ATTACHMENT G

THE SUGAR FACTORY – REPORT ON INCLUDED BRANCHES

ATTACHMENT G

Report

Inspection of Included Bark on Twenty-two

Hill's Weeping Fig *Ficus microcarpa* var. *hillii*

In Hyde Park North & South, Sydney CBD

Prepared for

The Council of the City of Sydney

By

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Ref: cos020

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1 Introduction

This report was commissioned by Ms Karen Sweeney, City Arborist of the City of Sydney.

The brief for the report was:

1. Undertake an inspection of the 14 [Central Avenue] trees identified with 'significant inclusions' in the Tree Wise Men (TWM) report dated April 2013 (Attachment B – Tree Schedules).

2. Advise if you consider these trees to have a 'significant inclusion'. Please include information on what you consider is a 'significant inclusion'.

3. Review the email provided by TWM (dated 20 July) regarding the recommended actions (i.e. removal of trees with significant inclusions), and advise if these actions are supported.

4. Provide comments on alternative options considered appropriate for these trees – such as pruning, cable/ bracing etc.

While on site, the brief was extended to include a further eight trees in the inspection.

The assessment found that twenty-one of the trees can be retained and subjected to maintenance pruning, and that one (younger) tree is of such defective structure it would best be removed and replaced (tree 292S).

2 The Trees

The trees were those numbered as follows:

Hyde Park North - 195N, 188N, 184N, 186N, 218N, 169N, 227N, 264N, 255N, 129N, 79N.

Hyde Park South – 86S, 89S, 90S, 69S, 71S, 270S, 269S, 266S, 271S, 292S, 245S.

The location and size of the members with included bark was contained in the report by Tree Wise Men, reference 1487-2012 MonAerialNTabFinalRev C.

3 Methodology

The trees were assessed by my self and Mr Peter Castor of Tree Wise Men Australia P/L.

The trees were inspected from ground level and from an Elevating Work Platform or 'cherry-picker' where the height of the member with included bark warranted. The EWP was provided by City of Sydney.

The Tree Wise Men definition of 'significant' in terms of included bark was said by Mr Castor to be when the line of inclusion extends down both sides and across the top of the union. In many instances it was necessary to use the EWP to verify that the line of inclusion extended across the top of the union.

In my experience with Hill's Weeping Figs, I have come to regard included bark as a characteristic which has a tendency to fail when accompanied by warning signs in the trees' body language or when in particular configurations. The appendix to this report contains extracts from various reports I have written concerning the failure of Hill's Figs with included unions, for Council's information.

4 Summary of Findings

Each of the 14 trees in the Central Avenue described by TWM as having 'significant' inclusions were found to have unions which met the TWM description of 'significant'. Mr Castor and I discussed the implications of the unions and agreed upon a course of either removing the affected part or modifying the load by pruning.

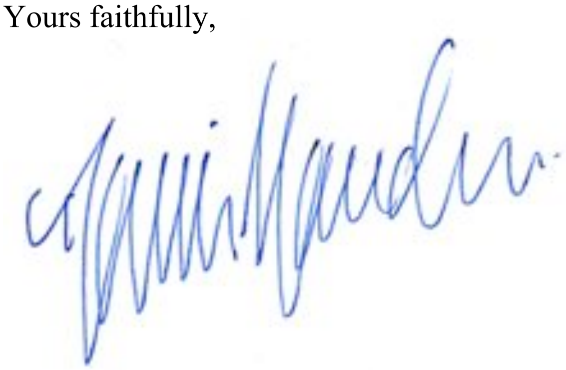
The location and description of potential defects is contained in the TWM report dated 9 August 2013, reference 2110-J21HydeParkAugust13ReviewAdden02Final.

I have been provided with a copy of that report, and confirm that the details contained therein are an accurate and faithful record of our joint inspection.

In respect of the failure patterns contained in the Appendix to this report, none of the inspected trees displayed actual cluster-wedge arrangements although some trees were tending towards this. Several of the inspected trees displayed 'I-beam' reaction wood although none were particularly pronounced. One tree only displayed a potential notch defect on a fork on a lateral however this had already been identified by TWM as a problematic union (tree 195N).

In relation to Points 3 and 4 of the Brief, I understand that the removal of trees with 'significant inclusions' *etc* was put forward as an option in the event that the proposed Block Removal programme did not proceed. As stated in my previous report to Council, I support the Block Removal programme. I consider that the recommended monitoring and pruning outlined in the TWM report of 9 August 2013 is an appropriate interim measure that will allow those trees, the subject of the joint inspection, to be retained for the near future, with the exception of tree 292S.

Yours faithfully,



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Appendix A Observations Concerning Included Bark in Hill's Figs

A.1 The Cluster Wedge

Mattheck & Breloer (1994) describe the effect of multi-stemmed hardwood trees with individual stems growing on leans as developing problems due to the formation of reaction wood on the tensile side of the stems towards the base. (Figure A, below).

MANIFESTATIONS OF TREE FRACTURES 61

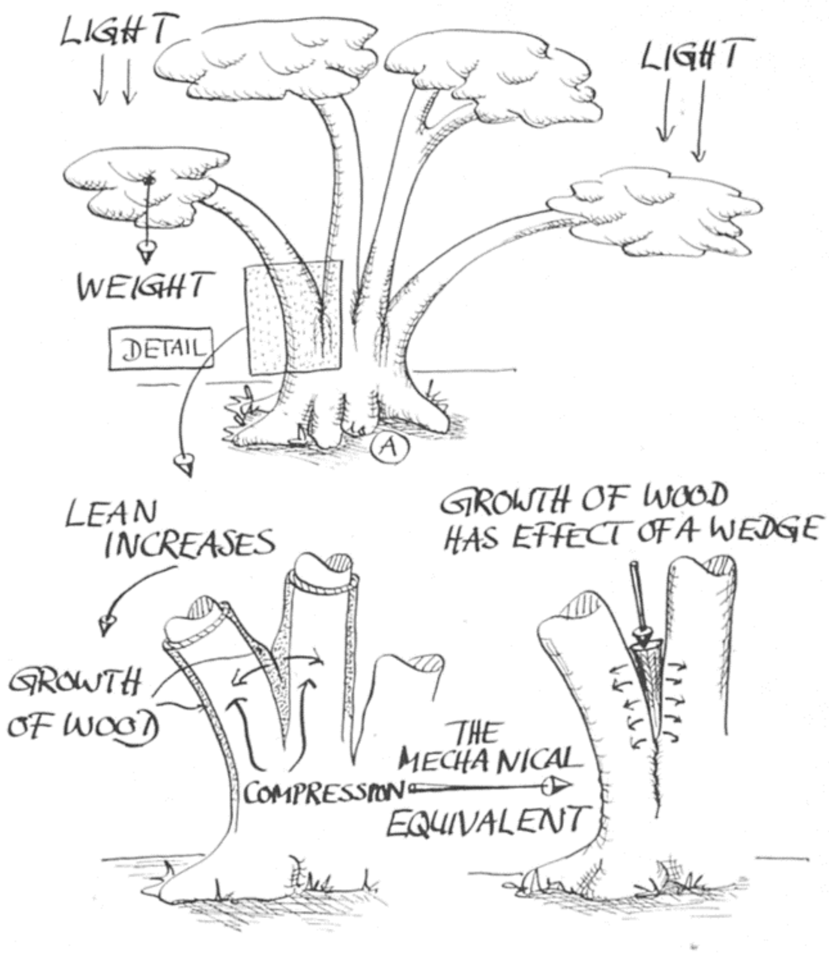

Fig 36. A cluster of beech stems struggling to escape each other so as to get to the light do not form common annual rings but press against each other at their stem bases, which are thus forced apart.

Hardwood species will preferentially reinforce loaded areas by the formation of locally thicker growth rings (reaction wood) on the upper or tensile side of the lean.

With 'cluster wedges' the reaction wood thickens on the topside of the leaning stem and presses against the neighbouring stem.

The stems also produce growth rings, meaning that the vertical stem, while not necessarily producing reaction wood, will still increase in girth and press against the adjacent stem. The reaction wood of the leaning stem exacerbates the problem.

Mattheck & Breloer describe this pattern of growth as being the mechanical equivalent of a wedge acting to drive the stems apart, adding that the cluster is "suicidally programmed to fall apart."

This particular pattern of growth has been a major factor in stem failure of multi-stemmed Hill's Figs in Newcastle Precinct (photograph A, below).

Photograph A. Stem failure due to 'cluster wedge' configuration. Note large ridge of reaction wood on tensile side of failed stem (arrow).

This configuration can be found not only in multi-stemmed Hill's Figs, but also in the congested regrowth of stems/scaffolds in Hill's Figs when the tree has been topped or heavily lopped long ago and left to regrow.

A.2 The 'Notch' Defect

Mattheck & Breloer (1994) write in regard of notches:

> *"… a flawed structure is characterised by one or more potential fracture points where locally high stresses develop. Failure is predictable in certain kinds of structure that show such faults. This is most commonly the case at so-called 'notches', which is an engineer's description of any concave configuration within a component which diverts the force flow around it…. Notch stresses…occur where the force flow, diverted by the notch, is greatly intensified, i.e. a higher force flow per surface element is conveyed."*

Elsewhere, Mattheck & Breloer (1994) write of the 'notches' caused by beavers in stems, whereby the beavers have an uncanny ability to gnaw out a notch to more or less the precise point that will lead to the failure of the stem under normal, day-to-day conditions. In computing the forces that act upon the stem, it was found that the safety factor of the stem had been reduced to 1 (from approximately 4.5) once the notch occupied 50% of the stem diameter (figure B. left). At this point the failure load equals the day-to-day working load, and so the component breaks.

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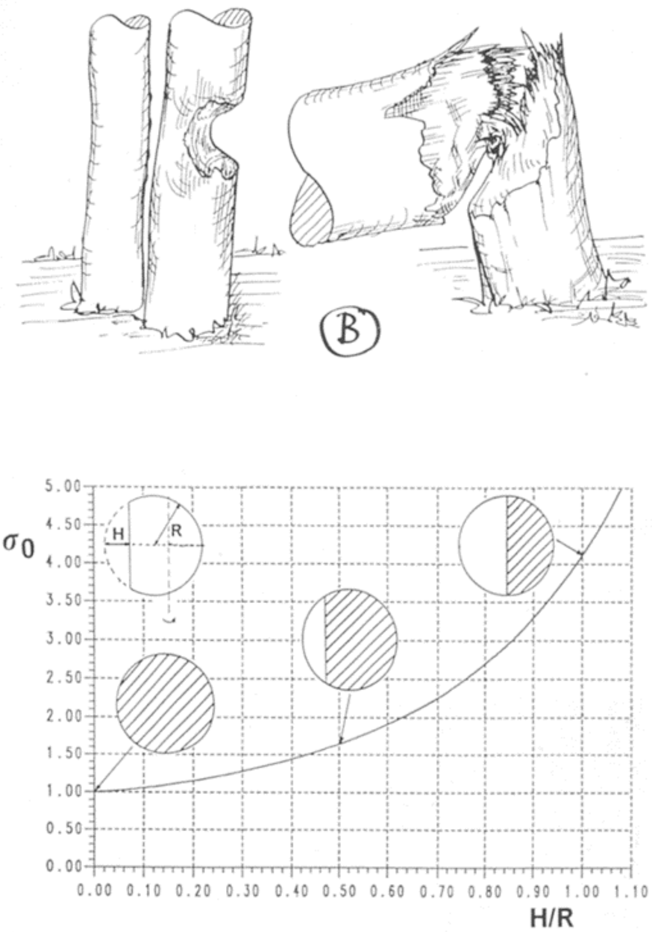


Computing: Dagmar Erb

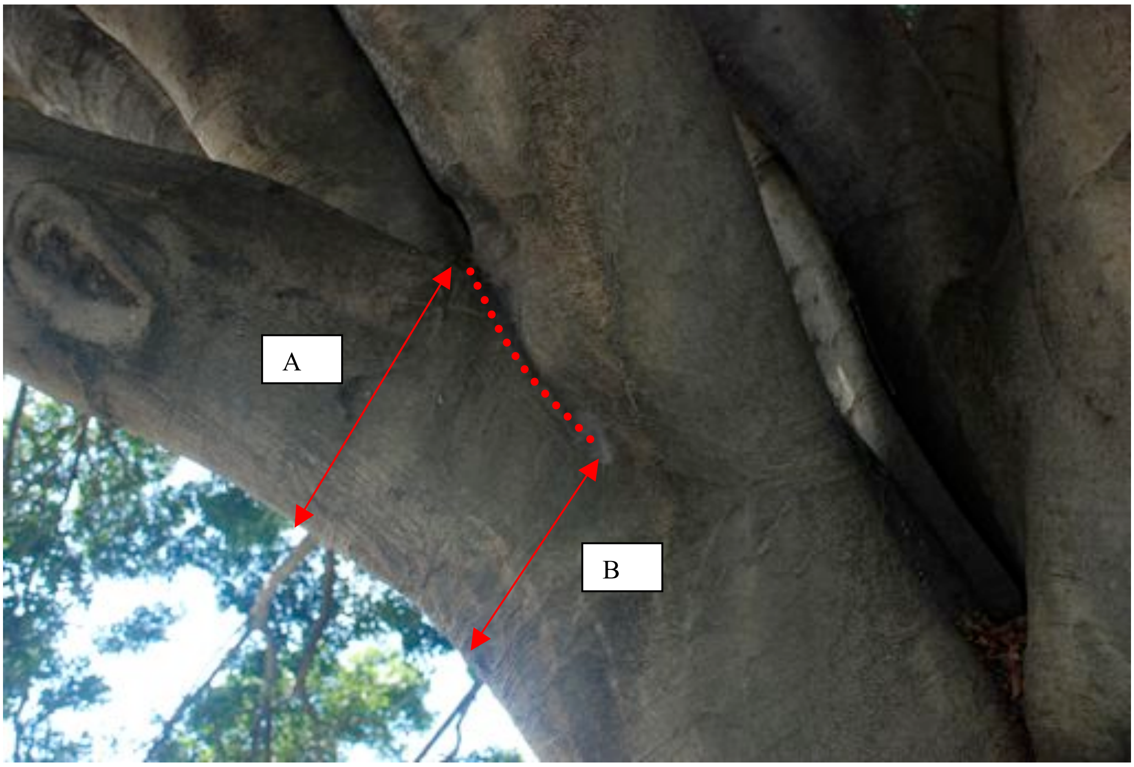
Fig 77. Field experiments for determining the safety factor in resistance to stem-breaking in trees (sawn sections: Jörg Sigmund).

A: Window cut in tree.

B: 'Beaver gnawings and related increase in stress' (Prof. Dr. Kübler kindly showed us these trees).

The 'notch' defect has a general corollary in the type of constriction sometimes caused by included bark, that is, the stem or branch diameter above the inclusion is sometimes much greater than the stem or branch diameter below the inclusion. The proximity of the adjacent member constricts the development of the first member.

This is perhaps best illustrated by Tree #5/018 in *[Redacted]* Park (photograph B, below).



Photograph B. 'Notch' defect in Tree #5/108.

Note the difference in branch diameters at Line A and Line B. The dotted line shows the seam of included bark. From the photograph it should be clear that a tensile force or downward-bending load applied to that particular branch will result in a tensile force flow along the topside of the branch with the force flow then being deflected along the concave seam of the inclusion. The stress of the force flow is greatly intensified in the notch between points A and B.

While included bark is recognisable as a defect, the condition is common to Hill's Figs and it would not be an appropriate treatment to remove all branches or fell all trees that display this characteristic. Not all branches with included bark fail. Anecdotally and empirically, failure due to included bark appears to be the exception and not the rule, given the high incidence of included bark on Hill's Figs and the relatively few reports of failure.

There currently exist no qualitative parameters for the assessment of the likelihood of branch failure due to included bark, yet because included bark is recognised as a defect, there exists a need to 'draw the line' somewhere in order to identify parts which may have a higher than normal risk of failure, based upon known failure patterns of the species.

Matheny and Clark attach great weight to species failure profiles, as differing species can vary widely in their failure patterns. They state that knowledge of the type of failure and associated defects is invaluable in making hazard evaluations. By observing typical failure patterns, it can be recognised that species have general themes in defects and failure[1].

There appears to be two themes in branch failure due to included bark in Hill's Figs: failure of young or smaller diameter branches, and failure of large mature branches. What is common to both, though, is that the inclusions are deep rather than shallow.

In our experience, branches with included bark on young Hill's Figs or smaller diameter branches with included bark on mature trees are more likely to fail under wind load. Mature, large diameter branches are more likely to fail due to end weight. The reason for this is the greater degree of flexibility of young or small diameter branches. When under wind load, such branches can flex over their entire length, which has the effect of concentrating the stresses at the point of branch attachment. If the inclusion is relatively deep when compared to branch diameter, the branch fails.

Mature, large diameter branches possess a greater degree of rigidity towards the base, with the outer portions of the branch being flexible. Wind loads will bend the outer part with the stresses being dissipated over the length of the branch before the stress reaches the base. (This is obviously not the case under extreme wind conditions, when even the soundest of branches or trees can fail).

In Newcastle Precinct, failures of mature parts have occurred under relatively calm conditions. One factor common to stem failure (in particular, the cluster wedge failure) has been light rainfall over the night preceding the failure. The additional weight of water held by the foliage was an apparent 'straw that broke the camel's back' in a cumulative group of factors that lead to failure.

Mattheck (2007) describes included bark as functioning as a pre-existing crack, saying that the crack becomes longer as the branch increases in girth with failure occurring when the 'critical crack length' is reached[2]. Mattheck does not put a figure on the 'critical crack length', and perhaps rightly so given that failure due to included bark varies widely across different species and included bark *per se* is not the sole factor influencing failure.

However, the tree assessor is required to reasonably foresee the failure of defective parts and put in place measures that will minimise or eliminate the risk of injury or damage to persons and property.

The absence of qualitative parameters for assessing included bark on tree species such as Hill's Figs (which have a propensity to produce branches and stems with included bark) has lead to Newcastle City Council adopting a method of assessing included bark whereby branches or stems that do not comply with the adopted parameter will be *deemed* to be at risk of failure and the part will then be modified or removed as necessary.

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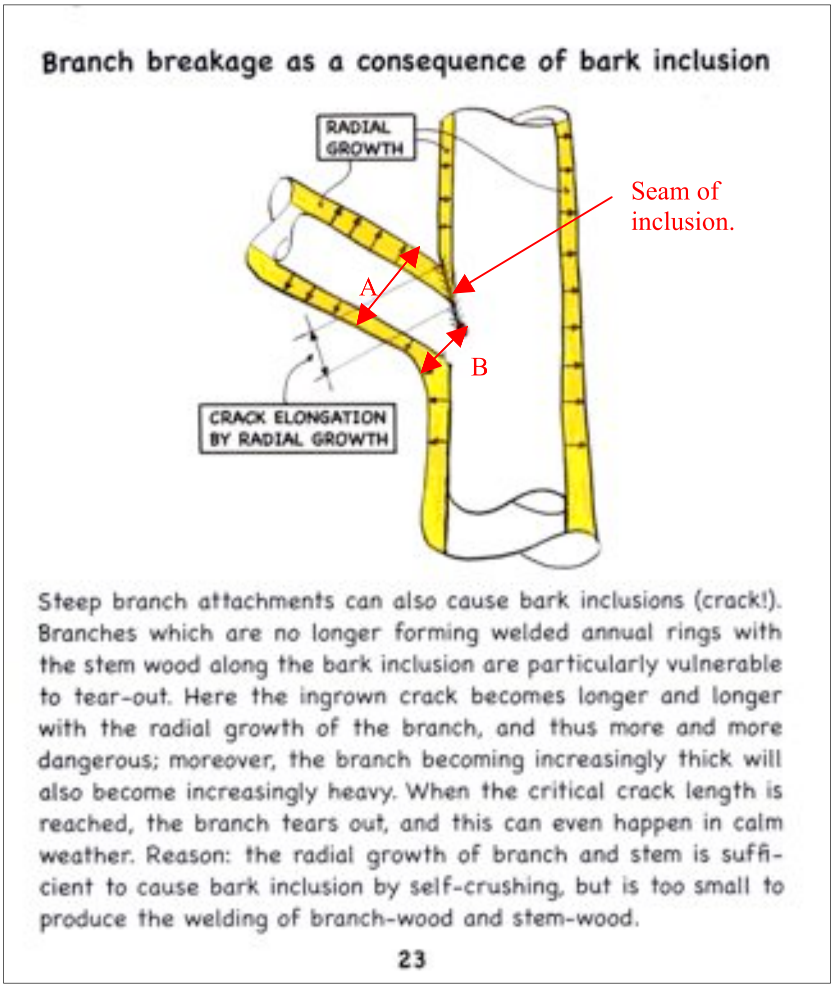
[1] Matheny, N. P and Clark, J. R (1994, 2nd ed) *'A Photographic Guide to the Evaluation of Hazard Trees in Urban Areas'* International Society of Arboriculture, Champaign, Illinois.
[2] Mattheck, C (2007) *'Updated Field Guide for Visual Tree Assessment'* Karlsruhe Research Centre, Karlsruhe.

The parameter is derived from the 'notch' described earlier in this report, where stem failure occurs if the notch reaches halfway (50%) through the stem. (Admittedly the notch caused by beaver gnawing is a sudden change introduced to the tree, akin to taking a chainsaw and cutting a scarf in the stem. Branches with included bark will slowly optimise to reduce the stresses acting on the weak point and strictly speaking will not be so quick to fail).

Included bark can cause a constriction similar to a notch. The 'critical crack length' of the inclusion is described in Figure C, below, from Mattheck 2007. In that figure, the red arrows, the letters A and B, and the words "seam of inclusion" have been added by this author.

The parameter developed for and adopted by Newcastle City Council is this: if the distance B is 60% or less of the distance A, the branch or stem will be deemed to be at risk of failure due to weak attachment. Once distance B is 60% of distance A, the constriction or 'notch' extends to 40% of the branch diameter. Compare this to Photograph B, two pages previous.



The configuration is first visually assessed with the distances A and B measured by tape, and then evaluated. If doubt exists over the shape of the branch within the union, the location of the seam of inclusion can be verified by taking a few readings with a resistograph.

Note again that this is not an industry-wide parameter. The adoption of this a parameter for assessing included bark on Hill's Figs in Newcastle Precinct involved discussion with the City Arborist, Council Engineers (Structural), Council's Safety/Risk Management Officer, and Managerial Staff, before approval was granted to use this method of assessment. To date, this methodology has only been applied to Hill's Figs.

Other organizations are advised to follow a similar consultative course in order to determine the acceptability of the methodology to the organization involved.

Caution should be applied in the adoption of this methodology, as it will not necessarily identify all parts that may fail because of included bark. Arborists cannot detect every condition that can possibly lead to the structural failure of a component.

Another configuration which tends to fail is when laterals grow horizontally and carry a fork in vertical alignment, i.e. one member above the other, with the interface characterised by included bark. The typical failure profile is the lower member tearing out.

A.3 The I-beam

The I-beam is used to describe the shape of the stem or branch, which has a tendency to form a girder-like cross section (more like an inverted 'T') due to the amount of tension wood formed on the topside. This has been one sign in the tree's body language that has been common to the failure of major parts of Hill's Figs in Newcastle precinct (photographs C and D, below).

Photograph C. I-beam shape of failed stem, September 2008.

Photograph D. I-beam shape of failed stem, April 2004.

Hill's Figs will produce this type of tension wood on heavily loaded leaning stems or branches as a matter of course. In order for the I-beam to be considered a component of a potentially defective part, several other conditions should be met: the branch or stem is growing on a moderate to strong lean, the point of attachment is characterised by included bark, and, an actual cluster-wedge configuration exists at the point of attachment.