cheshire woodlands
arboricultural consultancy

TREE RISK ASSESSMENT

OF

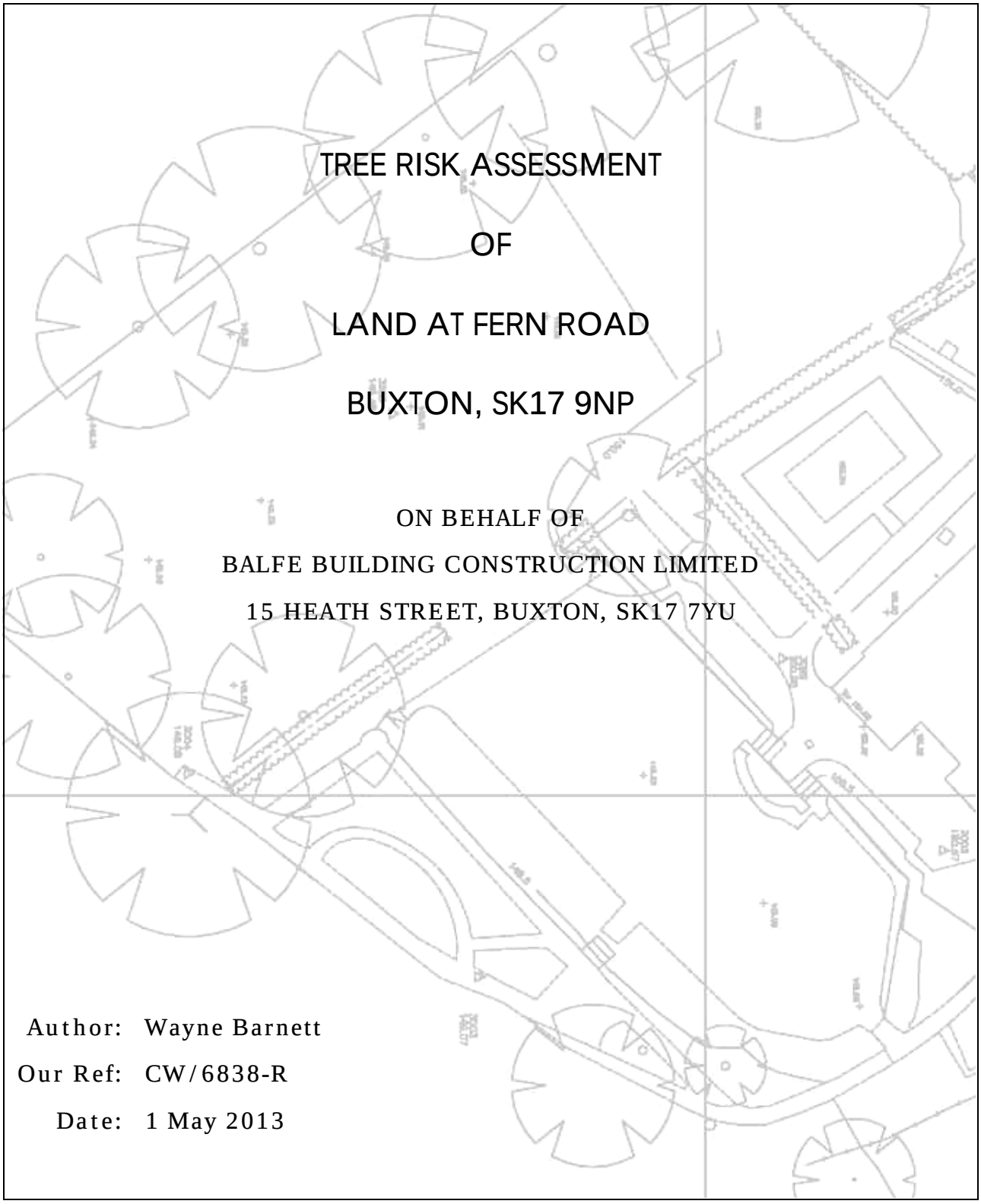
LAND AT FERN ROAD

BUXTON, SK17 9NP

ON BEHALF OF

BALFE BUILDING CONSTRUCTION LIMITED

15 HEATH STREET, BUXTON, SK17 7YU



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Our Ref: CW/6838-R

Date: 1 May 2013

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1. EXECUTIVE SUMMARY

1.1 Nine trees were assessed individually in relation to current land-uses. The positions of the trees are plotted on the tree risk assessment drawing and the results of the assessment are set out in the risk assessment schedule.

1.2 In terms of risks from falling trees, tree T1 and T5 are elevated and of particular note. It is recommended that tree T1 be removed, and that failed branches which overhang the access road are removed from tree T5.

1.3 The risks associated with the remaining seven trees are 'broadly acceptable' and require no further control measures save for annual re-assessment.

1.4 Tree T5 is colonised by Horse Chestnut Bleeding Canker. The tree currently exhibits good vitality but its condition should be monitored for signs of deterioration.

1.5 Past ground disturbance has resulted in decay to buttress roots and lower stems of several trees. In this regard, it is recommended that the affected trees are monitored for signs of reduced vitality.

2. TERMS OF REFERENCE

2.1 Instruction

2.1.1 Cheshire Woodlands is instructed by Balfe Building Construction Ltd to:

- Carry out a risk assessment of nine trees on land at Fern Road, Buxton, and record our findings
- Assess the trees at an appropriate level of detail using the Quantified Tree Risk Assessment (QTRA) method
- Produce a plan and a tabulated schedule of trees setting out our survey data
- Produce a report outlining our findings and proposing future management of the surveyed trees

2.2 Limitations

2.2.1 We have not considered the influence of trees on buildings or other structures resulting from the drying of shrinkable load-bearing soils, otherwise known as 'subsidence risk'.

2.2.2 The assessment of trees was carried out from ground level and while the disclosure of hidden crown defects cannot be expected, a reasonable and sufficient view was taken of the trees.

2.2.3 Our assessment was restricted where basal growth or other vegetation obscured lower stems and root collars.

2.2.4 This report and associated documents remain the copyright of Cheshire Woodlands and there should be no transfer of rights to any third party without our express written consent.

3. INTRODUCTION

3.1 In consideration of the risks associated with the trees, the QTRA method has been applied. Guidance on the method, its application, and the use of results to inform management decisions is provided in the practice note at appendix 5. Table 1 below at 5.6, outlines how the risk values are used to inform the management recommendations, which are formulated on the presumption that these principles are acceptable to the tree manager.

3.2 The assessment takes account of damage, or significant potential for damage, to infrastructure and the management recommendations are prioritised in terms of the severity, or potential severity, of damage.

3.3 While not the primary objective, the assessment considers the general condition, species and age diversity, conservation and landscape values of trees. These issues are reported in broad terms only.

4. STATUTORY CONTROLS

4.1 A telephone enquiry to Derbyshire County Council confirmed that all of the surveyed trees are subjects of The Derbyshire County Council (Staden, Cowdale and Harpur Hill) Tree Preservation Order (TPO) No. 56 of 1975. See appendix 4 for further guidance. The site is not in a conservation area.

5. METHOD

5.1 Nine trees were assessed from ground level and recorded. They were assessed in relation to the adjacent land-uses and in sufficient detail to inform the risk assessment. The heights and stem diameters of the trees were measured or estimated.

5.2 A visual assessment of physiological and structural condition was carried out. This assessment is informed by visual observations of growth characteristics, decay and defects.

5.3 Most trees have dead branches, cavities or growth patterns that indicate the presence of possible defects. Only where the surveyor considers that they could significantly affect the outcome of the risk assessment are these features investigated or recorded.

5.4 A risk assessment was carried out for each tree and where appropriate, management is recommended and prioritised in the appended schedules. As set out in table 1 below at 5.5, the risk values are used to inform management decisions based on the use of thresholds of 'acceptability' and 'tolerability' of risk.

5.5 Table 1. Risk Decision Making

Risk of Harm Thresholds		Description	Action
	Risk Index <1	**Unacceptable Region A (high risk)** Risks will not ordinarily be tolerated, irrespective of the costs of risk control in terms of expenditure and lost benefits	Control the risk
1/1,000			
	Risk Index 1<10	**Unacceptable region B** Where imposed on others, risks will not ordinarily be tolerated, irrespective of the costs of risk control	Assess and control risk unless broad stakeholder agreement to retain risk
		Tolerable Region A Risks may be tolerated in extraordinary circumstances. Risks will be considered in order to determine whether they are As Low As Reasonably Practicable (HSE 2001) by balancing the costs of expenditure and lost benefits against the benefits of risk reduction	Assess and control risk unless broad stakeholder agreement to retain risk
1/10,000			
	Risk Index 10 - <1,000	**Tolerable Region B** Risks are generally tolerable and might reasonably be imposed upon others. Risks will be considered in order to determine whether they are As Low As Reasonably Practicable (HSE 2001) by balancing the costs of expenditure and lost benefits against the benefits of risk reduction	Assess the risk and control only where a significant reduction can be achieved at a reasonable cost
1/1,000,000			
	Risk Index ≥1,000	**Broadly Acceptable Region (low risk)** Within which the risk is already As Low As Reasonably Practicable	No action

The Risk Index is used to shorten the values in the tree risk assessment schedule and represent the reciprocal of the risk ÷ 1,000, e.g. Risk Index 10 = Risk of Harm 1/10,000.

5.6 In the schedules, each recommendation is allocated a priority, which is provided to inform management decisions. The priorities are listed below in table 2 along with a description of how the priorities might influence management decisions.

5.7 Table 2. Management Priorities

No.	Priority	Description	Order of Priority
1	Safety – High	To control a risk that is in the unacceptable (red or, where an imposed risk, yellow) region	1
2	Safety – Medium	To control a risk that is in the unacceptable (red or, where an imposed risk, yellow) region	2
3	Safety – Low	To control a risk that is at the low end of the tolerable (blue) the unacceptable (red or, where an imposed risk, yellow) region	9
4	Safety – Long-term	To prevent or limit the potential for high risks to develop in the long-term	8
5	Damage to structures - High	To prevent or limit the extent of ongoing high-value or potentially dangerous damage to a structure	3
6	Damage to structures - Medium	To prevent or limit the extent of ongoing medium-value, or medium-term damage to a structure, or to limit or prevent likely damage	6
7	Damage to structures - Low	To prevent or limit the extent of ongoing minor damage to a structure, or to limit or prevent likely damage in the long-term	10
8	General management – High	Good tree husbandry of high importance	4
9	General management – Medium	Good tree husbandry of medium importance	7
10	General management - Low	Good tree husbandry of low importance	11
11	Ongoing management	Works that are most effectively carried out on a regular basis, perhaps by suitably trained site staff or grounds maintenance contractors	5
12	Immediately prior to next assessment	Work required to facilitate the next tree risk assessment, such as removal of ivy or other vegetation	N/A
13	No priority	Does not fit into 1 – 12 above	N/A

5.8 Significant Findings

5.9 Tree T1 was identified as having elevated risk above the 'general limit of tolerability', and removal of this tree is recommended on safety grounds.

5.10 Tree T5 was also identified as having an elevated risk, which although not exceeding the 1/10,000 'General limit of tolerability', removal of failed and partially failed branches is recommended for reasons of safety.

5.11 The risks associated with the remaining seven trees were identified as 'broadly acceptable' and require no further controls at this stage.

5.12 At several locations, there has been past ground disturbance within the rooting zone of trees. Tapping stems and buttress roots with a sounding hammer identified several trees that exhibit signs of internal decay adjacent to areas of ground disturbance. The trees generally exhibit good vitality, and in this regard are able to generate compensatory tissue and adaptive growth. Trees identified as having reduced vitality, should be assessed and monitored as set out in the tree risk assessment schedule at appendix 1.

5.13 Trees T4 and T5 are located adjacent to a partially collapsed dry-stone wall. It is reasonable to assume that roots from both trees were in part responsible for its displacement. Any attempt to repair or replace the stone wall should be designed to accommodate the future growth of stems and roots of protected trees. In this regard, it is recommended that advice is sought from a competent arboriculturist prior to any proposed works.

5.14 Tree T5 is colonised by Horse Chestnut Bleeding Canker. At the time of survey the tree exhibited good vitality and it should be monitored for any signs of a reduction in vigour.

6. CONCLUSIONS

6.1 The risks from trees on the site are generally low save for trees T1 and T5, which require remedial works for reasons of safety.

6.2 The risks associated with the remaining seven trees are 'broadly acceptable' and require no further controls at this stage.

6.3 Past ground disturbance in the vicinity of trees has resulted in decay to buttress roots and lower stems of several trees. In this regard, it is recommended that all surveyed trees are monitored for signs of reduced vitality.

6.4 A single horse chestnut, T5, was identified as exhibiting signs of Horse Chestnut Bleeding Canker and should be monitored for signs of deterioration.

7. RECOMMENDATIONS

7.1 There would be some merit in implementing all of the works listed in the management schedules.

7.2 Any rebuilding of stone walls adjacent to trees should be designed to accommodate the future growth of stems and roots of protected trees. Advice should be sought from a competent arboriculturist prior to any construction works.

7.3 BS3998 2010 *Tree work - Recommendations* should be used as a reference point for standards of tree work.

7.4 The trees should be reviewed periodically, and given the nature of both the site and the past ground disturbance, an annual review would be appropriate.

7.5 Statutory protection of wildlife should be taken into account in the planning and execution of tree pruning and removal. See appendix 6 for further guidance.

8. REFERENCES.

BS3998: 2010. *Tree work - Recommendations*. British Standards Institute, London. 68 pp.

HSE 2001. *Reducing Risks: Protecting People*. Health and Safety Executive. HSE Books, Sudbury, Suffolk. 80pp. Available for download at http://www.hse.gov.uk/risk/theory/r2p2.pdf

APPENDIX 1

TREE RISK ASSESSMENT SCHEDULE

CLIENT: Balfe Building Construction Ltd

PROJECT: Land at Fern Road
Buxton, SK17 9NP

REF: CW/6838-RAS

DATE: 09 May 2013

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HEADINGS & ABBREVIATIONS

REFERENCE:	TREE OR GROUP REFERENCE
TAG NO:	TAG NUMBER WHERE A TAG HAS BEEN AFFIXED TO TREE
HEIGHT:	HEIGHT OF TREE OR MAXIMUM HEIGHT FOR THE GROUP , APPROXIMATELY 1 IN 10 TREES ARE MEASURED AND THE REMAINDER ESTIMATED AGAINST THE MEASURED TREES
AGE RANGE:	Y = YOUNG, SM = SEMI MATURE, EM = EARLY MATURE, M = MATURE, PM = POST MATURE
DIA:	STEM DIAMETER FOR THE TREE OR MAXIMUM DIAMETER FOR THE GROUP- MEASURED OR ESTIMATED AT A HEIGHT OF APPROXIMATELY 1.5 METRES
VITALITY:	A MEASURE OF PHYSIOLOGICAL CONDITION. D = DEAD, MD = MORIBUND, P = POOR, M = MODERATE, G = GOOD
SIZE VALUE:	VALUE FOR THE RISK ASSESSED TREE OR BRANCH - EXPRESSED AS A FRACTION
PROB OF FAILURE:	PROBABILITY OF FAILURE WITHIN 12 MONTHS OF THE ASSESSMENT
TARGET VALUE:	LIKELIHOOD OF A TARGET BEING OCCUPIED OR THE REPAIR OR REPLACEMENT VALUE OF PROPERTY EXPRESSED AS A FRACTION OF £1,000,000
MULTIPLE TARGET:	WHERE TARGET HAS A VALUE GREATER THAN CONSTANT OCCUPATION BY ONE PERSON, OR A LIKELY REPAIR/REPLACEMENT VALUE GREATER THAN £1M, A MULTIPLE VALUE IS RECORDED
WEATHER FACTOR:	SEE QUANTIFIED TREE RISK ASSESSMENT PRACTICE NOTE
REDUCED MASS %:	WHERE THE MASS OF A BRANCH IS REDUCED BY DEGRADATION, A FRACTION MAY BE INTRODUCED TO REFLECT THE PROPORTION OF THE REDUCTION
RISK INDEX:	E.G. RISK INDEX 20 = RISK OF SIGNIFICANT HARM 1 IN 20,000
HIGHWAY:	SIGNIFICANT THOROUGHFARES ARE RECORDED AND ALLOCATED A BUFFER DISTANCE, WHICH IS EQUAL TO OR GREATER THAN THE HEIGHT OF ANY TREE THAT IS WITHIN FALLING DISTANCE

MANAGEMENT PRIORITIES

1) SAFETY - HIGH
2) SAFETY - MEDIUM
3) SAFETY - LOW
4) SAFETY - LONG TERM
5) DAMAGE TO STRUCTURES - HIGH
6) DAMAGE TO STRUCTURES - MEDIUM
7) DAMAGE TO STRUCTURES - LOW
8) GENERAL MANAGEMENT - HIGH
9) GENERAL MANAGEMENT - MEDIUM
10) GENERAL MANAGEMENT - LOW
11) ONGOING MANAGEMENT
12) IMMEDIATELY PRIOR TO NEXT ASSESSMENT
13) NO PRIORITY

Reference	Species	Age	Height (m)	Dia (mm)	Vitality	Targets	Multiple Targets	Target Value (1 in)	Size Value (1 in)	Prob Failure (1 in)	Reduced Mass (1 in)	Risk Index
T1	Sycamore	EM	20	830	M	Vehicle						
Tag No						Human						
						Property	1	72.0	1.00	100	1	7.0
						Risk assessment of: first order branch failure onto dwelling						

Comments	Management & Priority
Part of Group G1 of the 1956 TPO Adaptive growth response on southern buttress root Stem bifurcates at 8.0 metres, at which point there is an acute included bark union of co-dominant stems with signs of past failure, bark decay and cambial dieback extending downwards for 4.0 metres, with no signs of adaptive growth. Located within a wider group of trees Located adjacent to building/s Exhibits reduced vitality Forms part of a wider group of trees	2: Fell and grind stump/s

Reference	Species	Age	Height (m)	Dia (mm)	Vitality	Targets	Multiple Targets	Target Value (1 in)	Size Value (1 in)	Prob Failure (1 in)	Reduced Mass (1 in)	Risk Index
T2	Sycamore	EM	18	800	G	Vehicle						
Tag No						Human	1	72.0	8.60	10000	1	6,000
						Property	1	720.0	1.00	10000	1	7,000
						Risk assessment of: first order branch failure onto veh access						

Comments	Management & Priority
Part group G1 of the 1956 TPO Located within a wider group of trees Acute included bark union/s with signs of adaptive growth Visual and audible signs of decay to the lower stem and exhibiting adaptive growth Ground disturbance beneath crown Decay to the rootplate	11: Monitor vitality

Reference	Species	Age	Height (m)	Dia (mm)	Vitality	Targets	Multiple Targets	Target Value (1 in)	Size Value (1 in)	Prob Failure (1 in)	Reduced Mass (1 in)	Risk Index
T3	Sycamore	EM	18	765	G	Vehicle	1	718.5	8.60	10000	1	60,000
Tag No						Human						
						Property	1	720.0	1.00	10000	1	7,000
						Risk assessment of: first order branch failure onto veh access						

Comments	Management & Priority
Part group G1 of the 1956 TPO Tapping with sounding hammer indicates decay in buttress roots on western side of stem Located within a wider group of trees Acute included bark union/s with signs of adaptive growth Ground disturbance beneath crown Decay to the rootplate Adaptive growth to the stem/s	11: Monitor vitality

Reference	Species	Age	Height (m)	Dia (mm)	Vitality	Targets	Multiple Targets	Target Value (1 in)	Size Value (1 in)	Prob Failure (1 in)	Reduced Mass (1 in)	Risk Index
T4	Sycamore	EM	16	720	M	Vehicle	1	718.5	2.03	1000	1	1,000
Tag No						Human						
						Property	1	720.0	1.00	1000	1	700
						Risk assessment of: first order branch failure onto veh access						

Comments	Management & Priority
Part group G1 of the 1956 TPO Displacing adjacent wall/s Decay to the stem/s Cavity to the stem/s Visual and audible signs of decay to the lower stem and exhibiting adaptive growth Exhibits reduced vitality Located within a wider group of trees Decay to the rootplate	11: Monitor vitality

Reference	Species	Age	Height (m)	Dia (mm)	Vitality	Targets	Multiple Targets	Target Value (1 in)	Size Value (1 in)	Prob Failure (1 in)	Reduced Mass (1 in)	Risk Index
T5	Horse chestnut	M	21	1,200	G	Vehicle	1	718.5	8.60	100	1	600
Tag No						Human	1	72.0	8.60	100	1	60
						Property	1	720.0	1.00	100	1	70
						Risk assessment of: second order branch failure onto car park						

Comments	Management & Priority
Part group G1 of the 1956 TPO Tapping with sounding hammer exhibits audible signs of internal decay to buttress roots Partially failed second order branch/es Hung up second order branch/es Displacing adjacent wall/s Located within a wider group of trees Decay to the rootplate Visual and audible signs of decay to the lower stem and exhibiting adaptive growth Stem lesions indicating infection by horse chestnut bleeding canker Ground disturbance beneath crown	11: Monitor vitality 2: Remove failed branch/es

Reference	Species	Age	Height (m)	Dia (mm)	Vitality	Targets	Multiple Targets	Target Value (1 in)	Size Value (1 in)	Prob Failure (1 in)	Reduced Mass (1 in)	Risk Index
T7	Sycamore	EM	16	800	G	Vehicle						
Tag No						Human	1	17,280.0	8.60	10000	1	1,000,000
						Property	1	720.0	1.00	10000	1	7,000
						Risk assessment of: first order branch failure onto building						

Comments	Management & Priority
Part group G1 of the 1956 TPO Wooden slats nailed to stem at between 1.0 and 2.0 metres Rope constricting low first order branches on south side Informal play area located beneath the canopy on the south side Located within a wider group of trees Located adjacent to a play area Ground disturbance beneath crown Severance of roots Visual and audible signs of decay to the lower stem and exhibiting adaptive growth	11: Monitor vitality

Reference	Species	Age	Height (m)	Dia (mm)	Vitality	Targets	Multiple Targets	Target Value (1 in)	Size Value (1 in)	Prob Failure (1 in)	Reduced Mass (1 in)	Risk Index
T8	Sycamore	EM	16	720	M	Vehicle						
Tag No						Human	1	17,280.0	8.60	1000	1	100,000
						Property	1	720.0	1.00	1000	1	700
						Risk assessment of: first order branch failure onto building						

Comments	Management & Priority
Part group G1 of the 1956 TPO Stem leans to the east Recent adaptive growth response on buttress roots on eastern side Clear stem to 4.0 metres, at which point there has been a past failure of a first order branch or co-dominant stem resulting in a stem of 2.0 metres in length Located within a wider group of trees Located adjacent to a play area Past first order branch failure/s Ground disturbance beneath crown Visual and audible signs of decay to the lower stem and exhibiting adaptive growth Exhibits reduced vitality	11: Monitor vitality

Reference	Species	Age	Height (m)	Dia (mm)	Vitality	Targets	Multiple Targets	Target Value (1 in)	Size Value (1 in)	Prob Failure (1 in)	Reduced Mass (1 in)	Risk Index
T9	Sycamore	EM	14	650	M	Vehicle						
Tag No						Human	1	17,280.0	8.60	1000	1	100,000
						Property						
						Risk assessment of: first order branch failure onto informal play area						

Comments	Management & Priority
Part group G1 of the 1956 TPO Located within a wider group of trees Located adjacent to a play area Ground disturbance beneath crown Epicormic shoots to the stem/s Leaning stem/s Visual and audible signs of decay to the lower stem and exhibiting adaptive growth Exhibits reduced vitality	11: Monitor vitality

TREE RISK SURVEY

@Cheshire Woodlands

CLIENT: Balfe Building Construction Ltd

SURVEYOR: WEB

PROJECT: Land at Fern Road

DATE: 09 May 2013

BRIEF: Risk assessment of 9 trees

REF: CW/6838-RAS

Reference	Species	Age	Height (m)	Dia (mm)	Vitality	Targets	Multiple Targets	Target Value (1 in)	Size Value (1 in)	Prob Failure (1 in)	Reduced Mass (1 in)	Risk Index
T10	Sycamore	M	21	830	G	Vehicle						
Tag No						Human	1	17,280.0	8.60	10000	1	1,000,000
						Property	1	720.0	1.00	10000	1	7,000
						Risk assessment of: first order branch failure onto building						

Comments	Management & Priority
Part group G1 of the 1956 TPO Ground disturbance beneath crown Located within a wider group of trees Decay to the rootplate Adaptive growth to the root-collar Acute included bark union/s with signs of adaptive growth Visual and audible signs of decay to the lower stem and exhibiting adaptive growth	11: Monitor vitality

APPENDIX 2

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TREE MANAGEMENT SCHEDULE

CLIENT: Balfe Building Construction Ltd

PROJECT: Land at Fern Road
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REF: CW/6838-MP

DATE: 09 May 2013

HEADINGS & ABBREVIATIONS

REFERENCE: TREE OR GROUP REFERENCE
TAG NO: TAG NUMBER WHERE A TAG HAS BEEN AFFIXED TO TREE
RISK INDEX: E.G. RISK INDEX 20 = RISK OF SIGNIFICANT HARM 1 IN 20,000

MANAGEMENT PRIORITIES

1) SAFETY - HIGH
2) SAFETY - MEDIUM
3) SAFETY - LOW
4) SAFETY - LONG TERM
5) DAMAGE TO STRUCTURES - HIGH
6) DAMAGE TO STRUCTURES - MEDIUM
7) DAMAGE TO STRUCTURES - LOW
8) GENERAL MANAGEMENT - HIGH
9) GENERAL MANAGEMENT - MEDIUM
10) GENERAL MANAGEMENT - LOW
11) ON-GOING MANAGEMENT
12) IMMEDIATELY PRIOR TO NEXT ASSESSMENT
13) NO PRIORITY

Reference	Tree Tag	Management	Priority	Risk Index
T1		Fell and grind stump/s	Safety Medium	7.00
T5		Remove failed branch/es: Removed failed branches overhanging carpark and accesss road	Safety Low	60
T5		Monitor vitality	Ongoing	60
T4		Monitor vitality	Ongoing	700
T8		Monitor vitality	Ongoing	700
T2		Monitor vitality	Ongoing	6,000
T3		Monitor vitality	Ongoing	7,000
T7		Monitor vitality	Ongoing	7,000
T10		Monitor vitality	Ongoing	7,000
T9		Monitor vitality	Ongoing	100,000

APPENDIX 3

TREE SURVEY PLAN

T1
T2
T3
T4
T5
T10
T9
T7
T8

TREE SURVEY PLAN

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CLIENT	BALFE BUILDING CONSTRUCTION LTD
PROJECT	LAND AT FERN ROAD BUXTON SK17 9NP
JOB REF	CW/6838 P-TS
DATE	26 APRIL 2013
SCALE	1:250 at A3

T — SURVEYED INDIVIDUAL TREE

STEM POSITION APPROXIMATED

APPENDIX 4

GLOSSARY OF ARBORICULTURAL TERMS

Abscission. The shedding of a leaf or other short-lived part of a woody plant, involving the formation of a corky layer across its base; in some tree species twigs can be shed in this way

Abiotic. Pertaining to non-living agents; e.g. environmental factors

Absorptive roots. Non-woody, short-lived roots, generally having a diameter of less than one millimetre, the primary function of which is uptake of water and nutrients

Adaptive growth. In tree biomechanics, the process whereby the rate of wood formation in the cambial zone, as well as wood quality, responds to gravity and other forces acting on the cambium. This helps to maintain a uniform distribution of mechanical stress

Adaptive roots. The adaptive growth of existing roots; or the production of new roots in response to damage, decay or altered mechanical loading

Adventitious shoots. Shoots that develop other than from apical, axillary or dormant buds; see also 'epicormic'

Anchorage. The system whereby a tree is fixed within the soil, involving cohesion between roots and soil and the development of a branched system of roots which withstands wind and gravitational forces transmitted from the aerial parts of the tree

Architecture. In a tree, a term describing the pattern of branching of the crown or root system

Axil. The place where a bud is borne between a leaf and its parent shoot

Bacteria. Microscopic single-celled organisms, many species of which break down dead organic matter, and some of which cause diseases in other organisms

Bark. A term usually applied to all the tissues of a woody plant lying outside the vascular cambium, thus including the phloem, cortex and periderm; occasionally applied only to the periderm or the phellem

Basidiomycotina (Basidiomycetes). One of the major taxonomic groups of fungi; their spores are borne on microscopic peg-like structures (basidia), which in many types are in turn borne on or within conspicuous fruit bodies, such as brackets or toadstools. Most of the principal decay fungi in standing trees are basidiomycetes

Bolling. A term sometimes used to describe pollard heads

Bottle-butt. A broadening of the stem base and buttresses of a tree, in excess of normal and sometimes denoting a growth response to weakening in that region, especially due to decay involving selective delignification

Bracing. The use of rods or cables to restrain the movement between parts of a tree

Branch:

- **Primary.** A first order branch arising from a stem
- **Lateral.** A second order branch, subordinate to a primary branch or stem and bearing sub-lateral branches
- **Sub-lateral.** A third order branch, subordinate to a lateral or primary branch, or stem and usually bearing only twigs

Branch bark ridge. The raised arc of bark tissues that forms within the acute angle between a branch and its parent stem

Branch collar. A visible swelling formed at the base of a branch whose diameter growth has been disproportionately slow compared to that of the parent stem; a term sometimes applied also to the pattern of growth of the cells of the parent stem around the branch base

Brown-rot. A type of wood decay in which cellulose is degraded, while lignin is only modified

Buckling. An irreversible deformation of a structure subjected to a bending load

Buttress zone. The region at the base of a tree where the major lateral roots join the stem, with buttress-like formations on the upper side of the junctions

Cambium. Layer of dividing cells producing xylem (woody) tissue internally and phloem (bark) tissue externally

Canker. A persistent lesion formed by the death of bark and cambium due to colonisation by fungi or bacteria

Canopy species. Tree species that mature to form a closed woodland canopy

Cleaning out. The removal of dead, crossing, weak, and damaged branches, where this will not damage or spoil the overall appearance of the tree

Compartmentalization. The confinement of disease, decay or other dysfunction within an anatomically discrete region of plant tissue, due to passive and/or active defences operating at the boundaries of the affected region

Compression fork. An acute angled fork that is mechanically optimised for the growth pressure that two or more adjacent stems exert on each other.

Compression strength. The ability of a material or structure to resist failure when subjected to compressive loading; measurable in trees with special drilling devices

Compressive loading. Mechanical loading which exerts a positive pressure; the opposite to tensile loading

Condition. An indication of the physiological vitality of the tree. Where the term 'condition' is used in a report, it should not be taken as an indication of the stability of the tree

Construction exclusion zone. Area based on the Root Protection Area (in square metres) to be protected during development, by the use of barriers and/or ground protection

Crown/Canopy. The main foliage bearing section of the tree

Crown lifting. The removal of limbs and small branches to a specified height above ground level

Crown thinning. The removal of a proportion of secondary branch growth throughout the crown to produce an even density of foliage around a well-balanced branch structure

Crown reduction/shaping. A specified reduction in crown size whilst preserving, as far as possible, the natural tree shape

Crown reduction/thinning. Reduction of the canopy volume by thinning to remove dominant branches whilst preserving, as far as possible the natural tree shape

Deadwood. Dead branch wood

Decurrent. In trees, a system of branching in which the crown is borne on a number of major widely-spreading limbs of similar size (cf. excurrent). In fungi with toadstools as fruit bodies, the description of gills which run some distance down the stem, rather than terminating abruptly

Defect. In relation to tree hazards, any feature of a tree which detracts from the uniform distribution of mechanical stress, or which makes the tree mechanically unsuited to its environment

Delamination. The separation of wood layers along their length, visible as longitudinal splitting

Dieback. The death of parts of a woody plant, starting at shoot-tips or root-tips

Disease. A malfunction in or destruction of tissues within a living organism, usually excluding mechanical damage; in trees, usually caused by pathogenic micro-organisms

Distal. In the direction away from the main body of a tree or subject organism (cf. proximal)

Dominance. In trees, the tendency for a leading shoot to grow faster or more vigorously than the lateral shoots; also the tendency of a tree to maintain a taller crown than its neighbours

Dormant bud. An axial bud which does not develop into a shoot until

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after the formation of two or more annual wood increments; many such buds persist through the life of a tree and develop only if stimulated to do so

Dysfunction. In woody tissues, the loss of physiological function, especially water conduction, in sapwood

DBH (Diameter at Breast Height). Stem diameter measured at a height of 1.5 metres (UK) or the nearest measurable point. Where measurement at a height of 1.5 metres is not possible, another height may be specified

Deadwood. Branch or stem wood bearing no live tissues. Retention of deadwood provides valuable habitat for a wide range of species and seldom represents a threat to the health of the tree. Removal of deadwood can result in the ingress of decay to otherwise sound tissues and climbing operations to access deadwood can cause significant damage to a tree. Removal of deadwood is generally recommended only where it represents an unacceptable level of hazard

Endophytes. Micro-organisms which live inside plant tissues without causing overt disease, but in some cases capable of causing disease if the tissues become physiologically stressed, for example by lack of moisture

Epicormic shoot. A shoot having developed from a dormant or adventitious bud and not having developed from a first year shoot

Excrescence. Any abnormal outgrowth on the surface of tree or other organism

Excurrent. In trees, a system of branching in which there is a well defined central main stem, bearing branches which are limited in their length, diameter and secondary branching (cf. decurrent)

Fastigiate. Having upright, often clustered branches

Felling licence. In the UK, a permit to fell trees in excess of a stipulated number of stems or volume of timber

Flush-cut. A pruning cut which removes part of the branch bark ridge and or branch-collar

Girdling root. A root which circles and constricts the stem or roots possibly causing death of phloem and/or cambial tissue

Guying. A form of artificial support with cables for trees with a temporarily inadequate anchorage

Habit. The overall growth characteristics, shape of the tree and branch structure

Hazard beam. An upwardly curved part of a tree in which strong internal stresses may occur without being reduced by adaptive growth; prone to longitudinal splitting

Heartwood/false-heartwood/ripewood. Sapwood that has become dysfunctional as part of the natural aging processes

Heave. A term mainly applicable to a shrinkable clay soil which expands due to re-wetting after the felling of a tree which was previously extracting moisture from the deeper layers; also the lifting of pavements and other structures by root diameter expansion; also the lifting of one side of a wind-rocked root-plate

High canopy tree species. Tree species having potential to contribute to the closed canopy of a mature woodland or forest

Incipient failure. In wood tissues, a mechanical failure which results only in deformation or cracking, and not in the fall or detachment of the affected part

Included bark (ingrown bark). Bark of adjacent parts of a tree (usually forks, acutely joined branches or basal flutes) which is in face-to-face contact

Increment borer. A hollow auger, which can be used for the extraction of wood cores for counting or measuring wood increments or for inspecting the condition of the wood

Infection. The establishment of a parasitic micro-organism in the tissues of a tree or other organism

Internode. The part of a stem between two nodes; not to be confused with a length of stem which bear nodes but no branches

Lever arm. A mechanical term denoting the length of the lever represented by a structure that is free to move at one end, such as a tree or an individual branch

Lignin. The hard, cement-like constituent of wood cells; deposition of lignin within the matrix of cellulose microfibrils in the cell wall is termed Lignification

Lions tailing. A term applied to a branch of a tree that has few if any side-branches except at its end, and is thus liable to snap due to end-loading

Loading. A mechanical term describing the force acting on a structure from a particular source; e.g. the weight of the structure itself or wind pressure

Longitudinal. Along the length (of a stem, root or branch)

Lopping. A term often used to describe the removal of large branches from a tree, but also used to describe other forms of cutting

Mature Heights (approximate)**:**

- **Low maturing** – less than 8 metres high
- **Moderately high maturing** – 8 – 12 metres high
- **High maturing** – greater than 12 metres high

Microdrill. An electronic rotating steel probe, which when inserted into woody tissue provides a measure of tissue density

Minor deadwood. Deadwood of a diameter less than 25mm and or unlikely to cause significant harm or damage upon impact with a target beneath the tree

Mulch. Material laid down over the rooting area of a tree or other plant to help conserve moisture; a mulch may consist of organic matter or a sheet of plastic or other artificial material

Mycelium. The body of a fungus, consisting of branched filaments (hyphae)

Occluding tissues. A general term for the roll of wood, cambium and bark that forms around a wound on a woody plant (cf. woundwood)

Occlusion. The process whereby a wound is progressively closed by the formation of new wood and bark around it

Pathogen. A micro-organism which causes disease in another organism

Photosynthesis. The process whereby plants use light energy to split hydrogen from water molecules, and combine it with carbon dioxide to form the molecular building blocks for synthesizing carbohydrates and other biochemical products

Phytotoxic. Toxic to plants

Pollarding. The removal of the tree canopy, back to the stem or primary branches, usually to a point just outside that of the previous cutting. Pollarding may involve the removal of the entire canopy in one operation, or may be phased over several years. The period of safe retention of trees having been pollarded varies with species and individuals. It is usually necessary to re-pollard on a regular basis, annually in the case of some species

Primary branch. A major branch, generally having a basal diameter greater than 0.25 x stem diameter

Primary root zone. The soil volume most likely to contain roots that are critical to the health and stability of the tree and normally defined by reference BS5837 (2005) Guide for Trees in Relation to Construction.

Priority. Works may be prioritised, 1. = high, 5. = low

Probability. A statistical measure of the likelihood that a particular event might occur

Proximal. In the direction towards from the main body of a tree or other living organism (cf. distal)

Pruning. The removal or cutting back of twigs or branches, sometimes applied to twigs or small branches only, but often used to describe most activities involving the cutting of trees or shrubs

Radial. In the plane or direction of the radius of a circular object such as a tree stem

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Rams-horn. In connection with wounds on trees, a roll of occluding tissues which has a spiral structure as seen in cross-section

Rays. Strips of radially elongated parenchyma cells within wood and bark. The functions of rays include food storage, radial translocation and contributing to the strength of wood

Reactive Growth/Reaction Wood. Production of woody tissue in response to altered mechanical loading; often in response to internal defect or decay and associated strength loss (cf. adaptive growth)

Removal of dead wood. Unless otherwise specified, this refers to the removal of all accessible dead, dying and diseased branchwood and broken snags

Removal of major dead wood. The removal of, dead, dying and diseased branchwood above a specified size

Respacing. Selective removal of trees from a group or woodland to provide space and resources for the development of retained trees.

Residual wall. The wall of non-decayed wood remaining following decay of internal stem, branch or root tissues

Ring-barking (girdling)**.** The removal of a ring of bark and phloem around the circumference of a stem or branch, normally resulting in an inability to transport photosynthetic assimilates below the area of damage. Almost inevitably results in the eventual death of the affected stem or branch above the damage.

Root-collar. The transitional area between the stem/s and roots

Root-collar examination. Excavation of surfacing and soils around the root-collar to assess the structural integrity of roots and/or stem

Root protection area. An area of ground surrounding a tree that contains sufficient rooting volume to ensure the tree's survival. Calculated with reference to Table 2 of BS5837 (2005) and shown in plan form in square metres

Root zone. Area of soils containing absorptive roots of the tree/s described. The **Primary** root zone is that which we consider of primary importance to the physiological well-being of the tree

Sapwood. Living xylem tissues

Secondary branch. A branch, generally having a basal diameter of less than 0.25 x stem diameter

Selective delignification. A kind of wood decay (white-rot) in which lignin is degraded faster than cellulose

Shedding. In woody plants, the normal abscission, rotting off or sloughing of leaves, floral parts, twigs, fine roots and bark scales

Silviculture. The practice of controlling the establishment, growth, composition, health, and quality of forests to meet diverse needs and values.

Silvicultural thinning. Removal of selected trees to favour the development of retained specimens to achieve a management objective

Simultaneous white-rot. A kind of wood decay in which lignin and cellulose are degraded at about the same rate

Snag. In woody plants, a portion of a cut or broken stem, branch or root which extends beyond any growing-point or dormant bud; a snag usually tends to die back to the nearest growing point

Soft-rot. A kind of wood decay in which a fungus degrades cellulose within the cell walls, without any general degradation of the wall as a whole

Spores. Propagules of fungi and many other life-forms; most spores are microscopic and dispersed in air or water

Shrub species. Woody perennial species forming the lowest level of woody plants in a woodland and not normally considered to be trees

Sporophore. The spore bearing structure of fungi

Sprouts. Adventitious shoot growth erupting from beneath the bark

Stem/s. The main supporting structure/s, from ground level up to the first major division into branches

Stress. In plant physiology, a condition under which one or more physiological functions are not operating within their optimum range, for example due to lack of water, inadequate nutrition or extremes of temperature

Stress. In mechanics, the application of a force to an object

Stringy white-rot. The kind of wood decay produced by selective delignification

Storm. A layer of tissue which supports the fruit bodies of some types of fungi, mainly ascomycetes

Structural roots. Roots, generally having a diameter greater than ten millimetres, and contributing significantly to the structural support and stability of the tree

Subsidence. In relation to soil or structures resting in or on soil, a sinking due to shrinkage when certain types of clay soil dry out, sometimes due to extraction of moisture by tree roots

Subsidence. In relation to branches of trees, a term that can be used to describe a progressive downward bending due to increasing weight

Taper. In stems and branches, the degree of change in girth along a given length

Target canker. A kind of perennial canker, containing concentric rings of dead occluding tissues

Targets. In tree risk assessment (with slight misuse of normal meaning) persons or property or other things of value which might be harmed by mechanical failure of the tree or by objects falling from it

Topping. In arboriculture, the removal of the crown of a tree, or of a major proportion of it

Torsional stress. Mechanical stress applied by a twisting force

Translocation. In plant physiology, the movement of water and dissolved materials through the body of the plant

Transpiration. The evaporation of moisture from the surface of a plant, especially via the stomata of leaves; it exerts a suction which draws water up from the roots and through the intervening xylem cells

Tree Risk Assessment. An assessment and description of the risks and where appropriate the values associated with a tree or trees. The primary risk being considered is that from falling trees. Other risks, such as damage to infrastructure, interruption of service and building subsidence may also be considered.

- Walkover – A general view of the tree population considered in the context of the adjacent land-use to identify trees that present significantly elevated risks
- Drive-by - A general view of the tree population from a moving vehicle and considered in the context of the adjacent land-use to identify trees that present significantly elevated risks
- Individual – the assessment of risks from a single tree considered in the context of the adjacent land-use to identify trees that present significantly elevated risks

Understorey. A layer of vegetation beneath the main canopy of woodland or forest or plants forming this

Understorey tree species. Tree species not having potential to attain a size at which they can contribute to the closed high canopy of a woodland

Vascular wilt. A type of plant disease in which water-conducting cells become dysfunctional

Vessels. Water-conducting cells in plants, usually wide and long for hydraulic efficiency; generally not present in coniferous trees

Veteran tree. A loosely defined term for an old specimen that is of interest biologically, culturally or aesthetically because of its age, size or condition and which has usually lived longer than the typical upper age range for the species concerned

Vigour. The expression of carbohydrate expenditure to growth (in trees).

Vitality. A measure of physiological condition expressed through the

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health and growth of foliage, shoots and adaptive woody tissues.

White-rot. A range of kinds of wood decay in which lignin, usually together with cellulose and other wood constituents, is degraded

Wind exposure. The degree to which a tree or other object is exposed to wind, both in terms of duration and velocity

Wind pressure. The force exerted by a wind on a particular object

Windthrow. The blowing over of a tree at its roots

Wound dressing. A general term for sealants and other materials used to cover wounds in the hope of protecting them against desiccation and infection; only of proven value against fresh wound parasites

Woundwood. Wood with atypical anatomical features, formed in the vicinity of a wound

APPENDIX 5

QTRA Tree Safety Management

Quantified Tree Risk Assessment

PRACTICE NOTE

VERSION 4

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

The Quantified Tree Risk Assessment (QTRA) method was first published in 2005 (Ellison 2005), following which a programme of training and user registration was developed. Registered users of the QTRA method attend either a one or a two-day training workshop and receive tuition in the basic application of the method. Update workshops provide both advanced training and update information relating to revision of the method; attendance is at the discretion of the user. Users, currently, from fifteen countries have access to an internet discussion forum and receive updated information as the method evolves and develops.

A Balanced Approach

In the management of trees, risk minimisation is often cited as an objective. This alone is not a reasonable aim because the benefits of risk reduction must be balanced with its costs, both financial and in terms of lost benefits from the tree. Where risk reduction comes at a disproportionately high cost in relation to lowering the level of risk, the risk control measure can be said to be disproportionate and unreasonable. Indeed, where safety from trees is concerned, the law in the UK, both common and in statute, requires only that the occupier of land does what is reasonable (Mynors 2011). By quantifying the risk of harm from falling trees, QTRA enables comparison of the costs and benefits of risk reduction.

When managing risks in all walks of life we strive to balance the costs of our actions and choices with the benefits that they provide, and managing trees should be no different. Although the majority of tree-risk management decisions are not analysed in terms of the detailed costs and benefits of risk reduction, the balance between the costs and benefits of implementing risk control underpins the process.

Risk Assessment

Risk assessment is the overall process of risk identification, risk analysis and risk evaluation. (ISO 2009). Developed for the assessment of risks from falling trees, the QTRA method enables cost-effective identification of the risks and quantification of the risk analysis to provide a numerical aid for the evaluation and treatment of risks.

A risk from tree failure exists only if (1) there is potential for tree failure and (2) potential for harm to result. It is the task of the risk assessor to consider both the likelihood and potential consequences of tree failure. The outcome of this assessment, which in QTRA is termed the 'risk of harm', will then inform the tree manager's evaluation of the risks. Additionally, the assessor's observations can inform consideration of benefits accruing from the tree.

Through the provision of a comprehensive range of values[1], QTRA enables the tree assessor to evaluate and quantify the risk from tree failure in three key stages. (1) to value property and land-use in terms of both vulnerability to impact and likelihood of occupation, (2) to consider the relative severity of impact, taking account of the size category of the tree or branch etc. concerned, (3) to quantify within broad bands, the assessor's estimate of the probability that the tree or branch will fail within the coming year. By multiplying these values the assessor can calculate an annualised[2] risk of harm from a particular hazard. This risk is considered against broadly acceptable and tolerated levels of risk and the risks from different hazards can be ranked and compared.

Taking a Proportionate Approach

The risks from tree failure are usually very low and high risks will most commonly be encountered in areas either with high levels of human occupation or

[1] See tables 1, 2, 3 & 4.

[2] The inputs to the calculation are considered over the coming year, therefore the risk of harm relates to the same timeframe.

with valuable property. In areas of low human occupation and low property value, the assessment of risks from trees may be unnecessary beyond valuing or categorising land-use. Even when land-use indicates that the assessment of trees is appropriate, it is seldom proportionate to calculate the risk for each tree in a population. Often, all that is required is a brief but particular consideration of the trees to identify gross characteristics of structural weakness or declining health.

QTRA enables a range of approaches from the broad risk assessment of large collections of trees to the detailed assessment of each tree where land-use and the character of the trees dictate. QTRA risk calculations for groups of trees are based on the highest risk tree and if the risk from that tree is tolerable, it follows that risks from the remaining trees will also be tolerable and further calculations are unnecessary.

2. DEFINITION OF TERMS

Risk

Risk is the combination of the probability of an event and its consequence (ISO 2009).

In terms of assessing risks from falling trees and branches, the commonly quoted equation 'risk = likelihood x consequence' is appropriate; e.g. risk is the product of (1) the likelihood that the tree will fail in the coming year, (2) the likelihood of the target being occupied, and (3) the magnitude of the expected consequence.

Risk of Harm

The QTRA output is termed the 'risk of harm' and is a combined measure of the likelihood and the consequence of tree failure considered in terms of the loss, within the coming year, of a human life, something of comparable value or a proportion thereof.

ALARP (As Low As Reasonably Practicable)

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

Cost and Benefit

Trees confer many benefits on people and the wider environment. Trees are essential to our well-being and enhance both built and natural environments. It is reasonable to assume that removal of all risks from trees would have disastrous consequences for the quality of life and our environment. When managing the risk from falling trees, as with 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 (HSE 2001). 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.

Acceptable and Tolerable Risks

People are constantly exposed to and accept varying degrees of risk. 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, air bags, and crash barriers, there is still a significant risk of death. This is an everyday risk that is taken for granted and accepted by millions of people in return for the benefits of convenient travel.

The 'Tolerability of Risk Framework' (ToR) (HSE 2001), which is represented graphically in Figure 1 considers a range of risk, with at one end the risk being 'broadly acceptable' – where there is no need to consider further risk reduction – and at the other end the risk is 'unacceptable' and not to be tolerated. However, when a risk is of such a magnitude that it is no longer broadly acceptable, it may still be tolerated if it is ALARP. In other words, the risk may be tolerable if the cost of further reducing it is grossly disproportionate to the benefit of risk reduction. Both 'tolerability' and 'gross disproportion' are concerned with whether or not the benefits of risk control are sufficient to justify the cost of the control.

In terms of its general application, the Tolerability of Risk Framework can be summarised as having (1) a 'broadly acceptable region' where the upper limit is an annualised risk of death 1/1 000 000, (2) an 'unacceptable region' of which the lower limit is 1/1 000, and between these (3) a necessarily wide 'tolerable region' within which the tolerability of a

risk will be dependent upon the costs and benefits of further risk reduction.

In respect of trees, many risks cross the broadly acceptable 1/1 000 000 boundary, but remain tolerable 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.

The UK Health and Safety Executive (HSE 2001) suggests that "***an individual risk of death of one in a thousand per annum should on its own represent the dividing line between what could be just tolerable for any substantial category of workers for any large part of a working life, and what is unacceptable for any but fairly exceptional groups. For members of the public who have a risk imposed on them 'in the wider interest of society' this limit is judged to be an order of magnitude lower – at 1 in 10 000 per annum.***" Furthermore, ***"HSE believes that an individual risk of death of one in a million per annum for both workers and the public corresponds to a very low level of risk and should be used as a guideline for the boundary between the broadly acceptable and tolerable regions."***(ibid).

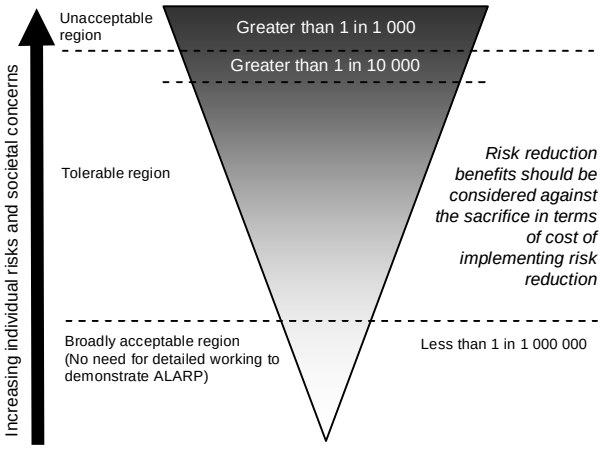

Figure 1. Adapted from the Tolerability of Risk framework (HSE 2001)

Value of Statistical Life

In QTRA, placing a statistical value on a human life has two particular benefits. Firstly, the 'value of statistical life' (VOSL), as a widely applied risk management device, uses the notional value of a hypothetical individual life to guide the proportionate allocation of resources to risk reduction. In the UK, this value is currently in the region of £1 000 000 - £1 500 000. ***"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). Secondly, the QTRA method utilises VOSL to equate the value of damage to property with the value of life e.g. where a life has a statistical value of £1 000 000, a building with a replacement cost of £10 000 is valued at 0.01 (1/100) of a life, which allows comparison of the risks to people and property.

Internationally, there is wide variation in VOSL and its computation. In QTRA, the value of £1 000 000 is currently applied both to provide a consistent basis for comparing the loss of life with the loss of property and to equate the costs and benefits of risk reduction. To provide consistency in QTRA outputs, VOSL of £1 000 000 should be applied internationally.

Target

In the context of tree-failure risk assessment, a target is anything of value that could be harmed in the event of tree failure.

3. 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. As individuals, we are concerned mostly with the risks to ourselves and those close to us, but as shared risks that are imposed upon the wider community become elevated, societal concern – through regulatory control or common law duties - will usually require the implementation of risk controls.

Although QTRA outputs might occasionally relate to the individual, this is seldom the case. More often in QTRA, calculation of the risk of harm is based on the total time that the target area is occupied – i.e. how many people per hour or how many vehicles per day – without attempting to identify how many different individuals 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 when formulating management decisions. On the one hand, the benefits associated with the risk may be enjoyed by the wider community, but not by those exposed to the risk and on the other, an

exposed person might explicitly accept an elevated risk in return for particular benefits.

4. THE QTRA METHOD

When applying the QTRA method, the assessor quantifies, as probabilities, the three components of the tree failure risk: 1) Target, 2) Impact Potential (size), and 3) Probability of Failure within the coming year. The quantifications are applied in broad ranges of value[3] and calculated using the upper value for each range, which are multiplied and their product is the annualised 'risk of harm'. To simplify the assessment process, the ranges, or bands, are applied on the basis of their upper values, but where the risk of harm approaches an actionable threshold the assessment can be considered in more detail before proposing control measures.

Target Evaluation

Frequent assessment of trees and of associated risks may be essential in areas of high public access where trees are within striking range of people or valuable property that is susceptible to damage. Conversely, in locations without valuable property and having very low human access, the survey and assessment of trees for safety is unlikely to be necessary. Therefore, the nature of the target beneath or adjacent to a tree will usually dictate the level of risk assessment that is required.

In the initial assessment of targets, six ranges of value are used. Table 1 sets out these values 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 a pedestrian will spend, on average, five seconds walking beneath the average tree. For example, ten pedestrians per day each occupying the target for five seconds is a daily occupation of fifty seconds, by which 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 structure, 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).

[3] See tables 1, 3 & 4.

The target will ordinarily be recorded in the QTRA as a range (1 - 6, Table 1). When the assessor identifies an elevated risk, the target can be more accurately calculated and recorded.

Often the nature of a structural weakness in a tree is such that the probability of failure is greatest during windy weather, whilst the probability of the site being occupied by people during such weather conditions is often considerably reduced; this particularly applies in woodlands, parks and private gardens. To account for the influence of weather on the risk from tree failure, the occupation by people is considered specifically in relation to weather conditions. 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 significantly increase, what will be the likely level of human occupation?' Taking this approach, rather than valuing the average usage, ensures that the assessor considers the multi-faceted relationship between weather, people and trees, and the sentient nature of the average person with their ability to recognise and avoid unnecessary risks.

A target can be constantly occupied by more than one person and it is necessary to consider the probability of multiple occupancy. For example, if it is projected that the average over a one-year period will be constant occupation by 10 people, the risk of harm in relation to one person constantly occupying the target is calculated before going on to identify that the average occupation is 10 people. This is expressed as target 1(10T)/1, where 10T represents the number of people or vehicles constantly occupying the target. In respect of monetary value of property, this would be equivalent to a risk of losing £10 000 000 as opposed to £1 000 000.

Vehicles on the Highway

In the case of vehicles, probability 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. 'Stopping distances' and an average vehicle length are used in the calculation of vehicle occupation of highways. The probability of a vehicle occupying any particular point in the road is the ratio of the time a point in the road is occupied by vehicles - including a safe stopping distance - to the total time in a day. 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-failure impacts and in particular, frontal collisions, QTRA values the substantially protected 1.6 average occupants summed with the average vehicle value as equivalent to one exposed human life.

Property

When assessing risks in relation to buildings, the target might be the building or the occupants and the building. It is necessary for the assessor to consider whether occupants of a building are either protected from harm by the structure or substantially exposed to the impact from a falling tree.

When evaluating the exposure of property to tree failure, it is necessary to estimate approximately the cost of repair or replacement that might result from failure of the tree as represented in Table 1.

As previously described, the ranges of monetary value for property used in Table 1 are based on the assumption that, for the purpose of the risk assessment, the loss of £1 000 000 is equivalent to the loss of a life. For example, target range 2 represents a probability of human occupation up to 1/20 (£1 000 000 ÷ 20 = £50 000). Therefore, a likely property repair cost of £50 000, which is one-twentieth the value of VOSL, is apportioned 1/20 in the QTRA.

On 1st January each year, Quantified Tree Risk Assessment Ltd. provides users of the method with monetary conversion rates that enable application of the method internationally.

Table 1. 'Target' ranges for property, pedestrians and vehicles.

Target Range	Property (repair or replacement costs)	Pedestrian Frequency	Vehicular Frequency examples	Probability (of occupation or fraction of value of £1 000 000)
1	>£50 000 - £1 000 000	>36 per hour - constant	26 102 vehicles @ 110kph (68mph) 32 359 vehicles @ 80kph (50mph) 46 702 vehicles @ 50kph (32mph)	1/1
2	>£14 000 - £50 000	>10 per hour - 36 per hour	1 305 vehicles @ 110kph (68mph) 1 617 vehicles @ 80kph (50mph) 2 335 vehicles @ 50kph (32mph)	1/20
3	>£1 400 - £14 000	>1 per hour - 10 per hour	363 vehicles @ 110kph (68mph) 449 vehicles @ 80kph (50mph) 649 vehicles @ 50kph (32mph)	1/72
4	>£60 - £1 400	>1 per day - 1 per hour	36 vehicles @ 110kph (68mph) 45 vehicles @ 80kph (50mph) 65 vehicles @ 50kph (32mph)	1/720
5	>£10 - £60	> 1 per week - 1 per day	2 vehicles @ 110kph (68mph) 2 vehicles @ 80kph (50mph) 3 vehicles @ 50kph (32mph)	1/17 280
6	≤ £10	≤ 1 per week	None	1/120 960

Vehicular, pedestrian and property targets are categorised by their frequency of use or their monetary value. For example, the probability of a vehicle or pedestrian occupying a target area in 'target' range 4 is between the lower and upper limits of >1/17 280 and 1/720. E.g. using the 'value of statistical life' of £1 000 000 the property repair or replacement value for 'target' range 4 is >£60 - £1 400.

Vehicular frequency examples for 'target' range 1 are calculated on the basis of the stopping distance for a given road speed providing a duration of occupation for the average vehicle on that road. The total time in a day is divided by the duration of occupation with the quotient being the number of vehicles per day required to produce constant occupation. All other 'target' ranges are calculated as a proportion of the 'target' range 1 value.

Impact Potential

A small dead branch of less than 10mm diameter is unlikely to cause significant harm even in the case of direct contact with a target, whilst on average 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 increased potential for harm in relation to the size of tree or branch is proportional to a degree but this is by no means a linear relationship and there is a limit to the severity of harm in relation to the force upon impact by a tree.

The QTRA method categorises 'Impact Potential' by the diameter of tree stems and branches. A biomass equation derived from weight measurements of trees of different stem diameters is used to produce a data set (Table 2) of comparative weights of trees and branches ranging from 10 to 600mm diameter.

A diameter of 600mm has been selected to represent upper limit of size in the QTRA calculation. This threshold provides a baseline for the comparative valuation of potential impact from trees. The increased potential for harm from trees larger than 600mm diameter is not considered in terms of increased force upon impact, but might be considered in relation to the increased target area that could be affected by a larger tree.

The 'impact potential' values are grouped into five ranges of size (Table 3).

Occasionally, an assessor will take the view that the reduction in mass arising from dieback and degradation of a tree or branch is significant in the risk assessment and will discount the Impact Potential component by applying a 'reduced mass' value. If the mass of a branch is considered to be half that of a live branch of the same diameter, a reduced mass of 1/2 might be applied, reducing the 'impact potential' and thereby the overall risk of harm by half. This consideration might be on the basis that the branch is lighter as a result of degradation (lesser force on impact) or is reduced in size (smaller area of impact), and while the latter could be considered by adjusting the target value, this would usually require a disproportionate amount of time in revaluing the target.

Table 2. Biomass weight estimates.

Dbh (mm)	Weight (kg) $y=ax^b$	Fraction of weight as a ratio
10	0. 11263	1/23 505.722
25	1. 0713	1/2 471.6699
50	5. 8876	1/449.74
100	32. 357	1/81.834
150	87. 67	1/30.203
200	177. 82	1/14.891
250	307. 77	1/8.604
300	481. 81	1/5.496
350	703. 8	1/3.762
400	977. 26	1/2.71
450	1 305. 5	1/2.03
500	1 691. 4	1/1.566
550	2 138	1/1.24
600	2 647	1/1

Source. Tritton & Hornbeck (1982)x=dbh (cm); y=dry weight estimate; a=allometric coefficient 0.1126294414; b= allometric coefficient 2.458309949

Table 3. Impact Potential.

Impact potential range	Size of part likely to impact the target	Impact Potential
1	> 450mm (18") dia.	1/1
2	> 250mm (10") dia.- 450mm (18") dia.	1/2
3	>100mm (4") dia.- 250mm (10") dia.	1/8.6
4	> 25mm (1") dia.- 100mm (4") dia.	1/82
5	10mm (2/5") dia.- 25mm (1") dia.	1/2 500

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

Probability of Failure

The Probability of Failure component has seven ranges, each representing a range of probability of tree or branch failure occurring within the coming year, and calculated from the upper value of that range. Probability of failure is recorded in the QTRA assessment as the upper limit of a range (1 – 7, Table 4).

Table 4. Probability of Failure.

Probability of failure range	Probability
1	1/1 - 1/9
2	1/10 - 1/90
3	1/100 - 1/900
4	1/1 000 - 1/9 000
5	1/10 000 – 1/90 000
6	1/100 000 – 1/900 000
7	≤1/1 000 000

The probability that the tree or selected tree-part will fail within a year.

The QTRA Calculation

The product of the three component values is the annualised 'risk of harm', which is expressed as a probability and rounded, to one significant figure.

Below are two examples of QTRA calculations.

Example 1.

	Target		Impact Potential		Probability of Failure		Risk of Harm
Range	6		1		3		
Probability	1/120 960	x	1/1	x	1/100	=	1/10 000 000

Example 1 is the assessment of a large, very unstable tree with a probability of failure of between 1/100 and 1/900 for the coming year situated in a low use recreational area. The target is a footpath with less than one pedestrian passing the tree each day and falls within target range six.

Example 2.

	Target		Impact Potential		Probability of Failure		Risk of Harm
Range	1		2		5		
Probability	1(5T)/1	x	1/1	x	1/10 000	=	1(5T)/10 000

In example 2, a large defective branch overhangs a busy urban high street that is on average occupied constantly by five people and here multiple target occupation is considered.

The risk of harm 1(5T)/10 000, having an occupancy of five people, has a fivefold increase in the magnitude of consequence and is therefore equivalent to a risk of harm 1/2 000 and would ordinarily require risk control.

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 a risk can be assessed within broad ranges where this is sufficient and with greater rigour when required.

Where the input values are broadly estimated, the proposed risk thresholds should be applied cautiously. Where the manager is reasonably confident in the input values, the thresholds can be more rigorously applied. An example of this would be where, based on an initial brief assessment, a recreational woodland target is estimated to be within range 5 (up to one person passing each day). As a result, no tree in the woodland can achieve a risk of harm exceeding 1/20 000. This is because even with a large unstable tree the 'general limit of tolerability' of 1/10 000 is not exceeded (target 1/17 280 x impact potential 1/1 x probability of failure 1/1 = 1/20 000). If the occupancy is based on accurate historical data, a detailed assessment of the trees is unlikely to be necessary for safety purposes. However, in order to make a decision not to assess the trees, it would be necessary to be reasonably confident that the target valuation is either based on accurate data or an over estimate. If the landowner had estimated an occupation of one person every two or three days, one could be reasonably confident that there was no need to assess the trees because range 5 values the target at one person a day. Conversely, where the occupancy might be as high as two or three people a day, then it could be appropriate to monitor and measure occupation more accurately.

5. MAKING RISK MANAGEMENT DECISIONS

Applying the ToR Framework to QTRA Outputs

It is proposed that, in applying ToR to the outputs of QTRA, an annualised risk of harm 1/1 000 000 is the 'broadly acceptable limit', below which the risk is already ALARP. A risk of significant harm, 1/10 000 is the 'general limit of tolerability' and 1/1 000 is the 'extraordinary limit of tolerability'.

Between the 'broadly acceptable limit' (1/1 000 000) and the 'extraordinary limit of tolerability' (1/1 000) is the 'tolerable region of ToR. Where a risk falls within this region, it is necessary to consider whether it is ALARP. Here, management decisions are informed by consideration of the costs of risk control, including the nature and extent of benefits that would be lost to risk control measures. The assessor might consider the costs of risk control when providing options for management, but the tree manager, who owns the risk and exercises control over the costs, will consider the balance and make the final decision.

Considering Benefits from Trees

When implementing risk reduction there will usually be a financial cost. In this regard and even without considering the non-monetary costs, VOSL can be used to evaluate the proportionality of a risk control.

Using a VOSL of £1 000 000, it can be established that a reduction in the risk of death from 1/10 000 to 1/1 000 000 – from the 'general limit of tolerability' to 'broadly acceptable' - has a value of £100 per year. Example 3 puts this evaluation into a tree management context where the benefit in terms of risk reduction can be considered against the financial cost.

Example 3.

	Target		Impact Potential		Probability of Failure		Risk of Harm
Range	3		3		3		
Probability	1/72	x	1/8.6	x	1/100	=	1/60 000

In example 3, a large defective branch (impact potential range 3) overhangs a country road along which travel on average five hundred vehicles each day at an average speed of 30 mph (target range 3). The branch has a compromised attachment to the tree and is assessed as having a probability of failure for the coming year of between 1/100 and 1/900. The risk of harm is calculated as 1/60 000 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 roughly estimated at £250. To establish whether this is a reasonable cost of risk control, the following equation is applied. £1 000 000 x 1/60 000 = £16.66 indicating that the projected cost of £250 would, even if allocated over ten years, probably be grossly disproportionate to the risk when considered in addition to the tree-related benefits that will be lost and the risks to tree workers from implementing the risk control measure.

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 the 'general limit of acceptability' of 1/10 000 would be deemed tolerable. These thresholds and costs, against which risk reduction is balanced, can be informed by the risk assessor but must be selected by or agreed with the owner or manager of the risk.

Summary of QTRA Risk Thresholds

1. Broadly Acceptable: 1/1 000 000 – below which the risk is already ALARP.
2. Tolerable Region: between 1/1 000 000 and 1/1 000 – risks will be considered in order to determine whether they are ALARP and the costs of both expenditure and lost benefits will be balanced against the benefits of risk reduction.
3. General Limit of Tolerability: 1/10 000 – the limit of tolerability for the imposition of a risk upon others. This limit will usually be tolerable if the risk manager considers that tree confers not necessarily a special benefit, but a reasonable level of benefit that might ordinarily be expected from a tree of its type and age.
4. Extraordinary Limit of Tolerability: 1/1 000 – The upper limit of risk tolerance, which might be applied in exceptional circumstances where particularly special benefits would be lost to risk control measures. Management decisions to retain trees that are assessed as being between 1/10 000 and 1/1 000 would ordinarily require broad stakeholder support.

A tree owner may choose to operate to a higher or lower 'general limit of tolerability' than the proposed 1/10 000, but whatever level is chosen, the precision with which limits are applied should reflect the manager's confidence in the risk assessment outputs.

International Versions

As with previous versions, monetary values in this practice note will be adapted for use in all countries where there are QTRA users. Currency specific versions will be available at www.qtra.co.uk from 1 September 2012.

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Revisions

Revision 4.02 (September 2011). Modified layout.
Revision 4.03 (August 2012). Modified probability of failure component. Table 4 and examples updated. Outputs modified to one significant figure. Comma separators removed from numerical values. References updated.

APPENDIX 6

GUIDANCE NOTE- STATUTORY CONTROLS

TREES AND HEDGES:

Subject to certain specified exemptions, the Town and Country Planning Act 1990, requires that an application must be made to the local planning authority (LPA), to carry out works upon or remove trees that are subject to a tree preservation order (TPO).

Six weeks' notice must be given to the LPA of intention to carry out works upon or remove trees within a conservation area and not protected by a TPO.

Local planning authority consent may be required to carry out works upon or remove trees, shrubs and hedges that are the subjects of planning conditions.

LPA consent may be required for the removal of hedgerows under the Hedgerow Regulations 1997.

Your Council's planning department will advise whether or not any of the above controls apply to your trees, shrubs and hedges.

Subject to certain exemptions, the Forestry Act (1967 specified) requires that a licence must be obtained for the felling of growing trees

Your nearest Forestry Commission office will advise whether you require a felling licence.

WILDLIFE

The Wildlife and Countryside Act 1981 (together with the amendments of 1985 & 1991, the subsequent variations to the schedule orders, and strengthening amendments made within the Countryside and Rights of Way Act 2000) forms the basis for legislation protecting Britain's flora and fauna.

Nesting birds and all species of bat are afforded statutory protection. It is an offence to:

- disturb a nesting bird
- disturb a roosting bat or damage, destroy or block access to a bat roost
- intentionally kill, injure or take a bat
- sell, hire, barter or exchange a bat, dead or alive
- be in possession or control of a bat or anything derived from a bat

Your local Wildlife Trust or your Council's Ecologist will provide guidance on statutory controls relating to wildlife.