Tree Risk Management Appraisal

of Trees within Identified Site Boundaries of

St Mary's Church Graveyard, Longridge Road, Chipping, Lancashire, PR3 2QD

Prepared by:

Bowland Tree Consultancy Ltd

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Contact Details

Bowland Tree Consultancy Ltd
Unit Two
First Floor
11 Cannon Street
Preston
Lancashire
PR1 3NR

T: 01772 437150
E: info@bowlandtreeconsultancy.co.uk

TREE RISK MANAGEMENT APPRAISAL
ST MARY'S CHURCH GRAVEYARD, CHIPPING

Project Details

Project No.:	BTC1675
Site:	St Mary's Church Graveyard, Chipping, PR3 2QD
Survey Type:	Individual Tree Survey
Tree(s) Considered:	Within identified ownership area
Report Time Frame:	12 months from date of issue
Client:	St Mary's Church
Survey Date:	13 November 2018
Surveyor:	Phill Harris MSc BSc(Hons) HND MArborA CEnv MICFor
Report Prepared by:	Phill Harris MSc BSc(Hons) HND MArborA CEnv MICFor
Report Checked by:	Jennie Keighley PhD MSc MArborA
Date of Issue:	23 November 2018
Version No:	1 (first draft)

QTRA METHODOLOGY OVERVIEW AND APPLICATION IN MANAGEMENT DECISIONS

The QTRA methodology utilised quantifies the three components of tree failure risk, which are:
i. *Target* (i.e. something having potential to be harmed and/or damaged by the mechanical failure of trees);
ii. *Impact Potential*; and
iii. *Probability of Failure* (within the coming year).

The product of the three component values is the annualised 'Risk of Harm', which is a combined measure of the likelihood and the consequence of tree failure considered in terms of the loss within the coming year, and is expressed as a probability. In applying the 'Tolerability of Risk Framework' (ToR) the QTRA methodology divides the 'Risk of Harm' into three threshold values, being;

1. *Unacceptable* (i.e. >1/1,000), which is unacceptable and will not ordinarily be tolerated;
2. *Tolerable* (i.e. between 1/1,000,000 and 1/1,000, where the Risk of Harm will be tolerable if it is As Low As Reasonably Practicable (ALARP); but a Risk of Harm 1/10,000 or greater will not ordinarily be Tolerable where it is imposed on others, such as the public. In the Tolerable range management decisions are informed by consideration of the benefits and costs of risk control, including benefits provided by trees that would be lost to risk control measures; and
3. *Broadly Acceptable* (<1/1,000,000), which is already ALARP.

The QTRA advisory thresholds, (see Table 1, below) are proposed as a reasonable approach to balancing safety from falling trees with the costs of risk reduction. This approach takes account of the principles of ALARP and ToR, but does not dictate how these principles should be applied. <u>While the thresholds can be the foundation of a robust policy for tree risk management, tree managers should make decisions based on their own situation, values and resources.</u>

Table 1: QTRA Advisory Risk Thresholds:

Threshold	Description	Action
Risk of harm of 1/1,000 or greater	**Unacceptable** - Risks will not ordinarily be tolerated	▪ Control the risk
Risk of harm between 1/1,000 and 1/10,000	**Unacceptable** (where imposed on others) - Risks will not ordinarily be tolerated	▪ Control the risk ▪ Review the risk
	Tolerable (by agreement) Risks may be tolerated if those exposed to the risk accept it, or the tree has exceptional value	▪ Control the risk unless there is broad stakeholder agreement to tolerate it, or the tree has exceptional value ▪ Review the risk
Risk of harm between 1/10,000 and 1/1,000,000	**Tolerable** (where imposed on others) - Risks are tolerable if ALARP	▪ Assess costs and benefits of risk control ▪ Control the risk only where a significant benefit might be achieved at reasonable cost ▪ Review the risk
Risk of harm less than 1/1,000,000	**Broadly Acceptable** - Risk is already ALARP	▪ No action currently required ▪ Review the risk

As detailed in the Table a Risk of Harm less than 1/1,000,000 is Broadly Acceptable and already ALARP (i.e. 'as low as reasonably practicable'). A Risk of Harm 1/1,000 or greater is unacceptable and will not ordinarily be tolerated. Between these two thresholds, the Risk of Harm is in the Tolerable region of the ToR Framework and will be tolerable if it is ALARP, but a Risk of Harm 1/10,000 or greater will not ordinarily be Tolerable where it is imposed on others, such as the public. Here, management decisions are informed by consideration of the benefits and costs of risk control, including benefits provided by trees that would be lost to risk control measures.

<u>In respect of the above the assessor (i.e. Bowland Tree Consultancy Ltd) may consider the costs of risk control when providing options for management if specifically asked to do so, but the tree owner/manager, who owns the risk and therefore exercises control over the costs, must consider the balance and make the final management decision(s).</u>

SUMMARY OF SURVEY FINDINGS

An 'Individual Tree Survey' (see 'Schedule of Operations' in accepted project quote) was carried out on 13 November 2018, within the area of the site under consideration, as identified by Mr George Erdozain.

The survey identified three individual trees and one group of five trees, equating to eight trees in total. The surveyed trees consist of various deciduous broadleaf species being Horse Chestnut, Sycamore and Beech, which are in the early-mature to post-mature age range, with heights of up to 25 metres, stem diameters up to 1300 millimetres, and maximum diametrical crown spreads up to 14 metres.

All of the surveyed trees are located within the church graveyard, which is bordered by the church access road to the north-east and south-east, Longridge Road and the rear gardens to a terraced block of residential properties to the south-west, and gardens to the north-west.

Various targets were identified to be within falling distances of the surveyed trees, including, but not restricted to, persons visiting and/or managing the graveyard, the graves themselves, persons accessing the church and other associated properties, parked vehicles on Longridge Road and the access road, the neighbouring properties to the south-west and persons using the associated gardens, and pedestrians and moving vehicles and their occupants using Longridge Road.

None of the surveyed trees were identified to having QTRA risk indices that fall within the unacceptable risk threshold range of greater than 1/10,000. However, as highlighted with the colour yellow in Table 2 below, all of the trees were classed as having risk indices that fall within the tolerable risk threshold range of between 1/10,000 and 1/1,000,000.

Table 2: Tree Work Recommendations:

No.	Species	Management Works Recommended	Work Priority
T1	Sycamore	▪ Remove grass cuttings from between stem and boundary wall (M). ▪ Remove ivy from stem (M). ▪ Discuss options for long-term crown management with consulting arboriculturist.	M
T2	Horse Chestnut	▪ Prune to remove areas of adventitious growth from stem (M). ▪ Discuss options for long-term crown management with consulting arboriculturist.	M
T3	Horse Chestnut	▪ Prune to remove areas of adventitious growth from stem (M). ▪ Discuss options for long-term crown management with consulting arboriculturist following outcome of aerial inspection (see Table 3, below).	H
G1	3no. Sycamore, 2no. Beech	▪ Remove ivy from stem of Sycamore at road frontage.	M

Nonetheless, Table 2 also details tree works that have been recommended for non-risk management related reasons (denoted with the suffix (M)). In this respect the relevant risk thresholds are highlighted accordingly, as per Table 1 (previous page).

In turn, Table 3 (overleaf) details trees that are recommended for re-inspection, along with accompanying re-inspection schedules, which should be set from the date of this report. In certain cases however, it may be necessary to carry out works recommended in Table 2 (e.g. the severance and/or removal of ivy and the removal of epicormic growth in order to facilitate a detailed visual inspection) in advance of the recommended re-inspection date. The implementation of the schedule of works in respect of Tables 1 and 2 should therefore be discussed between the client and the consulting arboriculturist that prepared the report immediately following the client's review of the recommendations.

Table 3: Tree Re-Inspection Recommendations:

No.	Species	Re-Inspection Recommendations	When?
T1	Sycamore	▪ Monitor structural and physiological condition through annual inspections.	Every 12 months
T3	Horse Chestnut	▪ Climbing arboriculturist to carry out aerial inspection of cavities to western primary branch in order to appraise potential effects on structural stability, and report findings to consulting arboriculturist.	As soon as practicable
G1	3no. Sycamore, 2no. Beech	▪ Re-inspect Sycamore at road frontage following removal of ivy. ▪ Climbing arboriculturist to carry out aerial inspection of cavities to Sycamore's primary branches in order to appraise potential effects on structural stability, and report findings to consulting arboriculturist.	Within 12 months

Site:	St Mary's Church Graveyard, Longridge Road, Chipping, Lancashire, PR3 2QD
Client:	St Mary's Church
Brief:	Carry out an individual tree survey of area(s) of site specified by client, report on risk, and make management recommendations where appropriate

Surveyor:	Phill Harris Chartered Arboriculturist
Survey Date:	13 November 2018
Viewing Conditions:	Light clouds and light wind
Job Reference:	BTC1675

No.	Species	Age	Height (m)	Stem Diam. (mm)	Crown Spread (m)	Vital-ity	Comments	Management Recommendations	Risk Assessment Description (Part/Target)	Target	Size	P.O.F	Reduced Mass %	Risk Index	Work Priority
T1	Sycamore	M/ PM	18	1000	11	M	▪ Deep pile of grass cuttings between wall and stem base which can be damaging to roots and stem tissue. ▪ Light ivy to lower stem. ▪ Highly biased crown north, evidently due to a combination of poorly executed past pruning and previous branch loss. ▪ Crown showing signs of a moderate reduction in vitality. ▪ Due to its age, and current form and structure, the tree is considered to have a relatively short remaining life expectancy, and it would therefore be prudent to consider crown management options to enable its long-term retention.	▪ Remove grass cuttings from between stem and boundary wall (M). ▪ Remove ivy from stem. ▪ Monitor structural and physiological condition through annual inspections. ▪ Discuss options for long-term crown management with consulting arboriculturist.	P: Branches to 300mm diameter. T: Adjacent garden(s) to north and west and associated sheds, greenhouse, etc.	3	P	3	N/A	30K	M
T2	Common Horse Chestnut	PM	25	1200	10	G	▪ Stem bifurcates at a height of approximately 7m. ▪ Rapid adaptive growth increment strip extending down stem for up to 3m below bifurcation point. ▪ Number of dense areas of adventitious growth to stem, evidently resultant of past pruning events. ▪ Upper crown evidently previously pruned to reduce height. ▪ Large neighbouring tree to north evidently previously removed, thereby increasing tree's exposure to wind forces. ▪ Due to its age, and current form and structure, the tree is considered to have a relatively short remaining life expectancy, and it would therefore be prudent to consider crown management options to enable its long-term retention.	▪ Prune to remove areas of adventitious growth from stem (M). ▪ Discuss options for long-term crown management with consulting arboriculturist.	P: Primary branch ≥450mm diameter. T: Neighbouring properties to west.	2	P	4	N/A	30K	M

HEADINGS & ABBREVIATIONS

NO.	TREE/GROUP REFERENCE NUMBER. REFER TO PLAN OR NUMBERED TAGS WHERE APPLICABLE
SPECIES:	COMMON NAME
AGE:	Y = YOUNG, SM = SEMI MATURE, EM = EARLY MATURE, M = MATURE, PM = POST MATURE
HEIGHT:	APPROXIMATELY 80% OF TREES ARE MEASURED USING AN ELECTRONIC CLINOMETER AND THE REMAINDER ESTIMATED AGAINST THE MEASURED TREES
DIAMETER:	STEM DIAMETER MEASURED OR ESTIMATED AT A HEIGHT OF APPROXIMATELY 1.3 METRES
CROWN SPREAD:	MEASURED OR ESTIMATED DIAMETER OF CROWN(S) AT THE WIDEST POINT
VITALITY:	A MEASURE OF PHYSIOLOGICAL CONDITION WHEREBY D = DEAD, MD = MORIBUND, P = POOR, M = MODERATE, G = GOOD
MANAGEMENT:	SUFFIXES: (M) = FOR GENERAL ARBORICULTURAL OR SILVICULTURAL MANAGEMENT; (S) = TO REMOVE OR REDUCE THE RISK OF DIRECT DAMAGE TO A FIXED STRUCTURE BY MEANS OF CIRCUMFERENTIAL ROOT, STEM OR BRANCH GROWTH
TARGET RANGE:	HIGHEST VALUE TARGET THAT THE MOST SIGNIFICANT PART LIKELY TO FAIL COULD STRIKE. RANGES 1-6. 1 = HIGH, 6 = LOW VALUE/OCCUPANCY
RISK ASSESSMENT DESCRIPTION:	DESCRIPTION OF PART IDENTIFIED AS MOST LIKELY TO FAIL AND ASSOICATED TARGET, ASSESSED IN ACCORDNACE WITH QTRA SYSTEM
SIZE RANGE:	SIZE CATEGORY OF MOST SIGNIFICANT PART CONSIDERED LIKELY TO FAIL. - RANGES 1-4 WHEREBY 1 = LARGE, 4 = SMALL, P = PROPERTY
P.O.F:	PROBABILITY OF FAILURE WITHIN 12 MONTHS. RANGES 1-7. 1 = HIGH, 7 = LOW
REDUCED MASS %:	WHERE THE MASS OF A TREE OR BRANCH IS REDUCED BY DEGRADATION THE RISK INDEX IS MULTIPLIED TO REFLECT THE PERCENTAGE OF MASS REDUCTION
RISK INDEX:	E.G. RISK INDEX 20 = RISK OF SIGNIFICANT HARM 1 IN 20,000. AN ADDITIONAL FIGURE, IN BRACKETS, MAY BE SUFFIXED 'T' REPRESENTING THE RATE OF MULTIPLE OCCUPATION OVER THE YEAR, E.G. 10(10T) REPRESENTS A RISK OF HARM 1/10,000 TO 10 OCCUPANTS OR AN EQUIVALENT MONETARY VALUE. SEE QTRA PRACTICE NOTE FOR MORE INFORMATION REGARDING COLOURS USED TO SIGNIFY RISK INDEX
WORK PRIORITY:	H (HIGH) = TREE WORKS TO BE GIVEN IMMEDIATE CONSIDERATION. M (MODERATE) = TREE WORKS TO BE CARRIED OUT WITHIN 12 MONTHS OF SURVEY (TIMING MAY BE SPECIFIED IN MANAGEMENT RECOMMENDATIONS). L (LOW) = TREE WORKS THAT ARE NOT CONSIDERED ESSENTIAL FOR RISK MANAGEMENT PURPOSES, BUT ARE RECOMMENDED IN ACCORDANCE WITH PRUDENT ARBORICULTURAL MANAGEMENT (TO BE REVIEWED IN 12 MONTHS, OR SPECIFIED TIME, IF APPLICABLE). N/A = NO WORKS RECOMMENDED

Site:	St Mary's Church Graveyard, Longridge Road, Chipping, Lancashire, PR3 2QD	**Surveyor:**	Phill Harris Chartered Arboriculturist
Client:	St Mary's Church	**Survey Date:**	13 November 2018
Brief:	Carry out an individual tree survey of area(s) of site specified by client, report on risk, and make management recommendations where appropriate	**Viewing Conditions:**	Light clouds and light wind
		Job Reference:	BTC1675

No.	Species	Age	Height (m)	Stem Diam. (mm)	Crown Spread (m)	Vital-ity	Comments	Management Recommendations	Risk Assessment Description (Part/Target)	Target	Size	P.O.F	Reduced Mass %	Risk Index	Work Priority
T3	Common Horse Chestnut	PM	23	1300	13	G	▪ Several rapid adaptive growth increment strips extending up length of stem to east. ▪ Number of dense areas of adventitious growth to stem, evidently resultant of past pruning events. ▪ Stem bifurcates at a height of approximately 4m. ▪ Largest primary branch bifurcates at a height of approximately 8m, and has a rapid adaptive growth increment strip extending below union down to ground level. ▪ Western primary branch evident previously extensively pruned with resultant pruning wounds and associated cavities to approximately 350mm diameter – wounds and cavities not inspected in details, but one is evidently resultant of a previously failed branch. ▪ Due to its age, and current form and structure, the tree is considered to have a relatively short remaining life expectancy, and it would therefore be prudent to consider crown management options to enable its long-term retention.	▪ Prune to remove areas of adventitious growth from stem (M). ▪ Climbing arboriculturist to carry out aerial inspection of cavities to western primary branch in order to appraise potential effects on structural stability, and report findings to consulting arboriculturist. ▪ Discuss options for long-term crown management with consulting arboriculturist following outcome of aerial inspection.	P: Upper primary branch ≤450mm diameter. T: Neighbouring properties to west.	3	P	3	N/A	30K	H
G1	3no. Sycamore, 2no. Beech	EM-M	≤ 23	≤ 900	≤ 14	G	▪ Moderately spaced group, with trees located close to boundary to neighbouring properties, access road to church and associated properties, and Longridge Road. ▪ Dense ivy up stem and branches of Sycamore that is located at road frontage. ▪ Sycamore internal to graveyard evidently has several large decay cavities up to 400mm diameter to primary branches.	▪ Remove ivy from stem of Sycamore at road frontage. ▪ Re-inspect Sycamore at road frontage following removal of ivy. ▪ Climbing arboriculturist to carry out aerial inspection of cavities to Sycamore's primary branches in order to appraise potential effects on structural stability, and report findings to consulting arboriculturist.	P: Ivy covered Sycamore branches ≤150mm diameter. T: Pedestrians using neighbouring Longridge Road.	2	3	4	N/A	500 K	M

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DISCLAIMER

Survey Limitations: Unless otherwise stated all trees are viewed from ground level using non-invasive techniques. The disclosure of hidden crown and stem defects, in particular where they may be above a reachable height or where trees are ivy clad or in areas of ground vegetation, cannot therefore be expected. All obvious defects, however, are reported. Where the QTRA Risk Index is calculated as Tolerable or Broadly Acceptable, but the tree(s) have not been adequately inspected (e.g. due to the presence of ivy and/or ground vegetation which impeded the inspection), then it is essential to follow the recommendations made in the Management Recommendations column and to have the applicable tree(s) re-inspected as recommended.

Detailed tree safety appraisals are only carried out under specific written instructions. Comments upon evident tree safety relate to the condition of said tree at the time of the survey only. The level of detail of the survey is as per the brief detailed on the Tree Survey Schedule and as per the specifics set out in the associated fee estimate for the project.

Unless otherwise stated all trees should be re-inspected annually in order to appraise their on-going mechanical integrity and physiological condition. It should, however, be recognised that tree condition is subject to change, for example due to the effects of disease, decay, high winds, development works, etc. Changes in land use or site conditions (e.g. development that increases access frequency) and the occurrence of severe weather incidents are also significant considerations with regards tree structural integrity and trees should therefore be re-assessed in the context of such changes and/or incidents and inspected at intervals relative to identified and varying site conditions and associated risks.

Where trees are located wholly or partially on neighbouring private third-party land then said land is not accessed and our inspection is therefore restricted to what can reasonably be seen from within the site. Any subsequent comments and judgments made in respect of such trees are based on these restrictions and are our preliminary opinion only. Recommendations for works to neighbouring third-party trees are only made where a potentially unacceptable risk to persons and/or property has been identified during our survey. Where significant structural defects of third-party trees are identified and associated management works are considered essential to negate any risk of harm and/or damage then we will first attempt to inform the site occupier of the issues and, if not possible, then inform the relevant Council. Where a more detailed assessment is considered necessary then appropriate recommendations are set out in the Tree Survey Schedule.

The potential influence of trees upon existing or proposed buildings or other structures, resulting from the effects of their roots abstracting water from shrinkable load-bearing soils, is not considered herein.

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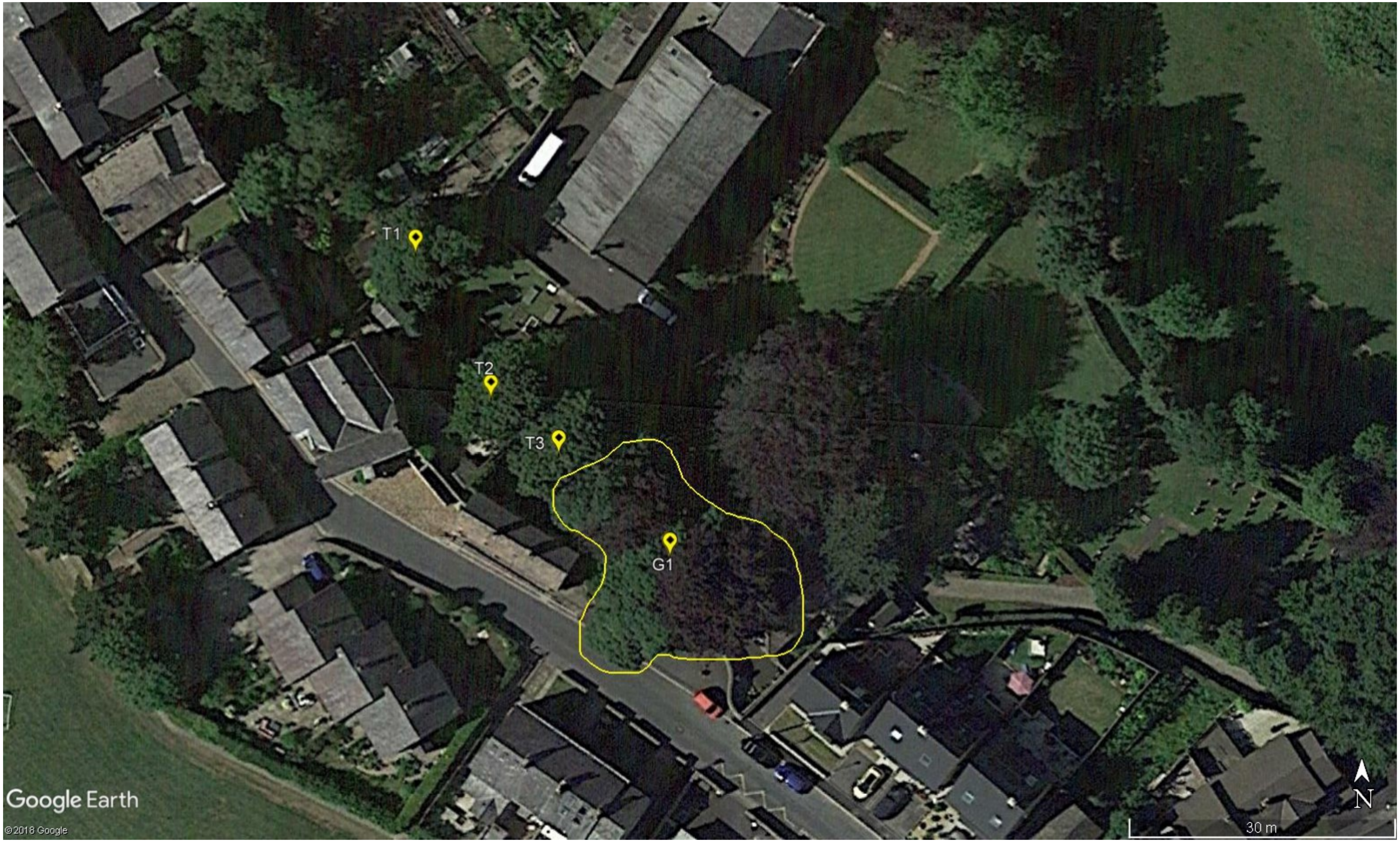

T = Individually Surveyed Tree, G = Group of Trees

- = Tree/Group with Risk of Harm of 1/1,000 or greater
- = Tree/Group with Risk of Harm between 1/1,000 and 1/10,000
- = Tree/Group with Risk of Harm between 1/10,000 and 1/1,000,000
- = Tree/Group with Risk of Harm less than 1/1,000,000

Site St Mary's Church Chipping, PR3 2QD

Job No.: BTC1675

Scale: Not to Scale

Paper Size (for printing): A3

Date November 2018

TREE SURVEY PLAN

Bowland Tree Consultancy Ltd

e: info@bowlandtreeconsultancy.co.uk
t: 01772 437150

* See QTRA Methodology Overview and Application in Management Decisions Section of Report for details regarding Risk of Harm

QTRA Quantified Tree Risk Assessment

Simply Balancing Risks With Benefits

Quantified Tree Risk Assessment

PRACTICE NOTE

VERSION 5

Quantified Tree Risk Assessment Practice Note

"***When you can measure what you are speaking about, and express it in numbers, you know something about it; but when you cannot measure it, when you cannot express it in numbers, your knowledge is of a meagre and unsatisfactory kind***"

William Thomson, Lord Kelvin, Popular Lectures and Addresses [1891-1894]

1. INTRODUCTION

Every day we encounter risks in all of our activities, and the way we manage those risks is to make choices. We weigh up the costs and benefits of the risk to determine whether it is acceptable, unacceptable, or tolerable. For example, if you want to travel by car you must accept that even with all the extensive risk control measures, such as seat-belts, speed limits, airbags, and crash barriers, there is still a significant risk of death. This is an everyday risk that is taken for granted and tolerated by millions of people in return for the benefits of convenient travel. Managing trees should take a similarly balanced approach.

A risk from falling trees exists only if there is both potential for tree failure and potential for harm to result. The job of the risk assessor is to consider the likelihood and consequences of tree failure. The outcome of this assessment can then inform consideration of the risk by the tree manager, who may also be the owner.

Using a comprehensive range of values[1], Quantified Tree Risk Assessment (QTRA) enables the tree assessor to identify and analyse the risk from tree failure in three key stages. 1) to consider land-use in terms of vulnerability to impact and likelihood of occupation, 2) to consider the consequences of an impact, taking account of the size of the tree or branch concerned, and 3) to estimate the probability that the tree or branch will fail onto the land-use in question. Estimating the values of these components, the assessor can use the QTRA manual calculator or software application to calculate an annual Risk of Harm from a particular tree. To inform management decisions, the risks from different hazards can then be both ranked and compared, and considered against broadly acceptable and tolerable levels of risk.

A Proportionate Approach to Risks from Trees

The risks from falling trees are usually very low and high risks will usually be encountered only in areas with either high levels of human occupation or with valuable property. Where levels of human occupation and value of property are sufficiently low, the assessment of trees for structural weakness will not usually be necessary. Even when land-use indicates that the assessment of trees is appropriate, it is seldom proportionate to assess and evaluate the risk for each individual tree in a population. Often, all that is required is a brief consideration of the trees to identify gross signs of structural weakness or declining health. Doing all that is reasonably practicable does not mean that all trees have to be individually examined on a regular basis (HSE 2013).

The QTRA method enables a range of approaches from the broad assessment of large collections of trees to, where necessary, the detailed assessment of an individual tree.

Risk of Harm

The QTRA output is termed the Risk of Harm and is a combined measure of the likelihood and consequences of tree failure, considered against the baseline of a lost human life within the coming year.

ALARP (As Low As Reasonably Practicable)

Determining that risks have been reduced to As Low As Reasonably Practicable (HSE 2001) involves an evaluation of both the risk and the sacrifice or cost involved in reducing that risk. If it can be demonstrated that there is gross disproportion between them, the risk being insignificant in relation to the sacrifice or cost, then to reduce the risk further is not 'reasonably practicable'.

Costs and Benefits of Risk Control

Trees confer many benefits to people and the wider environment. When managing any risk, it is essential to maintain a balance between the costs and benefits of risk reduction, which should be considered in the determination of ALARP. It is not only the financial cost of controlling the risk that should be considered, but also the loss of tree-related benefits, and the risk to workers and the public from the risk control measure itself.

[1] See Tables 1, 2 & 3.

When considering risks from falling trees, the cost of risk control will usually be too high when it is clearly 'disproportionate' to the reduction in risk. In the context of QTRA, the issue of 'gross disproportion'[2], where decisions are heavily biased in favour of safety, is only likely to be considered where there are risks of 1/10 000 or greater.

Acceptable and Tolerable Risks

The Tolerability of Risk framework (ToR) (HSE 2001) is a widely accepted approach to reaching decisions on whether risks are broadly acceptable, unacceptable, or tolerable. Graphically represented in Figure 1, ToR can be summarised as having a Broadly Acceptable Region where the upper limit is an annual risk of death 1/1 000 000, an Unacceptable Region for which the lower limit is 1/1 000, and between these a Tolerable Region within which the tolerability of a risk will be dependent upon the costs and benefits of risk reduction. In the Tolerable Region, we must ask whether the benefits of risk control are sufficient to justify their cost.

In respect of trees, some risks cross the Broadly Acceptable 1/1 000 000 boundary, but remain tolerable. This is because any further reduction would involve a disproportionate cost in terms of the lost environmental, visual, and other benefits, in addition to the financial cost of controlling the risk.

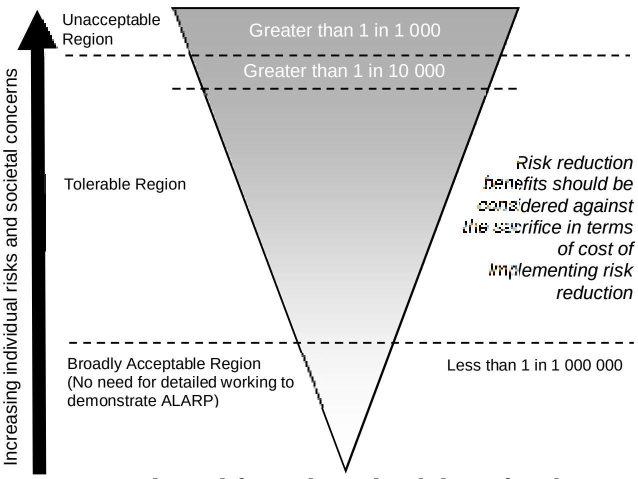

Figure 1. Adapted from the Tolerability of Risk framework (HSE 2001).

Value of Statistical Life

The Value of Statistical Life (VOSL), is a widely applied risk management device, which uses the value of a hypothetical life to guide the proportionate allocation of resources to risk reduction. In the UK, this value is currently in the region of £2 000 000, and this is the value adopted in the QTRA method.

In QTRA, placing a statistical value on a human life has two particular uses. Firstly, QTRA uses VOSL to enable damage to property to be compared with the loss of life, allowing the comparison of risks to people and property. Secondly, the proportionate allocation of financial resources to risk reduction can be informed by VOSL. "***A value of statistical life of £1 000 000 is just another way of saying that a reduction in risk of death of 1/100 000 per year has a value of £10 per year***" (HSE 1996).

Internationally, there is variation in VOSL, but to provide consistency in QTRA outputs, it is suggested that VOSL of £2 000 000 should be applied internationally. This is ultimately a decision for the tree manager.

2. OWNERSHIP OF RISK

Where many people are exposed to a risk, it is shared between them. Where only one person is exposed, that individual is the recipient of all of the risk and if they have control over it, they are also the owner of the risk. An individual may choose to accept or reject any particular risk to themselves, when that risk is under their control. When risks that are imposed upon others become elevated, societal concern will usually require risk controls, which ultimately are imposed by the courts or government regulators.

Although QTRA outputs might occasionally relate to an individual recipient, this is seldom the case. More often, calculation of the Risk of Harm is based on a cumulative occupation – i.e. the number of people per hour or vehicles per day, without attempting to identify the individuals who share the risk.

Where the risk of harm relates to a specific individual or a known group of people, the risk manager might consider the views of those who are exposed to the risk when making management decisions. Where a risk is imposed on the wider community, the principles set out in the ToR framework can be used as a reasonable approach to determine whether the risk is ALARP.

3. THE QTRA METHOD - VERSION 5

The input values for the three components of the QTRA calculation are set out in broad ranges[3] of Target, Size, and Probability of Failure. The assessor

[2] Discussed further on page 5.

[3] See Tables 1, 2 & 3.

estimates values for these three components and inputs them on either the manual calculator or software application to calculate the Risk of Harm.

Assessing Land-use (Targets)

The nature of the land-use beneath or adjacent to a tree will usually inform the level and extent of risk assessment to be carried out. In the assessment of Targets, six ranges of value are available. Table 2 sets out these ranges for vehicular frequency, human occupation and the monetary value of damage to property.

Human Occupation

The probability of pedestrian occupation at a particular location is calculated on the basis that an average pedestrian will spend five seconds walking beneath an average tree. For example, ten pedestrians per day, each occupying the Target for five seconds, is a daily occupation of fifty seconds. The total seconds in a day are divided to give a probability of Target occupation (50/86 400 = 1/1 728). Where a longer occupation is likely, as with a habitable building, outdoor café, or park bench, the period of occupation can be measured, or estimated as a proportion of a given unit of time, e.g. six hours per day (1/4). The Target is recorded as a range (Table 2).

Weather Affected Targets

Often the nature of a structural weakness in a tree is such that the probability of failure is greatest during windy weather, while the probability of the site being occupied by people during such weather is often low. This applies particularly to outdoor recreational areas. When estimating human Targets, the risk assessor must answer the question 'in the weather conditions that I expect the likelihood of failure of the tree to be initiated, what is my estimate of human occupation?' Taking this approach, rather than using the average occupation, ensures that the assessor considers the relationship between weather, people, and trees, along with the nature of the average person with their ability to recognise and avoid unnecessary risks.

Vehicles on the Highway

In the case of vehicles, likelihood of occupation may relate to either the falling tree or branch striking the vehicle or the vehicle striking the fallen tree. Both types of impact are influenced by vehicle speed; the faster the vehicle travels the less likely it is to be struck by the falling tree, but the more likely it is to strike a fallen tree. The probability of a vehicle occupying any particular point in the road is the ratio of the time it is occupied - including a safe stopping distance - to the total time. The average vehicle on a UK road is occupied by 1.6 people (DfT 2010). To account for the substantial protection that the average vehicle provides against most tree impacts and in particular, frontal collisions, QTRA values the substantially protected 1.6 occupants in addition to the value of the vehicle as equivalent to one exposed human life.

Property

Property can be anything that could be damaged by a falling tree, from a dwelling, to livestock, parked car, or fence. When evaluating the exposure of property to tree failure, the QTRA assessment considers the cost of repair or replacement that might result from failure of the tree. Ranges of value are presented in Table 2 and the assessor's estimate need only be sufficient to determine which of the six ranges the cost to select.

In Table 2, the ranges of property value are based on a VOSL of £2 000 000, e.g. where a building with a replacement cost of £20 000 would be valued at 0.01 (1/100) of a life (Target Range 2).

When assessing risks in relation to buildings, the Target to be considered might be the building, the occupants, or both. Occupants of a building could be protected from harm by the structure or substantially exposed to the impact from a falling tree if the structure is not sufficiently robust, and this will determine how the assessor categorises the Target.

Multiple Targets

A Target might be constantly occupied by more than one person and QTRA can account for this. For example, if it is projected that the average occupation will be constant by 10 people, the Risk of Harm is calculated in relation to one person constantly occupying the Target before going on to identify that the average occupation is 10 people. This is expressed as Target 1(10T)/1, where 10T represents the Multiple Targets. In respect of property, a Risk of Harm 1(10T)/1 would be equivalent to a risk of losing £20 000 000 as opposed to £2 000 000.

Tree or Branch Size

A small dead branch of less than 25mm diameter is not likely to cause significant harm even in the case of direct contact with a Target, while a falling branch with a diameter greater than 450mm is likely to cause some harm in the event of contact with all but the most robust Target. The QTRA method categorises

Size by the diameter of tree stems and branches (measured beyond any basal taper). An equation derived from weight measurements of trees of different stem diameters is used to produce a data set of comparative weights of trees and branches ranging from 25mm to 600mm diameter, from which Table 1 is compiled. The size of dead branches might be discounted where they have undergone a significant reduction in weight because of degradation and shedding of subordinate branches. This discounting, referred to as ‘Reduced Mass’, reflects an estimated reduction in the mass of a dead branch.

Table 1. Size

Size Range	Size of tree or branch	Range of Probability
1	> 450mm (>18”) dia.	1/1 - >1/2
2	260mm (10$^{1}/_{2}$”) dia. - 450mm (18”) dia.	1/2 - >1/8.6
3	110mm (4$^{1}/_{2}$”) dia. - 250mm (10”) dia.	1/8.6 - >1/82
4	25mm (1”) dia. - 100mm (4”) dia.	1/82 - 1/2 500

* Range 1 is based on a diameter of 600mm.

Table 2. Targets

Target Range	Property (repair or replacement cost)	Human (not in vehicles)		Vehicle Traffic (number per day)	Ranges of Value (probability of occupation or fraction of £2 000 000)
1	£2 000 000 – >£200 000	Occupation: Pedestrians & cyclists:	Constant – 2.5 hours/day 720/hour – 73/hour	26 000 – 2 700 @ 110kph (68mph) 32 000 – 3 300 @ 80kph (50mph) 47 000 – 4 800 @ 50kph (32mph)	1/1 – >1/10
2	£200 000 – >£20 000	Occupation: Pedestrians & cyclists:	2.4 hours/day – 15 min/day 72/hour – 8/hour	2 600 – 270 @ 110kph (68mph) 3 200 – 330 @ 80kph (50mph) 4 700 – 480 @ 50kph (32mph)	1/10 – >1/100
3	£20 000 – >£2 000	Occupation: Pedestrians & cyclists:	14 min/day – 2 min/day 7/hour – 2/hour	260 – 27 @ 110kph (68mph) 320 – 33 @ 80kph (50mph) 470 – 48 @ 50kph (32mph)	1/100 – >1/1 000
4	£2 000 – >£200	Occupation: Pedestrians & cyclists:	1 min/day – 2 min/week 1/hour – 3/day	26 – 4 @ 110kph (68mph) 32 – 4 @ 80kph (50mph) 47 – 6 @ 50kph (32mph)	1/1 000 – >1/10 000
5	£200 – >£20	Occupation: Pedestrians & cyclists:	1 min/week – 1 min/month 2/day – 2/week	3 – 1 @ 110kph (68mph) 3 – 1 @ 80kph (50mph) 5 – 1 @ 50kph (32mph)	1/10 000 – >1/100 000
6	£20 – £2	Occupation: Pedestrians & cyclists:	<1 min/month – 0.5 min/year 1/week – 6/year	None	1/100 000 – 1/1 000 000

Vehicle, pedestrian and property Targets are categorised by their frequency of use or their monetary value. The probability of a vehicle or pedestrian occupying a Target area in Target Range 4 is between the upper and lower limits of 1/1 000 and >1/10 000 (column 5). Using the VOSL £2 000 000, the property repair or replacement value for Target Range 4 is £2 000 - >200.

Probability of Failure

In the QTRA assessment, the probability of tree or branch failure within the coming year is estimated and recorded as a range of value (Ranges 1 – 7, Table 3).

Selecting a Probability of Failure (PoF) Range requires the assessor to compare their assessment of the tree or branch against a benchmark of either a non-compromised tree at Probability of Failure Range 7, or a tree or branch that we expect to fail within the year, which can be described as having a 1/1 probability of failure.

During QTRA training, Registered Users go through a number of field exercises in order to calibrate their estimates of Probability of Failure.

Table 3. Probability of Failure

Probability of Failure Range	Probability
1	1/1 - >1/10
2	1/10 - >1/100
3	1/100 - >1/1 000
4	1/1 000 - >1/10 000
5	1/10 000 – >1/100 000
6	1/100 000 – >1/1 000 000
7	1/1 000 000 – 1/10 000 000

The probability that the tree or branch will fail within the coming year.

The QTRA Calculation

The assessor selects a Range of values for each of the three input components of Target, Size and Probability of Failure. The Ranges are entered on either the manual calculator or software application to calculate a Risk of Harm.

The Risk of Harm is expressed as a probability and is rounded, to one significant figure. Any Risk of Harm that is lower than 1/1 000 000 is represented as <1/1 000 000. As a visual aid, the Risk of Harm is colour coded using the traffic light system illustrated in Table 4 (page 7).

> Risk of Harm - Monte Carlo Simulations
>
> The Risk of Harm for all combinations of Target, Size and Probability of Failure Ranges has been calculated using Monte Carlo simulations[4]. The QTRA Risk of Harm is the mean value from each set of Monte Carlo results.
>
> In QTRA Version 5, the Risk of Harm should not be calculated without the manual calculator or software application.

Assessing Groups and Populations of Trees

When assessing populations or groups of trees, the highest risk in the group is quantified and if that risk is tolerable, it follows that risks from the remaining trees will also be tolerable, and further calculations are unnecessary. Where the risk is intolerable, the next highest risk will be quantified, and so on until a tolerable risk is established. This process requires prior knowledge of the tree manager's risk tolerance.

Accuracy of Outputs

The purpose of QTRA is not necessarily to provide high degrees of accuracy, but to provide for the quantification of risks from falling trees in a way that risks are categorised within broad ranges (Table 4).

4. INFORMING MANAGEMENT DECISIONS

Balancing Costs and Benefits of Risk Control

When controlling risks from falling trees, the benefit of reduced risk is obvious, but the costs of risk control are all too often neglected. For every risk reduced there will be costs, and the most obvious of these is the financial cost of implementing the control measure. Frequently overlooked is the transfer of risks to workers and the public who might be directly affected by the removal or pruning of trees. Perhaps more importantly, most trees confer benefits, the loss of which should be considered as a cost when balancing the costs and benefits of risk control.

When balancing risk management decisions using QTRA, consideration of the benefits from trees will usually be of a very general nature and not require detailed consideration. The tree manager can consider, in simple terms, whether the overall cost of risk control is a proportionate one. Where risks are approaching 1/10 000, this may be a straightforward balancing of cost and benefits. Where risks are 1/10 000 or greater, it will usually be appropriate to implement risk controls unless the costs are grossly disproportionate to the benefits rather than simply disproportionate. In other words, the balance being weighted more on the side of risk control with higher associated costs.

Considering the Value of Trees

It is necessary to consider the benefits provided by trees, but they cannot easily be monetised and it is often difficult to place a value on those attributes such as habitat, shading and visual amenity that might be lost to risk control.

A simple approach to considering the value of a tree asset is suggested here, using the concept of 'average benefits'. When considered against other similar trees, a tree providing 'average benefits' will usually present a range of benefits that are typical for the species, age and situation. Viewed in this way, a tree providing 'average benefits' might appear to be low when compared with particularly important trees – such as in Figure 2, but should nonetheless be sufficient to offset a Risk of Harm of less than 1/10 000. Without having to consider the benefits of risk controls, we might reasonably assume that below 1/10 000, the risk from a tree that provides 'average benefits' is ALARP.

In contrast, if it can be said that the tree provides lower than average benefits because, for example, it is declining and in poor physiological condition, it may be necessary to consider two further elements. Firstly, is the Risk of Harm in the upper part of the Tolerable Region, and secondly, is the Risk of Harm likely to increase before the next review because of an increased Probability of Failure. If both these conditions apply then it might be appropriate to consider the balance of costs and benefits of risk reduction in order to determine whether the risk is ALARP. This balance requires the tree manager to take a view of both the reduction in risk and the costs of that reduction.

[4] For further information on the Monte Carlo simulation method, refer to http://en.wikipedia.org/wiki/Monte_Carlo_method

Fig. 2

Lower Than Average Benefits from Trees

Usually, the benefits provided by a tree will only be significantly reduced below the 'average benefits' that are typical for the species, age and situation, if the life of the benefits is likely to be shortened, perhaps because the tree is declining or dead. That is not to say that a disbenefit, such as undesirable shading, lifting of a footpath, or restricting the growth of other trees, should not also be considered in the balance of costs and benefits.

The horse chestnut tree in Figure 3 has recently died, and over the next few years, may provide valuable habitats. However, for this tree species and the relatively fast rate at which its wood decays, the lifetime of these benefits is likely to be limited to only a few years. This tree has an already reduced value that will continue to reduce rapidly over the coming five to ten years at the same time as the Risk of Harm is expected to increase. There will be changes in the benefits provided by the tree as it degrades. Visual qualities are likely to reduce while the decaying wood provides habitats for a range of species, for a short while at least. There are no hard and fast measures of these benefits and it is for the tree manager to decide what is locally important and how it might be balanced with the risks.

Where a risk is within the Tolerable Region and the tree confers lower than average benefits, it might be appropriate to consider implementing risk control while taking account of the financial cost. Here, VOSL can be used to inform a decision on whether the cost of risk control is proportionate. Example 3 below puts this evaluation into a tree management context.

There will be occasions when a tree is of such minimal value and the monetary cost of risk reduction so low that it might be reasonable to further reduce an already relatively low risk. Conversely, a tree might be of such considerable value that an annual risk of death greater than 1/10 000 would be deemed tolerable.

Occasionally, decisions will be made to retain elevated risks because the benefits from the tree are particularly high or important to stakeholders, and in these situations, it might be appropriate to assess and document the benefits in some detail. If detailed assessment of benefits is required, there are several methodologies and sources of information (Forest Research 2010).

Fig. 3

Delegating Risk Management Decisions

Understanding of the costs with which risk reduction is balanced can be informed by the risk assessor's knowledge, experience and on-site observations, but the risk management decisions should be made by the tree manager. That is not to say that the tree manager should review and agree every risk control measure, but when delegating decisions to surveyors and other staff or advisors, tree managers should set out in a policy, statement or contract, the principles and perhaps thresholds to which trees and their associated risks will ordinarily be managed.

Based on the tree manager accepting the principles set out in the QTRA Practice Note and or any other specific instructions, the risk assessor can take account of the cost/benefit balance and for most situations will be able to determine whether the risk is ALARP when providing management recommendations.

Table 4. QTRA Advisory Risk Thresholds

Thresholds	Description	Action
	Unacceptable Risks will not ordinarily be tolerated	• Control the risk
1/1,000		
	Unacceptable (where imposed on others) Risks will not ordinarily be tolerated	• Control the risk • Review the risk
	Tolerable (by agreement) Risks may be tolerated if those exposed to the risk accept it, or the tree has exceptional value	• Control the risk unless there is broad stakeholder agreement to tolerate it, or the tree has exceptional value • Review the risk
1/10 000		
	Tolerable (where imposed on others) Risks are tolerable if ALARP	• Assess costs and benefits of risk control • Control the risk only where a significant benefit might be achieved at reasonable cost • Review the risk
1/1 000 000		
	Broadly Acceptable Risk is already ALARP	• No action currently required • Review the risk

QTRA Informative Risk Thresholds

The QTRA advisory thresholds in Table 4 are proposed as a reasonable approach to balancing safety from falling trees with the costs of risk reduction. This approach takes account of the widely applied principles of ALARP and ToR, but does not dictate how these principles should be applied. While the thresholds can be the foundation of a robust policy for tree risk management, tree managers should make decisions based on their own situation, values and resources. Importantly, to enable tree assessors to provide appropriate management guidance, it is helpful for them to have some understanding of the tree owner's management preferences prior to assessing the trees.

A Risk of Harm that is less than 1/1 000 000 is Broadly Acceptable and is already ALARP. A Risk of Harm 1/1 000 or greater is unacceptable and will not ordinarily be tolerated. Between these two values, the Risk of Harm is in the Tolerable Region of ToR and will be tolerable if it is ALARP. In the Tolerable Region, management decisions are informed by consideration of the costs and benefits of risk control, including the nature and extent of those benefits provided by trees, which would be lost to risk control measures.

For the purpose of managing risks from falling trees, the Tolerable Region can be further broken down into two sections. From 1/1 000 000 to less than 1/10 000, the Risk of Harm will usually be tolerable providing that the tree confers 'average benefits' as discussed above. As the Risk of Harm approaches 1/10 000 it will be necessary for the tree manager to consider in more detail the benefits provided by the tree and the overall cost of mitigating the risk.

A Risk of Harm in the Tolerable Region but 1/10 000 or greater will not usually be tolerable where it is imposed on others, such as the public, and if retained, will require a more detailed consideration of ALARP. In exceptional circumstances a tree owner might choose to retain a Risk of Harm that is 1/10 000 or greater. Such a decision might be based on the agreement of those who are exposed to the risk, or perhaps that the tree is of great importance. In these circumstances, the prudent tree manager will consult with the appropriate stakeholders whenever possible.

5. EXAMPLE QTRA CALCULATIONS AND RISK MANAGEMENT DECISIONS

Below are three examples of QTRA calculations and application of the QTRA Advisory Thresholds.

Example 1.

	Target		Size		Probability of Failure		Risk of Harm
Range	6	x	1	x	3	=	<1/1 000 000

Example 1 is the assessment of a large (Size 1), unstable tree with a probability of failure of between 1/100 and >1/1 000 (PoF 3). The Target is a footpath with less than one pedestrian passing the tree each week (Target 6). The Risk of Harm is calculated as less than 1/1 000 000 (green). This is an example of where the Target is so low consideration of the structural condition of even a large tree would not usually be necessary.

Example 2.

	Target		Size		Probability of Failure		Risk of Harm
Range	1	x	4	x	3	=	1(2T) / 50 000

In Example 2, a recently dead branch (Size 4) overhangs a busy urban high street that is on average occupied constantly by two people, and here Multiple Target occupation is considered.

Having an average occupancy of two people, the Risk of Harm 1(2T) / 50 000 (yellow) represents a twofold increase in the magnitude of the consequence and is therefore equivalent to a Risk of Harm 1 / 20 000 (yellow). This risk does not exceed 1 / 10 000, but being a dead branch at the upper end of the Tolerable Region it is appropriate to consider the balance of costs and benefits of risk control. Dead branches can be expected to degrade over time with the probability of failure increasing as a result. Because it is dead, some of the usual benefits from the branch have been lost and it will be appropriate to consider whether the financial cost of risk control would be proportionate.

Example 3.

	Target		Size		Probability of Failure		Risk of Harm
Range	3	x	3	x	3	=	1 / 500 000

In Example 3, a 200mm diameter defective branch overhangs a country road along which travel between 470 and 48 vehicles each day at an average speed of 50kph (32mph) (Target Range 3). The branch is split and is assessed as having a probability of failure for the coming year of between 1 / 100 and 1 / 1 000 (PoF Range 3). The Risk of Harm is calculated as 1 / 500 000 (yellow) and it needs to be considered whether the risk is ALARP. The cost of removing the branch and reducing the risk to Broadly Acceptable (1 / 1 000 000) is estimated at £350. To establish whether this is a proportionate cost of risk control, the following equation is applied. £2 000 000 (VOSL) x 1 / 500 000 = £4 indicating that the projected cost of £350 would be disproportionate to the benefit. Taking account of the financial cost, risk transfer to arborists and passers-by, the cost could be described as being grossly disproportionate, even if accrued benefits over say ten years were taken into account.

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