Arboricultural Impact Assessment Report

Site Address: 89 George St
Parramatta

Prepared For: Nic Webb
Duxton Developments PTY LTD
C/- PO BOX 385
GALSTON NSW 2159

Prepared On:

Prepared By: **Mark Hartley**
Dip Hort (Arboriculture) with Distinction
LMNAAA LMISA LMIPS MASCA
ISA Certified Arborist WC-0624
NAAA Consulting Arborist # 6222-01
Senior Consultant for

The Arborist Network
58 South Creek Road
Shanes Park NSW 2747
Phone (+612) 9835 1234
Email: *reports@arboristnetwork.com.au*

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Executive Summary

A proposal exists to develop a block of land adjacent to an olive tree located on the curtilage of Perth House. The tree is in fair to good health and has no significant structural issues. The tree is growing close to an existing building that is to be demolished and a new building constructed that will include a basement excavated boundary to boundary. Concerns exist as to how this may impact on the olive tree and what should be done to address this.

It appears from an arboricultural perspective that the most appropriate option would be to prune the roots and the branches that cross the boundary line and to retain the tree in its current location throughout the development process. This may however impact on any construction works that may be required to be performed from the Perth House side of the property.

In order to address this problem the process of transplanting the tree from the site and returning at the completion of the works has been considered. Provided that suitable storage can be found locally it would appear that this tree could be moved without any significant loss of visual amenity, once returned to the site and replanted in the same location. Such transplanting work will add to the cost of construction and it may be more economical to consider alternate work methods to address works adjacent to the tree.

In the event that temporary storage for the tree cannot be found locally then the costs of moving the tree with a full canopy are likely to be prohibitive and a trunk transplant with a significantly modified canopy is the only option remaining to retain the tree.

Brief

I have been asked to inspect an olive tree on the property adjacent to 89 George Street and to prepare an Arboricultural Impact Assessment Report including a Transplant Feasibility Assessment.

Information Provided

Woods Bagot concept images
G.J Atkins & Associates Consulting Surveyors – Detail Survey 7/11/1995

Limits

Inspection date:

The site inspection was carried out on the 11th December and the site related observations contained in this report arise from the inspection on that date.

Method:

The inspection of all trees was made from the ground and involved inspection of the external features only. Inspection of trees on the neighbouring property was from the property and or the public footpath. The inspection included the performance of a **V**isual **T**ree **A**ssessment

(**VTA**)[1]. No invasive testing was carried out. A starch test was undertaken using a standard IKI histology test in transverse section.

Plans:

This report adopts the terms and nomenclature provided in the Australian Standard AS 4970-2009. To avoid confusion that this can cause the term Tree Protection Plan refers to the recommendations and processes required to protect the trees and the Tree Protection Plan (drawing), is a plan that may or may not have on it sections of or all of the Tree Protection Plan (other than a repetition of the drawing).

The trees that were not located on the survey plans provided are shown with their approximate centres marked on the Tree Protection Plan (drawing) (See Appendix 1).

Only the plans referred to above have been used in assessing the impact of the proposed DA on the trees. Where recommendations are made in this report including those recommendations contained in the Tree Protection Guidelines it is essential that these recommendations be able to be implemented. Any additional drawings, details or redesign that impact on the ability to do so may negate the conclusions made in this report

Observations

The tree is a young to medium aged *Olea europaea* (Olive) that is somewhere between 60 and 120 years of age. It is located on the curtilage of Perth House (the property adjacent to the proposed development). The tree is in fair good health and there are no indicators to suggest that the tree poses an abnormal Risk of Harm[2] risk of causing harm

The tree is approximately 10 metres high, has a canopy spread of approximately 16 metres north south and approximately 11 metres east west. The tree has a DBH[3] of 95cm measured using a diameter tape. The canopy overhangs the boundary line by approximately 3 metres at the widest point. The largest limb overhanging the boundary line is approximately 180mm in diameter and the average limb size overhanging the boundary is about 50mm in diameter.

There has been a history of some minor pruning to the eastern side of the canopy although several larger branches have been pruned in the past the largest being about 150 mm in diameter.

[1] **VTA** – Visual Tree Assessment is a systematic inspection of a tree for indicators of structural defects that may pose a risk of failure. This is made from ground level, unless otherwise stated. Dr Clause Mattheck describes the method in *The Body Language of Trees*. It is the recognised assessment process and is supported by the International Society of Arboriculture as the standard visual assessment process. Invasive and other diagnostic fault detection procedures will generally only be recommended when visual indicators of potential concern are observed.

[2] As with most things in life, all trees pose an element of risk. The average tree poses a Risk of Harm that is less than the Risk of Harm form stairs and substantially less than the Risk of Harm from cars. An abnormal risk of harm is used to mean that the Risk of Harm is estimated to be in the order of 1in 10,000 or greater (or about the same order of magnitude of the Risk of Harm associated with driving a car).

[3] Diameter at Breast Height: The trunk measured 1.4 Metres above ground level) as outlined in appendix "A" of AS4970 -2009

The trunk of the tree is located about 80cm from the boundary wall and is approximately 3.3 metres from the veranda of Perth House. The ground level around the tree is about 600 mm above the level at the footpath and it appears that the wall extends 200mm below this. In addition there will be a footing with a depth of approximately 400-500mm. The floor level in the office of Betta Brakes appears to be about 400mm below the surface adjacent to the olive tree.

There is a drainage pit about 4 metres from the base of the tree and it appears that a storm water line may run about 2 .5 metres away from the tree The level of a grate over a drainage pit is the only thing that would indicate that soil build up may have occurred at some stage in the past. The difference in the levels suggest a grade change of somewhere between 100 and 200mm. There is no obvious root flair but there is a reasonably heavy organic layer. The accumulation of organic material and its breakdown to form soil may account for a 100 - 200mm of soil build up otherwise the ground level appears to be natural.

There is a water main and hydrant about 4.5 metres from the base of the tree and on the northern boundary of Perth House. There is a backflow prevention device in a raised garden to the south east of Perth House and it is conceivable that water runs from the front through to this point and even to the office block at the rear of Perth House.

A proposal exists to demolish the existing building to excavate and to construct to the building line including the construction of basement parking with the basement excavations occurring along all boundaries.

Discussion

Roots on Development Sites

The critical issue when constructing adjacent to trees is the impact of construction activities on the roots. To fully understand this impact it is important that we understand that there are two substantially different components to the root system.

- The structural roots are essentially underground branches. They are long lived. They provide physical support for the tree and act as the connection between the absorbing roots and the rest of the tree. These roots can be a little under a millimetre in diameter and can grow to be hundreds of millimetres in diameter over time. Their thick bark prevents them from drying out but as a result they are not effective at absorbing water and nutrients from the soil.

- Absorbing roots are very small and the absorbing components usually microscopic. The absorbing roots are responsible for nearly the entire uptake of water and nutrients. They are highly ephemeral (come and go quickly), often lasting only two or three months but sometimes, in association with beneficial fungi, they can last a year or more.

  Absorbing roots are readily stimulated by water, soluble nutrients and soil temperatures over 16 degrees. (It can be assumed that soluble nutrients are always present in most

soils at satisfactory levels particularly when organic material is present. This is one of the reasons that we encourage the use of mulch.)

In clay soils the majority of roots occur in the first 600mm of soil depth. This is primarily because all plant tissue respires (burns oxygen) in order to function. Oxygen levels, nutrient levels and root density all diminish as soil depth increases. Absorbing roots and absorbing root organs are always at their highest density close to the surface. This zone is richer in oxygen, nutrients and beneficial micro and macro organisms.

The cutting of a structural root with a diameter of 25mm could conceivably result in the death of many thousands or even millions of root hairs, depending on the amount of root division.
The most important structural roots are those that grow directly from the trunk (first order lateral roots) and those roots that branch near the trunk and get rapidly thinner (zone of rapid taper). Damage to these roots is extremely undesirable.

Tree Retention

The tree is located on the neighbouring property and as such all effort must be maintained to retain and protect the tree. A development needs to adequately consider site constraints and this tree is a constraint. All trees on neighbouring properties must be retained unless the tree owner and the council consent to its removal.

AS 4970 indicates that this tree requires a Tree Protection Zone with a radius of 11.4 metres. Clearly this is not possible if construction is to take place to the boundary and will involve basement excavation. AS4790 does allow for a 20% deviation to the TPZ provided there is an offset that allows for the same area. Even at 9.1 metres, the tree is still far to close based on AS4770 for the construction of a basement.

It is possible under AS4790 to encroach even closer based on root investigation. In this instance however, root investigation is not possible without demolition of a portion of the property and this is clearly not appropriate without having a DA approved for the proposed building. A more theoretical approach needs to be applied

The tree has already been growing with the adjacent wall being present for quite some time (I would estimate 40 or 50 years). In this time the wall and the footing will have undoubtedly have impacted significantly on root morphology. As a result the root system is likely to be moderately confined to the Perth House property and this is certainly the case when it comes to the Zone of Rapid Taper, first order lateral roots and the majority of the large woody roots.

For this reason it seems practical to consider allowing a replacement building including basement excavation to be constructed along the boundary line whilst retaining the tree in situ. Clearly this may pose some additional problems but if these can be addressed then this may resolve the conflict.

The two main issues that need to be considered are the stability of the tree as a result of possible root cutting along the boundary line and the impact of this root cutting on the health of the tree.

Tree stability

Tree stability will still be provided by the existing roots acting in compression to the west and in compression and tension to the north and south. This may be adequate given that the tree is not particularly tall and does not have a very large crown. There is a potential for increased failure during construction but this could be readily addressed by the use of temporary props and ground anchors.

In addition, once built, the building will provide protection against winds from the east. To some extent the tower to the south and the building to the west also deliver some protection from winds if by no other means than creating turbulence. Lastly it is possible to design the building with a suitable anchor point or points in order to install bracing or similar failure protection system

Adequate root system

The question that needs to be addressed more than any other is the impact of severing roots that penetrate under the existing footings on the health of the tree. This cannot be determined for certain but we do have some general idea by considering the situation carefully.

For a starter we know that about 60% of the root system will be retained if the morphology of the root system were perfectly symmetrical. This however is unlikely to be the case because of the impact of the adjacent structure. What we are likely to see is woody roots to have been reflected by the wall and the footing. This will have resulted in a much higher proportion of the root system being contained on the Perth House land. It is conceivable that as much as 75-80 % of the root system has already been contained on the Perth House property. The loss of 25 – 30% of the root system is unlikely to cause significant health problem.

In addition we can look at the impact of transplanting and in particular considering the process of trunk transplanting that is commonly used overseas (See Transplant Feasibility).

These transplanted trees frequently survive particularly when given appropriate ongoing care. The reason for this is that there is a reduction in transpirational demand at the same time woody roots are cared for and to allow for absorption through cut ends along with the development of new absorbing roots. The same care process can be applied in this situation.

Trunk transplanting also raises the issue of canopy pruning and its impact when combined with root loss. Trees are not confined to “rules” and there is always a possibility that a number of large woody roots have penetrated under the adjacent footing. If these need to be cut then there will be some compensation provided by the fact that branches on the same side will also need to be cut to allow for construction.

Roots that cross the boundary line will need to be correctly cut and there will be a need for appropriate management of the cut ends and the soil interface between the development and the soil on Perth House.

Canopy pruning

For quite some time trees that were transplanted had their canopies removed in order to remove the demand for water required for evapotranspiration. This in part is the reason that trunk transplanting works. The reason that canopy pruning is not generally encouraged in transplanting is that it impacts on the aesthetics (moving a skeleton rather than a canopy). In addition stripping of the foliage results in the need for the plant to expend carbohydrate reserves on developing new roots and a new canopy and this typically reduces the growth rate of the tree. (This is the basic principle and science behind Bonsai.)

In this instance however about 25% of the canopy (All the material that overhangs the building line would need to be removed to in order to allow for the construction of the proposed building. Unlike with transplanting there would be no opportunity, in this instance, for the canopy to regrow. Clearly the remaining 75% of the trees canopy would remain. In many ways this is similar to loss of canopy caused by natural competition from another tree but in this instance the competition is man made and rapid.

The loss of 25% of the canopy will reduce the transpirational needs of the tree. This should adequately compensate for the loss of roots and it is likely the crown to root ratio is returned to an ideal balance fairly rapidly.

Construction Issues

It would seem that from a structural and a physiological stand point that the tree could be retained in its current position provided appropriate care was given and the recommendations in this report were followed. As far as the tree is concerned the construction issues only arises from the need to access the Perth House to undertake construction work, to finish external surfaces and to provide protection of the public.

These may require solutions such as:-

- Installing contiguous piers or shoring prior to excavation
- Internal scaffolding.
- Using finished surface materials such as tinted concrete. Low profile cladding or tilt up panels adjacent to the tree.
- Using EWP equipment to finish surfaces above the tree and adjacent to the tree.

Where such construction options are not possible or where the cost of such solutions is more prohibitive than transplanting, including an allowance to compensate for the addition adverse impact transplanting will have on the tree, then transplanting may be a more appropriate solution. The cost of transplanting this tree is likely to range anywhere from $50,000 to upwards of $500,000 depending on the extent of pruning and the method used to transport the tree.

Transplant Feasibility

Any tree that is reasonably healthy and structurally sound is a suitable candidate for transplanting. Transplanting large trees has a success rate in excess of 97%. This tree has no significant structural defects and with appropriate preparation it would be a suitable candidate for transplanting. Preparation works would need to start at least 6 months before the move is due to take place.

This genus is generally very tolerant of transplanting particularly when suitable preparation is carried out. The age of the tree is unlikely to be of concern and there is good evidence that significantly older olives can be successfully transplanted. (See transplant images included in appendix 4).

The restrictions to transplanting in this instance are:-

- Needing the agreement of the owner of the tree to allow it to be transplanted off the site and back again.
- The need to undertake canopy and root pruning to fit the tree back in the same location.
- The restricted root plate available due to the presence of adjacent structure and underground services.
- The dimensions of the tree and the need to move it along the street.

Retaining the tree on site and building requires the development of an appropriate Tree Protection Plan and approval of the DA. Transplanting in addition requires the consent of the property owner and the property owner needs to be fully aware of the process to avoid later concerns and complications.

Clearly to place the tree back into the same location at the end of the project will require the same pruning of the canopy and the roots along the eastern boundary as would be required to retain the tree throughout the construction process. This makes clear the issue that the pruning of roots on all other sides required to transplant the tree will result in the loss of significantly more structural and absorbing roots.

The presence of the adjacent structures limits the size of the root plate that can be taken. It would be ideal to get no closer than 500mm from the veranda of Perth House in order to avoid any structural impact associated with removing the tree. An allowance needs to be made for a trench between the root plate and Perth House. This will result in a maximum root plate of approximately 3.2 metres by 7 metres with a depth of 600 – 1000mm.

The east west dimension of the root plate is close to limits for moving this tree with its canopy in tact. The presence of underground services cannot therefore be used to further limit this dimension. This simply means that any service will need to be temporarily disconnected and or redirected before the transplanting process starts and will likely need to be permanently relocated, perhaps at a greater depth, before the tree is replanted.

The dimensions of the pruned canopy will be approximately 7 metres by 16 metres. If the tree is to be transplanted with the canopy in tact it will need to be transported upright. The tree can

be transported with the 16metre length running in the direction of movement. This means that the load will be a little over 2 lanes wide and that partial or full road closure along the route will most likely be required.

The tree is approximately 10 metres high and with the depth of the root plate, structural supports and the height of the truck that it will be carried on the top of the tree will be more than 12 metres above ground. This significantly limits the distance that this tree can be moved because of the presence of overhead wires. This means that a suitable storage site would need to found and leased or purchased within the wire free zone. It seems likely that this can be achieved but obviously it would add to the costs[4] involved in moving the tree.

If it cannot be achieved then the transplanting process becomes much more complicated. When, performing an ideal transplant the weight of the tree once removed from the ground will be in the order of 50 tonnes. This eliminates the use of heavy lift helicopters as the only helicopter capable of lifting this weight is no longer in operation. The amount of soil in the root plate could be reduced (bare rooting the tree) in order to meet the lift capacity of one of the largest helicopter currently operating.

The cost of the hire of such a helicopter to perform a single lift is likely to exceed $100,000 based on an estimate I obtained in 2002. Once slung, the helicopter route must follow along closed roads, vacant land and water ways. Finally similar costs will be incurred to return the tree to its current location. The cost of helicopter hire along with the additional work required to remove the soil and to wrap and protect the roots usually precludes it from consideration

The only other option is to significantly reduce the size of the root plate and the canopy to allow the tree to be transported horizontally on the back of a truck. This would require the canopy to be pruned so that when it is tied in it is no more than 3.5 metres by 5 metres. This represents less than 20% of the current canopy and physiologically this would be fairly similar to a trunk transplant. A root plate of 3 metres by 3 metres would be more than adequate to support this reduced canopy. (See transplant images in appendix 4)

Trunk transplants are successful but the trees tend to look rather bare but do recover. The advantage of using this process is that it reduces the cost and the trunk of the tree in its final position often gives the impression of age. (Essentially the impact is the same as if the tree had been left in place and the canopy had been so pruned.)

In performing this form of transplanting it is common to make non-nodal cuts. As a result the rate of regrowth can sometimes be a little faster than normal. However in order to accelerate the recovery or to provide more immediate affects such as a topiary form some Asian operators undertake multiple grafts to the ends of cut branches. ((See transplant images in appendix 4)

Based on the costs involved it may be more appropriate to consider design changes and adjustments to the work methods in order to retain the tree in its current position. In the event that it needs to be transplanted, the transplant is most likely to be successful.

[4] The cost of preparation transplanting, storing, moving back to site and replanting is likely to be in the order of $120,000-$150,000.

Tree Protection Zones

A Simple Solution

Over the last two decades there has been an increasing awareness of the need to appropriately protect and care for trees on development sites. There have been conferences, workshops as well as a number of publications written. Most notably these include British Standard BS 5837: 2005, "Trees and Development" by Matheny N & Clark J and "Protection of Trees on Construction Site" by Hartley M. These publications all focus on minimising damage to the root system of the tree by establishing appropriate **T**ree **P**rotection **Z**ones **(TPZ).**

The British Standard provides Matheny and Clark as the source of the formula for calculating the radius of the tree protection zone. Interestingly Matheny and Clark site the British Standard as the source of the formula. Such a circular argument is of concern particularly when the Matheny and Clark include many examples of successful encroachment of their Tree Protection Zone in their text.

Matheny said, ***"It is not that common that we get that much space."*** and ***"With tolerant species we can squeeze that down by half or two thirds".*** (ISA Annual Conference 2007) Mathematically that suggests that the Tree Protection Zone could potentially contain as little as 12% of the root volume provided for using either formula.

Calculations and tables in the first two publications aim at providing a Tree Protection Zone sufficiently large enough to ensure that the health of the tree is not adversely impacted and that this is achieved without the need for arboricultural input other than ensuring that the protection zones are maintained. The British Standards or Trees and Development are ideal documents to be applied by anybody regardless of their understanding of plant physiology.

Matheny rightly states, ***"Because the tree is an individual the table is not enough. You need to consider all the factors."*** (ISA Annual Conference 2007) If we are to find benefit in the **TPZ** given in either the British Standard or Trees and Development it is that this is a **TPZ** that can be determined by <u>any person and without any arboricultural input</u> since it is a simple formula. Anyone able to measure the trunk diameter and follow the formula can calculate the **TPZ**.

A suitably experienced consulting arborist is often able to support a smaller **TPZ** when combined with appropriate arboricultural care and some provision is given in the British standard for this to take place. This makes no sense unless the formula for calculating the **TPZ** in the British Standard is prefaced with a note saying that this is the point at which arboricultural input is required. Regrettably the Standard does not say this and as a result it becomes a prescriptive document that is overly prescriptive.

An Arboricultural Solution

Land and development costs along with the environmental impact of urban sprawl make the sterilisation of large areas of land to form a **TPZ** undesirably burdensome. It is often far more cost effective to provide even the highest level of Arboricultural care possible to a tree to

ensure that it thrives and prospers in the long term than to establish a **TPZ** that is unnecessarily large.

It makes logical sense to adopt a minimum **TPZ** that is based on the size of a root plate required to transplant the same tree. Transplanting of large and even very old trees has been carried out with enough frequency and over such a long time frame that we have a good understanding how transplanted trees respond to root loss. A success rate of 97% can be expected when a transplant is properly undertaken with appropriate ongoing care.

Perhaps the 3% failure rate could be considered as unacceptable but it is likely that a percentage of these would have died within a few years in any case. Matheny again points out ***"Transplanting is a far greater impact – if we are going to transplant it we might as well keep it where it is and squeeze the protection zone."*** (ISA Annual Conference 2007) A transplanted tree will clearly undergo a greater degree of stress than a tree that is retained with an identical sized root plate that is appropriately protected and cared for.

The site constraints, more often than not, result in benefit from a **TPZ** that is smaller than that specified by the British Standard and Trees and Development. This simply means that there will be a requirement for appropriate levels of arboricultural care. This often gives rise to the question "What is the minimum area required by the tree?" There is unfortunately no absolute answer to this question but there are a number of important benchmarks to be considered.

- The protection should be large enough to allow the tree to be maintained with appropriate arboricultural input. This is often called the **C**ritical **R**oot **Z**one **(CRZ)** and frequently relates to the size of the root plate that would be required to successfully transplant the tree and this in most instances is an area with a radius of 5 times the trunk diameter.

- Depending on the trees response to root damage, it is possible to come even closer to the tree particularly when construction impact is going to be limited to one side or better still to one quadrant of the Critical Root Zone **and** additional distance is provided around the remaining area of the root zone.

- The extent of any excavation should not result in the structural instability of the tree. There are a number of calculations that can be made but provided that the Critical Root Zone is retained there is generally no need to consider the issue of structural stability. In most circumstances the cutting of roots in the Zone of Rapid Taper is considered very undesirable.

There must be sufficient soil volume to allow the tree to grow to maturity with appropriate ongoing care. If the goal is to have minimal ongoing care this will clearly take a greater soil volume than a tree that will be extensively maintained (such as a tree growing in a rooftop planting).

AS 4970-2009

In August 2009 Standards Australia released AS 4970-2009 Protection of Trees on Development Sites. In its preface this document acknowledges its reliance on the British

Standard and Matheny and Clark. This standard requires a **TPZ** with a radius 12 times trunk diameter. As already discussed there is no question that this will provide adequate protection of the tree in almost all conceivable situations. It achieves this by enclosing and sterilising an enormous area.

The standard does acknowledge that it may be possible to encroach on this **TPZ** provided that the project arborist can demonstrate that the "trees will remain viable". As already stated most trees in good health and vigour are able to be successfully transplanted so the use of a reduced sized root plate remains demonstrated by several hundred years of successful tree transplanting. (Mathematically the standard sized root plate for a transplant has less than 20% of the root area of the **TPZ** specified in the AS 4970-2009.)

Of equal concern is the impact of the insistence of a **TPZ** with a radius of 12 times trunk diameter may have on tree retention and urban sprawl. Where there is a conflict between development and tree retention a decision will need to be made to refuse the development (potentially increasing urban sprawl) or to reduce the size of the **TPZ**.

If the development is acceptable then we are left to answer the question should we be removing trees that cannot be given a TPZ of the size recommended in AS 4970-2009. The answer should be "No!" whenever there is adequate potential for the tree to be retained with appropriate arboricultural input. Unfortunately this standard leaves us guessing on this issue.

Given that the standard is riddled with errors and seeks to be "informative" it is hard to give it the credence that it deserves. The standard does outline some important process namely, considering tree retention as a design consideration, seeking sound arboricultural advice and ensuring appropriate monitoring of the trees. As far as practical this document forms an important part of that process.

This report adopts the terms and nomenclature provided in the Australian Standard AS 4970-2009. This may be particularly true of the terms Tree Protection Plan (the recommendations and processes required to protect the trees and the Tree Protection Plan (drawing), which is a plan that may or may not have on it sections of the Tree Protection Plans

Methods of Tree Protection

It is important that the processes and methods of tree protection are understood. For that reason a number of images have been included in appendix 3 along with the information in this section to assist in ensuring that appropriate tree protection is implemented.

Protect the roots

As already explained the purpose of establishing a Tree Protection Zone is more than concerned with protecting the trunk of the tree, it is in fact primarily focused on protection of the roots of the tree.

The most appropriate method of protecting a tree is to establish an exclusion zone using some form of rigid temporary fence (a Tree Protection Zone or TPZ). Whilst it may seem easier to use flexible fabric barrier fence these products tend to fail over time and is easily pushed out of the way or damaged. In comparison damaging rigid fence requires more of a hit, can damage machinery and involves the cost of repair or replacement of the damaged fence.

Sometimes however, it may become necessary to work within or to gain access through a Tree Protection Zone. To do this a method needs to be developed to stop soil compaction and prevent direct physical damage to roots. A simple action such as walking on the same spot half a dozen times or more can lead to soil compaction. Pushing a full wheelbarrow will cause compaction on the first instance. It does not take long for that damage to accumulate and for the roots of a tree to be harmed.

There are a number of ways to protect roots against compaction and physical damage. These can be divided into two simple groups

- Systems that share the load and
- Systems that are fully load bearing.

Load-sharing surfaces are temporary and usually lightweight systems. Load-sharing surfaces sometimes can be as simple as mulch beneath plywood or planks or the use of scaffolding, to heavier duty systems such as the use of plastic or metal road plates or even rail decking. As can be seen in appendix 3 these can be enough to protect a delicate egg from breaking.

Fully load-bearing structures include finished structures such as the slab of a building, a driveway or a pathway. Obviously each of these has a limit to the weight that it can bear and if this is exceeded the structure and things beneath it can be damaged. Load bearing systems can also include scaffolding and temporary bridging structures.

Protect the trunk

In most instances fencing of a Tree Protection Zone ensures that the trunk of a tree cannot be damaged. Sometimes however work needs to take place within the Tree Protection Zone and as a result there is a risk of impact to the trunk. Damage to the trunk is extremely undesirable. Where it is possible to treat the wound this needs to be done quickly and treatment is very expensive. When treatment is not possible or is ineffective a trunk injury can lead to long-term structural and physiological problems.

Where possible operating machinery or performing activities that may result in impact to the trunk of the tree should avoided. Where this is not possible it is important to protect the trunk. Strapping pieces of timber to the trunk of the tree has been the traditional method for achieving this task.

As any high school science student will recall Conservation of Momentum (as demonstrated by Newtons cradle) tells us that this force is basically transferred through the pieces of timber to the trunk of the tree often providing little to no protection and in some circumstances actually resulting in increased damage.

In response to the failure of timber to absorb impact, hessian or carpet underlay were used and whilst these improved the situation the timber still lacked the ability to absorb any of the energy. The use of fabric wraps also carried new problems; in particular they often held moisture and this moist material was in constant contact with the trunk.

A more appropriate system needs a hard but flexible outer surface bonded to a soft impact absorbing material that has a low water holding capacity. This system is far more ideal at absorbing the energy of an impact … just think about a bicycle helmet. Just as with a bicycle helmet if a board is hit and damaged it needs to be replaced and at the same time the trunk of the tree should be inspected.

Lastly prevention is the best process. When machinery is operating in close proximity to the trunk of a tree using an observer can greatly reduce the likelihood of impact. To be effective the observer should maintain direct visual contact with the tree and the machine and should have direct audio contact with the operator. (Two-way earmuff systems are useful for this task).

Protection of the canopy

The canopy of the tree is often the part of the tree that is least harmed in the construction process. Even so there are two ways that the construction process can harm the canopy. The first is by direct impact between equipment and the branches of the tree and the second is from incorrect or excessive tree pruning.

Avoiding impact between machinery and branches simply requires care. When machinery needs to operate near branches an independent observer should be used. The observer should maintain direct visual contact with machine and the branches of the tree and should have direct audio contact with the operator.

All pruning work should be performed in accordance with the Australian Standard AS 4373-2007 “Pruning of Amenity Trees.” Any person who does not fully understand this and who has not been properly trained to perform pruning work to this standard should not attempt this work. The site arborist may provide instructions to workers on the site on making temporary cuts that will later be rectified by an arborist. These instructions should be carefully followed.

Tree Protection Plan (Recommendations)

Design Issues

No	Recommendation	Reason
1	Consider design alternatives and work methods that would allow the tree to be retained in its current position.	Transplanting at its best would result in additional damage to the tree and is likely to add considerably to the costs.
2	Ensure that a detailed work method for the works that are adjacent to the tree have been developed and checked by the project arborist.	To confirm before lodging a DA that the proposed work method will not cause any additional harm
3	Establish a tree protection policy document for inclusion as a part of the site induction process to be undertaken by all staff and contractors before commencing.	Ensuring all site staff and contractors understand the value and importance of protecting the tree reduces the likelihood of accidental damage.

Pre construction

4	Prior to commencing work on the site, a Tree Protection Zones must be established around the tree as shown on the Tree Protection Plan (drawing) contained in appendix 1. This would normally be achieved using 1.8 metre high rigid temporary fence but in this instance the use of a load sharing surface and a 900mm rigid temporary fence may be more appropriate.	Using mechanical barriers to restrict pedestrian movements and to prevent soil compaction will help preserve tree roots. Fences also establish “no go” zones and show the importance of the tree. (location of fence and tree protection fence to be determined prior to work commencing but must protect the TPZ shown).
5	TrunkGuard ™, or a similar system of 100mm wide boards with thick polystyrene foam bonded to one side, must be used to protect the trunk.	To provide additional level of protection for the trunk during adjacent demolition and construction works.
6	In accordance with AS 4970-2009 (5.2) a copy of the Tree Protection Plan including the Tree Protection Plan (drawing) (Appendix 1) must be on site prior to any work commencing on the site.	To ensure that documentation is present and available as a reference for all site personnel.
7	Correct and complete installation of Tree “Protection measures are to be certified by the project arborist” AS 4970-2009 (5.3.2).	To ensure that the tree is appropriately protected and that recommendations have been correctly understood.
8	Canopy pruning to behind the boundary line must be performed by an AQF Level 3 Arborist with all final cuts made in accordance with AS4373-2007. Climbing spikes must not be used.	To ensure that correct cuts are made and that the tree is not unnecessarily damaged. Whilst not mandated, it is strong suggested that an AQF Level 5 arborist be used for this work.

During site works

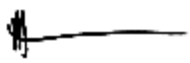
9	In accordance with AS 4970-2009 (5.4.1) the project arborist should perform regular site inspections. Monthly site inspections are recommended for this site.	To ensure a suitably qualified person has confirmed that the tree is in good health and the recommendations are being followed.
10	If at any stage an inspection reveals the Tree Protection Plan (recommendations) has not been complied with the project arborist must specify any required remedial works and the timeframe in which these works must be completed.	To ensure that all problems are appropriately rectified and that the all appropriate remedial works are carried out in a timely manner.
11	If at any stage an inspection reveals the Tree Protection Plan (recommendations) has not been complied with the project Arborist, site inspections thereafter **must** be carried out weekly	To provide additional supervision to avoid repeat problems and to ensure that remedial works are carried out.
12	Natural ground level must be maintained within the Tree Protection Zone. Trenching, stockpiling of materials or grade changes are not permitted.	To prevent unnecessary or unauthorised damage to the trunk, roots and branches of the tree
13	The Tree Protection Zones must remain in force until construction work has been completed on the Perth House curtilage.	To ensure that the tree is protected for the duration of the works that may impact on the tree.
14	Should the need arise to modify the Tree Protection Zone, the project arborist must prepare an amended Tree Protection Plan and submit it to the Council's Tree Preservation Officer for approval prior to access or changes taking place.	To enable changes to occur if necessary but to ensure that those changes do not adversely affect the tree.
15	An independent observer must be present during the demolition of any structure within 3 metres of the Tree Protection Zone.	To reduce the likelihood of accidental impact to the tree. (Note: The use of the project arborist for this task is strongly recommended)
16	Any root greater than 25mm in diameter that is exposed within 1 metre of the Tree Protection Zone must be cleanly cut at the boundary line prior to the root being removed.	To avoid tearing of roots.
17	The end of any root cut as a part of condition 16 must be kept moist using a root oasis, a temporary hoarding or a root curtain.	To ensure that cut roots are not allowed to dry out.
18	The project arborist must be present for any open excavation on the boundary line adjacent to the Tree Protection Zone.	To ensure that conditions 16 and 17 are followed.

19	Irrigation of the Tree Protection Zone must be performed as follows • Where less than 5mm of rain has fallen in the previous week from April to September. • Irrigation should be applied at 1 litre / square metre for every millimetre shortfall in the rainfall during the previous week.	To ensure healthy root growth and to ensure higher levels of readily available water to minimise stress. (Note: It may be easier to install a temporary irrigation system prior to installing any load sharing surface. This must not involve trenching of any sort. Use of an automated system with a moisture sensor will eliminate the need for condition 20)
20	An irrigation log must be maintained and kept on site and must record the weekly rainfall and the date and duration of any manual irrigation event.	To ensure appropriate records are available for monitoring and reporting.

Post Construction

21	At practical completion, the project arborist should "assess tree condition and provide certification" that the tree protection works have been in accordance with the Tree Protection Plan.	To provide a completion to the document trail for the certifier and or the certifying authority.
22	"Certification should include a statement on the condition of the retained trees, details of the deviations from the approved tree protection measures and their impacts on [the] trees"	To comply with AS 4970-2009 (5.5.2) To document the final condition of the tree.
23	The project arborist must continue to perform quarterly inspects, maintenance and reporting for whichever is greater: • For 24 months after completion of construction activities or • For 24 month after stable regrowth of the tree has been achieved.	To ensure the long tem recovery of the tree is certain.

Should you require any further information, do not hesitate to call our office for assistance.



Mark Hartley
Dip Hort (Arboriculture) with Distinction
LMNAAA, LMISA, LMIPS, MASCA
ISA Certified Arborist WC-0624 (since 1990)
NAAA Consulting Arborist # 6222-01

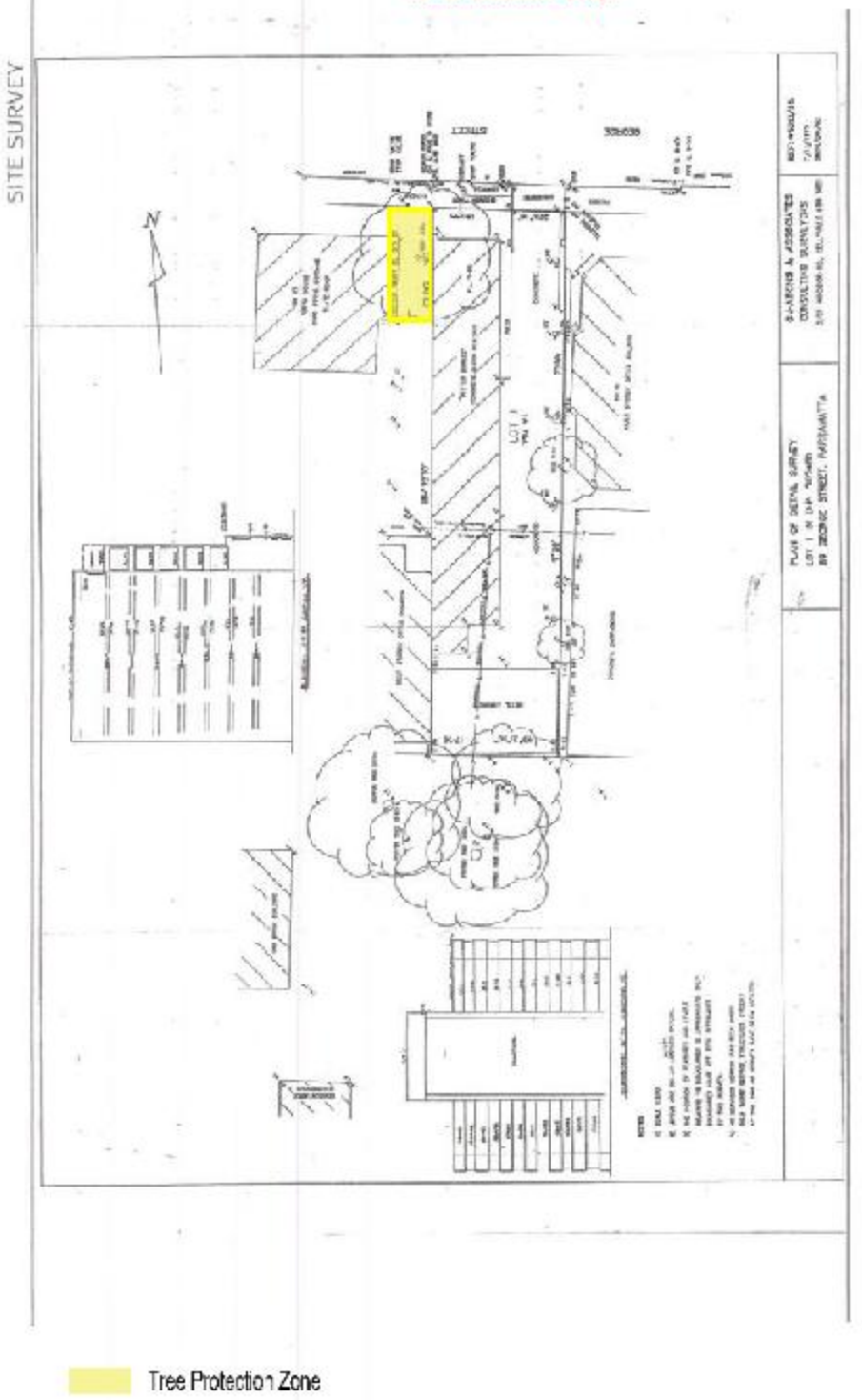
Appendix 1

Tree

Protection

Plan

Tree Protection Plan



Appendix 2

Generic

Tree

Protection

Guidelines

Generic Tree Protection Guidelines

FOR:

Site Address: 89 George St
Parramatta

Prepared For: Nic Webb
Duxton Developments PTY LTD
C/- PO BOX 385
GALSTON NSW 2159

Prepared By: **Mark Hartley**
Dip Hort (Arboriculture) with Distinction
LMNAAA. LMISA LMIPS MASCA
ISA Certified Arborist WC-0624
NAAA Consulting Arborist # 6222-01
Senior Consultant for

The Arborist Network
58 South Creek Road
Shanes Park NSW 2747
Phone (+612) 9834 1234
Email: *reports@arboristnetwork.com.au*

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1.0 Pre Construction:

1.1 Prior to the commencement of construction the consulting Arborist will issue a report outlining the following:

1.2 The trees that have been protected, the maintenance activities (if any) for each tree that have already been performed, that the protective fence or fences have been installed in accordance with the Arborist's Report.

1.3 A statement that the physical protection (items 7 and 8 of the POTOCS standards) of the trees has been performed to the above standards or if not any non-conformances and why. e.g. the fence around trees is incomplete because of boundary fences.

1.4 All trees to be removed are to be marked with a single white line around the trunk. No tree shall be so marked until council consent for its removal has been given.

1.5 Prior to removal one of the following will confirm the tree is to be removed by marking the tree with a single horizontal yellow or orange line. This should be done by one of the following persons, Surveyor, Landscape Architect, Arborist, Project Manager, and Tree Preservation Officer.

2.0 Tree Protection Zones:

2.1 The trees are to be protected by a 1.8 metre high fence to be constructed within 500mm of any construction activity and to include as much of the Primary Root Zone as possible.

2.2 Where the Tree Protection Zone occurs impart on the adjacent property, the fence will stop at the boundary lines.

2.3 Provision will be made to these protection zones for pedestrian access only.

3.0 Maintenance activities:

3.01 The following maintenance activities will be required for this site:

- Irrigation – by hand to comply with current specifications
- Soil Amelioration
- Mulching
- Crown cleaning in accordance with AS 4373-1996 - Pruning of Amenity Trees, removal of trees by sectional felling and stump grinding.
- Tree Removal

3.02 Timing: Maintenance activities are to be at the commencement of the construction process by qualified Arborists and then as required during the construction period.

3.1 Irrigation

3.11 Soil moisture during construction shall be maintained at not less than 60% of field capacity.

3.12 Irrigation is to be applied by hand. No construction activities are to take place within the Primary Root Zone until irrigation has been initiated and soil moisture reaches 70% of field capacity at a depth of 300mm.

3.13 On each visit the consulting arborist shall check the soil moisture and manually check the irrigation system, when installed.

3.14 Soil moisture levels should be checked by physical touch or with a tensiometer.

3.2 Soil amelioration

3.21 An application of rooting hormones, humic acids, soil microflora and mycorrhizae shall be applied by an arborist in accordance with the manufacturers instructions.

3.22 Chemical fertilizers are to be used only after representative soil testing and based on the soil scientists recommendations.

3.3 Mulching

3.31 The fenced area should be mulched with seed free mulch to a depth of at least 50mm.

3.4 Weed Control

3.41 Weed control shall be by hand pulling, wiping or spraying with a glyphosate based herbicide. Material likely to be root grafted to trees to be retained shall be removed manually.

3.42 Weed control shall not be performed by mechanical cultivation or by scraping or back burning.

3.5 Crown cleaning

3.51 Crown cleaning (AS4373-1996, Pruning of Amenity Trees) shall be performed in accordance with the standard, by an arborist and in compliance with the appropriate occupational health and safety regulations. All branches down to 50mm in size shall be inspected and appropriately treated.

3.52 Any concerns about health or safety that are observed by the arborist on the site will be reported in writing within 7 days to the superintendent/principal/client and/or head contractor.

3.53 The use of spurs on live trees and internodal cutting is strictly prohibited.

3.6 Tree Removal and Stump Grinding

3.61 Trees to be removed should be removed by controlled or sectional felling so as to avoid any damage to the trees to be retained.

3.62 All shrubs, under-scrub and woody weeds that are to be removed shall be removed by hand as per 3.4 above.

3.63 No tree shall be removed unless it has been marked with a horizontal white and yellow/orange line around the trunk.

4.0 Fences:

4.1 The fencing of the Tree Protection zone as defined in section 8.0 of the POTOCS standards should be commenced prior to the commencement of ANY work, including demolition and land clearing by earth moving machinery but may be erected after tree maintenance activities.

4.2 The fence surrounding the Tree Protection Zone must be a rigid fence not less than 1.8m high.

5.0 Signs:

5.1 At least every 25 metres attached to all tree protection fence there shall be a sign, a minimum of 600mm x 600mm, bearing the following phrase in red letters on white background at least 50mm in height:

"TREE PROTECTION ZONE - KEEP OUT. "

5.2 On the same sign above or on a separate sign attached adjacent, in red lettering on white background not less than 25mm in height is to be the following:

"PROHIBITED ACTIVITIES: "

Followed by the list below in black letters not less than 15mm in height.

a) Entry of machinery or people.
b) Storage of building materials.
c) Parking of any kind.
d) Erection or placement of site facilities.
e) Removal or stockpiling of soil or site debris.
f) Disposal of liquid waste including paint and concrete wash.
g) Excavation or trenching of any kind (including irrigation or electrical connections).
h) Attaching any signs or any other objects to the tree.
i) Placing of waste disposal or skip bins.
j) Pruning and removal of branches, except by a qualified Arborist.

5.22 In letters not less than 25mm in height on the above sign should be the name of the supervising Arborist or arboricultural company or other appropriate contact and a contact phone number.

6.0 Root Cutting

6.1 All roots greater than 50mm in diameter that are required to be removed shall be cleanly cut and kept moist at all times and shall not be left exposed to the air for more than 10 to 15 minutes.

7.0 Maintenance Reports:

7.1 Weekly inspections and monthly reports should be made until the end of construction.
7.2 A consulting Arborist should be on site during any excavation work within the Critical Root Zone and will report on that work in the monthly report.
7.3 A site log shall be maintained and include the date of each inspection, the person who performed the inspection, the items inspected or tested, the maintenance activities performed, any repairs undertaken or required to be undertaken, and any substantial breaches or non-conformances.
7.4 The arborist performing the inspection should sign the entries in the logbook
7.5 The log shall be maintained on site or alternatively copies of the log entries for the month shall be submitted each month with the monthly report.
7.6 All maintenance shall continue for the 3 months after completion of construction

8.0 Non-Conformance Reports:

8.1 The following are non-conformances that need to be managed if and when they occur.
8.11 The removal or relocation closer to the tree of all or part of any protective fence prior to landscaping.
8.12 The performing of any activity noted as prohibited on protection zone signage
8.13 The failure to maintain adequate soil moisture or the failure in the operation of the irrigation system.
8.14 Mechanical damage to the trunk, stems, branches or retained roots.
8.15 The sudden and abnormal or premature shedding or decline of the tree.
8.2 Substantial breaches and non-conformances:
8.21 Any breach or non-conformance of the tree protection zone, by any party, shall be notified in writing within 2 working days of it being first observed.
8.22 Notification of any non-conformance should be made in writing to the site foreman, the consent authority and any independent certifier.

Appendix 3

Protection of Trees on Construction Sites

Establishing a Tree Protection Zone

Good Work	Poor Work
	
The fence should be rigid and hard to move.	Too easily damaged and collapses when hit
	
The TPZ is mulched where appropriate and weed free.	Put the fence where it should be! The TPZ is not for storage.
	
The purpose of the fence is to isolate the tree from the works and to protect the roots	Woven fencing seldom work particularly when it is used close to the work or when space is scarce

Load –Sharing Surfaces and root protection

Good Work	Poor Work
	
Like an egg tree roots are delicate	A single movement of a truck will cause irreparable damage
	
Load sharing should be appropriately designed for the load that it is to carry.	Without protection soil is compacted and roots are broken and damaged
	
The goal is to ensure that impact on the roots that are to remain is minimal.	This shows no regard for tree roots

Trunk protection using TrunkGuard

Good Work	Poor Work
	
Designed to absorb impact just like a bicycle helmet.	Trunk damage is usually irreparable and often causes long-term damage!
	
Flexible to fit the trunk	Even installation of a poorly designed system can injure tree!
	
Able withstand moderate construction impact (not that this should happen but unfortunately it does).	Serves little purpose at all!

Appendix 4

Tree

Transplanting

Images

Olives are very tolerant of trunk transplanting but it is not as visually appealing. © C Humphries used with permission

Transplanting normally involves moving large volumes of soil in order to retain the canopy and avoid stress on the tree

Multi-grafts could be used to redevelop the canopy faster

Olives are extremely tolerant of over pruning

Trunk transplants usually have very small root plates.