with reduced sorting and wastage. Changes to fruit colour and size are only minor compared to non-netted fruit.
- The black net cannot be easily seen by birds and animals and some damage has been caused by animals and birds hitting the net sides.
- Pickers find it more comfortable working under the nets.

Case study 3—full canopy netting on lychee

A North Queensland Kwai May Pink orchard (Figure 55).

The canopy net is black extruded polythene (no longer available) with a 15 mm square mesh. On the sides a white vine net covers the black net to stop the birds flying into the black net. The net was installed in 1991 and is expected to last another five years. The total area covered is 4 ha.

All support poles are farm cut Cyprus logs taken from the owner's property, they are 8.5 m long with 2 m in the ground and 6.5 m out of the ground. The bigger logs with a SED of +/- 25 cm were used for the external poles and internal poles were the smaller SEDs (as available). There are 50 poles per hectare based on a pattern of a post on each corner of a 20 m sided square. Non-tensile, eight-gauge fencing wire was used for the canopy support but 2.8 mm high-tensile wire would be used in future. The grower expects the posts to last 30 years.

The grower installed everything himself and estimated it took one week to put in posts, one week to put out cables and two weeks to net using two people and his own cherry picker. The cost was around \$10 000/ha in 1991. Probably around two weeks a year are spent repairing and maintaining the net and structure.

- Birds and flying fox are completely controlled. Rhinoceros beetle and fruitpiercing moth damage is reduced.
- Prior to netting, 70% losses to parrots were incurred.
- It is a very basic low-cost netting system and in future the grower would use better quality, more expensive nets.
- The grower prunes harder with netted trees but otherwise has not changed his management policy after netting.
- The grower believes fruit ripens more evenly under the net.
- The grower feels shade from net reduces sunburn on fruit.
- Wastage at packing was 20% before netting but is now only around 4%.
- There is less work and faster sorting with cleaner fruit from a netted orchard.



Figure 55. A low-cost canopy net that is eight years old, much repaired but still serviceable



Figure 56. A 10 mm net with a double cross-stitch

Case study 4—full canopy netting on lychee

A 10 ha Kwai May Pink orchard in North Queensland.

The overhead and side netting is white, 10 mm diamond mesh net with a double cross-stitch (Figure 56), which gives protection against flying foxes, birds, fruitpiercing moths, macadamia nutborers and branch girdlers. The sides of the net are angled and are covered with 50% shade cloth to deflect wind. On the main windward side of the orchard, extra wind protection is provided by a 70% shade cloth material used to make a deflector panel. The cables are laid out on a 9 m square grid. A 7.5 mm wire cable is used for the internal grid and a 8.2 mm cable is used on the perimeter.

The structure is 6 m high and is made from CCA-treated pine poles. A series of 'X' frames made from railway lines from an old structure have been left to augment the new structure (Figure 57). The net, structure and cable grid are expected to withstand cyclonic winds.

Netting was installed by a contractor for \$15 000/ha. This includes the cost of net and cables. Posts were extra and the grower installed the structure. The net is leased for four years and then the residual will be paid out.

- Estimates of crop losses before netting were 60%.
- Netting costs for contractors can be reduced where growers in the same area negotiate as a group with contractors. The transport and relocation costs for equipment and materials can be minimised when this is done and spread over a larger area of netting.
- The trees are hedgerow-pruned to a height of around 4.5 m in late January or early February. Pruning is done mechanically.



Figure 57. An old metal net structure augments the new pole structure

Case study 5—full canopy netting on longan

A 1.5 ha Kahala orchard on the Atherton Tableland (Figure 58).

Black knotted nylon rope net with a 15 mm square mesh has been used for the canopy and sides (Figure 59). The net looks very strong and is guaranteed for 10 years and the grower expects it to last for 15 years. The net was installed five years ago and still looks in excellent condition. A flap panel along the bottom allows floodwaters from a nearby creek to wash through without damage and also allows small animals such as wallabies to walk through without breaking the net.

The external posts are 8.5 m ironbark logs with a minimum SED of 120 mm. They are concreted 1.5 m into the ground to give a 7 m high canopy. Internal posts are 75 mm square, box section, galvanised steel (7.75 m long with the bottom 75 cm concreted into the ground). The internal posts are on an offset 10 m x 20 m grid, which fits neatly with the 10 m x 10 m tree spacings. A 6 mm stranded wire is used for the overhead cables and 8 mm stranded wire is used on the perimeter post stays. Before erecting the nets a black nylon 'wire' (3 mm diameter) was pulled through the selvedging, which is then clipped to the cables using hog rings every 20 cm or so.

The net cost \$0.65/m² to cover the canopy and the sides of a 1.5 ha block and used a total of 19 840 m². The external ironbark posts cost \$80 each and the internal steel posts also cost \$80 each. The total cost for 1.5 ha was \$23 000 for materials plus about \$20 000 for labour (the grower's own plus family). The total cost was \$28 666/ha.

- The grower believes the net prevents losses of 20–50% by flying foxes and birds but does not prevent fruitpiercing moth damage.
- To reduce the risk that the netting would be installed in a year when there was a low crop, the structure was erected ready for netting but the net was purchased only when the grower could see that a good crop had set on the trees. The expenditure on the net itself (about 33% of the total cost) was therefore only made when the grower was reasonably sure he was going to be harvesting a good crop in that year (and would therefore get a return on the investment).
- The net guarantees a crop in a low crop season and the grower is in a position to benefit from the higher prices of a low crop season.
- The trees are manually pruned to 6 m (Figure 60).



Figure 58. Full canopy nets over longans



Figure 59. A 15mm mesh nylon rope net



Figure 60. The longans are pruned to 6 m under the 7 m canopy

Case study 6—tunnel netting on lychee (single pole and wire system)

A North Queensland orchard, mainly Tai So and Fay Zee Siu and Kwai May Pink, with a total of 180 netted trees planted on 8 m x 10 m spacings (1.5 ha).



Figure 61. An end pole

A very simple tunnel netting system consisting of a 12 mm square mesh white vine net held off the tops of the trees by a single wire suspended on metal posts. The current net is six years old and will probably last another six years.

The nets are 15 m wide and normally two nets are used per row to form a tunnel. nets are joined by ‘sewing’ them together above the tree row. Wider nets would reduce the amount of ‘sewing’ required to make the tunnel and 22 m nets are available. The nets are ‘sewn’ by tying them together with baler twine at 30 cm intervals. The sides of nets are pulled down and tied off to the nearest tree in the next row to give a tent shape. Flying foxes don’t seem to get under the sides to any significant extent.

Sometimes several pairs of nets are sewed together between the rows to form a simple temporary canopy net supported by the trees.

The row end posts are 6 m long, 100 mm x 100 mm square galvanised box section with 5 m above ground and 1 m concreted into the ground (Figure 61). To extend the posts, another section could be simply bolted onto the top if needed. There is a post every 40 m (eight trees) and 40 mm diameter metal pipe is used instead of box section at every 10th tree, thus the stronger square section poles alternate with the cheaper circular poles. Each pole has an end cap on it to prevent holing in the net caused by rubbing. Stainless steel eight-gauge wire is used to support the net between the poles.

The net cost \$0.32/m² and about \$2500/ha has been spent on poles and wires and caps. The net is put out just before the fruit starts to colour. It takes five people 1.5 days to cover the whole orchard. It takes two people three days to tie the whole orchard of 180 trees. After the nets have been taken down, they are left to dry out and then fed into bulk fertiliser sling bags for storage.

- The grower believes the net is saving an average 15% crop losses per year.
- The grower uses this low-cost system mainly because crops are inconsistent from year to year. There is no financial justification for more expensive netting. However, the grower is happy with the results and would probably stay with this system even if he had a more regular crop.
- Wear gloves to stop the net burning the skin when you are putting nets out and sewing them together. Wear a hard hat. Soft hats soon rub through on the net while putting it out and sewing from underneath!
- The grower still does some night time patrolling as 100% security is not achieved with this type of net system. Patrols do not need to be as intense to achieve reasonable control. Normally fruit does not get a lot of damage from lorikeets, but when they are a threat the grower patrols to control them (they get under the nets via the sides and will also cut through the net to get fruit).
- Having nets means the grower is able to rest more easily at night.
- No change in the maturity time of fruit has been noted by the grower following netting.
- The nets are on from October through to December. There has been some holing, with tree branches growing through and lifting the net.

Case study 7—tunnel netting on lychee (hoop frame system)

A small South East Queensland orchard, 0.4 ha of Kwai May Pink, planted on an 8 m row spacing with 5 m between the trees.

Polypipe hoops held on star pickets form the frame and a white, 12 mm hexagonal mesh vine net is pulled over the hoops to form a tunnel.

The net roll is 13 m wide and easily fits over the 9 m long hoops (Figure 62). The grower expects at least 10 years of use from the nets as they are used for only a short period each year. They are put out after the developing fruit are too large to go through the net mesh and taken in after the harvest is finished. Two people are needed to roll out the nets along the row. The net is pulled and pushed over the trees using a pole with a T-bar on the end (to push the net off branches) and another pole with an old tennis ball on the end (to flick the net over the canopy). The net is tied to every star picket on the windward side of the rows and every second star picket on the leeward side. This makes it easy for pickers to get under the nets, which are left on when harvesting. The fruit is simply passed out under the nets by the pickers for collection.



Figure 62. Placing nets over polypipe hoops

The structure consists of 50 mm diameter polypipe hoops slipped over star pickets driven into the ground on each side of the row. One hoop is erected over each tree and the hoops are joined by three strands of fencing wire (one running along the top and one 3 m to each side). The wires are tied to the hoops with tie wire to stop the hoops moving around. A solid post at the ends of each row anchors the wires and this helps hold the hoops rigid. Sometimes on very hot days some of the polypipe hoops can sag at the top of the arch. When this happens, the hoops have to be propped up with short aluminium poles and the poles are held in place by slotting them over a nail in the nearest sturdy branch.

- Yields average 45 kg per tree and there is an estimated 3% loss to macadamia nutborers. Without nets 20% or more losses to birds and flying foxes would be expected in a 'normal' year.
- Control through shooting or lights and noise scaring devices are not viable options because the orchard is in a residential area.
- The nets are good for public relations. Nets bring the business to the attention of the public, which increases farm gate sales.
- Fruit quality is improved as fruit is allowed to hang longer and develops a better flavour. Maturity time is the same as for the other growers in the area.
- Spraying is done through the nets when they are on and there are no problems with this.
- The nets must be packed and stored away from rats, which will build their nests in the rolled up netting and damage it.
- Make sure there is no old fruit in the nets when they are packed away. Store in woosacks numbered to correspond to the rows where they came from (as each net is cut to length to suit a specific row).
- In very windy weather, undo the windward side and let the nets blow over the trees onto the ground on the other side. This prevents damage to the nets.
- Pruning is necessary to keep the trees small enough to fit under the hoops. The grower feels that he would be doing this regardless of netting requirements.
- Besides flying fox and bird control, the grower feels that the nets limit fruitpiercing moth damage significantly, though the fruitpiercing moth can still damage any fruit touching the net and a few get through the net because the mesh is not quite small enough.
- The grower does not use any large machinery, so the problem of hoops and star pickets interfering with machinery operation is not an issue in this small orchard.
- Workers are more comfortable working under the nets. The nets create a cooler work environment.
- The harvesters work under the nets and moving between rows is less convenient. Picking is about 5% slower.



Figure 63. Galvanised water pipe can be used to make hoop frames

Metal pipes can be used to form the tunnel frames in a similar fashion to the polypipe system. The frames are a little larger and more rigid (they do not sag in the heat) and are made out of 25 mm galvanised water pipe (Figure 63).

Case study 8—tunnel netting on lychee (coathanger frame system)

A 13-year-old Kwai May Pink orchard in South East Queensland planted on a 5 m x 10 m spacing. The land is too steep and the row widths too wide to be economically canopy netted.

A white, 12 mm square mesh vine net is held over the tree canopy by a series of coathanger-shaped metal frames held on wooden posts (CCA-treated pine poles) 25 m apart. Three strands of high-tensile fencing wire run between the frames (one at the apex of the frame and two at each end of the frame). Two more runs of fencing wire are staked into the ground either side of the tree row below the ends of the frames. The net is tied to these with baler twine every metre or so to hold it to the ground and prevent birds and fruitpiercing moth getting under the net (Figure 64).

The net width is 16 m or 18 m. Normally the net is applied about six weeks prior to picking. A frame with a hoop mounted on a ladder on the back of a tractor tool-carrier is used to run the net out over the canopy (this is done at walking speed). Three people are required—one to drive the tractor and one on each side of the tree row to pull the net down evenly (Figure 65).



Figure 64. The net is tied to a wire running along the ground

- The poles are in the tree row and access for machinery is not impeded when the nets are not out.
- The grower estimates a 5–10 % slower output from pickers.
- The capital cost is \$30 per tree.



Figure 65. Nets being run out using a simple farm-made applicator

Case study 9—tunnel netting on lychee (coathanger frame system)

A North Queensland Tai So orchard planted on a 9 m x 7 m spacing.

The frames are made from an arc of metal hoop mounted on 75 mm square galvanised metal posts placed 28 m apart. The posts are 8 m high to allow for the vigorous growth of trees in North Queensland's climate (Figure 66).

The net is rolled out over the hoops from a cherry picker. The net is stored each year on a polypipe roll, which fits on a frame attached to the cherry picker. The net rolls off the frame as the cherry picker operator rolls the net out over the canopy. The nets are simply pinned to the ground every couple of metres using homemade wire tent pegs.

- The net controls birds and bats and prevents FPM damage to a significant extent.
- A significant advantage of the metal structure is that it is termite-proof.

Case study 10—full canopy hail netting on stone fruit

A 4 ha, low-chill stone fruit orchard in northern New South Wales.

White, diamond mesh hail net with double cross-stitch on the canopy and black bird net with 25 mm mesh on all sides. The net is seven years old and looks to be in good general condition. The net is expected to last at least another three years. The canopy is 5.5 m above the ground.

External posts are CCA-treated pine with an SED of 30 cm. Each post is anchored to a buried log deadman with stay wires. There is a main cable every 14 m, which is the same width as the net, and an intermediate cable every 14 m (alternating with the main cables) to give extra support. There are intermediate cables every 28 m at right angles to the main cable run. The intermediate cables and main cable form a 7 m x 28 m grid. The main cables are six-strand wires and the intermediate cables are four-strand. The internal poles are offset along each main cable every 28 m, forming a square diamond with a 28 m axis.

- Doors are kept closed even during the off-season.
- On the headlands the side nets are bevelled at 45 degrees to give room for machinery to turn easily. On the other two sides the nets are vertical.
- Significant wear of net on cable joints where the intermediate cables are strung between end posts (Figure 67) is a problem but the holes do not 'run'.
- Grower does not have any particular concerns regarding delays in fruit maturity or quality.

Case study 11—full canopy hail netting on stone fruit

White hail net over a 3.5 ha, low-chill stone fruit orchard in northern New South Wales.

The canopy is 6 m high and the posts are 1 m in the ground. The net was installed by a contractor for \$1.70/m². This included all the cables and the net, which is worth \$0.68/m². Locally purchased hardwood poles (bloodwood and north coast stringy) with a minimum SED of 200 mm were used for posts. These were oiled three times with old engine oil before erecting. Headlands are 10 m wide to give ample room for turning tractors and machinery. The structure and net are rated W44 for wind resistance.



Figure 66. An all-metal coathanger tunnel frame

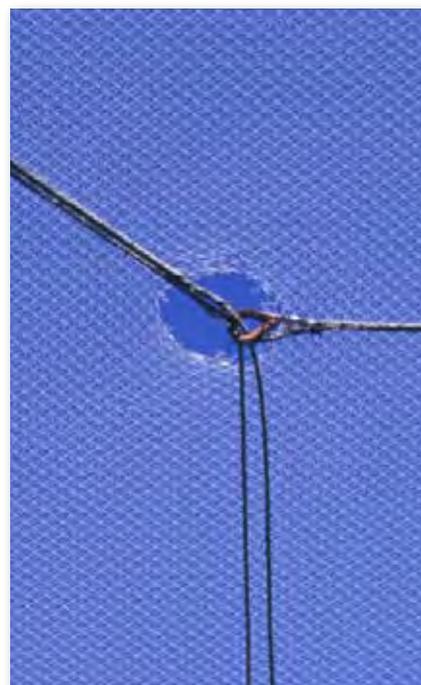


Figure 67. Rub tears occur on any irregular shape such as this eyelet

- Pest and disease problems are reduced under hail netting. The trees under hail netting are more sheltered and have less gumosis than those under bird netting. Monolepta beetle and possibly Queensland fruit fly numbers are reduced.
- Early flowering is delayed by about 1–2 weeks, but mid and late flowering is not affected. However, no fruit is lost to the rosellas and other birds, which always take most of the early fruit, so in practice the grower gets an early season crop.
- Beehives are brought into the orchard and sited just inside the gate. There has been no problem with pollination or the bees.
- Losses without netting are up to 100% in bad years.
- Fruit quality is good. There is less skin blemishing because wind rub is reduced by the sheltering effect of hail netting.
- The extra shelter provided by the net prevents the loosening of trees due to wind rock.
- Savings attributable to hail netting include \$9000 per annum previously paid for hail insurance, which is no longer needed.
- Frill-necked lizards cut the net and make holes. Holes in the net have to be patched and sewn each year but this is only a minor job.



Figure 68. Stone fruit under black hail net (bottom image is close up of net used)

Case study 12—full canopy hail netting on stone fruit

Black hail net (Figure 68) is used in a northern New South Wales orchard

The canopy is 5 m high and was installed in 1994. Windbreak material is used on the windward side of orchard to give extra protection to the trees. Six metre long Koppers log posts are used (5 m above ground and 1 m underground). The posts are on an offset 9.6 m x 24 m spacing, coinciding with tree rows and net width.

The netting cost \$25 000–30 000/ha, including installation. Normal losses to birds and flying foxes would be 30–40 % without netting. In 1989, a particularly bad year, there were 80–90% losses.

- Hail netting protects 50% of the orchard and the rest is under bird netting. With half the orchard protected from hail, the grower no longer takes out hail insurance. It is too expensive to cover the whole orchard with hail netting.
- One of the reasons that black hail netting is used is that a neighbour specifically asked him not to use white because of its unsightly impact on the landscape.
- Leaves tend to stay on longer under hail net, so he is able to defoliate the trees at a time of his choosing.
- Flowering of Sunwright nectarines in the non-netted and bird-netted parts of the orchard is usually more advanced than under the hail-netted part. The grower is not concerned by this, since the very early set fruit usually gets removed when he thins anyway.
- Practices such as defoliation and management of the orchard in general are more important in controlling flowering and fruit maturity and can override any effect caused by the hail net.
- Factors such as site and exposure to wind and cool air are crucial to controlling fruit maturity and a netted orchard on a site that favours earliness will outperform a non-netted orchard on a site that does not inherently lend itself to earliness.

- Less chemicals are used under the hail net to control pests and diseases than in other parts of the orchard (probably because there is more shelter and therefore less wind damage to trees and fruit).
- When the net was erected, some trees were moved using a hydraulic tree lifter to ‘tidy up’ the layout of the orchard and minimise non-productive area under the net.

Case study 13—full canopy bird and flying fox netting on stone fruit

A northern New South Wales orchard netted with a black 45 mm net on both the sides and canopy.

The net roll width is 36 m. Posts are on a 30 m x 30 m grid.

Estimated cost, including installation, was \$15000/ha.

- The grower would use an 18 m wide net in future because the 36 m width is difficult to erect (it is too wide and difficult to handle).
- Originally 100 mm mesh net was used but this is too large and did not prove effective (80% losses were incurred under this net in 1989).
- Flowering was slightly less advanced on the bird-netted trees than on the non-netted trees; however, this could also be attributed to other factors.

Case study 14—full canopy bird and flying fox netting on stone fruit

A 2.5 ha, low-chill stone fruit orchard in northern New South Wales.

A black 44 mm square mesh net is used overhead and on the sides. Chicken wire has been added to the sides to stop hares and wallabies from tearing the net. The chicken wire is more visible as well as being stronger. The net is in 9.6 m and 18 m wide rolls.

All poles are 7 m long. The internal posts are one metre in the ground and the external posts are 1.2 m in the ground. The external posts are stayed back to deadmen. The stay wires are at a 45 degree angle. The deadmen are 1800 mm x 300 mm logs buried 2 m deep. Placed under the posts at the bottom of each hole are 1000 mm x 300 mm logs, which have been used as anti-sink pads.

The netting took one week to erect (including cables) using two experienced riggers and three weeks to fit and sew the nets. Costs were \$14 000/ha for labour plus \$15 000/ha for materials.

- Netting probably prevents 10–20% losses to flying foxes in a normal year, but the entire crop was lost in 1990 to flying foxes in four nights.
- The 9.6 m wide net was easiest to handle and strain when erecting, but the 18 m was acceptable.
- No differences in maturity dates of fruit have been noted.
- The gates are kept shut at all times to keep birds out and this encourages frogs and lizards, which control some orchard pests.
- Originally a 90 mm mesh net was used. This was too big and did not control birds or flying foxes.
- A height of 6 m is needed to allow for the vigorous tree growth on the palmette system. The extra height is believed to reduce the impact of the net on the orchard microclimate.
- White net may have an unsightly impact on the general landscape but the grower has not had any concerns raised about the black bird net.
- Parrots can chew through the net and hares and kangaroos have also damaged the side netting. To prevent this, chicken wire is used to cover the side netting. Chicken wire is more visible so it also makes machinery operation easier and safer.
- White polypipe cut down one side can be used as a clip to hold nets over cables.

Case study 15—full canopy bird and flying fox netting on stone fruit

A low-chill stone fruit orchard in South East Queensland.

Three different types of black net have been used—a 23 mm mesh net with three cross-stitches and 20 mm or 14 mm mesh nets both with a double cross-stitch. The net canopy height is 4 m and in some parts of orchard only 3.6 m. These lower canopies may need raising. Canopy was limited because the steep site and



Figure 69. Stone fruit under a 3.6 m high canopy net after pruning



Figure 70. Angle iron welded to the base of metal support poles

the pronounced ridges (used to maximise soil depth and drainage in the orchard) made the use of cherry pickers and other machinery too difficult and dangerous to use when erecting a higher net canopy (Figure 69).

The posts and wire grid are on a 20 m x 20 m square layout. Some sections of the orchard have fencing wire diagonals across the grids to support the net. The wooden posts have a 150 mm SED and cost \$25 delivered.

- All three types of net keep out FPM but the 20 mm mesh with double cross-stitch is not quite 100% effective.
- Timely post-harvest and summer pruning is needed to control height under the low net canopy.
- Doors are kept open to encourage birds to inhabit the orchard in the off-season and control some insect pests.

Case study 16—full canopy bird and flying fox netting on stone fruit

A low-chill stone fruit orchard in northern New South Wales.

Originally a black, 50 mm square mesh net was used but this was replaced with black, 44 mm or 25 mm square mesh nets because birds got through the original net. Initially, the net was 4.2 m high but it had to be raised by 60 cm to give a total height of 4.8 m. The canopy has been raised by bolting an extra length of timber onto the top of existing posts. External posts are spaced 10 m apart along the orchard perimeter and the internal posts are on a 14 m x 20 m grid. Alternate rows of internal posts are lightweight wooden prop poles resting on bricks. The other rows are more substantial posts buried in the ground.

Net and structure are nine years old and still in a serviceable condition. Eight posts (out of 130) have had to be repaired because they have rotted at the base. This was done by imbedding a short post alongside the rotten one, bolting it to the sound part of the old post and then cutting off the rotten base of the old post.

Case study 17—full canopy bird and flying fox netting on stone fruit

A low-chill stone fruit orchard in South East Queensland.

Two sizes of net are in use—a 100 mm square mesh net (installed in 1986) and 50 mm square mesh net (installed in 1995). The net canopy height is 4 m.

Perimeter poles are wooden with a SED of 200 mm sunk 1.3 m into the ground, internal poles are either 100 mm SED wooden poles sunk into the ground (see front cover) or 40 mm metal posts which simply rest on 'T' pieces of angle iron that have been welded to the bottom (Figure 70). The top of these posts have piece of polypipe, which has a 'X' cut into it wedged into them, the X cuts are slotted onto the wires that support the net (Figure 71). Poles are on an offset 20 m x 20 m grid. The structure is low-cost and lightweight, but has lasted 13 years.

- Both flying foxes and birds can get through the 100 mm net but it stops most and is still in use. Losses under this size of net are estimated at about 5%.
- The 50 mm net is flying fox proof but lorikeets can still get through it.
- The iron poles, which rest on the ground, sometimes move when the net lifts in a high wind. Occasionally, following a storm, the grower spends a few days standing up any fallen posts.

Case study 18—tunnel netting on stone fruit

A low-chill stone fruit orchard in South East Queensland.

White vine net with a 12 mm or 15 mm square mesh is used. The net roll width is 11 m or 13 m and this fits over the 8.3 m polypipe hoops that form the frame of the tunnel. The net width can be adjusted by stretching it down the rows to make the net a little narrower. The same net is used on the same rows each year. The net is not cut but just looped around from one row to the next (Figure 72).

The net is folded under the bottom wire and is held in place using hooks made from bent wire to hook it back onto itself (Figure 73). The nets are normally put out around the beginning of August (as soon as bird damage is seen). The nets have been used for five years and are expected to last another 10 years.

The hoops are 8.3 m long sections of 50 mm polypipe. Each end is slipped over 165 cm star pickets driven into the ground on either side of the tree 2 m from the trunk. A 100 m roll of polypipe will give 12 hoops each 8.3 m long. The star pickets are lined up by eye to keep the line of hoops straight so these measurements are approximate. The star picket is driven with the double edges to the outside of the row as this helps prevent the polypipe hoops kinking. The arch of the hoop is about 3.4 m high. There is a hoop every second tree or about every 9 m. The hoops are joined by seven runs of galvanised fencing wire (one along the ground on each side, one on the apex and two pairs either side of the apex on the semi-circle of the hoop). The wires are threaded through holes in the hoops and fastened to each hoop with a tie wire loop. The whole tunnel is held secure by tying the wires back to a star picket driven almost completely into the ground to form an anchor, or by supporting the end hoops of the row with a solid wooden post and cross-beam.

The net cost \$0.32/m² and it took about three weeks to put out the star pickets and hoops over 300 trees (or 1 ha). Star pickets cost \$3.50 each and the polypipe hoops cost \$11 each. There is no problem putting the net on or pulling it off the hoops. The nets take two days to put out and another two days to recover and pack away.

- Before netting an average of 33 % of the crop was lost, mainly to lorikeets.
- A tunnel netting system is used in this orchard because irregular-shaped blocks make canopy netting uneconomical.
- The tree rows are 6.5 m apart, so there is 2.5 m of clearance between the hoops for tractors.



Figure 71. Slotted polypipe used to hold metal support poles in position on canopy wires



Figure 72. Hoop frame tunnel nets on stone fruit (the net is looped round from one row to the next to avoid cutting)



Figure 73. Nets pulled under a wire running along the ground and hooked back on themselves

- Before the nets are put out, weeds must be sprayed to stop grass growing through the bottom of the nets. Some spot spraying is done after the net is out to control grass growth. Generally the soft growth of tree shoots will pull easily back through the net when it is taken off.
- The trees are pruned to an open vase system but pruned slightly narrower than 'normal' along the sides of the row to keep trees away from the net. When the trees get older new wood will need to be developed earlier to allow for this, but no problems so far.



Figure 74. Nets stored on reels

- The usual stone fruit chemical fungicides and insecticides are simply sprayed through the net without any problem.
- The nets are stored on farm-made reels (Figure 74) and kept secure from mice when in storage.
- Damage from a light hail storm was minimised by the tunnel netting, which slowed down the hail.
- When picking it is necessary to lift the nets in advance of the pickers but if this is done there is no effect on the picking rate.
- Picking, sorting and packing is easier because there is very little damaged fruit.

Contact list for net manufacturers, suppliers and installation contractors

The following list is provided to help growers but is not definitive. Other contacts, suppliers and contractors can be found via the internet and/or the *Yellow pages*. Your local agricultural supplies store may be able to supply nets and structural materials. Many suppliers and contractors provide interstate services.

IMPORTANT: Names are provided solely for helping readers make contact. Inclusion of a person or organisation does not constitute an endorsement by the Department of Primary Industries and Fisheries or the author. DPI&F does not endorse a particular person or organisation. While every effort has been made to make this list as complete as possible, it should not be regarded as definitive.

Agricultural Netting Services (Tas.)

Mobile: 0404 489 880

Braidcore Industries (Vic.)

Ph: 03 9350 7333

Coast Guard Netting Services (NSW)

Ph: 02 6686 7321

Freecall: 1800 669 432

Fax: 02 6686 7242

Email: info@coastguardnetting.com

Web: www.coastguardnetting.com.au

Crendon Machinery (net application equipment, WA)

Toll free: 1300 761 922

Web: www.crendon.com.au

Environet Canopies (Vic.)

Ph: (03) 9735 2523; 0401 077 221

Fax: (03) 9735 2523

Email: info@environetcanopies.com

Web: www.environetcanopies.com

Gale Pacific Limited/Synthesis (Vic.)

Ph: 03 9518 3333

Fax: 03 9518 3398

www.synthesisfabrics.com

Geoff Miller Pty Ltd (Vic.)

Ph: 03 9597 0777

Fax: 03 9598 1638

Email: info@geoffmiller.com.au

www.geoffmiller.com.au

Haverford Pty Ltd (NSW)

Ph: 02 95881777

Fax: 02 95884777

Web: www.haverford.com.au

JA Grigson Trading Pty Ltd (SA)

Ph: 08 8384 3177

Fax: 08 8384 8377

Email: sales@jag.net.au

Web: www.jag.net.au

NetPro Protective Canopies (Qld)

Freecall: 1800 501 337

Ph: 07 4681 6666

Fax: 07 4681 6600

Email: sales@netprocanopies.com

Web: www.netprocanopies.com

Oblomov Trading Company (NSW)

Ph: 02 9660 6845

Fax: 02 9518 8372

Email: sales@otcobirdnet.com.au

Web: www.otcobirdnet.com.au

Oxley Nets Pty Ltd (Vic.)

Ph: 1800 816 505 or 03 9646 3497

Fax: 03 9646 4920

Email: info@oxleynets.com.au

Web: www.oxleynets.com.au

Peter Smith Contractors (NSW)

Freecall: 1800 078 708

Ph: 02 69 474 477

Fax: 02 69 474 479

Mobile: 042 8365 180

Email: peter@petersmithcontractors.com.au

Web: www.petersmithcontractors.com.au

Scarecrow (NSW)

Ph: 02 9910 4148

Fax: 02 9910 4191

Email: scarecrow@charlesparsons.com.au

www.scarecrownsolutions.com

The Netting Company (Qld)

Ph: 07 3282 7640

Email: multikn@bigpond.net.au

Web: www.thenettingcompany.com.au

Vine Nets Australia (WA)

Ph: 1800 677 757

Email: austnets@comswest.net.au

Web: www.vinenets.com.au

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The first part of the document discusses the importance of maintaining accurate records of all transactions and activities. It emphasizes that proper record-keeping is essential for ensuring transparency and accountability in the organization's operations. This section also outlines the various methods and tools used to collect and analyze data, highlighting the need for consistency and reliability in the information gathered.

In addition, the document addresses the challenges associated with data management, such as ensuring data security and privacy. It provides recommendations for implementing robust security protocols and access controls to protect sensitive information. Furthermore, it discusses the importance of regular data audits and updates to maintain the accuracy and relevance of the records over time.

The second part of the document focuses on the analysis and interpretation of the collected data. It describes the various statistical and analytical techniques used to identify trends, patterns, and correlations within the data. This section also discusses the importance of contextualizing the data and considering external factors that may influence the results.

Finally, the document concludes by summarizing the key findings and providing recommendations for future actions. It emphasizes the need for continuous monitoring and evaluation of the data to ensure that the organization remains informed and responsive to changing circumstances. The document also includes a list of references and a glossary of key terms used throughout the text.