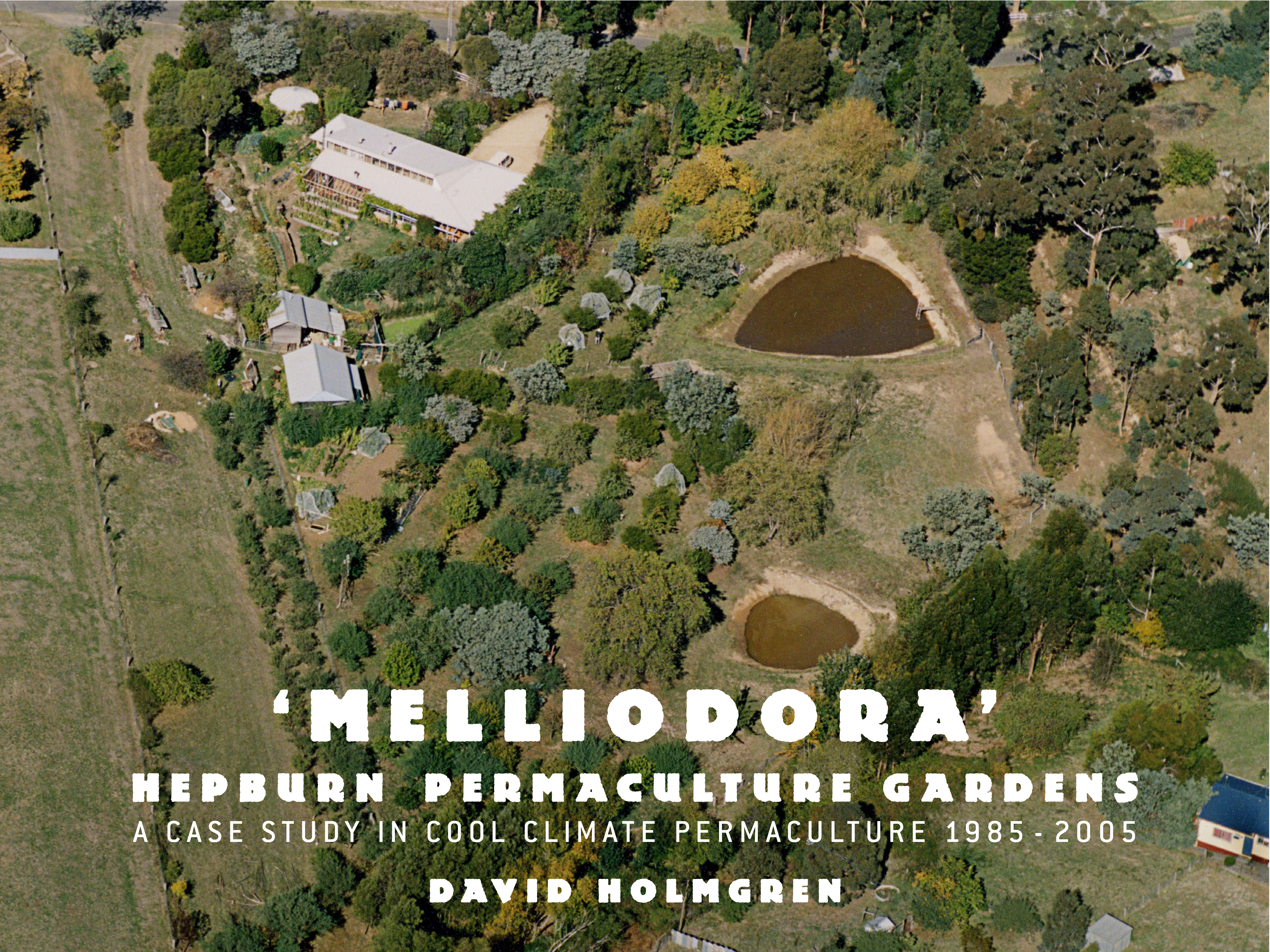

‘MELLIODORA’

HEPBURN PERMACULTURE GARDENS

A CASE STUDY IN COOL CLIMATE PERMACULTURE 1985 - 2005

DAVID HOLMGREN

SUSTAINABLE LIVING AT 'MELLIODORA' HEPBURN PERMACULTURE GARDENS

A CASE STUDY IN COOL CLIMATE PERMACULTURE 1985 - 2005

DAVID HOLMGREN

eBook Version 1.0

Combining family home, design consultancy office, self reliant small farm and demonstration site, Melliodora shows the best of cool climate permaculture design, relevant to both small rural properties and larger town blocks.

Book Credits 1995

Published by Holmgren Design Services
16 Fourteenth St, Hepburn, Victoria 3461

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Plans & Diagrams: Kerry Wise

Illustrations: Greg Holland

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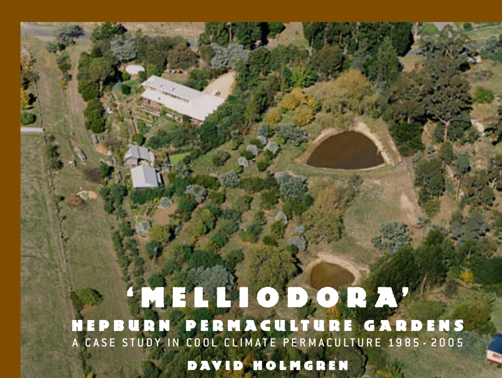
Dedication

Since beginning work on this book in 1991, the memory of Doug Swing keeps coming up. Doug became a close friend while helping to build our home. Like his tireless efforts in local community affairs and issues, Doug's contribution to this project and the people involved was greater than his paid job as builder's labourer. Doug Swing's death in August 1989 strongly affected our whole family.



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Richard Dent for his enthusiastic and foundational work on the virtual tour concept and in converting the original book into the prototype eBook.

Richard Telford for his creativity and dedication in the design and production of the eBook.

Others who contributed to the project were our neighbours Ewan McEoin, Joe Cummins, Fran Woodruff & Isolde Maranti

Dedication

The development and documentation of Melliodora over the last seventeen years reflects that of our son Oliver Holmgren who was born in Hepburn in May 1986. From the toddler on the building site, to the boy in the garden, to his creative contribution and technical support in producing this electronic update of the original book, Oliver's experience and memory of this place is another recording of Melliodora.

CONTENTS

Virtual Tour | Seasonal Cycles | More recent photo | More recent text | HDS resources

*"The question which must be addressed, ...
is not how to care for the planet, but how to care for each of the planet's millions of human and natural neighborhoods, each of its millions of small pieces and parcels of land, each one of which is in some precious and exciting way different from all others"*

Wendell Berry 1989

THE CASE STUDY APPROACH

Writing a book about permaculture (or any other subject for that matter) is normally about generalities; general principles, strategies and techniques which readers can apply in their own ways. Many books make use of examples to illustrate and maybe inspire but rarely are whole projects documented in their detail. To do so would be to reduce the universal or general value of the book for a wide readership. Consequently case studies with limited applicability (and therefore market) are of little interest to most book publishers.

There is now an increasing number of books available on permaculture which explain principles and provide a "toolkit" of design systems and elements which readers might apply. However, these books don't show how the constraints and prospects of a real situation have been tackled by real people. Videos and magazine articles can provide a glimpse but only a book can cover the nitty gritty details of interesting projects.

The widely acknowledged shift in electronic media from broadcasting to "narrowcasting" is paralleled by a fragmentation of the print media providing more detailed and specific information to smaller numbers of readers. Combined with the technology of desktop publishing this will lead to an increasing role for case study publications.

Melliodora is now well established as a permaculture demonstration site, documented in a variety of ways. The idea of this book, and a video currently in production, is to provide more detailed information about the project, its development and the lessons learned in the first decade. The long gestation period has allowed substantial revision (1995), of text first written in 1991.

Most importantly, I have been able to include some retrospective assessments of some of the elements of the property development, where significant lessons have been learned.

In encouraging readers to adapt and make use of what we have done to their own situations, I would like to emphasise the danger in attempting to transplant our design or parts of it to another site. Every place, context and person is unique, as should be every permaculture design. Similarly, just because we don't have a herb spiral, swales or chicken tractor doesn't mean these or many other elements are inappropriate in other sites and situations. My greatest fear from the success of Melliodora is that other equally creative examples of permaculture are ignored or undervalued.

A further note of caution is appropriate. Although Melliodora is clearly an example of my work, the degree to which I can design a similar system for clients as a design consultant is limited.

I can design, or help design the skeleton or framework within which clients may develop permaculture as a living evolving system. However, I cannot apply myself to someone else's design, the way I have to our own. Clients could not afford the cost and I would not be prepared to devote the time and creative energy required. The living, evolving system which we call permaculture can only come about as a result of the continuous interaction between the client as designer/practitioner and the elements of climate, soil, plants, animals, buildings and people.

David Holmgren May 1995

ORIGINAL ACKNOWLEDGEMENTS

The production of this book has been like the building of the house and development of the land, an effort by family and friends.

Kerry Wise's graphics accurately depict so much of what we have done, some of it redrawing my own drawings, much of it mapping for the first time a system which kept changing as she drew it.

Greg Holland has also made a major contribution to the look and feel of the book through his artwork as well as computer typesetting and layout.

Ian Lillington's editorial role and his gentle but persistent encouragement and management through the writing and production stages of the book has been very important.

Su Dennett, my partner in life, has done many tasks both from the practical to the inspirational in bringing this book to life. Trying to label Su's diverse role makes me realise how difficult it is for me to separate the writing and production of this book from the project itself, our own lives, and all the influences and contributions which lay behind the subject of this book.

HOW TO USE THIS eBOOK

This eBook is based on the A3 sized book of the same name published in 1995 and reprinted in 2001. The following notes about how to use the book also apply to this eBook version.

The book can be read section by section, working logically from the historical and environmental features of the area, through design of the property, to implementation of the design. The contents and their sequence are intended to provide an understanding of the conscious planning and design process I use in approaching any project. This provides a structured balance to the strong impressions gained by visiting the property in a particular season or stage of development (or viewing the Virtual Tour).

Alternatively, the reader may choose specific sections which are currently interesting or relevant to his or her own situation.

The notes on the land use history of the locality and site, the land systems of the area and development context are necessary to set the scene, especially for the reader not familiar with the locality. My attention to this detail is to emphasise that no permaculture project exists in isolation and the significance of things depends on their context. This information is not simply taken from published sources but is largely derived from my own "readings" of the natural and cultural landscape.

As well as the formal documentation, the book provides an insight into the personal stories, idiosyncracies, organic evolution and open ended nature of the project. I often tell clients that they are their land's greatest asset and greatest liability. With us it is no different.

Most sections outline general principles and strategies first, and then give detailed information on the design and its implementation. However, a full explanation of the principles of permaculture which underlie the design is beyond the scope of this book.

Explanation of technical terms and cross references to other sub-systems are given on the relevant page. Generally, common names for plants are used in the main text, with botanical and common names in the Perennial Species Index.

Because of the different nature of the media used, this eBook lacks some of the qualities of the book, most notably the A3 landscape format with text, plans and photos laid out in thematic presentation. On the other hand the eBook provides many advantages;

- All original colour photos
- Plans, graphics and photos zoom-able to see a higher level of detail than possible in the book
- Additional information and photos to update the book

Thus the eBook can be considered as both a complimentary update and an alternative to the original book. Any comments on the format and content of this eBook are welcome including bug reports: please email us (with *Melliodora eBook v1.0 Feedback* as the subject).

HELP

The easiest method of navigating to different parts of the eBook is by returning to the Contents page. Different coloured bars indicate chapters and the text below the bars indicate sections within the chapters. Clicking on these will link you to the relevant page.

Chapters begin with a menu page, sections are listed in capital letters and articles within the section are listed below in lower case. Click on the topic of interest to link to that page. Return to the chapter menu by clicking on chapter heading in the top right hand corner. There are also links within the text that link you to related pages elsewhere in the document.

Click on text to view at full screen width, continue clicking the mouse to move to the next section of text, alternatively you can use the scroll wheel or the up and down arrow keys.

Pictures can be enlarged. In Acrobat 5 click once to enlarge and again to reduce. Acrobat 6 is not recommended (update www.adobe.com), but you can click on the image followed by the Previous button. In Acrobat 7 hold the mouse button down to enlarge and release to reduce. 'Preview' (the default pdf reader on Mac OSX) is not recommended, download Acrobat Reader.

Five buttons on the contents page, and used throughout the document link to new content.

Virtual Tour - a visual tour of Melliodora in your web browser. Throughout the eBook this button links to relevant views within the Virtual Tour.

Seasonal Cycle - a series of images that show the changes of seasons on the property.

More recent photo - updated photographs in Second Decade chapter which updates this information.

More recent text - links to new related text in the Second Decade chapter which updates this information.

HDS resources - related articles by David Holmgren (on contents page, this button opens web browser and links to Holmgren Design Services website).

You will notice a menu bar at the bottom of the screen.

QUIT *(rollover - bottom left)* - will quit Acrobat and leave the eBook.

FULL SCREEN *(rollover - bottom left)* - The eBook automatically starts in full screen mode but this button allows you to switch between Full Screen and Acrobat Window mode.

- **SEARCH** - find a word or series of words to match your query.
- **HELP** - brings you back to this page.
- **CONTENTS** - returns you to the contents page.
- **PREVIOUS** - returns you to your previous view.
- **BACK** - go back one page in the document.
- **FORWARD** - go on to the next page in the document.

PERSONAL HISTORY

In 1985 Su and I purchased a one hectare block of land on the edge of Hepburn, Victoria to build a family home and develop a self reliant lifestyle which reflected our values.

For me, after several years in inner city Melbourne it was a return to a more rural location and another phase in the practical application of the permaculture concept and principles which I had developed with Bill Mollison in the mid 1970's. More specifically, the plan to owner-build a passive solar house drew on my experience of building my mother's new rural property in southern N.S.W. a few years earlier[1]. In Hepburn I was also able to apply cool climate experience from Tasmania, New Zealand and other parts of Victoria and focus my permaculture consultancy work in the region of my new home.

Jody with new born brother, Oliver May 1986 at Melliodora

For Su, life in a small country town was a new beginning with our blended family of Kimon (13), Jody (11) and Oliver, born in May 1986 at home in Hepburn.

As we loaded our truck with our possessions to leave North Carlton, a new Mercedes moved into the street, perhaps a suitable symbol of Australia in the mid 1980's obsessed with material wealth and fast money entrepreneurs. In joining the small rural community of Daylesford and Hepburn (about 7,000 people) we were arriving at a time when many of the previous "back-to-the-land" ex-urbanites were returning to the city in search of money, social acceptance or simply excitement.

1. *Holmgren, D.* Permaculture in the Bush, *Nascimanere, 1993*

Family photo 1991; David, Kimon (19), Oliver (5) and Su.

SELF RELIANCE

For us, the principle of self reliance and personal responsibility has been central to everything we have done from being owner builders and growing our own food to home birth and home schooling. This is not driven by a desire to separate ourselves from society but a strong belief that it is through citizens taking more, not less, responsibility for their own needs that the necessary social revolution to a sustainable society can be best initiated.

COMMUNITY DEVELOPMENT

Commitment to our local community has paralleled our increasing self-reliance and wider role in permaculture education. We believe the subtle and sometimes invisible integration of environmental alternatives into the local community which emphasises shared local values and understandings is one of the effective means of social change. Community self regulation and governance is a natural extension of the principle of self reliance. The local ratepayers' association, LETSystem and community management of public land have been some areas of our most active involvement in our local community.

PERMACULTURE DEVELOPMENT & EXTENSION

After the first wave of public interest in permaculture in the late 1970's I believed one of the weakest links in the spread and adoption of permaculture was the lack of demonstration sites which were:

- inspired by and consciously designed using permaculture principles,
- documented and accessible to the public in some way.

Private properties reflect personal responsibility, skills, and idiosyncracies and have a special value in permaculture extension because they show how real people have integrated the ideas into their lives.

The role of Melliodora as a demonstration site of cool climate permaculture was a natural consequence of my involvement in permaculture consultancy and education. We began to respond to a word-of-mouth demand for guided tours. In 1990, the house was featured in Bill Mollison's Global Gardener program on ABC television and the Owner Builder magazine in 1991. Since then over 1000 people, mostly Victorians, have participated in formal guided tours for groups.

Our Visitors' Guide, published in 1992, provides some basic information. A wider audience has seen at least some aspects of the project through magazine articles (Permaculture International Journal, Soft Technology, Your Garden, the Weekly Times), a geography school text, regional television and many slide presentations, (including through the European permaculture network in 1994).

The severity of the manifold crises facing humanity can hardly be overstated. Su and I believe the most effective way we can contribute to a positive future is through personal change and example. We aim to provide information and inspiration to other people most likely to make productive changes in their own lives but have no interest in providing yet another lifestyle curiosity for jaded consumers.

LAND SELECTION CRITERIA

While living in Melbourne we decided to move to the Daylesford-Hepburn area because we liked:

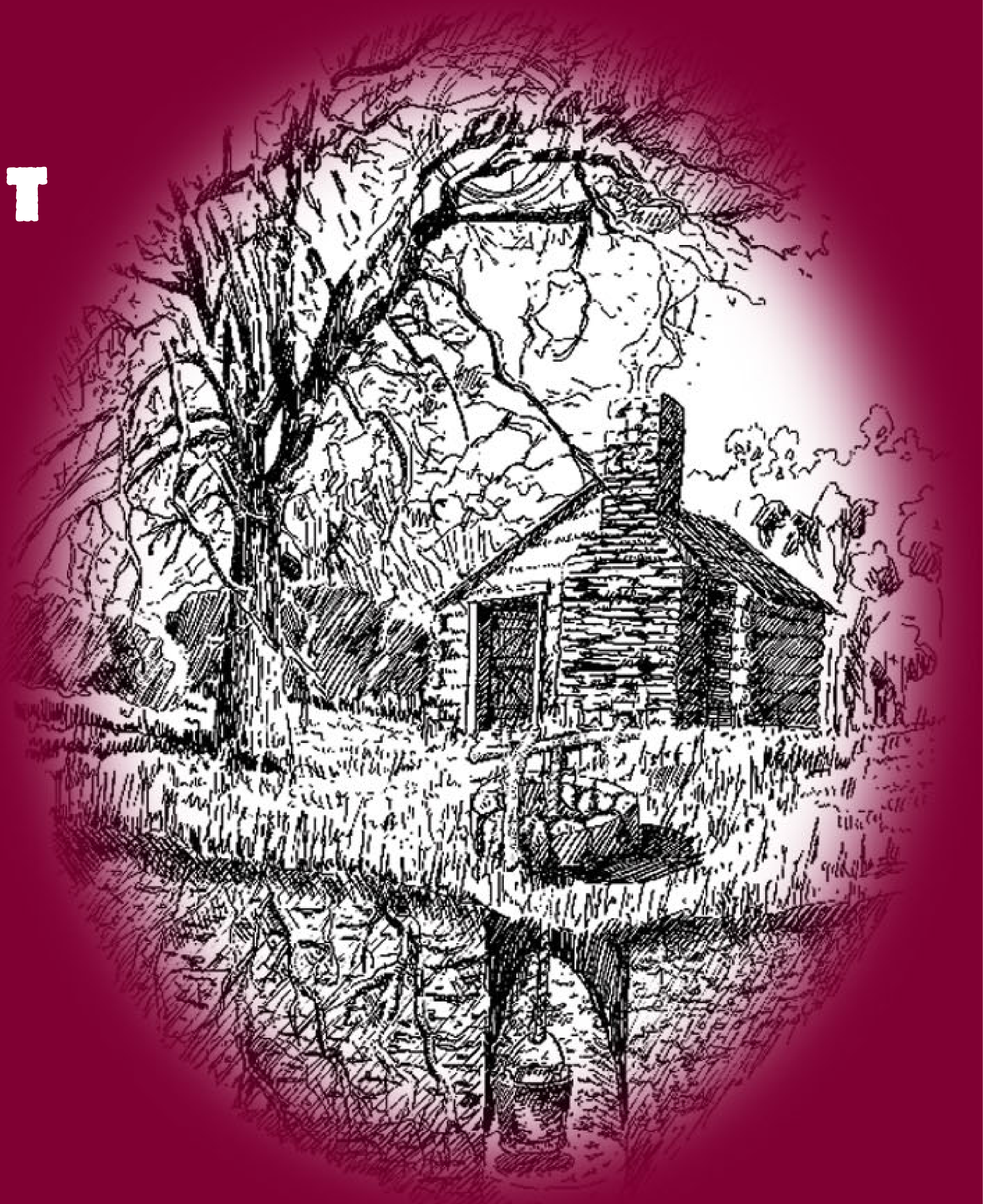
- the cool moist climate,
- the socially cosmopolitan nature of the community, and
- the prospects for work within the region.

As we investigated the area we developed the following criteria to select a block of land.

1. In, or close to, town to give easy access to school and town facilities, especially for teenage children. Though not a high priority, availability of town water, sewerage and electricity follow from this choice.
2. A large building block between 0.3 and 1 ha (0.75 - 2.5 acres), capable of development as an extensive permaculture garden to provide most fresh food needs of a family, but not so large as to require major capital investment and time to develop and manage.
3. Good solar exposure with minimal risk of being overshadowed by future tree planting or development on neighbouring land. Preferably north sloping for easy solar orientation of house and maximum heat gain to plantings.
4. On the Hepburn side of town for the more sheltered microclimate.
5. Soil of good depth and drainage. Preferably volcanic soil.
6. Side or rear boundary to road reserves, gullies or other undeveloped public land.
7. Low to moderate fire hazard.
8. Low cost of service connections.
9. Opportunities for independent water supplies from dams, wells, bores or springs.

Compromises are always involved in buying land, but the property does meet most of the above criteria. Perhaps the most substantial compromise was the predominantly west facing rather than north facing slopes. The ways in which we have dealt with this less than ideal situation for permaculture in a cool climate is one of the important lessons in this case study. There were also some financial advantages from our choice. Blocks of land the size we were seeking outside towns were so much in demand that prices were actually higher than serviced blocks in town. In addition, the fact that this particular block was covered in "weeds", had a drainage line through it, and was relatively steep, substantially reduced its market value.

THE LOCAL ENVIRONMENT



HEPBURN LOCAL HISTORY

Little is known about the pre-European history of the area, but from early accounts and interpretation of the natural environment, it appears that the volcanic areas provided diverse animal and vegetable foods and were more open than the denser forests of the sedimentary country. Abundant springs would have made the area favourable for occupation in summer. Aboriginal populations would not have been as permanent or large as those on the extensive volcanic landscapes to the west of the Wombat Forest around Mt.Kooroocheang, where Captain Hepburn settled in 1838.

Following the discovery of gold in 1851 at Hepburn Springs, the area was quickly transformed (in a few decades) from a relatively pristine indigenous landscape to a moonscape of felled forests, gullies with flumes and sluices, mullock heaps and boom town development. The immediate locality of our property, known as Hepburn to the locals, became the focus of mining and settlement.

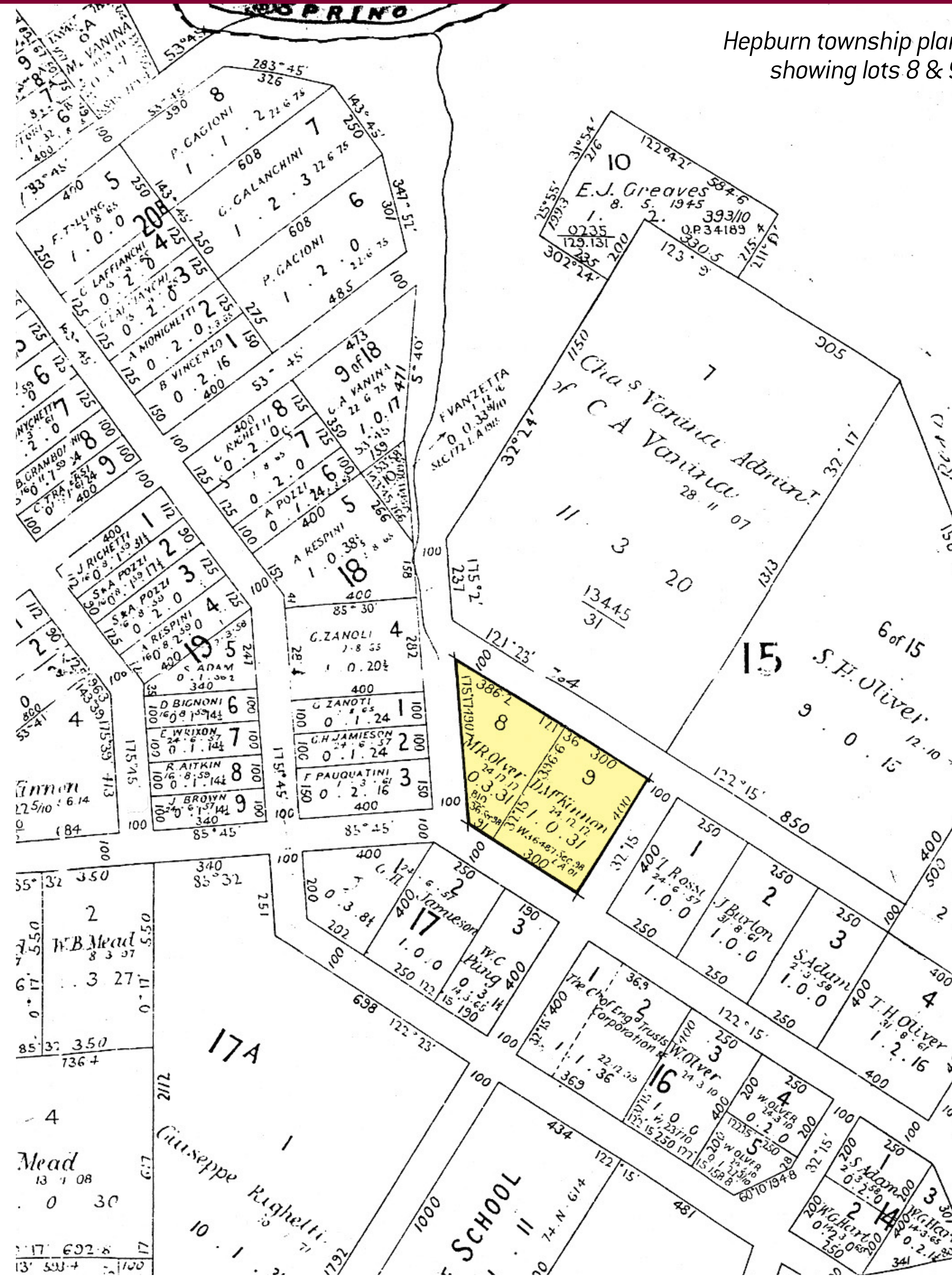
By 1880 most of the alluvial gold[1] had been worked out and small scale agricultural activities including wine making and market gardening became important land uses drawing on the peasant traditions of the Swiss Italian and Chinese miners. Agriculture is likely to have been concentrated on the basaltic landscapes not covered by mullock from mine shafts, but the Chinese managed to make market gardens on turned over gully floors such as the present Springs Reserve.

Deep lead[2] mining continued to demand large amounts of timber for shoring of shafts, and by the end of the century much of the sedimentary country had lost its top soil. The broad drainage lines had become massive erosion canyons with tree cover reduced to a few scattered remnants.

With the cessation of surface mining and the gradual decline in population the landscape began to heal. Small scale farming continued on the better land but the introduction of the Phylloxera aphid and poor seasons are reputed to have destroyed the local wine industry. However, local varieties of grapes from Swiss Italian stock are still grown in the area. Exotic weeds such as blackberry and gorse joined native species in recolonising eroded gullies.

With the popularity of the mineral springs early this century, guest houses and associated tourist development concentrated on the steeper slopes and ridges around the Springs Reserve. A good market developed for produce from small scale mixed farming. By the 1940's regrowth forests also provided increasing work for firewood, sleeper and post cutters.

The resurgence in mineral water based tourism, improved services and the rural resettlement movement of the 1970's and 80's has resulted in infill development within the township area and maintenance and renovation of existing dwellings.



Hepburn township plan showing lots 8 & 9

1. *alluvial gold: gold deposited by rivers and streams in gravels and sands along existing stream courses*
2. *deep lead (pronounced 'leed'): geologically ancient stream courses buried under valley lava flows*

MELLIODORA SITE HISTORY

Earliest use of the site by Europeans was probably the dairy cows of Maurizio Bolla in the 1850's. Shortly afterwards mining along the gully below the property would have transformed the landscape.

None of the details of what happened on the site during the gold rush have come to light, but at some stage late in the 19th century, a small hut was constructed and a well dug just above the old pear tree. From its great size and girth we assume the pear was planted about the same time.

Old locals recall the place being spoken of as the home of the Pinner (or Pinna) family although nothing else is known about these people. It is probable that the occupation of the site was based on a miners right as no title for the land in this period can be traced. In 1906 a bushfire swept through Hepburn. We presume the hut burnt down during that fire as older locals recall nothing more than a pile of stones by the early 1930's.

In December 1912 crown allotments 8 and 9 were created and the title documents show Duncan McKinnon, the postmaster and shoemaker of Hepburn as being granted lot 9 while Margaret Rose ("Rosie") Olver was granted lot 8 (for a price of 6 pounds each). Locals remember Duncan McKinnon as the sole owner, the property being fenced as a whole and grazed by Duncan's cows.

In 1947 Duncan died and in 1951 George Rodgers purchased the property from Duncan's widow and son. Over the next seven years Rodgers ran free range poultry on the property. In 1957 he set up a sawmill on the present housesite, initially to cut palings but sold the property the following year to Val Wallace. Val continued to operate the mill, mostly cutting box and red gum. In 1963 a crop of potatoes was grown on the red soil slope of lot 8 as much a fire break to the sawmill as for the harvest.

In 1964 the title of allotment 8 was finally transferred from Rosie Olver and in 1966 the land and mill were transferred to Val's son, Johnny Wallace who continued to operate the sawmill.

In 1968, Fourteenth St, then nothing more than a goat track, was constructed by the council to give better access to the new subdivision to the south east of the property. Because of the hard sandstone reef which was struck in grading off the top of the hill, extra fill for the drainage line crossing was excavated from the Olver Street reserve creating a level access track in the process.

Through the sixties, Jack Monaghan, our neighbour to the east, ran a long campaign to have the sawmill closed due to nuisance created by smoke, ash and sawdust. The mill was finally closed in 1970. In over two decades the impact on the land had been substantial. In some spots, dumping of sawdust, bark and ash resulted in highly enriched soil, in others,

Pear tree on the lower slopes of the property. 18m tall and probably 100 years old, it is a living monument to the Swiss-Italian pioneers and for us a symbol of the persistence and abundance of nature.

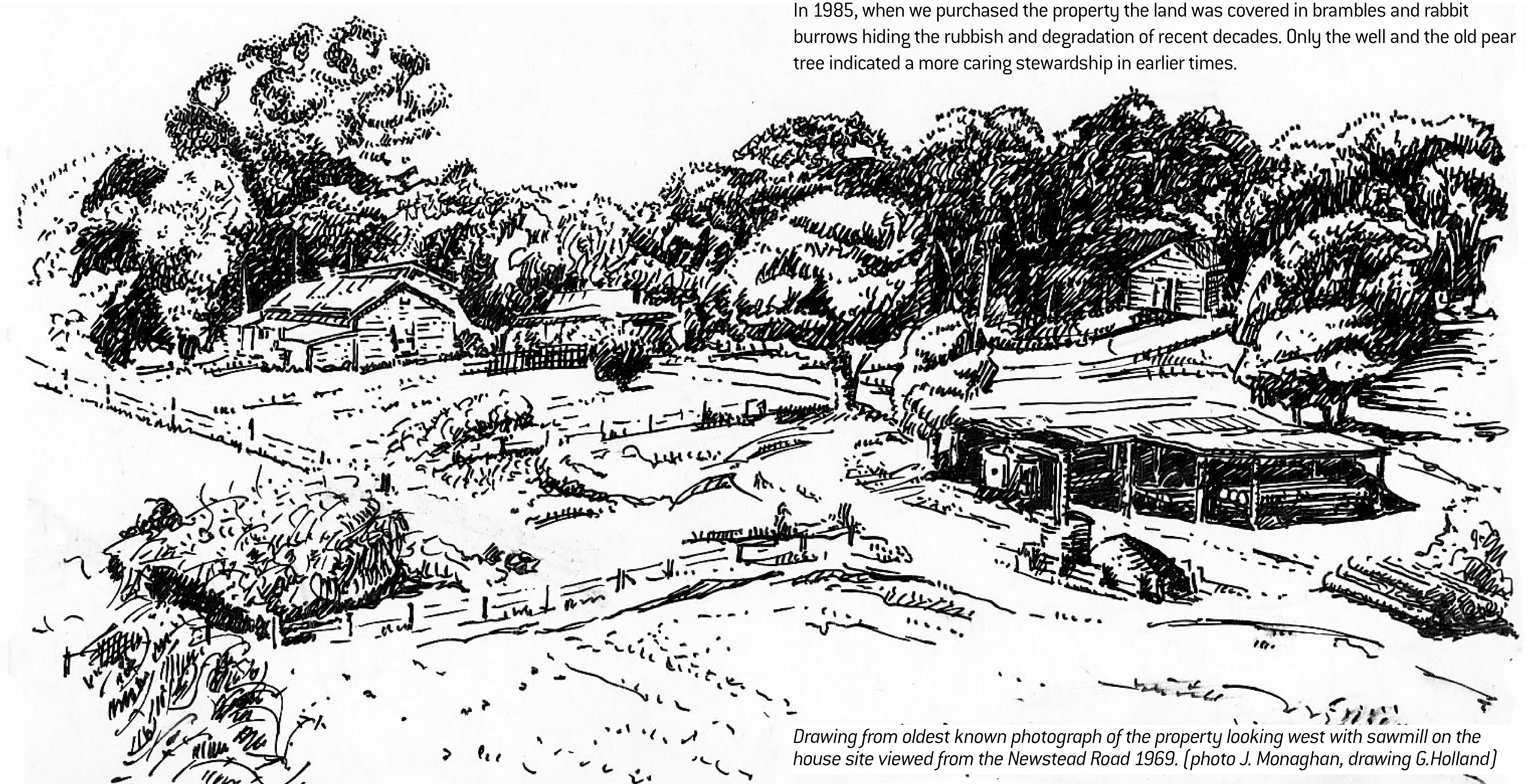
machinery had compacted and inverted it. Trees, mostly yellow box surrounding the mill had been progressively cut down.

The property was "cleaned up" for sale with a bulldozer. A small bench was cut into the hillside as a housesite and in the process sawmill waste, old blackberry covered fences, truck parts and other hard rubbish were buried in the fill slope. The eroded drainage line in the lower part of the property was filled with similar material. In the process topsoil was stripped from some areas.

In 1975 the property was sold to the Stracks from Melbourne. Over the following years, blackberry, gorse and cape broom grew back, covering the scars of earthworks.

In 1982 the installation of the town sewerage system was another major impact on the land. The laying of the trunk main along Olver Street and the branch main along the boundary between the two lots resulted in clay and shale being spread over a significant area of the property and topsoil being buried in the sewer trenches. On the other hand, the predominance of the indigenous wallaby grass on the steep slope beyond the pear tree indicated there had been very little, if any, earth moving or digging on this part of the property since settlement.

In 1985, when we purchased the property the land was covered in brambles and rabbit burrows hiding the rubbish and degradation of recent decades. Only the well and the old pear tree indicated a more caring stewardship in earlier times.



Drawing from oldest known photograph of the property looking west with sawmill on the house site viewed from the Newstead Road 1969. (photo J. Monaghan, drawing G.Holland)

DEVELOPMENT PATTERNS

The location of the land and its relationship to both town services and the surrounding natural and community environment affect its potential as much as the natural characteristics of the land. On the other hand it is important to understand these influences as constantly changing.

LOCAL CONTEXT

The urban-rural fringe is an edge where the resources of both the city and the country are accessible. The preference of people to live in a rural environment but as close as possible to town services is a reflection of this. A mosaic of development maximises the edge, but the costs of providing reticulated services of roads, water, sewerage, power and telephone and the additional adverse effects on the environment can be substantial. Planning authorities use zoning controls and rates to encourage infill development.

In Hepburn, infill development is occurring on titles created last century as well as recent subdivision of larger allotments, but the Hepburn Regional Park and road reserves on steep gullies and slopes between developed ridges ensure a patchwork fabric of development. For the shire council the undeveloped road reserves represent weed and fire hazard management problems as well as potential demand for future road construction to service existing titles or proposed subdivisions. For us the public land represents a sense of "wild hinterland" for exploration, especially exciting for children.

Subdivision and development of private land to the NE of the property may involve construction of the first section of McKinnon Road in the future, while construction of Olver Street to service much smaller parcels of land to the SW is less likely. The gully road reserve is never likely to be developed. Property owners sometimes take responsibility for maintenance of adjacent road reserves since the council is unable to maintain all areas of public land within the town. This represents an opportunity to develop the road reserves to suit private interests within the informal constraints of neighbours and council officers. In the future we may see the unused road sold off or, alternatively, more formal planning and management for them.

COMMUNITY AND TRANSPORT SERVICES

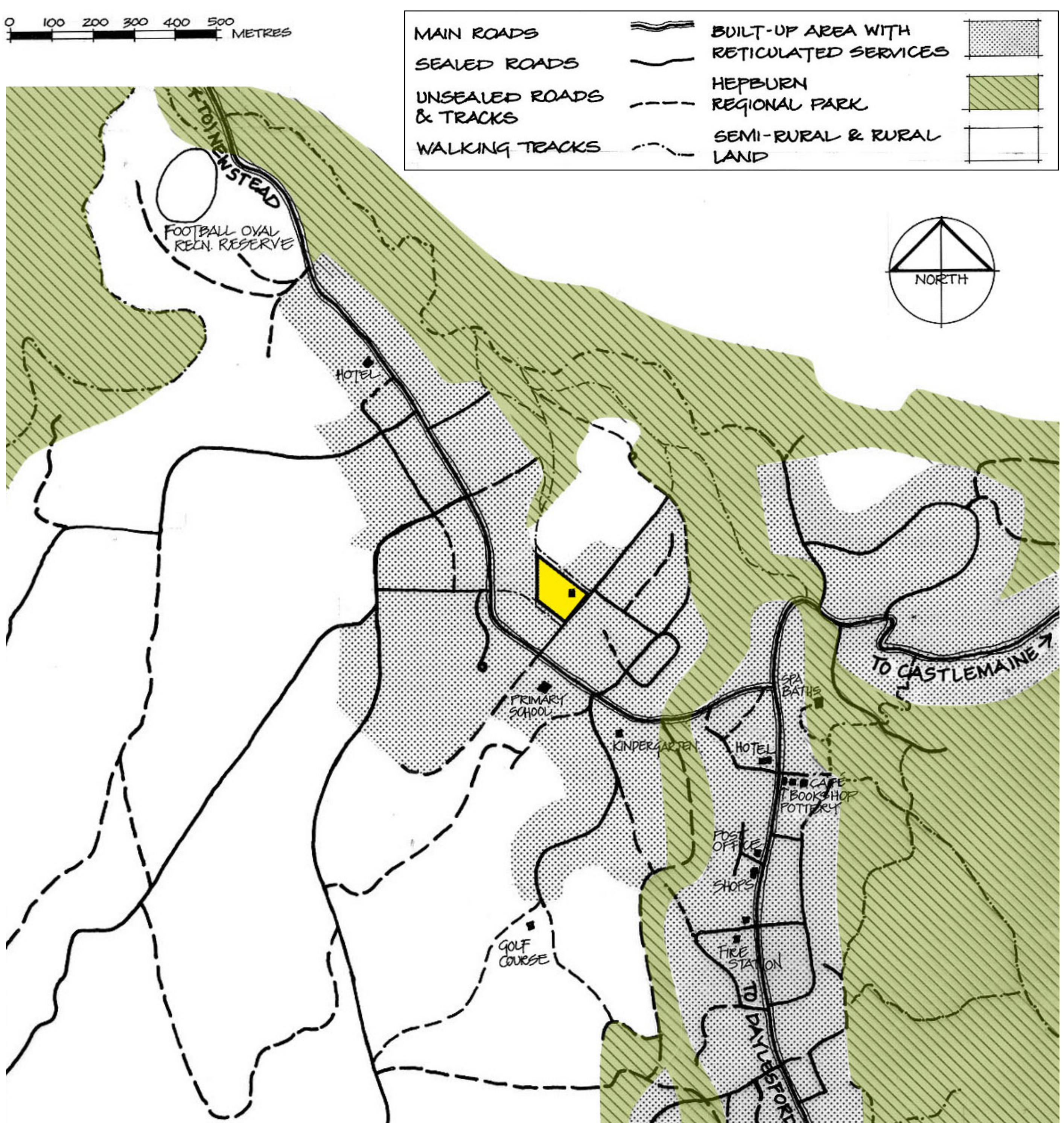
Kindergarten and primary school are within walking distance. General Store, Post Office and bank agency, hotels as well as mineral springs reserve and bath house are all within 1km, while Daylesford (4km) provides most town services including the centre for recently amalgamated local government. City services including government regional offices are mostly available in Ballarat, 50km distant.

Aerial view of locality autumn 1989, showing Melliodora at the centre. Newstead Road lower right to centre left, Hepburn Primary School lower right, new subdivision estate lower left. Spring Creek and Elevated Plain in background.

DEVELOPMENT PATTERNS

Some local residents commute to Melbourne. Public transport from Hepburn to Daylesford and on to Melbourne and regional centres is poor and reducing. This relative isolation has accounted for the moderate real estate values and development pressure compared to areas such as Woodend/Kyneton. Recent rapid expansion of tourism is leading to steeper rises in values and larger numbers of houses not occupied by permanent residents. Continued tourist expansion could erode the very strong rural community.

LOCALITY MAP



RETICULATED SERVICES

WATER

The town water supply is generally reliable high pressure water of reasonable quality. Rapid growth is likely to increase the incidence of water restrictions in dry years and potential failure of supply during major bushfires. Grazing and cultivation in water supply catchments occasionally result in sediment and possibly biological contamination in the supply. Connection costs for lot 9 were low but for lot 8 would be substantial.

Rates are high and allocation fell from 400kl (1988) to 250kl (1994) and has now switched to the user pays system with each kilolitre (tonne) of water costing more than A$1. This pattern has shown the good sense of the self reliant approach of making use of existing services while developing on-site systems.

SEWERAGE

Pollution of local streams by septic systems led to sewering of the town in the last ten years. This involved expensive capital works and ongoing costs for pumping stations. The high cost led to strong pressure for connection within the serviced area so in 1986 we felt any attempt to get approval for alternative on-site recycling of human waste and greywater would not succeed. Connection costs for lot 9 were moderate but rates are high. Waste water use fees (75% of metered water use) are now being charged making effective water supply costs over A$1.60 / kl.

Secondary treated effluent is used for the irrigation of lucerne pasture at the Shepherds Flat sewerage farm but in winter excess effluent is discharged to the Jim Crow Creek. Mounting concerns over nutrient pollution of streams and greater acceptance of composting toilets would make an independent approach more likely to succeed[1].

GAS

Reticulated gas is available in most of Hepburn and Daylesford but our gas usage is so low that we could not justify connection.

ELECTRIC POWER

Overhead lines run up 14th Street Connection cost for lot 9 was minimal though lot 8 would now be quite expensive. Rates can be expected to rise in the future due to financial and environmental pressures, making grid-connected photo-voltaics an economic option to provide our power needs from the sun.

1. *In September 1995 our neighbours M.Wilson and F. Buining gained approval from Central Highlands Water for their composting toilet and reed bed (greywater) as an alternative to sewer connection - a real victory for the environmental and economic logic of on-site recycling.*

THE NATURAL ENVIRONMENT

Melliodora is located in the ecotone[1] where climate, soils and vegetation change between the montane uplands and the sub-humid inland slopes of Central Victoria. On the bioregional scale this means we have some of the advantages and disadvantages of both regions for living and growing.

CLIMATE

"Mediterranean with maritime and continental influences".

Cold wet winters with most rain from the north ahead of south west changes which tend to bring scattered showers. Summers are mild to warm and moderately dry with occasional heavy thunderstorms generally from the north. Hot dry winds (generally from the N W) bring severe plant stress and extreme fire danger most summers. Frosts number about 20 p.a. with November to April generally frost free. Light snowfalls are recorded some years.

Average Rainfall 825mm. July mean temperature 7°C. February mean temperature 17°C. This is substantially wetter than the dry Central Goldfields to the north but warmer than the cold, wet top of the Great Divide to our south.

LAND SYSTEMS[2]

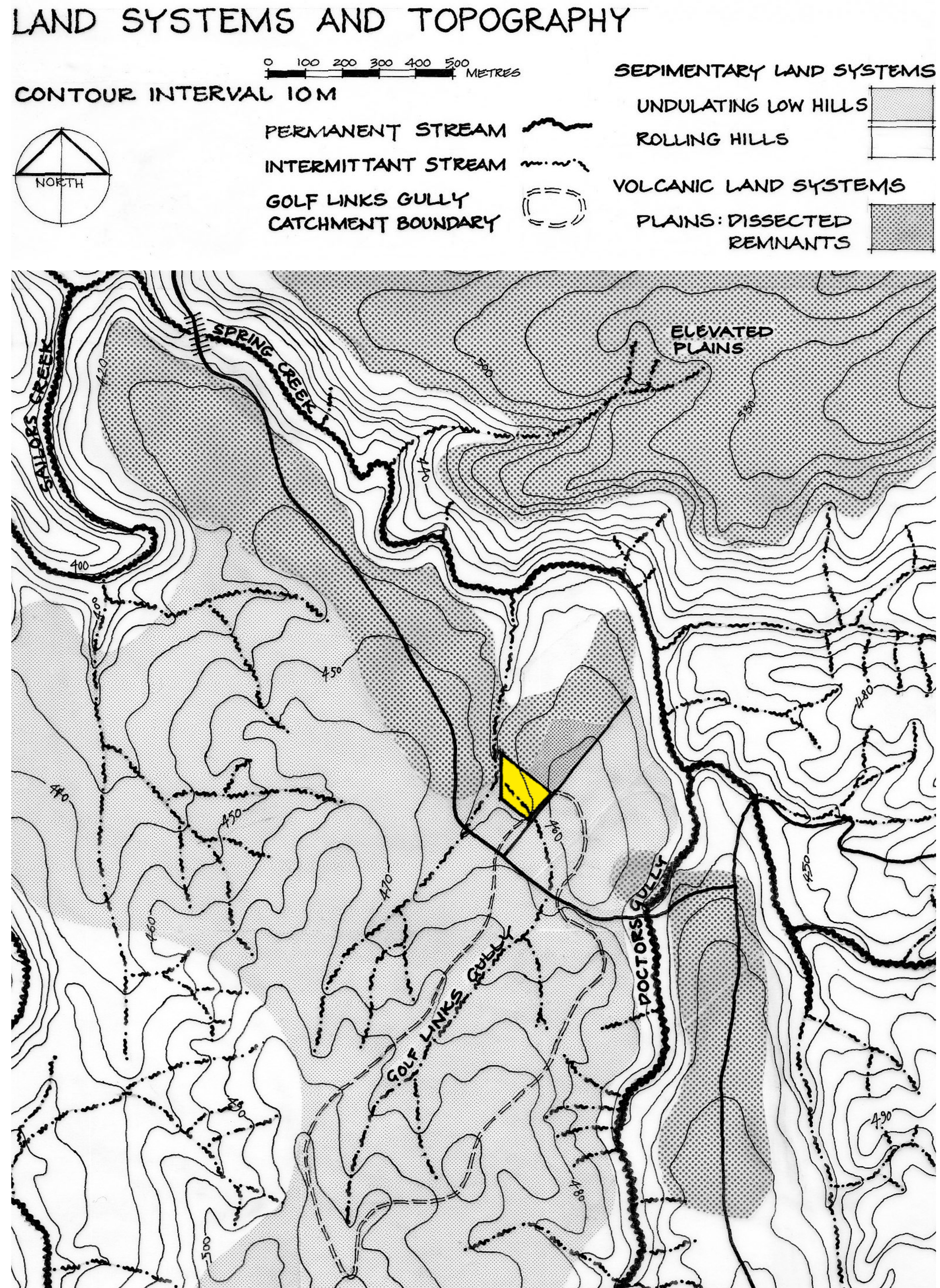
Sedimentary Landscapes

These are predominant in the region and the locality and are formed from an Ordovician (400 million year old) geology of near vertical strata of shales, fine sandstones and slates which run north/south.

These have been dissected by the various tributaries of the Jim Crow Creek, including Spring Creek, to form a series of gullies and ridges. The degree of dissection by these streams has been controlled by the lava flow a few million years ago. Spring Creek cut a new course around the north side of the lava through the softer shales and sandstone allowing it to rapidly downcut to form Breakneck Gorge and create a deeply dissected "rolling hill" landscape in its catchment to the east of Hepburn. The smaller north flowing tributaries such as the Golf Links Gully and Doctors Gully were prevented from downcutting by the resistant rock of the lava flow, thus forming a "low undulating hill" landscape to the south and west of the site.

The soils of these low undulating hills are predominantly gradational and duplex soils of moderate depth with loamy topsoil and deep yellow clays, while steeper slopes and crests have shallow gradational soils.

1. *ecotone: an edge or transitional zone between major ecosystems or bioregions*
2. *land systems: a way of classifying land which integrates climate, geology, landform, soils, vegetation and fauna*



In the sedimentary landscapes, the dominant vegetation on the ridges is a moderate height dry sclerophyll[1] forest of Eucalyptus goniocalyx, E. macrorhyncha, E. dives and E. polyanthemos. The gullies and southern slopes have a tall moist sclerophyll forest of E. viminalis, E. rubida, E. obliqua and E. radiata. The gentler north facing slopes and drainage lines are characterised by an unusual association of E. radiata and E. melliodora.

These associations of trees delineate soil, microclimate and fire frequency differences within the Hepburn Springs landscape. Of particular significance is the severe frost that occurs over this last land type due to cold air ponding dammed by the Elevated Plain escarpment to the north.

Volcanic Landscapes

Olivine basalt lava flows and their rich chocolate soils are characteristic of the district. Springs, both fresh and mineral, commonly occur on the sedimentary slopes and gullies immediately below the lava flows. At Hepburn the lava flow has been dissected to the point where only small erosional remnants are left along the main road ridge.

The soils in these areas range from shallow stony loams to deep gradational loams but all are free draining, and well structured. The common name 'chocolate soils' reflects their colour and desirable richness.

The original vegetation on the chocolate soils was a tall grassy forest dominated by E. viminalis. Today gardens of cool climate exotics such as oaks, rhododendrons, cornelian cherry, walnut and chestnut are noticeably more vigorous and healthy than on nearby sedimentary clays.

MICROCLIMATE AND SOILS

The site straddles the Golf Links Gully, a north facing drainage line with deep clay soils. Beyond the property the gully dissects the basaltic remnant before it drops down to Breakneck Gorge. The edge of the remnant with its shallow soils runs across the northern end of the property while deeper chocolate loams overlay the sedimentary clays on about one third of the property.

This combination of land and soil types provides a diverse potential for food production and a favourable microclimate for human habitation. The greatest limitation of the site is probably frost, the severity and frequency of which was not fully realised for some years. The lowest parts of the property (with deep chocolate soil) are subject to spring frost as late as December.

The Original Site Condition plan shows the features of the site at the time of purchase in 1985.

Aerial view of Melliodora December 1993 showing dominantly westerly slope and minor north east slope of property either side of gully. Note the leaking dam (top) in the paddock built on the free draining stony volcanic soils. (Photo B. Hedge)

Frost hollow in orchard block 3 below old pear tree. Regular light frosts make this site with deepest, most fertile soil unsuitable for many tree crops including walnut.

1. *sclerophyll: thick skinned, drought resistant leaves; dry sclerophyll forest: forest dominated by sclerophyll leaved trees (ie eucalypts) and with sclerophyll understory species*

SOIL TYPES

1. Shallow Chocolate Loam

Friable red/brown uniform[1] loam 0.2 - 0.5m over highly fractured and weathered basalt:

- very free draining
- prone to leaching and acid condition
- shallow depth leading to rapid drying off of annual pastures
- highly resistant to erosion
- fractured and weathered rock giving minerals and good root access for deep-rooted perennial pasture and trees.

2. Deep Chocolate Loam

Friable red/brown gradational[2] clay-loam 0.5 - 2m over high fractured and weathered basalt:

- very free draining
- highly resistant to erosion
- good rooting volume for perennials and trees
- prone to leaching but relatively high mineral fertility from weathered rock

3. Transitional Soil

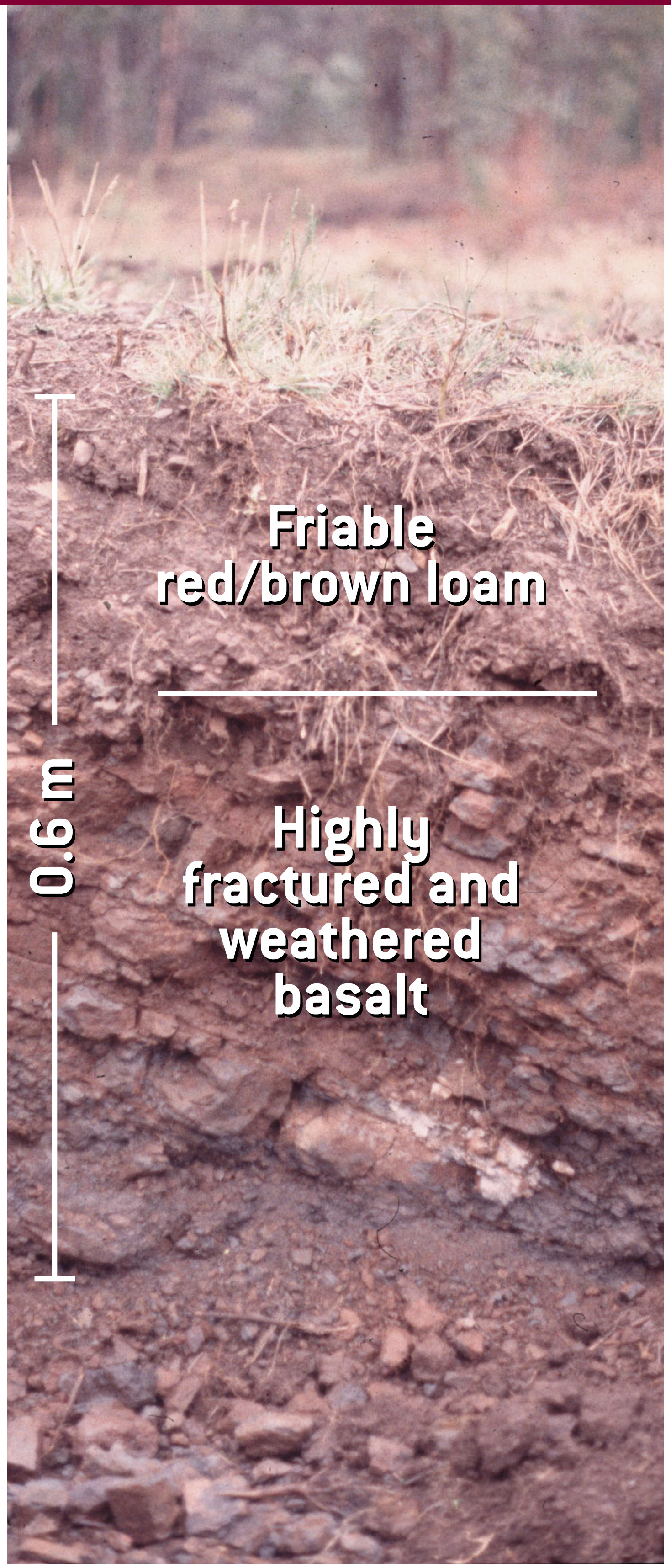
Friable red/brown loam over deep yellow clay:

- moderately well drained
- resistant to erosion
- deep soils with good moisture retention in subsoil
- reasonable fertility from mixed mineral origins

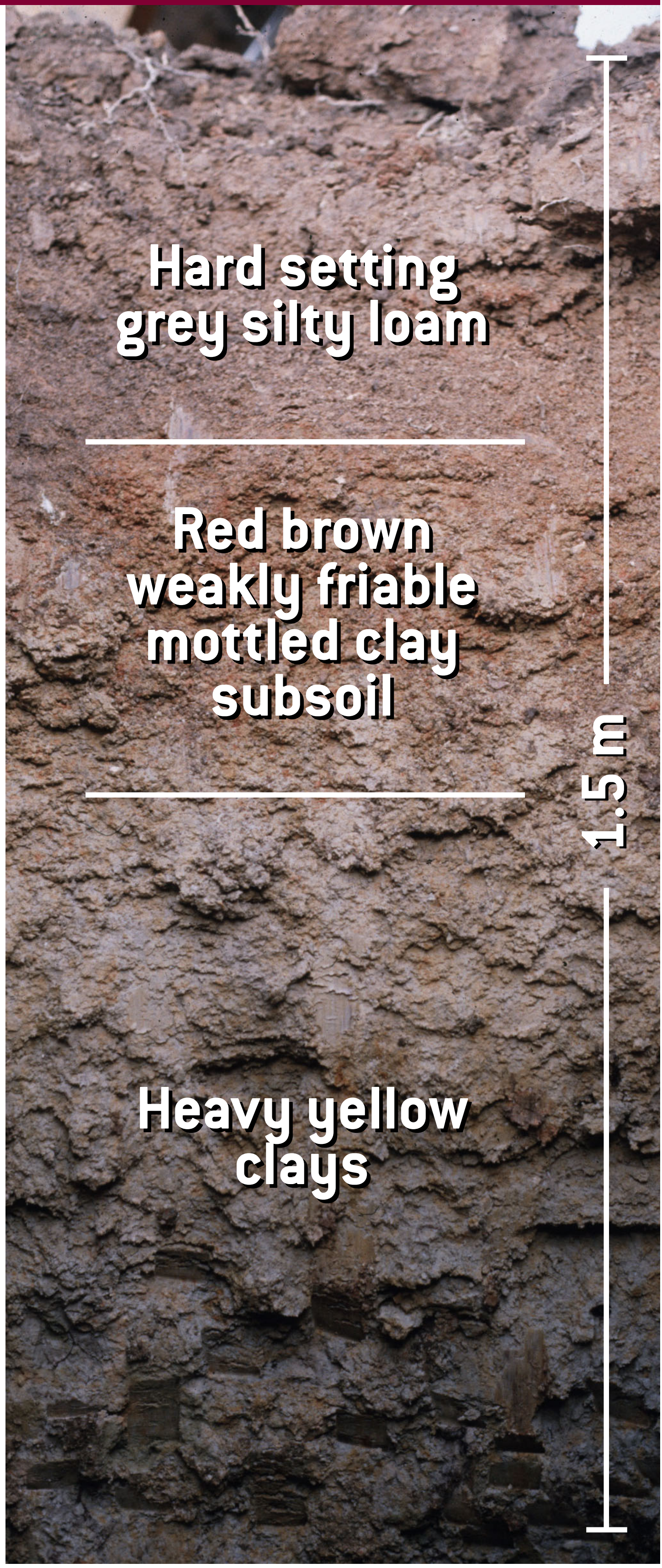
4. Grey Loam over Clay

Gradational and duplex[3] soils over shales and interbedded fine sandstones. Topsoils: hard setting to weakly friable grey silty loams 0.1 - 0.4m deep. Subsoil: yellow clay with moderately developed pan[4] over friable yellow clay with red/brown mottles:

- drainage moderate to slow with intermittent waterlogging
- cultivation can lead to hard setting surface with high runoff
- moderately erodable
- good moisture retention where subsoil is deep
- moderate fertility



Shallow chocolate loam over weathered basalt (0.6m) similar to red soil garden natural profile



Grey loam over clay (1.5m) at sewer connection point in Orchard Block 2

1. *uniform soil: one with uniform distribution of clay down the profile*
2. *gradational soil: one with a gradual increase in clay down the profile*
3. *duplex soil: one with a distinct clay subsoil*
4. *pan: a hard less permeable layer usually in the top of the clay subsoil*

NATURAL CHARACTERISTICS

Despite the degradation of the site by previous use, the underlying potential of the property for intensive agricultural development is high:

Yellow box (Eucalyptus melliodora) growing on Olver Street reserve, 0.6m diameter, 20m tall which is typical of regrowth from early this century on deep sedimentary clays of Hepburn. It indicates the lower rainfall and greater heat during growing season than in nearby Daylesford.

1. The north facing gully and adjacent slopes form a sun trap which produces a relatively warm microclimate.
   The majority of the block has a WNW aspect which is as hot as a north aspect in summer. Inland of the Great Divide, heat build up in the afternoon, with no sea breezes, makes westerly aspects far warmer than easterly ones.
   Westerly slopes which don't catch the first rays of the morning sun are also less subject to frost damage.
2. The gentle midslope position of the property produces deep clay subsoils capable of storing moisture and supporting extensive tree roots.

   (In a local context yellow box (E. melliodora) can be considered a totem species[1] reflecting these first two factors.)
3. The gully running through the property is suitable for dam construction and has a catchment of about 40 hectares, which yields about 50 Megalitres in runoff.
4. The high quality reliable groundwater tapped by the well is an asset but the yield rate is low.
5. The small area of chocolate soil at the NW end of the site will support species of trees needing free draining subsoils.
6. The acidic and leached nature of the soils due to the high rainfall is a natural restriction on the range of food plants which will thrive without substantial modification.

Some important factors restrict or threaten the productive potential of the site:

1. Frost, especially on the lower part of the site, from May to November, and often in April and December.
2. Northerly winds which funnel up the property through the gully. In summer the north winds increase water demand and cut back growing tips in most food trees and crops. During extreme conditions the threat from wildfire is substantial and accentuated by the relatively steep and predominant N W aspect.
3. Exposure to southerly wind has also become a problem, since the felling of mature forest on the other side of Fourteenth Street
4. The moderately steep slopes (10 - 25%) restrict access and movement of materials.
5. The heavy clay subsoils impede drainage which results in waterlogging during winter in areas receiving runoff.
6. The acidic and leached nature of the soils due to the high rainfall is a natural restriction on the range of food plants which will thrive without substantial modification.

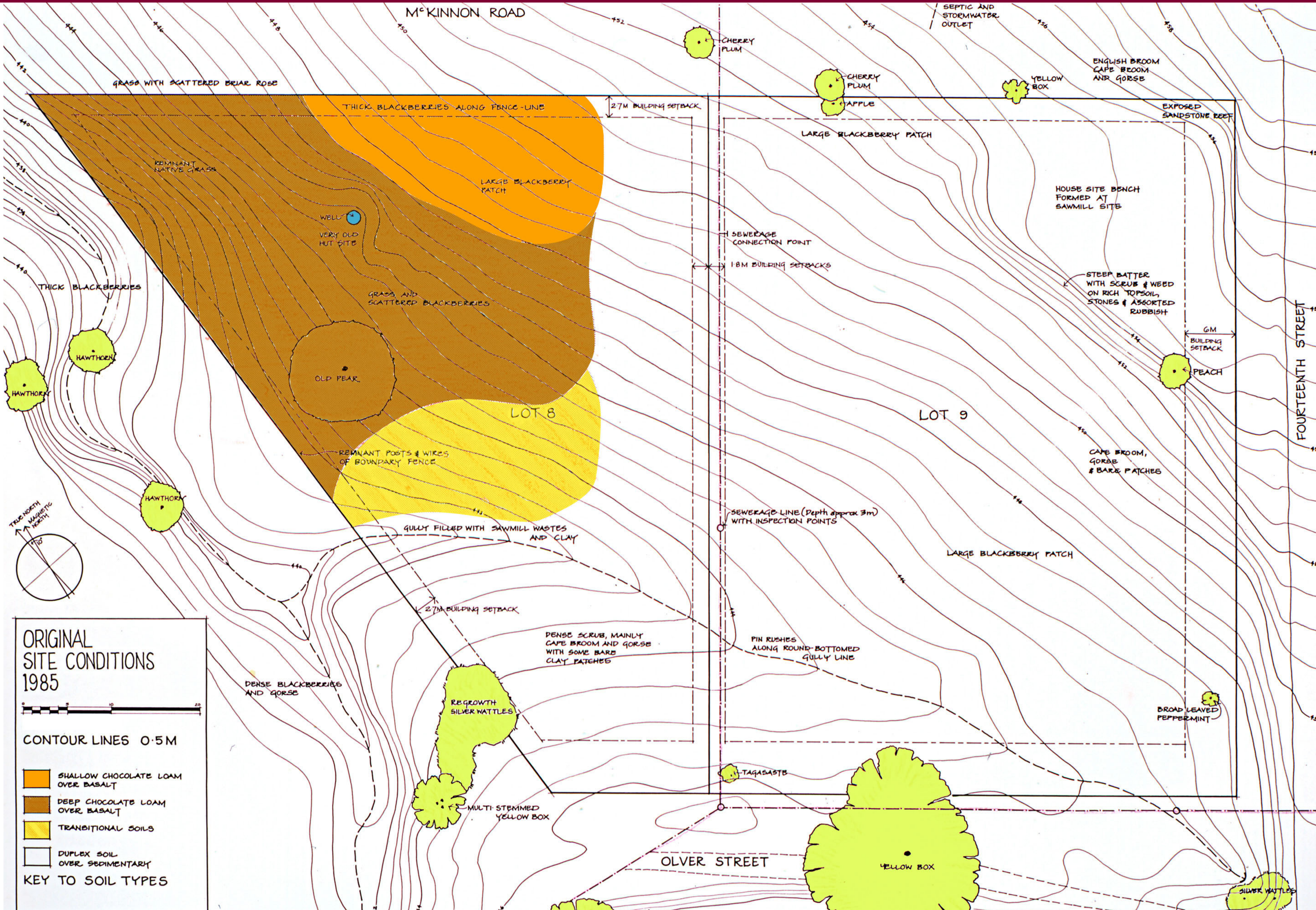
INTENDED LAND USE

The main aim of developing the land was to produce most of the food needs of a family and, over time, some tradeable surplus. There is a special emphasis on tree crops and providing as much of the inputs needed for food production from the on-site system such as irrigation water, mulch, nutrients and animal fodder to create a good example of permaculture principles applied in a cool temperate climate. Other land within the local area and wider region is better suited to producing our grain and fuel needs.

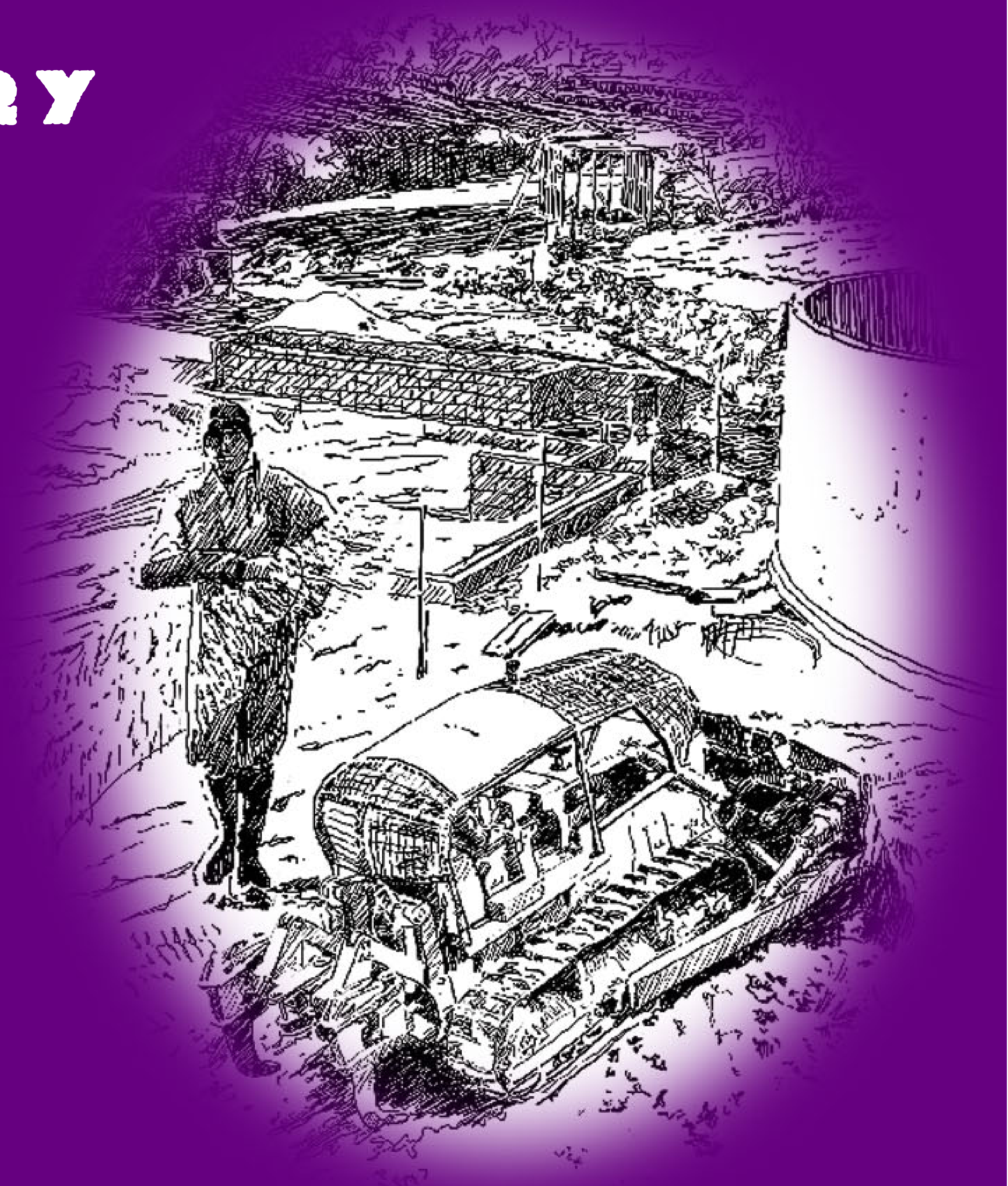
Many permaculture systems are designed following the biological model of the rainforest with a high density of evergreen trees, vines and understorey. While very successful in moist tropical and subtropical regions, lack of light, moisture competition and fungal diseases limit productivity of cool climate (mostly deciduous) tree crops in such systems. The traditional European orchard, when properly understood, is a better model for permaculture in this area.

1. Totem species: A concept common to indigenous peoples including Australian aborigines. The natural range of a plant or animal can be used to define a particular territory or land type and generally represents some characteristic quality important to the people.

SITE EVALUATION



PREPARATORY WORKS



KEY PLANNING PRINCIPLES

Integrated Landuses and Multi-purpose Buildings

By definition, Permaculture involves integrated landuses. In this case, residential use is integrated with elements of horticulture, urban forestry, water storage aquaculture and grazing. By siting buildings and dams on the land with low agricultural potential, maximum use can be made of the more productive parts.

The permaculture principle of integration of functions also applies to buildings. Large multi-purpose buildings have the following advantages:

1. Efficiencies in construction by use of common walls, roof etc.
2. Thermal efficiencies and reduced hazards in wind and firestorms.
3. Efficiencies in movement of people and materials and ease of integrating functions.
4. Less negative environmental and aesthetic impact.

Solar Access

Design to maximise use of solar energy is an essential element in permaculture. The importance placed on solar access on this site reflects the cool and relatively cloudy climate. Solar access to buildings, people and animals is most important over the autumn, winter and spring. The growing season (spring to autumn) is the important period for food producing crops and trees.

DEVELOPMENT OBJECTIVES

- To repair past land degradation and increase the total biological productivity of the site.
- To create a productive and pleasant living and working environment using permaculture principles of sustainable land use.
- To provide a working example of cool climate permaculture relevant to both larger town blocks and small rural allotments in the Central Victorian region.
- To take advantage of the dual titles to provide two dwellings on the property within the framework of integrated infrastructure and services. Thus the infill development of a fully serviced town area is furthered while increasing agricultural production and enhancing the natural landscape.
- To use unmanaged adjacent road reserves to enhance and complement the property design while achieving community objectives of aesthetic improvement and fire hazard control. In the process alternative management strategies and other functions including wildlife and pedestrian access corridors, urban forestry and food production can be demonstrated.

KEY PLANNING TOOLS

Zone Analysis

Zone analysis makes efficient use of human labour by clustering intensive land use around the house. The theoretical model involves a series of concentric zones around a homestead. The plan shows how topography and other factors affect the working of zoning on this property.

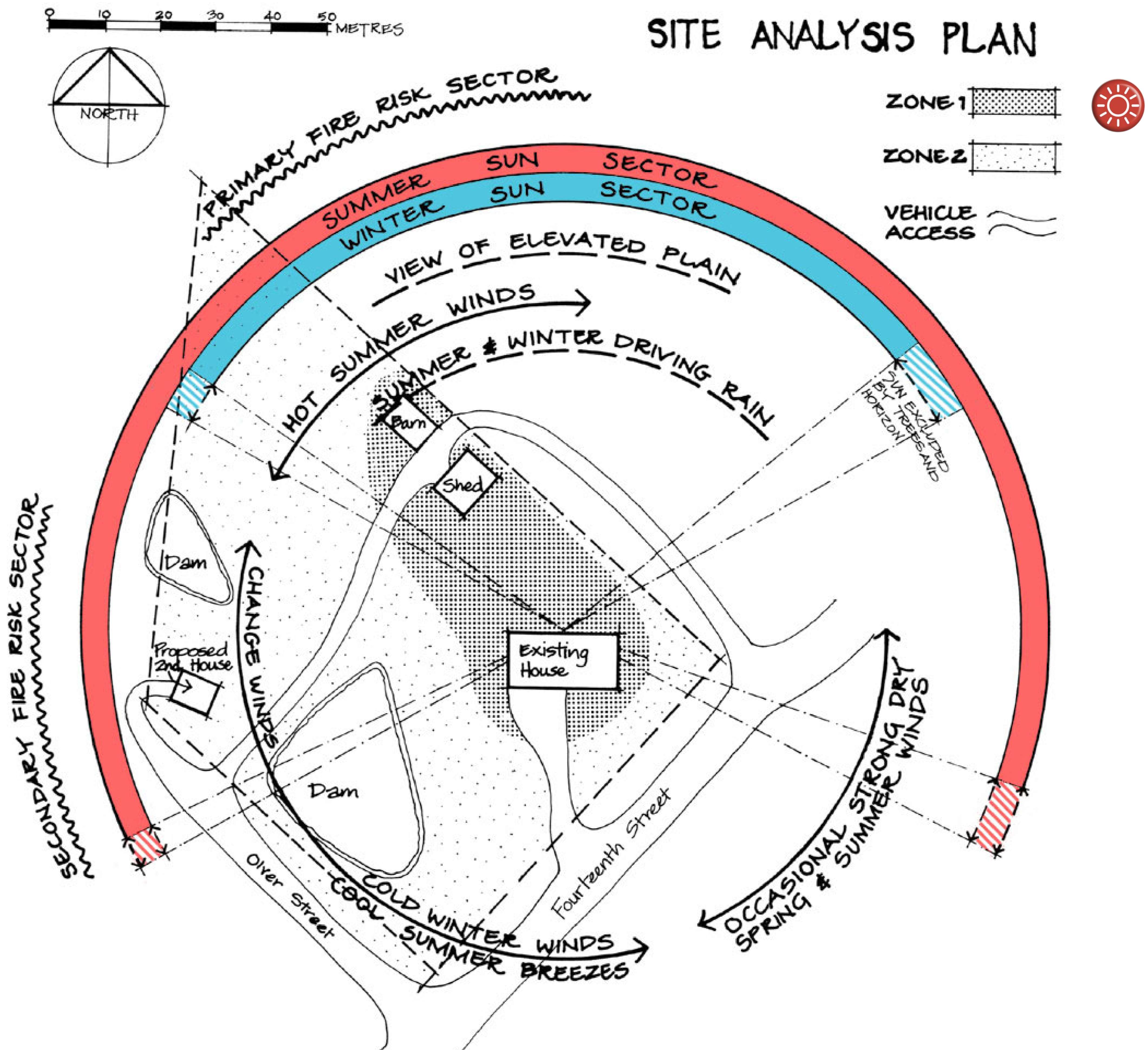
Sector Analysis

Sector analysis in permaculture considers how the various environmental forces act on the site as both resources and constraints or threats. Winter and summer sun sectors, hot, dry and cool summer winds, frontal change, cold winter and rain bearing wind, fire risk and view sectors are the main ones considered here.

Network Analysis

Zone and Sector analysis are geographical concepts which are well described in the permaculture texts[1]. Network analysis is another concept (borrowed from geography) which is useful in site planning but has not been described in the permaculture books. While the hierarchical nature of the zone concept is useful, more complex systems often exhibit a non-hierarchical, network structure of nodes between which materials, energy and information are exchanged. The concept was used here in identifying viable nodes or activity centres (the two house sites and the shed/barn complex) and their access and service connections.

1. *See* Introduction to Permaculture *Mollison B. and Slay R. Tagari 1994*


SITE ANALYSIS PLAN
0 10 20 30 40 50 METRES
NORTH
ZONE 1
ZONE 2
VEHICLE ACCESS
PRIMARY FIRE RISK SECTOR
SUMMER SUN SECTOR
WINTER SUN SECTOR
VIEW OF ELEVATED PLAIN
HOT SUMMER WINDS
SUMMER & WINTER DRIVING RAIN
SUN EXCLUDED BY TREES AND HORIZON
Barn
Shed
Dam
Existing House
Proposed 2nd House
CHANGE WINDS
SECONDARY FIRE RISK SECTOR
Dam
Fourteenth Street
Olver Street
COLD WINTER WINDS
COOL SUMMER BREEZES
OCCASIONAL STRONG DRY SPRING & SUMMER WINDS

HOUSE SITE SELECTION

Two sites were considered for the main dwelling, before and following the purchase of the land. The two sites were rated against a set of relevant criteria.

The chosen site (Site One) was suited to a large multi-purpose building. That building is a family-dwelling, office, greenhouse, workshop and garage and can be considered as the main activity centre or node on the property.

Site One, (the old sawmill site) viewed from the Newstead Road, following stripping of topsoil in March 1986. The form of the small house site platform constructed by the previous owners is visible (centre).

The alternative site was another node suiting a habitable building. It was allocated as a future development site for a small two storey cottage, the use of which might be studio/office, rental accommodation or granny flat.

Looking north from Site Two over geese pond, old pear tree and gully to Elevated Plain on the horizon.

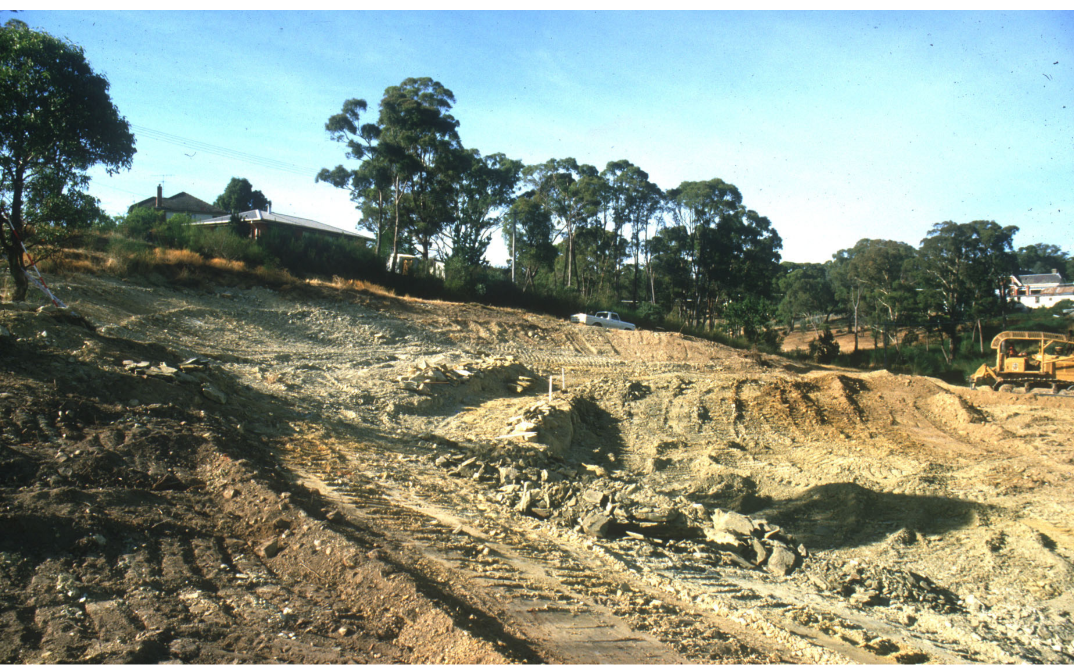
	SITE ONE	SITE TWO
Aspect:	Westerly, requiring major earthworks to create suitable platform for long east-west axis solar efficient house.	Excellent NNE orientation requiring only modest earthworks for solar efficient building.
Extent of site:	Existing house site platform is too small and poorly orientated to be useful but there are no severe constraints to creating a larger platform.	Building setbacks from boundaries and gully and sewer line severely constrain size of any building.
Slope:	Moderately steep (16% average).	Moderate (10%)
Vehicular access:	Excellent from sealed road and also from road reserve.	Would require all weather surface along Olver Street probably at own expense.
Electricity:	Close, minimum connection cost.	Would require costly extension down Olver Street
Water:	Close, low connection cost.	Would require costly extension down Olver Street but good pressure from dam header tank.
Sewerage:	Reasonably close.	Connection point close, minimal cost.
Solar access:	Good, a little early morning shading from hill, neighbouring houses and trees.	Excellent with early sunrise.
Microclimate:	Exposed to NW winds but low frost risk and intensity.	Sheltered and warm but prone to frost.
Site drainage:	Little run-on from above but seepage onto existing house bench.	Moderately well drained but height above wet gully is limited.
Privacy:	Poor, site visible from street and main road. Noise from main road.	Good with little noise from street and main road.
Views:	View to north of Elevated Plain escarpment, unsightly views SW to NW of backyards and main road.	Excellent north views of old pear tree and Elevated Plain escarpment.
Fire risk:	Moderate risk in severe bushfire from NW.	Moderate risk from low and high intensity fires funnelling up gully.
Environmental Impact:	Absence of topsoil means little loss of productive ground but major earthworks required.	Little topsoil so little loss of productive potential. Minimum visual impact and only modest earthworks required.
General Impressions:	A bleak and uninviting site requiring major work to create a pleasant and productive landscape but well suited to a large multi-purpose building.	An attractive site but severe frost problem for house gardens, substantial servicing costs and not suited to larger building.

EARTHWORKS - HOUSE SITE

DESIGN PRINCIPLES

Having chosen site one, several factors required major earthworks to modify the site.

1. Commitment to an energy efficient and bushfire resistant house demanded a structure set on the ground with a long east-west axis.
2. The need for some flat (and/or terraced) land for intensive vegetable gardening, outdoor living, working and vehicle access.
3. The need to separate existing hard rubbish from organic matter (eg decomposed sawdust) and topsoil, to control minor gully erosion and to make rabbit proof fencing possible.



Excavation work for house site in progress March 1986. Resistant sandstone reefs (exposed by bulldozer) which became features of the landscape design visible (centre).

The house design required a split level platform, 27m east-west, with cut and fill of over 2.5m. The major unknown factor was the location and hardness of sandstone reef outcrops which could not be removed by a D7 bulldozer. Initial assessment indicated resistant rock should be deep enough not to be a problem.

The standard practice of only building on the cut ground was not possible. Alternative house designs involving underground or partial earth berming and multiple stepping of the structure to the west were rejected as being too costly in construction and restrictive of inside/outside interaction when compared with the thermal and site impact benefits. Therefore pier and beam foundations[1] were used on the the filled ground.

Fill slopes were designed to be as gentle as possible (slope 1:4) to visually and functionally blend the housesite into the rest of the land, and allowing planting and access on the slope. Cut slopes were planned to be as steep as practical to get as much of the house on the cut ground as possible. Retaining walls and terracing were planned for these areas.

PRACTICE

All topsoil, organic matter and vegetation on the site was stripped and stockpiled in a windrow[2] which acted as a silt trap during excavations.

Excavation exposed two successive sandstone reefs which could not be moved by the bulldozer. Without resorting to blasting this required some modification of the house siting and design.

Large terraces were formed with the reefs acting as retaining walls and the house position was moved 2m lower down the slope to the west. The consequent reduction in the amount of excavated material demanded steeper fill slopes. Slope angles were varied to create concave slopes which blended well with the natural ground.

The fill sections of the platform were mounded with an extra 0.2m of material to allow for settlement. Both levels of the platform were sloped to table drains[3].

The access track down the road reserve was formed and surfaced with crushed rock. Ridges were made on the upper and lower sides to divert runoff away from the house site.

View from Newstead Road of house site excavation completed; split level main platform, tank terrace, fill slope roughly respread with topsoil and topsoil stockpile on left. Stakes in middleground marking out main dam in gully.

Excavated shale stockpiled from the foundation trenches was later used to build up around the shed to form level platforms to allow vehicle access to the building site from the north and integrate the shed complex with the housesite earthworks.

Excavation and installation of the sewer connection were done to allow completion of the earthworks between the house and shed.

1. *pier and beam foundations: steel reinforced strip foundation beams supported on reinforced concrete piers*
2. *windrow: long ridge of material, in this case, on contour*
3. *table drain: surface drain along the inside edge of a road or earth terrace*

HOUSESITE LANDSCAPING

Landscaping around houses is generally done as an afterthought. Here, it was an important part of the project right from the start. A general design concept had been worked out prior to the earthworks but this was modified following exposure of resistant sandstone reefs which now form the foundations of dry stone retaining walls built from the stone salvaged during the excavation work (approximately 100 tonnes). The bulk of the landscape construction work was completed following the house foundations.

Topsoil spread on the fill slope by bulldozer was immediately raked while dry and sown to a pasture seed mix, to minimise erosion.

David sowing pasture seed on freshly raked topsoil of fill slope, May 1986. Debris raked to contour lines for erosion control. Topsoil stockpile back right. Species mix; tall fescue, phalaris, cocksfoot, prairie grass, white and subterranean clovers.

EARTHWORKS - HOUSE SITE

Locally available timber (sawn yellow box) was used to construct a retaining wall along the drive.

Topsoiling the cut slopes and terraces with a front end loader followed construction of retaining walls and the concrete tank. Rather than being thinly spread and sown to grass, topsoil on the cut slopes was concentrated at tree and shrub planting sites. A temporary access track across the cut slope to allow construction of the concrete water tank was filled over.

The cut and fill slopes were planted with shelter and screening species the following spring (1986) and mulched. The first vegetable garden beds were established behind the dry stone retaining walls.

Excess topsoil from the main dam was moved to a stockpile on the house site platforms for raised garden beds and lawn. These were all established after the house was occupied and building materials and debris had been removed. (Spring 1988).

Wide angle view of house site September 1986 from roof of newly constructed shed. Dry stone and timber retaining walls, concrete water tank and house foundation walls, wheelbarrow path, terraces with first mulching over topsoil. Tree planting on fill slope (right) and cut slope (back). Note table drains formed by wheelbarrow path and main platform.

Su planting shrubs above timber retaining wall as visual screen from road September 1986; bottletop guards against rabbits, newspaper and sawdust mulch with tree chippings behind for groundcover. Retaining wall with housed tie backs to buried posts for stability.

Screen plantings 8 years later. Note grass growth in table drain of driveway.

DAM SITING

Several factors suggested devoting a substantial part of the property to dams:

1. the very large volume of water which flows through the property during winter and the ideal soil and site characteristics for dams. Because of the partially urbanised nature of the catchment, total water yield is higher than could otherwise be expected. Summer thunderstorms can produce substantial runoff from hard surfaces.
2. the poorly drained nature of the gully zone making it unsuitable for orchard or buildings.
3. the opportunities to develop a substantial fruit and nut orchard required careful consideration of water supply options. The cost and uncertainties of reliable supply in dry years of the town system had to be considered.
4. the risk of uncontrolled crown fire afflicting the town and the unreliability of town water supply in such conditions.
5. the aquaculture potential and wildlife value of dams.
6. the recreational and aesthetic value of dams.

David testing soil from auger holes in main dam site for clay content, February 1986. Higher stake marks where dam wall will meet the Olver Street reserve while the lower stake marks the top water level. The gentle form of the drainage line (visible following tractor slashing of the site) results from filling of the eroded water course with earth moved by previous land owners.

Some unusual factors constrained the design and construction of the dams:

1. the position of sewerage mains severely constrained the position of dam walls and the extent of water bodies.
2. the time for which the gully flows (6 months or more) and the total volumes of water during flood flows demand engineering solutions normally used on much larger dams.
3. past filling of parts of the gully with rubbish from the sawmill required care in wall construction.
4. the partially urbanised nature of the catchment means water quality can be affected by silt, nutrients and pollutants.
5. the close proximity of the second house site to the gully and the need to avoid problems and maximise the benefits from this proximity.

The way all of these issues are integrated by the siting and design can be seen by studying the Landscape Plan and referring to the following Dam Design notes.

View down drainage line in winter following construction of dams showing typical winter flood flow which rarely persists at this level for more than a day although a trickle flow can be continuous for several months. Average annual flow from the 40 hectare catchment may be 50 times the storage volume of the dams. Note the sod roofed pumphouse (lower right).

DAM DESIGN

Main Dam

- A 0.8 Megalitre capacity dam with the wall sited immediately upstream of the sewerage main which crosses the property. The top water level is below the sewerage trunk main inspection opening at the head of the gully.
- The main function of this dam is stored water for irrigation of gardens and orchard plantings via the header tank behind the house as well as fire fighting reserve water. A 50mm pipe through the base of the dam supplies constant pressure to prime[1] the pump on the lower side of the wall.
- A hole dug into the gully floor at the back of the dam serves as a silt trap to the main dam. Planted with reeds it will also filter some of the nutrients and pollutants from the runoff.
- A 150mm trickle pipe through the wall carries the normal winter flow of the gully while the well grassed spillway carries flood flows.
- A sump below the water supply pipe level with tree stumps to provide fish habitat safe from cormorants.
- Lining of the inside of the dam with topsoil to increase the biological productivity of the dam.
- A bridge over the spillway makes the dam wall an internal vehicle access route across the gully between the two gates from McKinnon and Olver Street road reserves.

Main dam construction complete March 1987. Topsoil spread on wall and inside slopes. Stakes and Pin rush tussocks mark top water line. Tree stumps in dam for fish habitat, spillway lower right, surplus topsoil stockpile (later moved to housesite garden areas) on left. Tree planting on housesite fill slope in foreground.

Construction of geese pond September 1987. Backhoe is excavating mixed topsoil/fill to form toe of wall, D3 bulldozer pushing clay into core trench.

Geese Pond

- A small wall formed by moving hard rubbish fill further down the gully to the boundary and lining with a core and inner slope of good clay to form a "pond" of approximately 0.3 megalitre capacity.
- A trickle pipe as on the main dam.
- A second dam increases aquacultural management options compared with one large dam. By not drawing on the pond for irrigation it may develop more permanent water edge vegetation and will be available in most seasons as a home pond for geese grazing the orchard. By keeping the geese off the main dam, water quality can be maintained for swimming and drip irrigation.
- In drought years when the main dam is run dry by irrigation use, this will act as a biological and/or water supply reserve.

1. prime: filling a pump with water before pumping can start

David installing 150mm PVC trickle pipe through main dam wall at the top water level 1987. Two PVC baffle plates prevent seepage along outside pipe.

DAM CONSTRUCTION AND MAINTENANCE

The main dam was constructed 12 months after the housesite excavation (autumn 1987) with a D7 bulldozer. Conflicts and communication problems with the contractor resulted in a number of problems.

Firstly, the wall position crept down the gully resulting in the pump house being sited over the sewer main, a less than desirable result.

Secondly, the spillway was cut below the pegged contour line making it vulnerable to erosion. Very heavy autumn break rains exceeded the capacity of the 50mm pipe through the base of the wall and overflow eroded the freshly raked and sown spillway. Installation of the 150mm trickle pipe, rock fill and re-topsoiling has solved the problem.

Lack of adequate compaction of the clay combined with high yabbie populations have resulted in additional problems with seepage through the upper part of the wall. Vigilance and strategic use of bentonite clay has prevented any holes developing into cavities which could threaten the wall. Harvesting of yabbies has had little effect.

We have plans to drain the main dam to deepen it, repack the waterline section of the wall and clad it with shale in an attempt to control yabbie burrowing. Heavy rain and runoff into an empty dam thwarted the autumn 1995 attempt. Salvage of excess topsoil from the dam made up for the deficit on the housesite. The transfer of topsoil from the gully to the hillside reversed soil bulldozed into the gully by previous landholders and increased the potential of zone one gardens around the house.

The geese pond was constructed the following spring (1987), with a small bulldozer and backhoe. Because the drainage line had been filled with logs, rubbish and fill, the construction technique involved pushing the fill down the drainage line to the gully confluence using the bulldozer and excavating the material with the back hoe to form a vertical face and exposing good clay for a core trench[1]. Good clay was then cut from the drainage line shoulders to form the inner water holding slope of the dam.

Excess topsoil was spread on the flat area to the south of the dam allocated as the vegetable garden of the second house. Seepage problems have also occurred with this dam due to high yabbie populations and the limited thickness of the clay blanket.

The spillway of this dam has worked well but following two very wet years in '92 and '93, minor erosion occurred outside the boundary fence where flood water re-enters the gully. Reforming the gully bank and a woven mat of living willow branches and periwinkle have solved the problem.

1. *core trench: excavation into the clay foundation to form a key or bond with the dam wall*

HOUSE

HOUSE DESIGN

HOUSE DESIGN PROCESS

The house design process was reasonably well advanced before the land was even purchased. Although there are great dangers in designing a house in isolation from site factors, a conceptual design can help in selection of land and siting within that land.
A willingness to modify or even scrap design details in the face of site factors is essential. Being owner/designer/builders makes modification to design details during construction also possible. Moving into the house before it was fully finished allowed further refinement of design details.

This does not mean that detailed plans and designs for houses or landscape are a waste of time. They are as essential as the preparedness to respond flexibly to new facts.

Above: *North aspect of house viewed from McKinnon Road reserve winter 1990 showing the large area of north facing glass. Stove flue pipe left, cool cupboard exhaust vent centre, greenhouse exhaust vent lower roof and wood heater flue right. Rabbit proof perimeter fence and rip lines for road reserve plantings in foreground.*

Right: *South aspect of house viewed from driveway late 1990. Timber floor level in bedrooms is just above outside garden terrace (right). Rainwater tank collects from east end of roof and supplies drinking water to third tap at kitchen sink by gravity feed.*

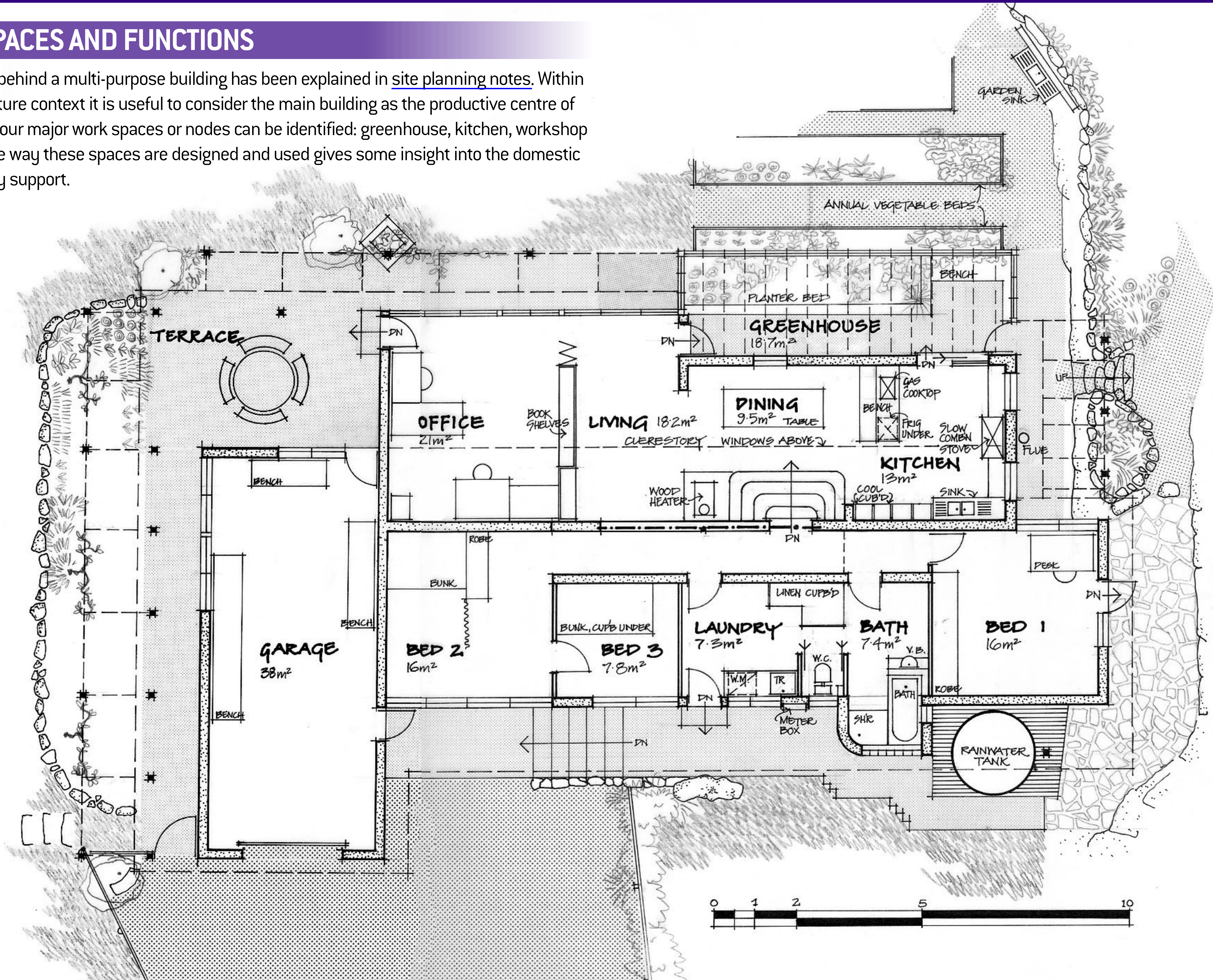
DESIGN CRITERIA

1. Passive solar design to provide the majority of space heating.
2. Bushfire (and storm) resistant design principles.
3. Use of natural and salvaged building materials for low energy cost, healthy house criteria and to support the local economy.
4. Multi-purpose building as family home, office, workshop/garage and greenhouse. Multi function design of spaces to contain overall size to 220m^2.
5. Clustering of plumbing facilities to reduce costs.
6. Create outdoor living, working and food producing spaces which act as a natural extension of internal spaces.
7. Minimal visual impact on an otherwise prominent site.
8. Total cost not to exceed A$70,000 (in 1985 dollars)

This chapter cover aspects of the house design and construction which reflect permaculture principles. Much of the design which is commonplace is not covered in any detail.

WORK SPACES AND FUNCTIONS

The rationale behind a multi-purpose building has been explained in site planning notes. Within the permaculture context it is useful to consider the main building as the productive centre of the system. Four major work spaces or nodes can be identified: greenhouse, kitchen, workshop and office. The way these spaces are designed and used gives some insight into the domestic economy they support.



HOUSE DESIGN

OFFICE

The office occupies the the north west corner of the house. It has its own entry via the covered walkway and porch surrounding the workshop. The dividing wall from the living room includes built-in bookshelves and cupboards as well as folding doors which allow the north side of the office to function as a corridor to the outside porch.

The office includes three work stations, desk, computer and drafting board as well as layout bench, file and plan storage and display space. It is adequate for a small home based consultancy service, permaculture research and education activities.

Being surrounded by one's own design work is part of the low key approach to promotion and can provide direct examples in discussions with clients. Any substantial expansion of Holmgren Design Services would require a larger office either at the second building or off site. In this situation the office would readily convert to a bedroom or other use.

Su at desk in office. Mid winter sun on mudbrick wall provides excellent natural lighting (and passive solar heating). Cord (centre) controls fanlight opener on triangular vent in clerestory for summer ventilation.

WORKSHOP

The workshop is an integral part of the house structure and design. The extension of the building beyond the main part of the house provides protection of the main entry to the house from westerly weather. The roofed porch on the north side provides covered entry to the office and an outdoor living area.

The main roller door provides access for the car while the side door allows undercover approach to the main entry. The garage space provides a large area for joinery and other special construction projects.

Above the garage area, the 200x50mm hardwood joists support stored timber and other building materials.

The northern end of the workshop has metal and woodworking benches, tools, hardware and paint storage shelves and cupboards. A main door in the north wall provides access to the undercover porch area and the office.

A half height door provides access down to the undercroft under the west bedroom. This area is used to store preserves, beer and some bulk foods as well as timber and materials.

KITCHEN

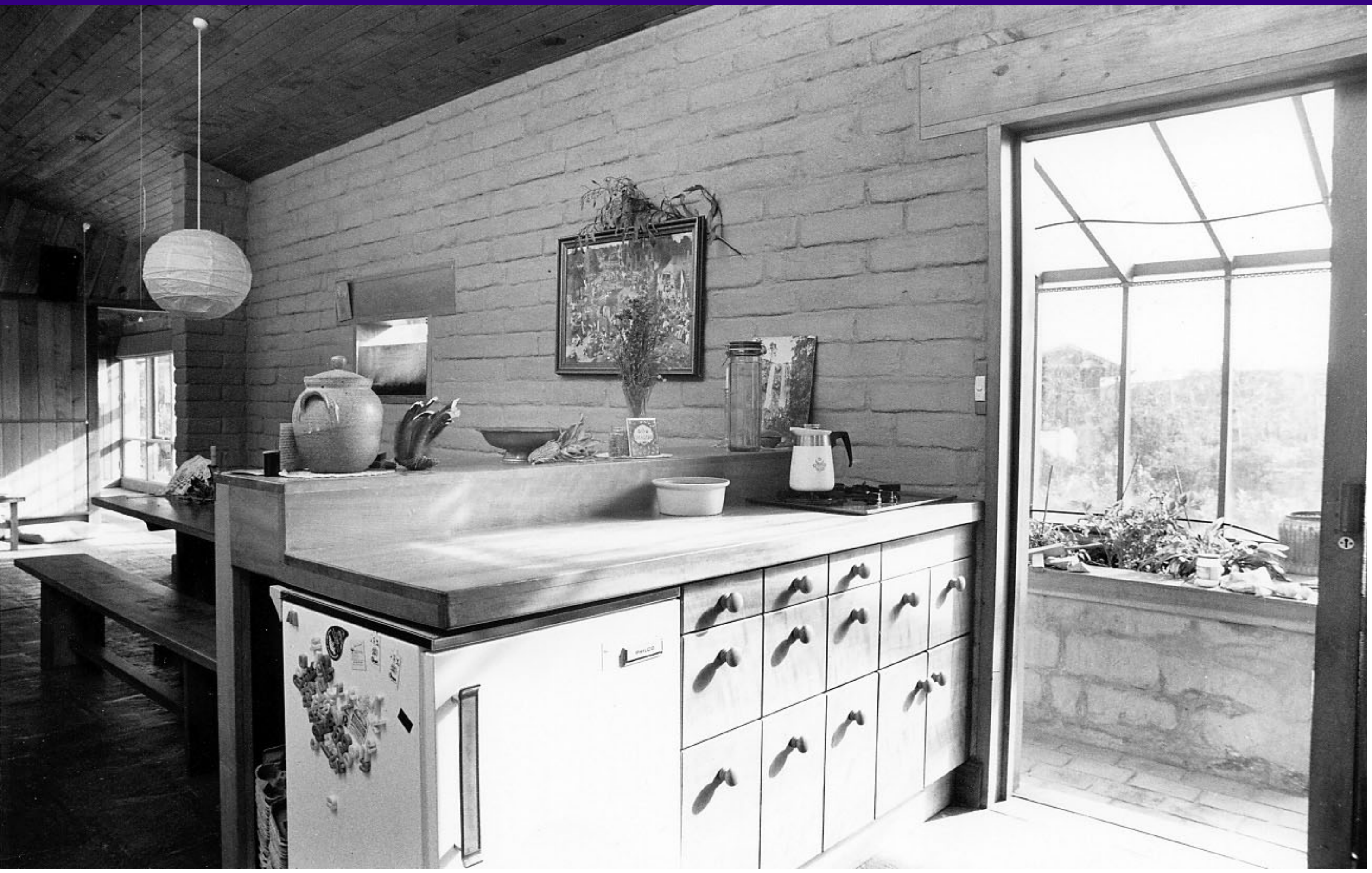
As in the traditional farmhouse, the kitchen is the centre of activity and is large enough for several people to work together or gather near the warmth of the stove in winter. The stove is in many ways the heart of the house and our home based lifestyle.

Slow combustion stove

The siting of the stove on the east wall allows for an external flue pipe and stove hood reducing costs and heat accumulation in the building during summer, while accepting some loss of heat in winter. Wood storage, along with waste paper, is in the cupboard alongside the stove and is adequate for 1-2 days. It is replenished from the undercover storage outside the greenhouse door.

The stove (second hand Everhot 204) bakes almost all the bread and other cooked food consumed by the household, warms bread dough, yoghurt, sprouts and germinating

Kitchen with slow combustion wood stove, blackwood bench, cupboard doors and plate draining rack over sink. Warming rack over stove used for sprouts, yoghurt and drying. Note: third tap over sink is gravity fed from rainwater tank.



Under-bench fridge, bulk food storage drawers and two burner gas cooktop in peninsular bench. Winter sunshine and warm air enter from greenhouse. Living room with sunshine from north windows in background.

seeds of tomato, capsicum and eggplant in late winter, dries herbs and does numerous other tasks. It has provided all our hot water for 7 years and even with the installation of a solar hot water panel will still be the major source. It is lit almost every day but is rarely slow combusted overnight which is unnecessary for heat and produces more creosote (flue blockage and air pollution). Perfectly dry good wood, careful management and regular (1-2 months) clean out are necessary for efficient working. A more efficient (and expensive) stove could reduce wood use, would be easier to manage and require less frequent cleaning.

Gas cooktop

The house does not get excessively hot in summer so there is not much impediment to use of the woodstove, but a preference for less baked food during summer and the efficient provision of hot water from the solar panel will reduce the need to light the stove and save considerably on wood. The gas cooktop is adequate for hot drinks and simple meals. The quantity of bottled gas used is very small (approximately 10kg/annum).

Food storage

Bulk buying and home production require good food storage facilities. Considerable effort has been made to provide adequate food storage without the luxury of a separate pantry.

The peninsula bench (see left) provides rodent proof storage for bulk rice, other grains and legumes, honey and tahini. The small underbench fridge is built into this bench. The cool cupboard and cooking and eating habits make a small fridge quite adequate, reducing environmental costs (both electricity and CFC's from refrigerators and freezers). We do not own a freezer but make occasional use of neighbours'. The undercroft[1] provides long term storage for home-brewed beer, bottled fruit, oil, tahini etc.

Cool Cupboard

The most notable feature of the kitchen is the convective cool cupboard. This double-doored 1m wide cupboard with sliding wire baskets provides storage for bulk quantities of fruit and vegetables, drinks, fresh flour, cheeses, eggs and other foods which only need cool storage.

Temperatures range from about 5°C in winter to 18°C in late summer. The upper compartments tend to be warmer but just as well ventilated and can be reached with a ladder. They are used for long term storage of pumpkins and other bulk foods which do not require such cool conditions.

The seasonal performance cross sections show the airflow from under the tank stand to the underfloor crawl space and up the cool cupboard to the flue pipe. This convection flow is created by the natural warming in the upper cupboard and flue pipe. Total height (5.5m), large exit flue (0.3m dia.) and well insulated crawl-space are all significant factors in the functioning of the cupboard. In summer, a wet screen on the inlet side of the cupboard reduces temperature by 1-2°C. However a substantially improved performance down to 14°C could be achieved with an earth duct (dia. at least 0.3m) under the house. Rock reefs made this difficult here.

Su opening sliding wire baskets in four doored cool cupboard. Open top door shows half section of 300mm metal exhaust flue pipe. Larger opening at base allows flow of cool air from below timber floor. Grocery and broom cupboards at lower left, bottled preserves upper left. Cupboard doors are made from melamine coated chipboard with blackwood frames giving a flush fitting and easily cleaned door with minimal gassing off of chipboard glues.

1. *undercroft: enclosed space below a raised timber floor*

GREENHOUSE

The greenhouse is the archetype of the multi-function space and is an important interface (or edge) between inside and outside, the biological and the built. It is an appropriate symbol of domestic permaculture in cool climates.

The greenhouse has several roles in the food producing system.

1. It is an ideal environment to raise seedlings of summer vegetables such as tomatoes, capsicums, eggplant, cucurbitas etc. Without greenhouse grown seedlings, these crops can be marginal in our climate. Production of seedlings surplus to domestic needs is easily achieved allowing barter or sale.
   Elements of the design which assist in growing seedlings are:
   - the large area of glazing providing adequate light to produce strong seedlings
   - ease of maintenance due to more than daily surveillance
   - installed spray irrigation
   - bench height garden bed and work space.
2. During winter the raised soil bed is large enough to grow adequate salad greens for the family for the winter/spring lean time.
3. During spring and summer early crops of summer vegetables, such as beans, tomatoes and basil can be grown in the soil bed and provide shade through the summer.
4. A limited number of sub-tropical perennials can be grown without compromising other uses and functions.

Storage of pots, seed trays and potting mixes is in the garden shed and barn but the ease of wheelbarrow access and the wash down floor and water supply make work in the greenhouse efficient and, in the winter, very pleasant.

The greenhouse also performs the functions of mudroom and airlock. Boots and coats are removed here before entering the kitchen. Containers for collection of produce from the garden are stored there. As the most used entry points, two doors between the inside warm spaces and the outside air provide a very useful airlock in winter.

As a living space the greenhouse is a pleasant sunroom/breakfast space on cold but sunny winter mornings and a good space for young children to play out of the weather and easily seen from the kitchen.

The contribution of the greenhouse to the thermal performance of the house is very important. This is described in the notes on solar design on the following pages.

Above: *Greenhouse in summer. Early trellised crops on mesh (beans and cucumber) block out sun and provide evaporative cooling. Winter self-sown silver beet to be removed as sweet potato groundcover expands in the shade of the other crops. Overhead mist sprayers provide cooling and irrigation early morning before hot days. Roof exhaust vent (upper right) and louvre inlet vents (hidden in foliage left) remain open all summer. Recently bottled beer (lower right) completes fermentation in warmth before maturation in undercroft. Fish tank (right) forms window from dining room.*

Left: *Propagation of vegetable and tree seedlings in early spring is an important function of the greenhouse. Seedlings (and the odd overwintering capsicum) don't block the sun needed for solar heating of the house. Sun on terracotta tile (greenhouse) and mudbrick (living room) contributes to thermal storage. Open door allows warm air into living room.*

SOLAR DESIGN FEATURES

Passive solar building is a major aspect of the project. I was confident that we could build a house, without excessive cost, or use of non-renewable materials, or indirect energy, which would largely heat itself from the sun. If we could do that in a climate which could be described as having an unfortunate combination of Melbourne's cloudiness with Canberra's cold, it could be done almost anywhere in southern Australia.

The following points and the seasonal performance diagrams describe and show what features of the design contribute to energy storage and efficiency in the house.

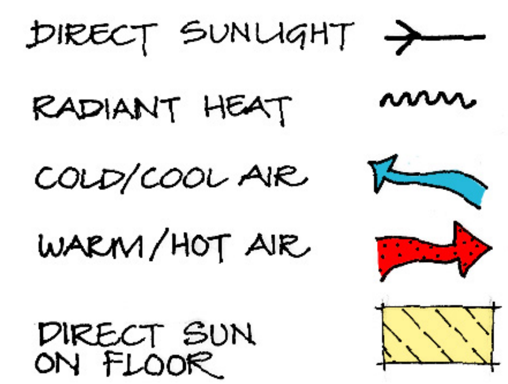
- Long east-west axis with over 90% north face glazed, in greenhouse, windows and clerestory.
- Exterior mudbrick walls for insulation value, R 2.5 roof insulation.
- Mudbrick garage/workshop on west side provides substantial insulation from effects of cold winds and afternoon summer sun.
- Laundry and greenhouse provide airlock spaces for most used entry points.
- Masonry floors and steps in north section for sun-exposed thermal mass.
- Mudbrick east-west internal walls for sun exposed thermal mass.
- Location of access corridors free of furniture ensures maximum exposure of thermal mass to winter sun.
- Inlet venting from louvre windows on south and east sides for cool air in summer cool changes and evenings.
- South louvres act as exhaust venting of excess heat on sunny winter days and keep south bedrooms well aired and dry.
- High vents in clerestory[1] to exhaust excess heat in summer.
- Louvres and roof exhaust fan ventilate greenhouse in summer.
- Doors vent warm air from greenhouse into kitchen and living room during winter.

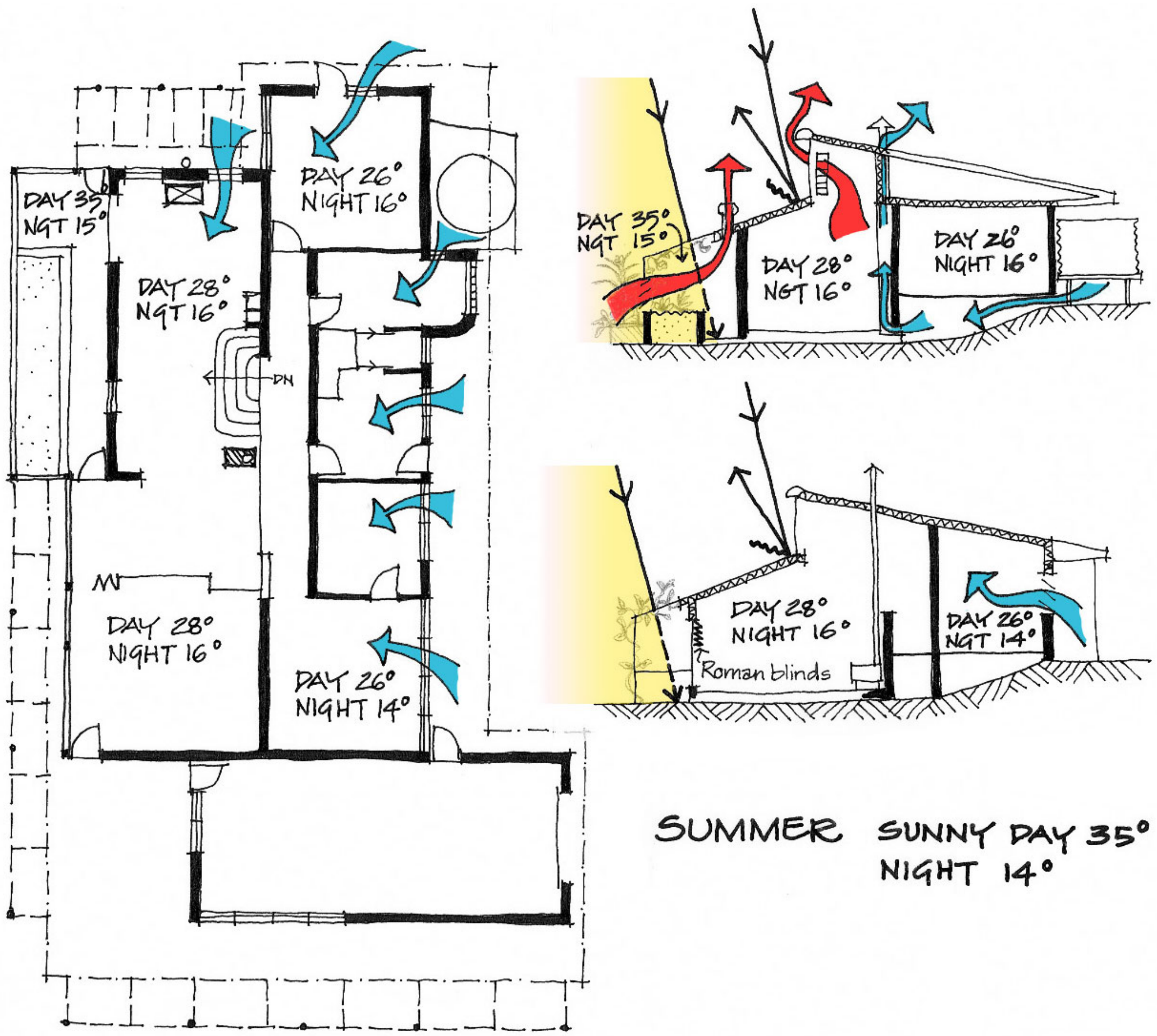
Exposed hardwood trusses allow entry of winter sunlight from clerestory which is then absorbed by thermal mass of mudbrick internal walls. Split level encourages movement of warm air from greenhouse, wood stove and backup wood heater (lower right) to the bedrooms on the south side. Doors (open) control flow of heat especially to laundry (centre) and bathroom. Slate covered mudbrick steps provide additional thermal mass and informal seating. Blackwood steps, cypress balustrade, door framing and flooring are all bushfire salvage timber from Mt Macedon. (Note hardwood trusses have greater resistance to burning in any house fire.)

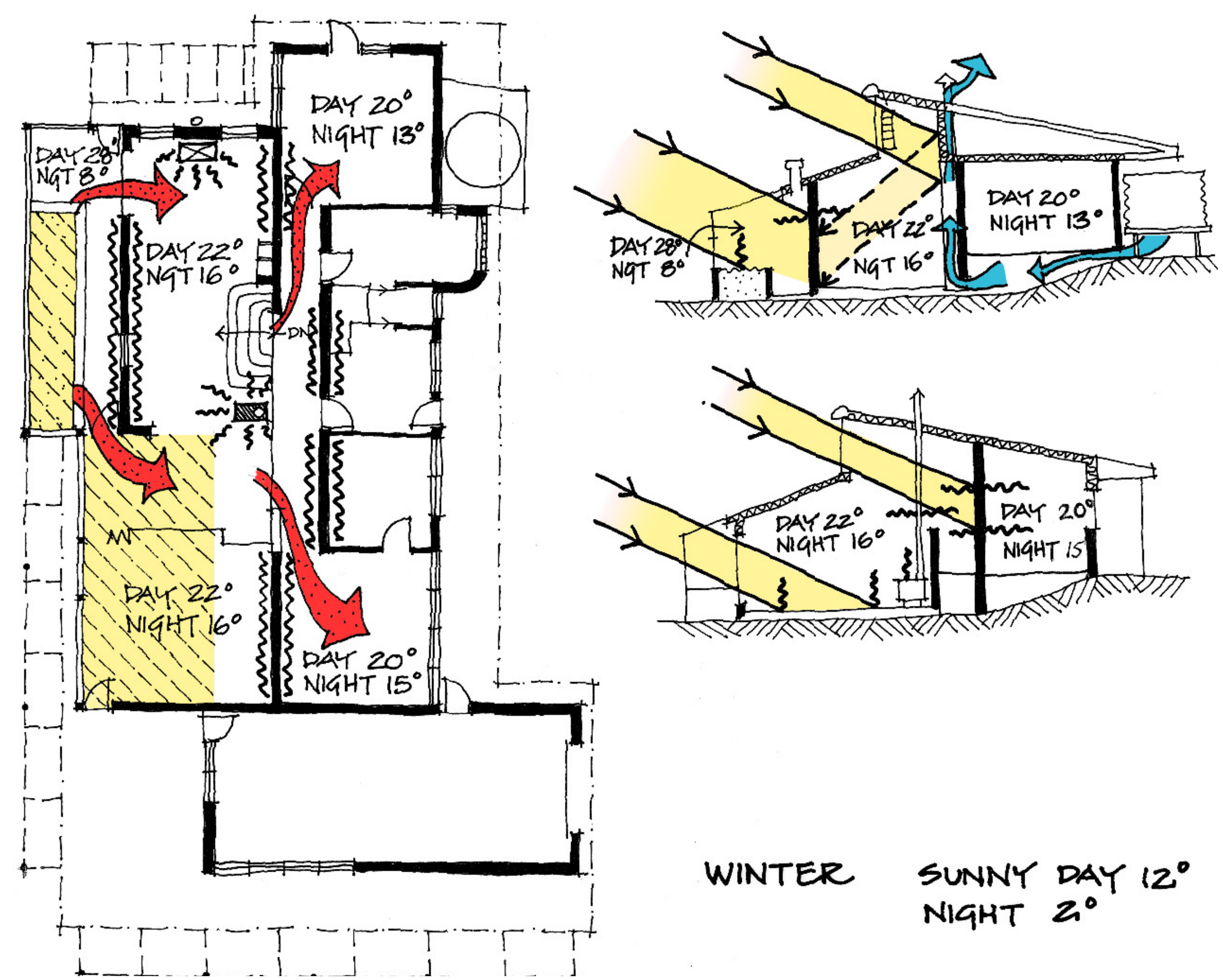
1. *clerestory: high windows which form a break in the roof line*

SOLAR DESIGN FEATURES

- Eaves exclude direct summer sun from clerestory and north windows and from mudbrick wall in greenhouse.
- Internal growth of annuals in greenhouse controls excess heat in summer.
- Deciduous vines on north, east and west pergolas control excess sun and heat in late summer-autumn period.
- Double glazing of clerestory and curtains on windows contain heat loss in winter.
- Crawl space under timber floor provides cool air mass to feed convective cool cupboard. Restriction of under floor ventilation to shaded cool areas below tank stand and near wood storage to keep under-floor temperatures in summer as low as possible. Draw of cool cupboard maintains adequate ventilation against damp.
- Slow combustion stove provides hot water and warm spot focus in kitchen all year round.
- Slow combustion radiant heater provides back up heat and warm spot focus during coldest months.
- Clerestory provides good indirect lighting during dull days to kitchen, dining, living and office spaces.
- Solar panel to be fitted on north roof to provide pre-heating for hot water.







BUSHFIRE RESISTANT DESIGN

Bushfire resistant design has been a long standing area of research and design for me. The principles and some of the technical details described in *The Flywire House* have been followed in the development of Melliodora.

The following features of the house design and construction contribute to the likely survival of the house in any bushfire.

1. On-ground construction, set into hillside, with low profile roof.
2. Steel rod from the foundations to the top plates, triple grip nail plates and self drilling roof screws into hardwood battens ensure security of roof in severe storm conditions (including fire storm).
3. Minimum of rough timber surfaces and preference for painted timber in vulnerable situations. Structural separation of timber pergolas from house framing. Absence of timber decks or other slatted timber structures.
4. 6mm glass on greenhouse and clerestory to resist damage even during firestorms (greenhouse roof is toughened glass). The plan to double glaze the clerestory will decrease the risk from this most vulnerable glazing in a bushfire.
5. Fully enclosed roof eaves and fibreglass batt stripping under ends of roofing iron to prevent entry of burning embers.
6. Metal flywire covered roof vents and external fly screens on louvre windows.

Contrary to popular belief, the mudbrick walls are not a particularly important factor in the fire resistant design.

Two factors in the design increase the risk of severe damage from fire inside the house (from any source).

1. The trusses are vulnerable to catching alight because they are exposed, so they are dressed, painted hardwood to substantially reduce the risk.
2. The connection between the workshop, undercroft and cool cupboard could lead to rapid spread of a workshop fire through the building. A heavy door between the work shop and undercroft reduces this hazard.

The shed and barn with rough sawn timber and open design are hardly fire resistant buildings and contain very flammable materials including fuel, firewood, racked timber, mulch etc. In a catastrophic fire these could be hard to save but the strong construction ensures they will not blow apart and threaten the house, while the microspray system around the eaves of both buildings dramatically increases their chance of survival in these conditions.

Clerestory with short eave overhang under bullnose to exclude summer sun. Triangular insulated opening provides venting after hot days. Trim roof (right) provides bracing for roof trusses eliminating the need for bracing across face of clerestory and contributes to low fire hazard roof profile.

View of buildings and "Zone One" from NW bushfire sector in drought conditions 1995. Slashed and grazed irrigated orchard provides first line of defence. Dense tagasaste and other low fire hazard hedges shelter irrigated food gardens around barn, shed and house. Spray system around eaves of barn and shed provide extra security.

HOUSE CONSTRUCTION

STRUCTURAL FEATURES

David and Oliver (18 months) fixing second hand north window glazing. Mudbrick floor with first layer of mud/cow manure grout dry and rammed (right) and second topping grout (left)

- Standard concrete strip footings on cut ground with extra strength mesh and piers down to natural surface on filled ground.
- Cavity concrete block footing walls to damp course level.
- Load bearing puddled mudbrick (adobe) walls up to 4m tall with cross tie stud walls and buttress features for bracing against lateral loads (eg. wind and earthquake). Barbed wire every third course for further resistance.
- Exposed cantilevered kiln-dried F17 hardwood trusses 8m long at 1m centres form main south roof and clerestory. Cantilevering over the main internal thermal mass wall allows sunlight from the clerestory to fall on the mass wall.
- Hip end (east) and trimming roof (west) provide bracing to clerestory.
- Boxed wooden beams with cypress facing timbers carry the load over doors in mudbrick walls.
- 6mm laminated roof glazing on greenhouse provides trafficable and hail resistant roof.
- Face fixing of secondhand 6mm glass onto structural timbers of clerestory and greenhouse wall with silicon mastic makes cheap and strong glazed area to resist damage (including during firestorms).
- Mudbrick floor living and working areas bedded on sand with vapour barrier over scoria[1] as thermal insulation from ground.
- Tongue and groove[2] (T&G) cypress flooring in bedrooms and hall and subfloor in bathroom/laundry under slate. Perforated foil insulation under timber floor.
- Stud frame, plasterboard lined cross walls in bedroom area with acoustic insulation of "apple packing" paper pulp sheets.
- Ceiling plasterboard and T&G cypress lining backed with insulation foil to act as vapour barrier against condensation in fibreglass insulation batts.

1. *scoria: very porous and light volcanic rock*
2. *tongue and groove: matching edges used to join flooring and lining boards.*

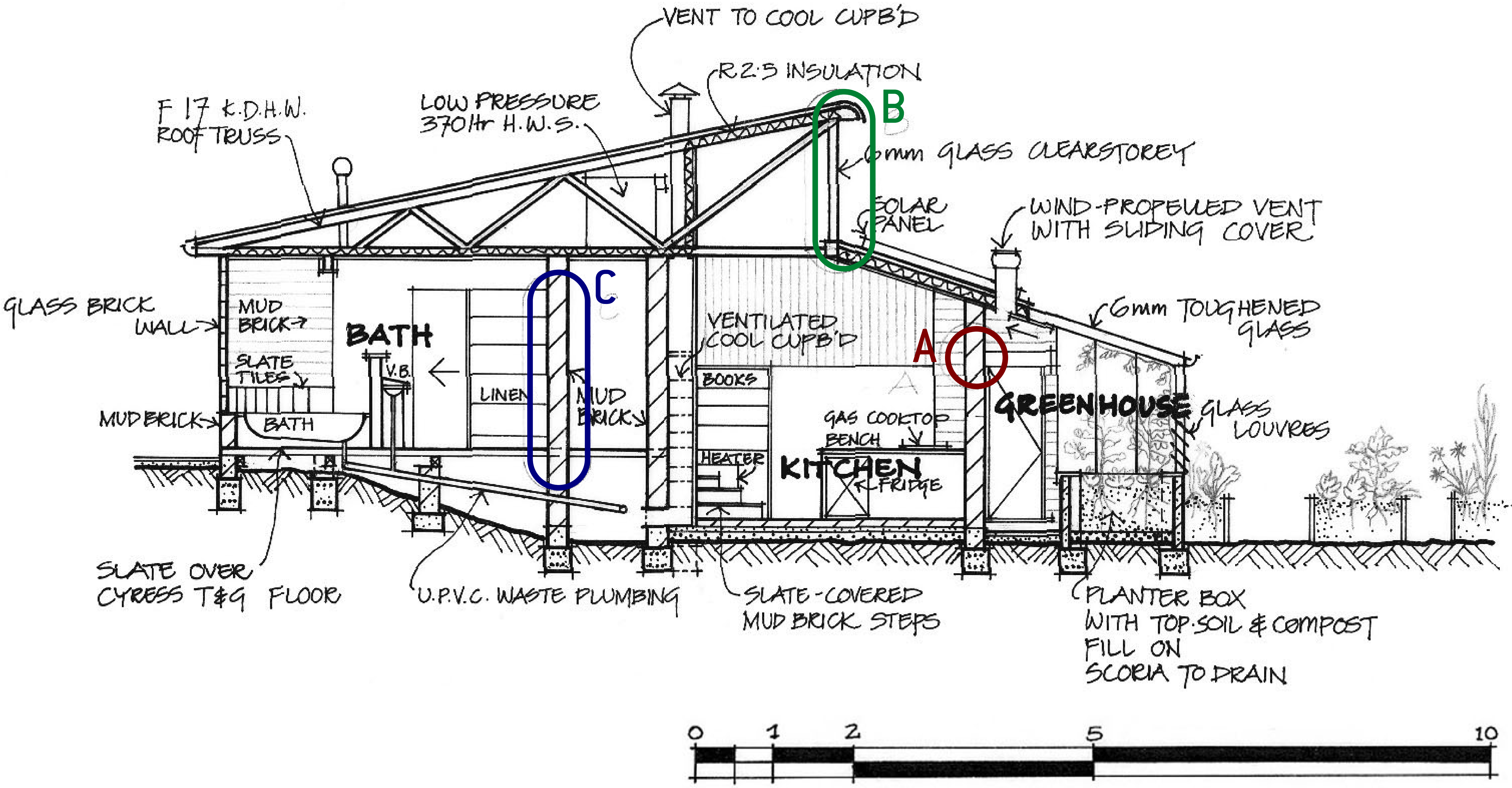
Wayne Irving and Doug Swing laying mudbricks on greenhouse/dining area thermal mass wall. Note boxed beam header above greenhouse-kitchen doorway and steel rods (upper left and centre left) for tie down of timber lintel and roof.

David checking position of pack of 14 pre-made hardwood trusses being lifted into position. Cantilevered truss ends form clerestory frame. Load bearing mudbrick walls tied by hardwood beams and lintels support the roof.

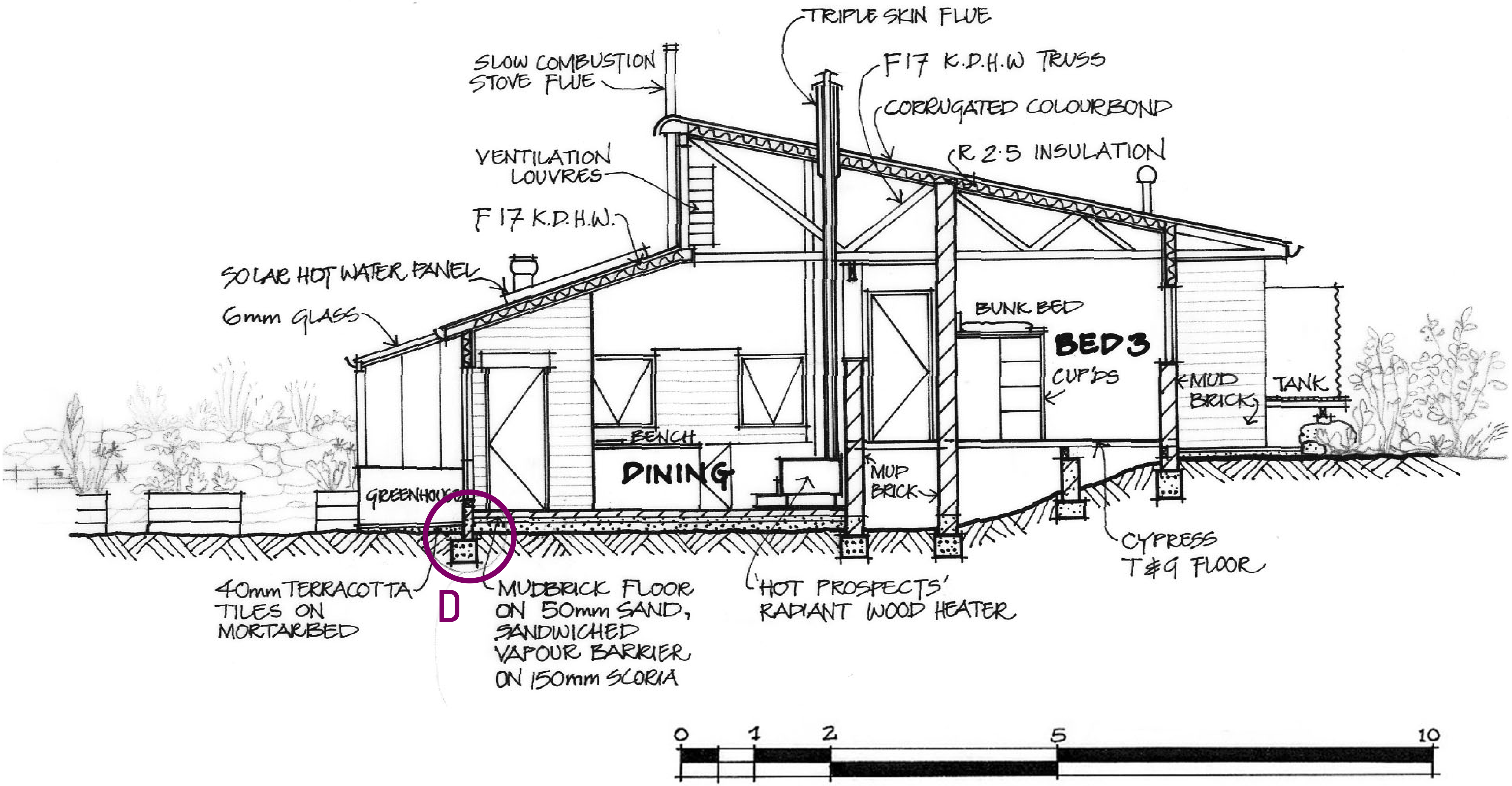
Above: *Graeme Harpley and Doug Swing (below) setting up to fix colourbond on north roof frame. Note fibreglass insulation along green house roof flashing and living room eave as barrier against burning ember entry to roof space in bushfires.*

Left: *John Logos and Kimon (15) fixing plaster on internal bedroom wall which provides bracing to mudbrick walls. Cardboard apple packing sheets stapled to studs provide sound insulation (from teenage music!).*

EAST SECTION



WEST SECTION



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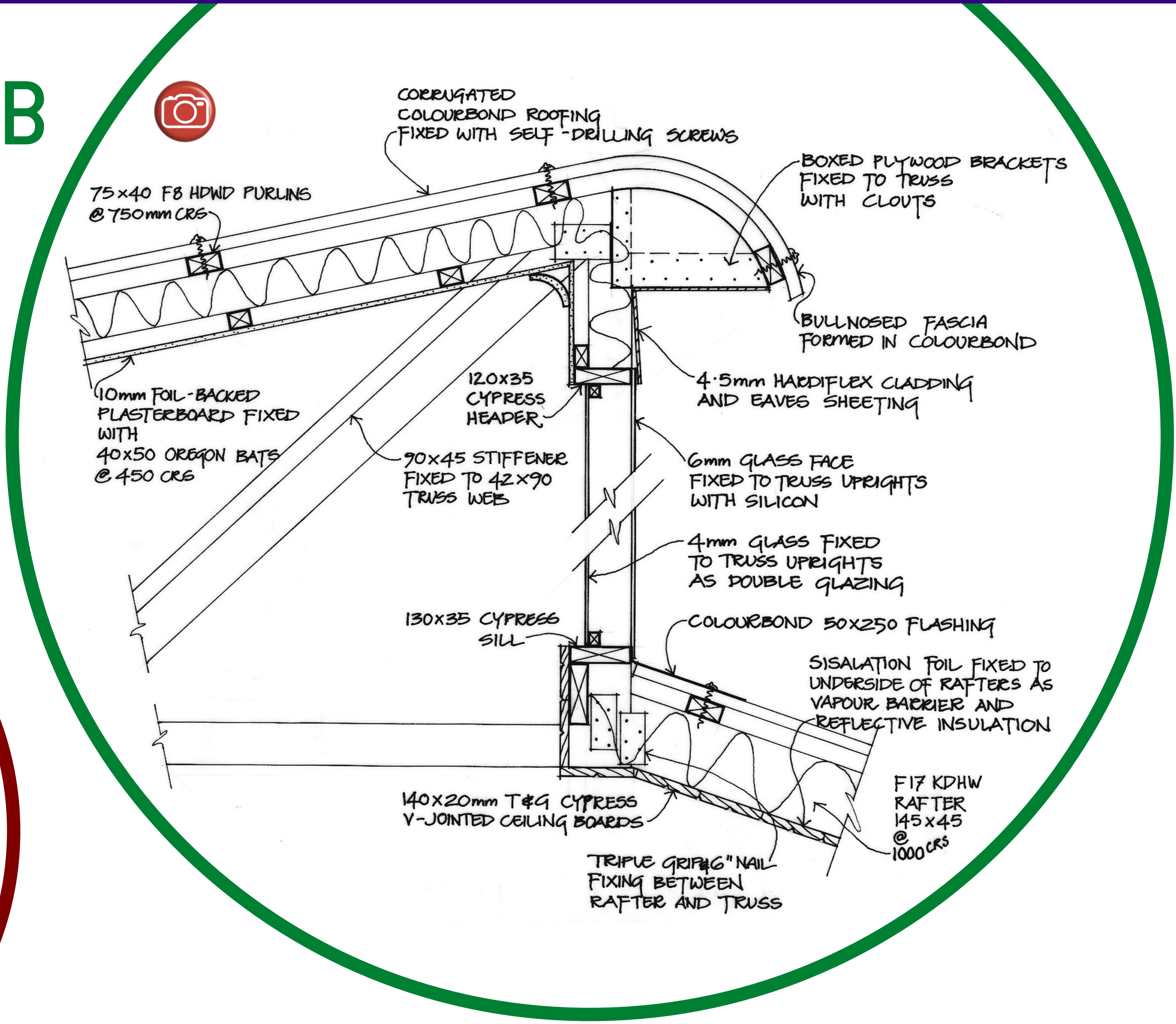

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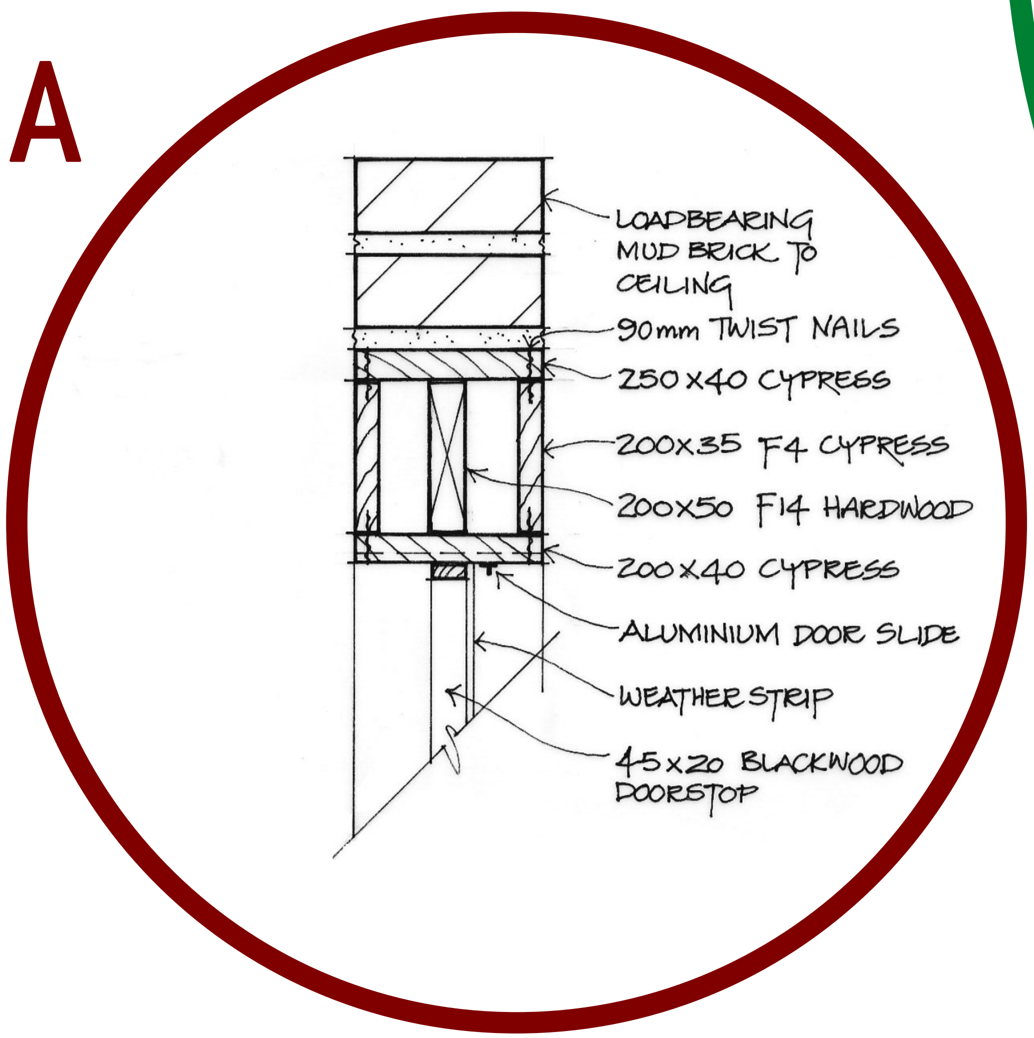

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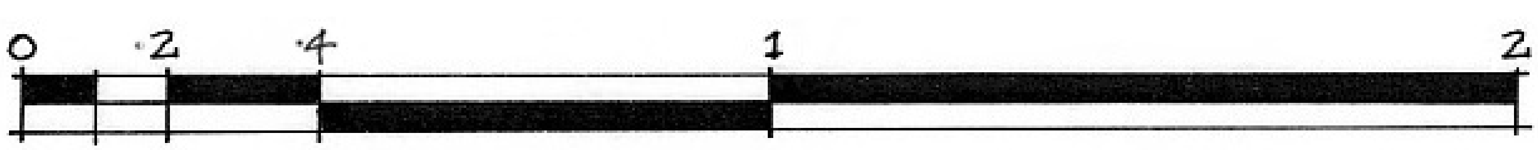

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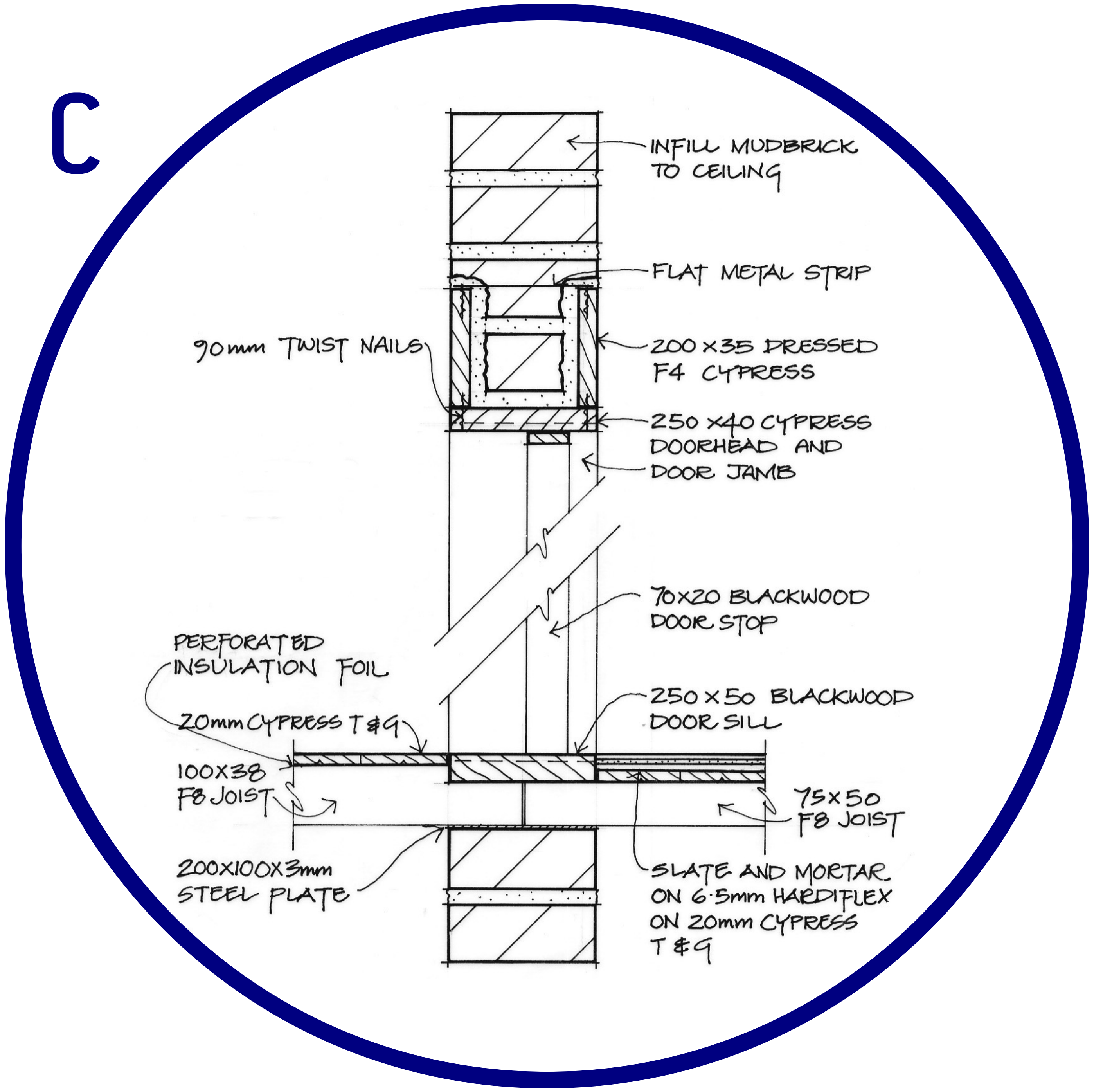

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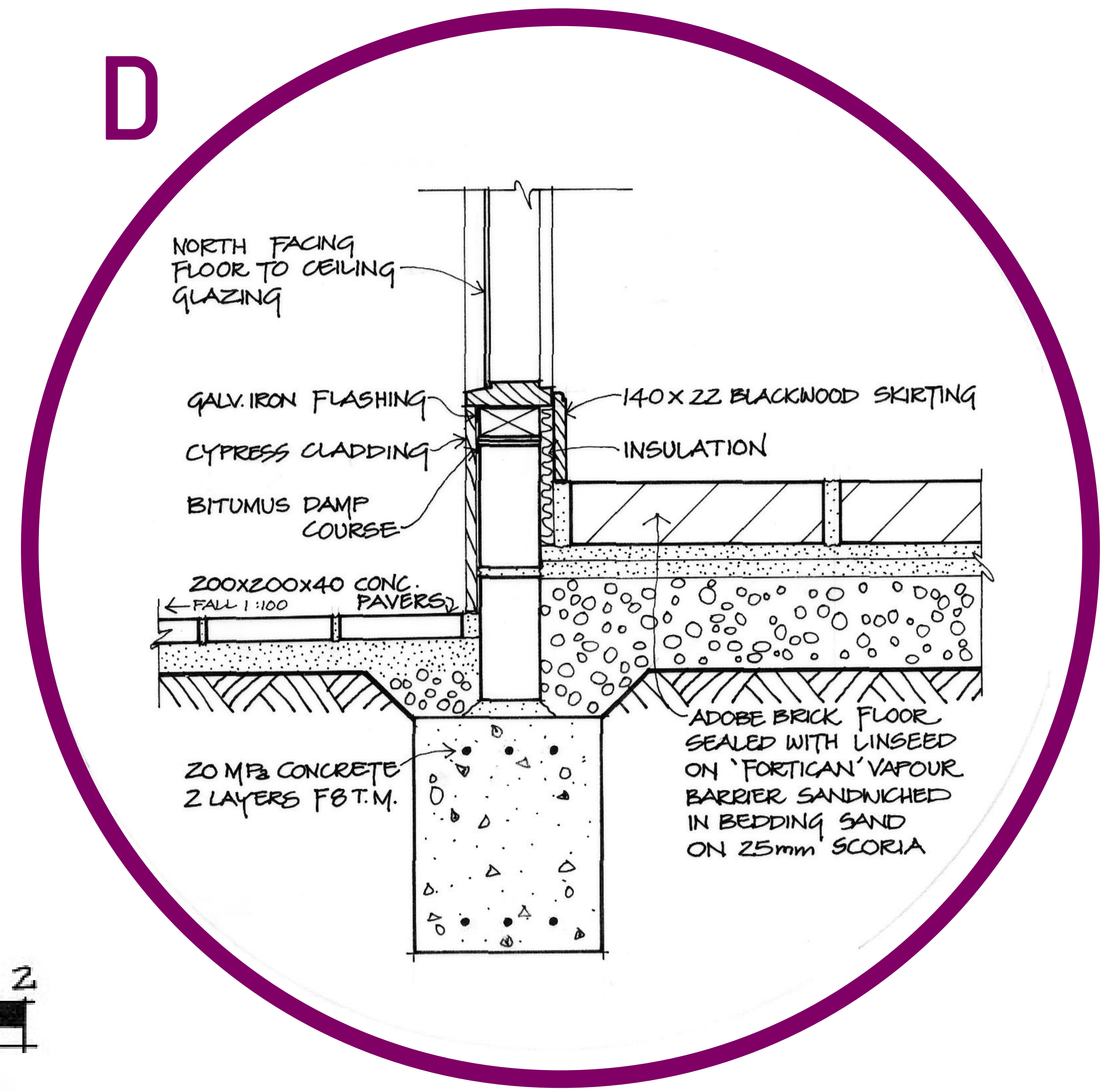

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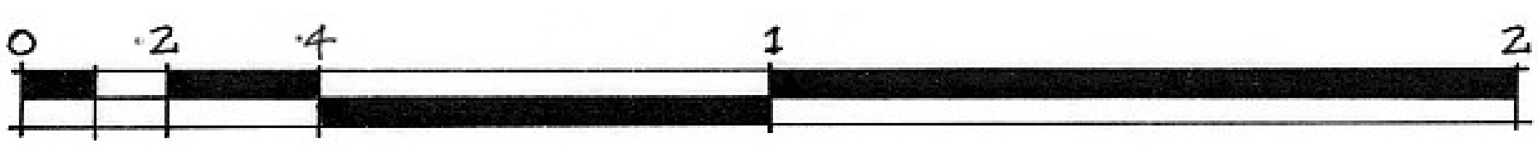


The following criteria were used to choose the materials for the house.

1. Low total energy cost. Materials which are labour intensive to use, involve minimal industrial processing (natural), secondhand, and locally produced will tend to have low total energy cost.
2. Low monetary cost.
3. Low toxicity and hazard during installation, use and fire. Natural materials tend to be healthy while highly processed materials involving glues and plastics tend to be hazardous.
4. Aesthetic harmony and individuality of natural materials while avoiding excessively "busy looking" collection of materials.

Individual choices reflect some criteria more than others as well as chance circumstances. With hindsight some decisions would have been different. The reasoning behind some of the choices is instructive.

MUDBRICKS

Mudbricks are a low energy cost, low toxicity, structurally and energy efficient material and the decision to use them predated the house design and land purchase.

The thermal performance of earth walls is much debated and even the ACF has suggested earth is not an environmentally sound building material because of poor insulation rating. Although a 250mm thick mudbrick wall may have an R value of only 0.6, the effective insulation value is much higher, partially due to thermal mass effects. Some authorities say the effective value may be 4 or 5 times this figure. This concurs with the experience of owners of earth homes.

On-site manufacture of the 5000 bricks required for the walls and floor was thoroughly investigated and found to be fraught with technical difficulties if costs of labour were to be kept below 90cents/brick, stacked, ready to lay. Given that good quality puddled bricks were available from Bendigo at a total cost of less than A$1.00/brick (delivered and unloaded), it was decided to purchase bricks.

Soil for mortar was collected locally and put through a mechanical drum screen and paddle mixer before being transported as a wet mix in a steel trailer to the site.

The whole process represented a compromise between energy cost and the monetary cost of labour. As a result the use of mudbricks was financially comparable to double brick while still being far more energy efficient.

JOINERY TIMBER

Joinery timber is a very sensitive environmental issue. It requires trees of much better quality and often older than those used for structural timber. Most joinery timber in Australia has been from imported old growth softwood from the North American west coast and tropical hardwood from rainforests.

Mount Macedon Fire Salvage Timber

This story began in 1983 with the salvage harvesting of exotic and native trees from the fire damaged gardens of Mt Macedon by Jason Alexandra. We helped finance the operation and pre-purchased cypress and blackwood timber prior to any plans to build a house. The salvage operation was large scale (hundreds of cubic metres of sawlogs) and integrated, involving sawing as well as processing of over 10,000 linear metres of cypress (Cupressus macrocarpa) to flooring and lining boards. This timber is not the native cypress (Callitris) timber from N.S.W. and Queensland commonly marketed for decking and flooring, but another faster growing exotic, rarely grown for timber but widely used for shelter in southern Victoria and Tasmania.

The damp-resistant and stable qualities of cypress were used to full advantage in the greenhouse framing and fascia boards. All flooring and lining timber used in the house is cypress. The small areas of external cladding are redwood (Sequoia). The bulk of the joinery timber including door and window frames and heads, skirting boards and doors is cypress, blackwood (Acacia melanoxylon) redwood and larch (Larix).

Kimon (14) and Su re-stacking air dried timber on the Olver Street reserve prior to the housesite earthworks. Blackwood (left) and cypress (right) salvaged after the Mount Macedon 1983 bushfires.

Office-living room dividing bookcase wall. Frame is cypress and blackwood, panelling is T&G cypress.

The following lessons were learnt from the salvage, processing and use of these timbers:

Portable sawmills have a great potential to increase the value of small lots of timber at or close to the growing site. This potential is now being developed by a new generation of farm and bush sawmillers with small modern equipment. They can provide structural timber for local use and support the burgeoning craftwood market.

A labour and skill intensive approach, from tree to finished product, using appropriate small equipment, will always get the best value from a limited supply of trees.

Cypress, redwood, and blackwood are suitable for farm forestry in high rainfall areas of southern Australia to provide high value joinery timbers from rotations of 40-80 years. There are no established markets for cypress, redwood and other useful exotics. Quantities planted would need to be large and continuous enough to allow product development and marketing of these valuable alternatives to tropical rainforest timbers.

STRUCTURAL TIMBER

Hardwood from native forests was used for most structural timber in preference to plantation pine because of its greater absolute strength,better fire resistance and greater resistance to decay and some insect pests (eg. Anobium borer). Pine was used in some less critical partition walls.

Green hardwood (rated F8)[1] from local sawmills working the Wombat State Forest was used for the timber floor and most of the roof framing. Local hardwood has been a relatively environmentally sound construction material from managed regrowth forests.

Kiln-dried and dressed hardwood (rated F17) was used for the exposed main trusses and rafters for its highest strength and minimal shrinkage. This timber is Ash (Eucalyptus regnans), probably from old growth Gippsland forests

In the last few years kiln drying by some local mills of local Messmate (Eucalyptus obliqua) is producing structural timber rated up to F27. It is encouraging to see the high strength of our local wood being recognised. (Ironically the F8 rated 200 x 50mm ceiling joists over our workshop approved to hold a plaster ceiling now support two tonnes of timber and other stored materials!)

As prejudice amongst building inspectors, builders and architects is changing for the better, ironically management in the Wombat Forest is getting worse with more and more future sawlogs ending up in the "pulp bin".

1. *F8: a strength rating used in the Light Timber Framing Code to compare the stiffness (resistance to deflection) of timber for structural use*

BUILDING MATERIALS

INDUSTRIAL MATERIALS

Glass

Glass is a very energy intensive industrial product essential for passive solar construction. In general, plastic alternatives are not long lasting. Uncertainty about durability under sunlight is the main issue. As upper atmosphere ozone depletion increases, plastics will break down even faster from increased U.V. radiation.

Secondhand glass represents a cheap and environmentally sound option and was used in most situations. 6mm louvre glass was cheap because it uses offcuts. The high cost (monetary and energy) of toughened glass used in the greenhouse roof was justifiable given the multiple values of this space.

Louvre windows

Considering the options for windows led to some unusual solutions. We considered double hung for good venting but the cost, or alternatively the quality of timber and skill needed for construction put us off. Our salvage timber was good enough for frames but not opening sashes.

Well designed louvres (made from polypropylene and aluminium) seal well, give excellent ventilation and the simple clean lines and matt black anodised finish look good against the natural cypress framing timber with its strong knot and fiddleback features.

This comparison between the use of salvage timber combined with energy intensive aluminium and plastics and the use of high quality old growth forest timber for alternative window materials illustrates the complexities in assessing what constitutes environmentally sound materials.

Bedroom louvre windows ("Breeseway"). Black anodised aluminium on fire -salvaged cypress frame, polypropylene blade clips and 6mm glass blades. External fly screens removed for winter.

Particle board

Particle board with a melamine finish has been extensively used in the built-in cupboards. This represents a compromise on the energy and health side but a melamine finish does minimise the out-gassing of glue solvents. The quality and quantity of timber necessary to make all cupboard shelving, panelling and doors would have required first grade timber and the labour costs would have been very high.

Insulation

Reluctantly, fibreglass batts were used for roof insulation instead of paper fibre or eel grass loose fill insulation, because the construction method requires that insulation be placed in from below, necessitating a batt type.

Metal roofing

Although metal roofing is very common in Australia it is only regarded as suitable for sheds in most affluent countries. In fact corrugated zinc coated roofing is a light, strong, long lasting building material with many good design features and is part of an Australian tradition which is making a comeback. We used colourbond because our house roof is reasonably prominent from the main road and to minimise glare in consideration of the neighbours.

RETROSPECTIVE

- After 7 years experience living in the house, new information and experience have confirmed most aspects of the design as successful. Some, with hindsight we would change. A few need mentioning, mostly relating to choice of materials.
- Fibreglass insulation is the first and greatest mistake. Although it is probably not as bad as asbestos, we suspect the mounting evidence will eventually prove fibreglass insulation a health hazard. Wool batts now provide an excellent, if more expensive, alternative where a batt is required. Experience in Europe has shown that the use of vapour barriers under the wall and ceiling linings to prevent condensation in insulation is not necessary when hydroscopic[1] natural insulations are used.
- Not enough insulation is the next mistake. Although the solar design works very well, the R2.5 roof insulation (building reg. standard) means heat loss is still quite high compared with European houses. Although double glazing of the clerestory and completion of curtains will improve the performance, better roof insulation (about R3.5) would have been well justified.
- Better insulation under the timber floor and an earth duct into the cool cupboard would have improved its performance in the summer by about 3°C.
- Although my enthusiasm for zinc coated metal roofing is unchanged, I believe the modern material (Zincalume), a high tensile steel coated with a zinc/aluminium alloy is inferior to the more malleable but thicker material coated with pure zinc (Custom Orb) which is now generally only used for tanks. As a roof it will probably outlast the Zincalume with or without its Colourbond coating and although Custom Orb will dent with impact it will not crack as can happen with the high tensile material after repeated deformation. Roof batten spacing with the high tensile material should be closer than recommended to minimise this risk.
- The mudbrick floor has required regular maintenance due to minor movement of bricks causing cracking along joint lines. Bedding on a weak cement mortar may have avoided this problem.

1. hydroscopic: material capable of absorbing water vapour

INFRASTRUCTURE

OUTBUILDINGS

THE PLANNING PROCESS REVISITED

During construction of the main building, the need for a lock up shed on-site, and the future needs for under-cover space, called for a major review of site planning decisions. The workshop, an integrated part of the house, is the centre for building maintenance and development activities, but is not an adequate size to also be the centre for property maintenance and development. Both site and house design constraints precluded a larger workshop.

The following functions needed housing:

- storage of slasher, garden tools, fertilizers, bulk seed feed, fuels etc
- undercover parking for the second vehicle (a flat tray 1.5 tonne truck).
- housing for poultry.
- location for future compost toilet.

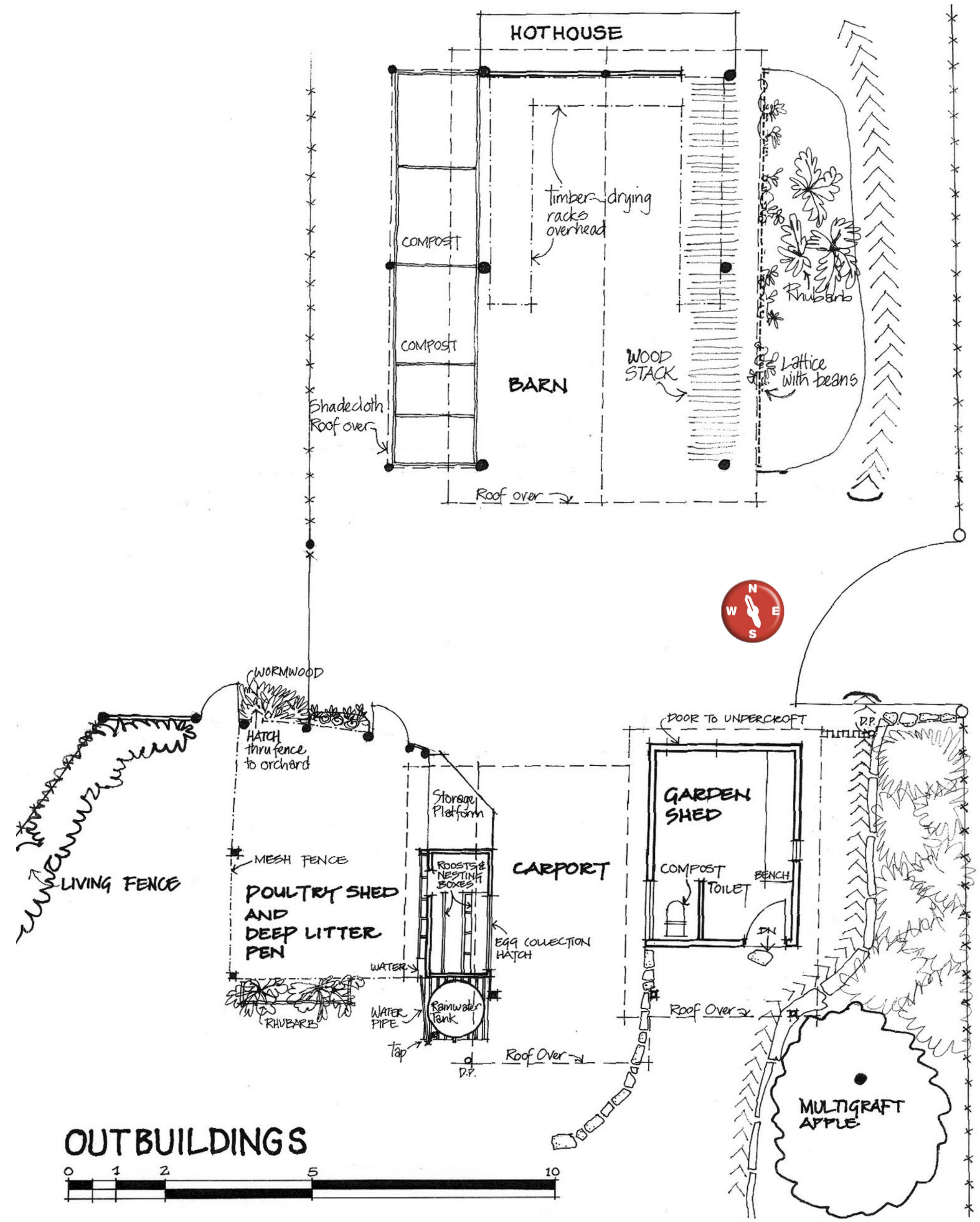
In addition, these all have a logical connection to certain outside functions such as deep litter yard, firewood storage and processing, mulch and manure handling and general materials storage.

Some unsightly and potentially noxious functions suggested a site away from the house but the need for frequent access and movement of materials demanded proximity. Use of the second house site would have severely reduced future options and been too remote. However, good accessibility to the rest of the property and vehicle access were essential.

The selected site just to the north of the house bench was the only site which met these criteria. It had already been allocated as a materials and firewood storage area with vehicle access from McKinnon road reserve constrained but adequate. The buildings interrupt the panoramic view of Elevated Plain from the housesite but provide a sense of enclosure to the main outdoor living and working space. It is the activity centre or node from which the property is managed and maintained.

Our planning principles suggested a multi-purpose building to avoid the proliferation of small single purpose buildings which characterise many rural properties. On the other hand it was hard to predict the full requirements for building space once the property was fully developed and it was impractical to devote too much time and money to this when we didn't have a house.

Because these uses only required uninsulated and unserviced structures, the potential of using a quickly constructed building as an onsite toolshed and workshop during construction of the main building was attractive. By resolving the complex design issues of site drainage, vehicle, wheelbarrow and pedestrian access, visual harmony and fire sector



design, construction of the shed was able to proceed immediately. Consequently this third node, belatedly identified and least costly, became the first to be established.

The construction of the poultry house took place in an organic way once we were in residence, its south-westerly aspect reflecting the compromises necessary to maintain an integrated design (eg. in winter hens do better with light from the east and north sides).

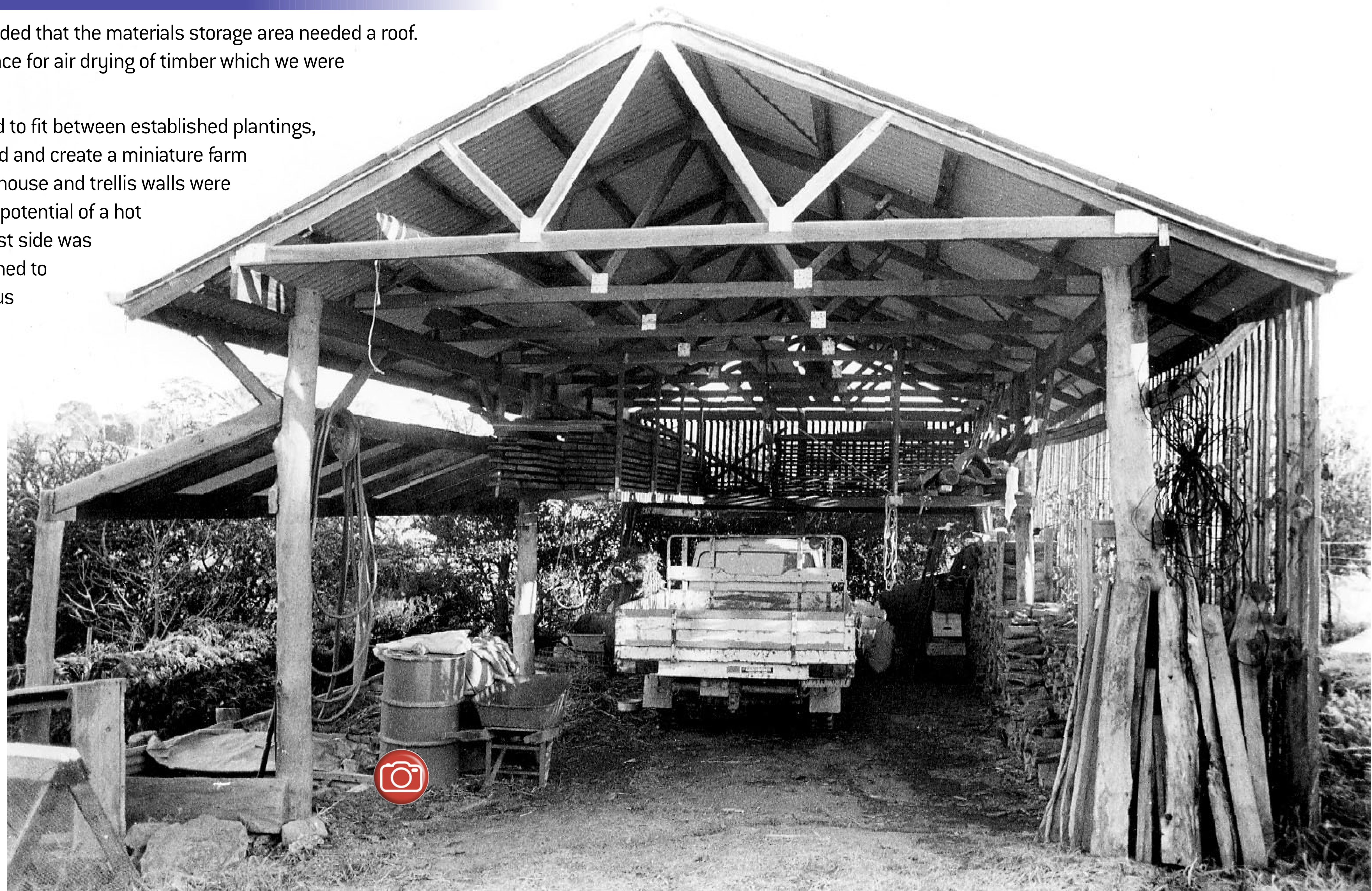
BARN CONSTRUCTION

It was not until 1991 that we decided that the materials storage area needed a roof. In particular we needed more space for air drying of timber which we were progressively accumulating.

In 1993 the barn was constructed to fit between established plantings, maintain the roof lines of the shed and create a miniature farm courtyard. Compost bays, shade house and trellis walls were added and after construction the potential of a hot bed/greenhouse on the north west side was realised. This last addition is planned to replace a section of the hedge, thus connecting the barn to the very productive red soil garden.

Addition of electric power to the shed for the electric fence unit, light in the (compost) toilet and power tool use reflects the increasing importance of this third node as a work centre for the on-going management of the whole property.

This example shows how even the most carefully considered plans are inevitably revised in the light of experience and that it is possible to do this in a way which builds on the foundations already laid and create a harmonious integration.



Barn constructed in 1993 to provide undercover parking for the truck, storage for firewood, racked timber and other materials. Trusses made on-site from local green hardwood support iron roof and suspended timber racks. Slatted wall allows air flow but reduces driving rain and used to support climbing beans in the summer. Shade cloth roof on left over compost and plant nursery bays.

FUEL MANAGEMENT

FOSSIL FUEL

Efficient use of solar energy in food production and space heating has been a primary focus for design at Melliodora. When compared with typical modern life, fossil fuel use directly and indirectly has been reduced dramatically. About 150 litres of petrol is used annually (93/94) in the slasher, brush cutter, lawn mower, pump and chainsaw and 1200 litres (93/94) in the truck and car (business and personal use). While reduction in petrol use will occur with introduction of grazing animals and optimal use of the windmill, it is reduced use of vehicles which is the main focus of fuel management.

Indirect fossil fuel use (eg. in power stations) has already been minimised by passive solar design and by use of firewood as a secondary heat source for space heating, cooking and water heating.

FIREWOOD

Firewood is an appropriate fuel from a permaculture perspective because it:

- is a renewable source of energy
- is a by-product of any sustainably managed forest
- requires minimal processing
- can substitute for fossil fuels in many uses
- creates only minor local air pollution problems outside of cities

Stove and heater

The Everhot slow combustion stove used for cooking and water heating requires 300mm long wood no more than 150mm diameter which is perfectly air dried. Wood use is currently 5 tonnes/annum but a more efficient (and expensive) stove might use half this.

The wood heater can take long (600mm) and large hard-to-split wood. Use has been about 2 tonnes/annum but with the heat conserving aspects of the house completed this should drop by one third.

Supply options

Intensively managed woodlots in this area could yield 20 tonnes/ha/annum so it would be possible in theory to supply two houses on the property with half the land covered in fast growing acacias and eucalypts. On a site with very limited water resources and food producing potential such a strategy might be reasonable.

Here, it is more appropriate to salvage presently wasted wood or support sustainable forest management which produces firewood as a by-product from thinning and harvesting for sawlogs and other higher value products.

Since 1992 some wood is being harvested as soil improving trees and shrubs reach the end of their useful lives and from thinning of some shelter plantings. Kindling and some larger wood should be available on a continuous basis from litter and prunings.

GATHERING, PROCESSING AND STORAGE

Efficiency in wood handling, storage and processing is an important part of the system and has been considered as an integral factor in the design. The following principles have been applied in the organisation of firewood:

- wood being fully air dry is more critical to fuel efficiency and pollution control than species. Nominally dry but fallen forest wood should be cut in summer for final air drying. Green wood should be cut and dried for two years in most cases.
- adequate space is needed for unloading, splitting and stacking the whole winter supply over summer and autumn within an easy wheelbarrow shift to the house.
- undercover storage for at least two tonnes, accessible in such a way as to allow newly moved wet wood time to dry before use.
- inside storage at each stove should be adequate for a day's supply.

We gather a mixture of box[1] and lower quality eucalypt firewood from a variety of local (within 10km) sources on private land. If we did not already own a truck and chainsaw and enjoy the family trips to the bush, buying from local woodcutters would be a good alternative.

The bulk of our firewood is cut in the bush as semi-dry wood (during summer) with the chainsaw to stove length (300mm). Rough and dirt covered ends, branched and knotty pieces (up to 600mm) are used for the heater. Minimising dirty cutting makes for efficient use of the chainsaw. We cut branches down to 50mm to help reduce forest fire hazard and provide more small wood needed for the stove.

The truck (1.5 tonne) is unloaded in the barn and if necessary wood split before being stacked in a double width stack for final air drying. Increasingly we are cutting green firewood (more available and easier to cut) and stacking for air drying on the road reserve. Kindling from chips, prunings etc. is collected in boxes and stored in the barn. Bark is used for mulch around trees.

Wood is moved by wheelbarrow along the main garden path (a level route) to the stack along the kitchen wall under the porch outside the greenhouse door. During the bush fire season the wood stack is kept below 0.5 tonne while in the winter it is not let fall below 0.5 tonne. From here it is moved in a crate to the underbench woodbox next to the stove and the hearth next to the heater. Ash from both fires is stored in the garden shed for fertiliser.

1. Box: local species of eucalypts noted for their hardness, density and good burning properties

WATER SYSTEMS

STRATEGY

On small rural properties water supply typically involves more design and capital input than any other aspect (except the house).

Failure to manage water resources to optimise the biological productivity of the land is a fundamental cause of land degradation symptoms as diverse as acidification, erosion, salinity, waterlogging and tree decline. It is a great irony that Australia, the driest continent, is suffering from the failure to effectively use rainfall.

The primary ways to effectively use rainfall are:

1. soil development methods which improve the water absorption
2. storage capacity of soil and deep rooted perennial plant systems which use the stored soil water

The soil development notes explain how these strategies have been applied on the property.

However, in addition to these strategies, water storage and reticulation systems are appropriate in all but the wettest of climates. At Hepburn evapo-transpiration exceeds rainfall for between 3 and 5 months and soil moisture levels are generally very low for 2 to 3 months. While this does not represent the major moisture deficit experienced further north, the short and cool growing season demands that warm season and marginal crops be kept growing at maximum potential if they are to ripen. At Hepburn this includes corn, tomatoes and other solanaceous vegetables, pumpkins and other cucurbitas. Most fruit and nut species need irrigation for rapid establishment and high yields but older trees will yield moderate crops in most seasons without irrigation.

Some aspects of the water sources and systems have already been described including the reasons for and design of the dams.

DESIGN PRINCIPLES

Permaculture design principles were applied in the design of water systems:

- priority to sources which store natural runoff rather than sources which tap base flow of streams and aquifers.
- high level of self reliance, reducing demand on town supply (reticulated water).
- priority to gravity feed over pumped systems. Where this is not possible header storage should be used to ensure reliability in the event of mechanical failure.
- design redundancy[1] which allows irrigation tasks to be performed in a number of different ways. For example:
    - **a.** wind and petrol powered pumps or
    - **b.** overlap of areas watered by town and dam water systems.
- priority to dripper and microspray reticulation for trees and perennials for conservative use of water and suitability for low pressure gravity supply.
- priority to hand watering of intensive annual gardens for precise application of water and the advantages of casual observation while watering.

SYSTEM DESCRIPTION

Roof runoff

A 3600 litre tank collects runoff from a small section of the house roof (a section without flue pipes to avoid creosote contamination). This supplies a third tap at the kitchen sink and an outside tap for potable water which we consume in preference to the town water.

Large tank storage of roof runoff for house or irrigation was not justified given the dam and town water alternatives. About two thirds of the roof runoff discharges via a 150mm pipe directly into the main dam though the contribution is small compared with the gully runoff.

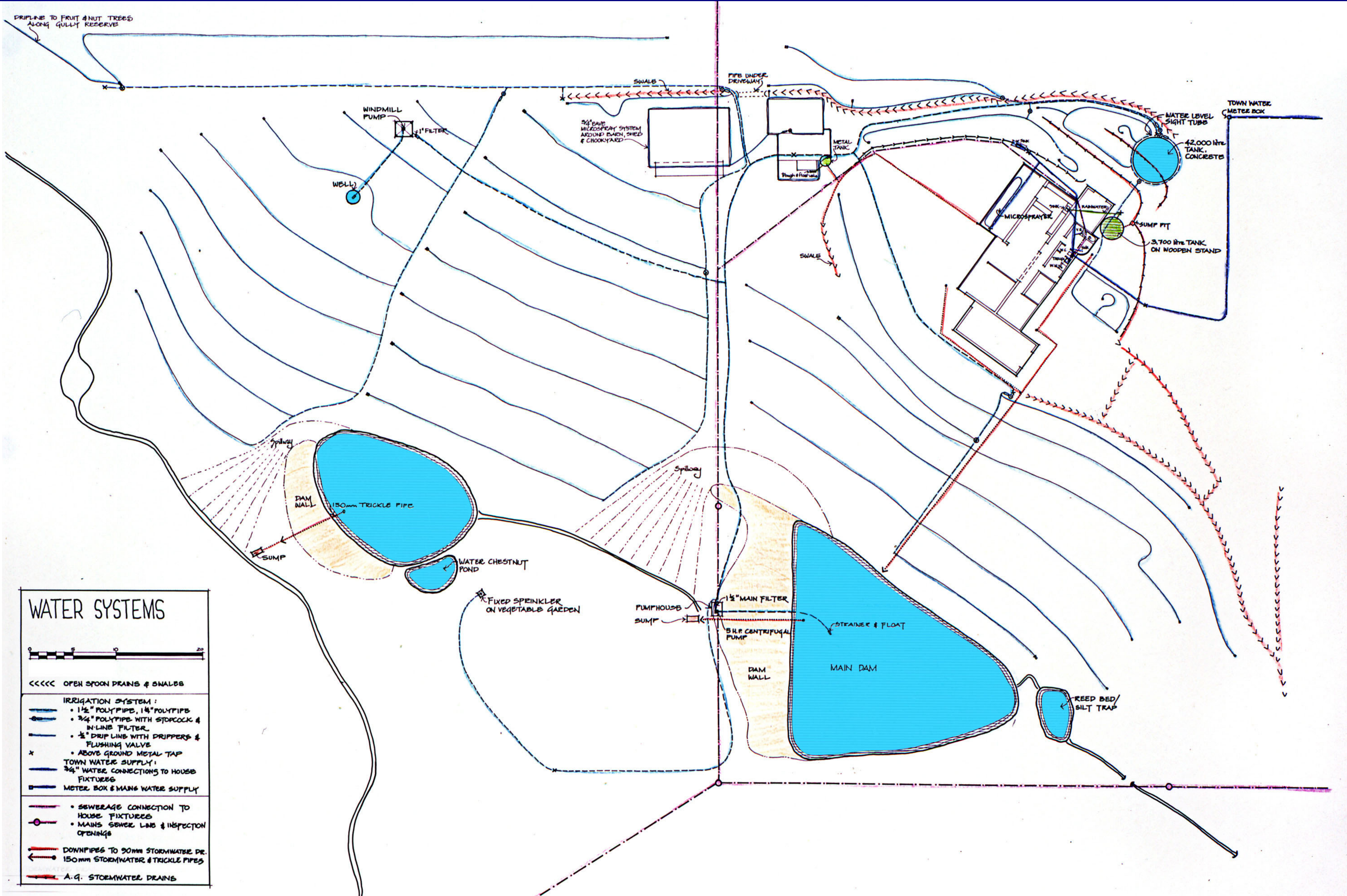
The north facing roof area (about 1/3) discharges via a 90mm storm water pipe onto the gentle slope to the north west of the housesite where it keeps a summer garden moist. In winter some of this water is absorbed by pasture and trees downslope before entering the drainage line and the lower dam. Part of the runoff from the garden shed is collected in a small tank on the north side of the poultry house for the needs of the birds.

House site drainage (see plan next page)

With a large cut into the hillside and substantial winter rain, the site would become a quagmire without good drainage. In cool climates with predominantly winter rainfall it is not generally possible to make use of runoff for irrigation through swales[2] but here, minor benefits have been gained from surplus water in summer by careful grading of drains and by specific use made of the very free draining volcanic soil.

Runoff from winter rain and any excess irrigation of the greenhouse and raised garden beds, as well as the garden sink, is carried by the scoria drain to the summer garden area mentioned above. Another scoria drain on the south side carries site runoff and seepage across the driveway to a small drain which contributes to street runoff. This runoff returns to the property, filtering through the roadside plantation to the silt trap behind the main dam. During summer, smaller amounts of surplus irrigation water from the terrace gardens are absorbed into the drain (functioning like a swale) to irrigate grapes immediately down slope.

1. *redundant: in industrial (and permaculture) design, a back-up element or system*
2. *swales: flat, water absorbing ditches*


DRIPLINE TO FRUIT & NUT TREES ALONG GULLY RESERVE
WINDMILL PUMP
1" FILTER
WELL
SWALE
3/4" EAVE MICROSPRAY SYSTEM AROUND BARN, SHED & CHOOKYARD
PIPE UNDER DRIVEWAY
METAL TANK
TOWN WATER METER BOX
WATER LEVEL SIGHT TUBE
42,000 litre TANK, CONCRETE
MICROSPRAYER
RAINWATER
SUMP PIT
3,700 litre TANK ON WOODEN STAND
SWALE
Spillway
DAM WALL
150mm TRICKLE PIPE
SUMP
WATER CHESTNUT POND
FIXED SPRINKLER ON VEGETABLE GARDEN
Spillway
PUMPHOUSE
SUMP
1½" MAIN FILTER
STRAINER & FLOAT
5 H.P. CENTRIFUGAL PUMP
DAM WALL
MAIN DAM
REED BED/ SILT TRAP
WATER SYSTEMS
0
5
10
20
<<<<< OPEN SPOON DRAINS & SWALES
IRRIGATION SYSTEM :
• 1½" POLYPIPE, 1¼" POLYPIPE
• 3/4" POLYPIPE WITH STOPCOCK & IN-LINE FILTER
• ½" DRIP LINE WITH DRIPPERS & FLUSHING VALVE
• ABOVE GROUND METAL TAP
TOWN WATER SUPPLY :
3/4" WATER CONNECTIONS TO HOUSE FIXTURES
METER BOX & MAINS WATER SUPPLY
• SEWERAGE CONNECTION TO HOUSE FIXTURES
• MAINS SEWER LINE & INSPECTION OPENINGS
DOWNPIPES TO 90mm STORMWATER DR.
150mm STORMWATER & TRICKLE PIPES
A.G. STORMWATER DRAINS

The table drain of the upper level wheelbarrow path (see photo below) carries substantial seepage and runoff from the cut slope of the housesite around the back of the garden shed and barn, picking up both vehicle access track and roof runoff. Beyond the red soil garden this runoff spreads out over the crown of the hill on the free draining chocolate loams at the top of the orchard. In the process it contributes to recharging the well. In summer the section of the drain behind the barn and red soil garden acts as a swale absorbing surplus irrigation. Sandbag blocks in the drain increase the absorption from occasional thunderstorms.

Main dam system

Water from the dam is pumped by a petrol driven centrifugal pump through a 40mm disk filter[1] and an underground 40mm poly pipe main to the 42,000litre concrete header tank behind the house. Although not the best image for a permaculture demonstration site, the incredibly low price (relatively to other options) and reliability of these mass-produced small petrol engines makes a compelling argument.

The lift to the top of the tank is only 12m over 100m of pipe which means pumping time (about 4 hours/week over 20 weeks) and fuel used (1 litre fuel/7,000litre water pumped) is not great. However in retrospect the water main should have been 50mm diameter. This would have reduced pumping time and fuel by at least 50%. This, in turn, would have required a larger filter and probably more frequent clean outs.

Regular filter cleanout is important for pumping efficiency. A cleanout after every 40,000 litres is necessary but as water quality falls toward the end of the season a cleanout every 20,000 litres is needed. In spring 1994 massive numbers of mosquito larvae blocked the filter and made pumping difficult for weeks. Exclusion of ducks from the dam during summer also seems to be important in managing water quality.

The pumping main also serves to deliver water back from the tank to the various outlets. Branch lines (40 & 20mm) supply galvanized standpipes and 20mm brass taps at the garden shed, south west corner of house, far north corner of property and behind proposed second building site. 20mm garden and fire hoses and sprinklers can be used for irrigation and firefighting.

At four points along the branch lines, low pressure 20mm stopcocks and in-line filters feed orchard drip and microspray irrigation circuits. At the tank another two stopcocks and filters service garden bed circuits.

All these outlets can be operated under pump pressure or gravity fed from the tank but sprinklers are generally used under pump pressure when the tank is being filled while drip circuits are gravity fed from the tank.

1. *disk filter: irrigation filter composed of circular plastic disks with grooves which catch sediment and easily cleaned with a hose.*

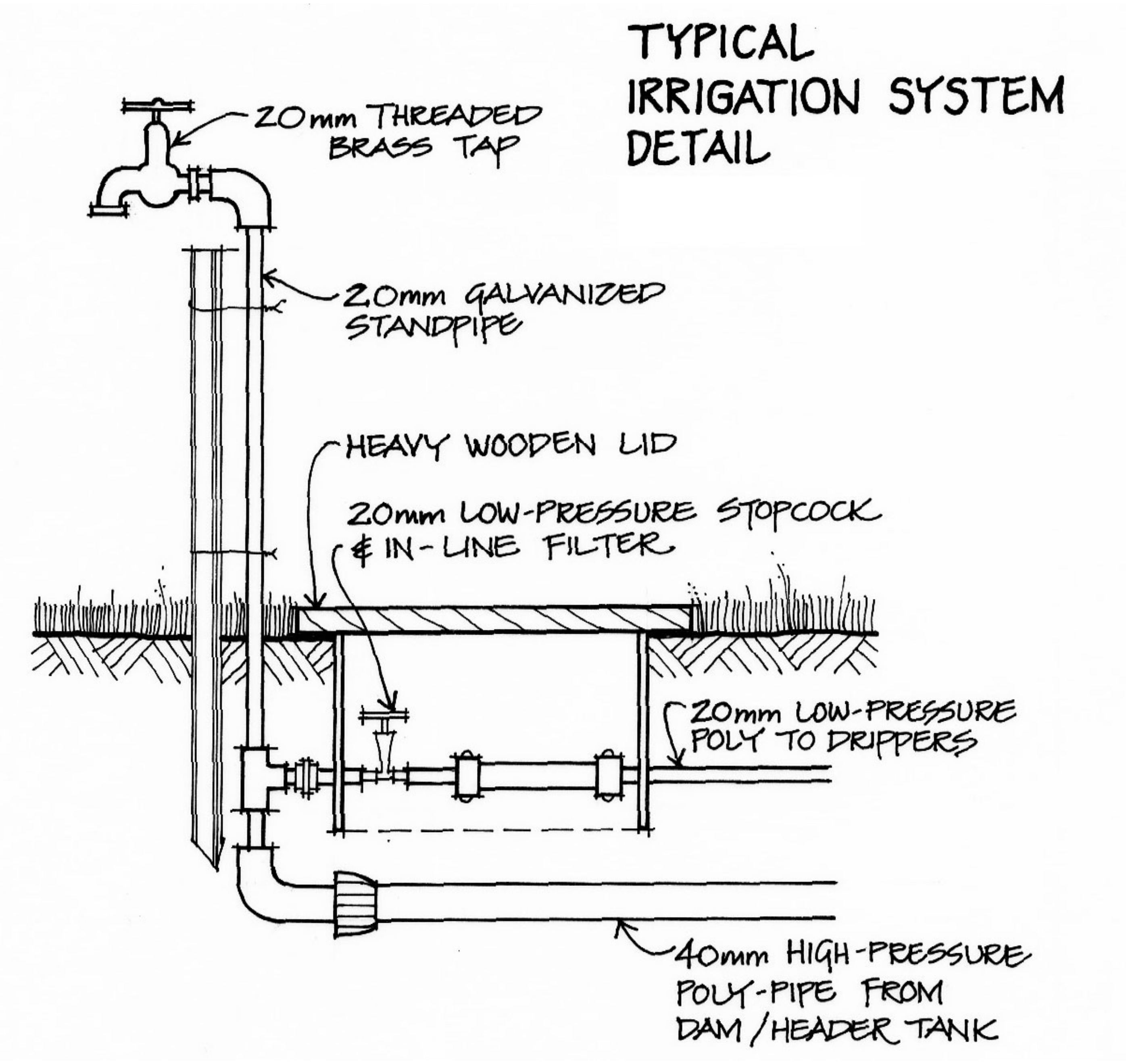
Main dam in early summer 1989 with trickle pipe intake, right, showing 300mm above falling water level from a combination of evaporation and pumping to the header tank for irrigation.

Concrete header tank (42,000l capacity) at highest practical point on property installed 1986 (photo 1992). Sight guage at left shows water level. Wheelbarrow path/table drain diverting seepage and runoff from cut slope away from housesite. Tank terrace garden ready for spring planting in foreground. Cut slope, screen plantings in background.

A sight gauge at the tank allows the water level to be checked at a glance from the house.

The placement of the main filter at the pump means the tank and the whole system is clean and can be used in drip circuits with only cheap in-line filters to take any additional sediment out of the system.

All piping except metal stand pipes and the drip lines are underground for protection from mechanical, frost and fire damage. Underground pipes are generally along paths and other uncultivated areas to avoid risk of damage. Driplines in the orchard are at waist height.
The placement of the drip lines underground would have involved a lot of work, wouldn't allow surveillance of dripper operation and would have precluded cultivation along the tree lines. If drip lines are lost in a severe bush fire, closing the stopcocks would minimise loss of water from the system.



Priming the windmill pump for the first time following installation November '92. Pump body at base of windmill shaft drawing from well down slope to left. Output line to header tank in foreground.

Su watering intensive garden with hand held 12mm hose from town water supply February 1995. High density planting in raised beds and terraces requires large amounts of water but productivity is very high.

The well

A small windmill on the well to complement the pump on the dam has been installed as a second stage development of the water systems. The plan was to reduce the use of the petrol pump, thus extending its life.

The mill site above the well is exposed to north, south west and south east winds and the small second hand mill (A$600 installed) can pump the 5000 litre capacity of the well on a good windy day. However the yield from the well is so low in a dry season that it takes 2 weeks for recharge to fill it. Plans to install a second suction line from the dam should allow better use to be made of the windmill.

Town water

The town supply serves the house, including sprayers in the greenhouse garden bed, the garden sink and two garden taps for high pressure watering with hand held 12mm hoses and sprinklers.

The advantages of town supply are not to be ignored, especially when the cost of connection is minimal and water rates must be paid in any case. However the decision to invest in independent systems based on permaculture principles has already proven prudent. In 1985 an allowance of 400 kilolitres was available before excess water rates where charged. Over the years this allowance was reduced to 250 kilolitres, and rates rose considerably. In 1994 a user pays system was introduced and every kilolitre costs more than A$1. Until now, annual house and garden use has been maintained below 200 kilolitres while the dam has supplied up to 500 kilolitres. This represents a saving of A$400 per annum after fuel cost giving a payback time of 8 years on the cost of the dam system of A$3000.

Roof sprays

The fire plan explains how the water system would be used to help defend the property in any serious bushfire. One feature of the system deserves further comment. The polythene microspray system around the eaves of the shed, barn and deep litter yard dramatically increases the chances of saving these buildings in a serious fire. If full pump pressure for fire fighting is required, the main valve into the header tank must be closed. This means at least one outlet must always be open to prevent a burst connection in the system. In a strong wind the roof sprays put out a fine spray over the whole area and provide a radiant shield for retreat into the house as a fire front approaches.

Continuous flow of water through the polythene pipes makes melting unlikely and if a fire did lead to a rupture it would probably be appropriate to have a cascade of water at that point. Loop construction ensures other outlets would still operate. Low cost and ease of assembly make polythene a practical alternative to metal for a system which has no other purpose. An installed spray system for the house was considered excessive, given its fire resistant construction and only modest hazard.

ACCESS & FENCING

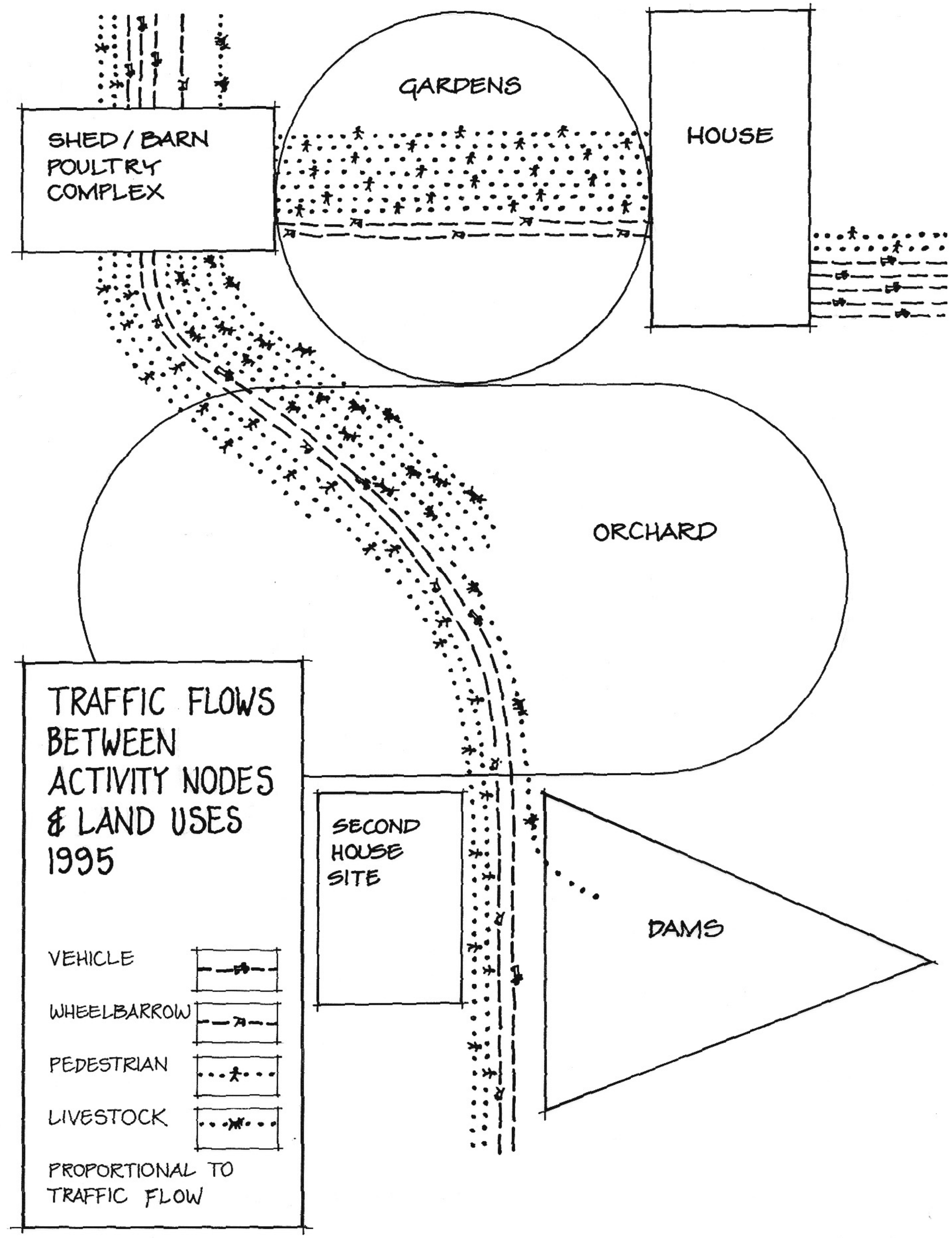
STRATEGY

Free access onto and around a property, including by vehicles, allows quick and easy movement of heavy and bulky materials during establishment and on-going management. However, on a small property the space allocated to tracks can use otherwise productive land. In addition, runoff from compacted road surfaces can cause waterlogging or erosion. Here, the steep slopes and wet soils for much of the year constrain access. House excavations, dams and extensive tree planting all provide further constraints.

Perhaps the greatest constraint to access is the need to fence. On small acreages with intensive tree planting, complete exclusion of livestock and pest animals is often the best strategy at least during the early years. Internal fencing is essential to manage livestock.

We have resolved this conflict thus:

- Road reserves make the east and west property boundaries reasonably accessible. By not fencing the property until all the major earthworks were completed, free access by vehicles and machines was possible and allowed earthworks to be best fitted to the landscape.
- The construction of the boundary fence then excluded rabbits and any stray stock allowing complete freedom in planting without guards or subdivision of the landscape.
- Internal fencing was envisaged from the beginning, the position of the internal access track and the layout of the orchard irrigation block indicating possible subdivision lines. The poultry house and deep litter yard were sited to be on the boundary fence separating "Zone One" from "Zone Two".
- Use of moveable and temporary fencing and pens, especially electric, was planned as at least part of the solution to the problem of integrating animals into the system.



ACCESS & FENCING

VEHICLE ACCESS DESIGN

- Primary access off Fourteenth Street to the main house entrance and garage with off-street car parking for at least 6 visitors' cars. This space also allows the car in the garage to turn for a safe exit onto the street. In addition, the driveway is the only large flat level hard surface without delicate plantings suitable for ball and other games.
- Formed, all weather vehicle access down McKinnon road reserve to a vehicle gate at the firewood and materials storage area and under cover parking and unloading at the garden shed and barn.
- Continuation of the track down the sewer main along the boundary of the two land titles and across a vehicle bridge on the spillway to the dam wall and the vehicle gate on the Olver Street reserve. Gravelling of the steep section down to the spillway will be necessary for all weather access. The soil is mostly clay fill from the sewer main and neither the sewer route nor the dam wall should be used for tree planting. By using this corridor as a vehicle route movement of mulch, produce and other materials is made easier without using productive land.
- Pre-existing formed vehicle track down Olver Street reserve as far as the second building site. Road gravel would be necessary for all weather permanent access.
- The gate and track onto the dam wall provide quick access to the dam for any firetruck fighting a fire in the locality.
- The contour alignment and spacing of fruit tree rows (7m) and the "standard" form of the trees allows vehicle access off the internal track along the rows and is expected to be used as a harvesting platform and transport for fruit and possibly fodder from the interplant trees.

FENCE DESIGN

The boundary fence provides effective exclusion of rabbits and livestock without the necessity to open a gate at the main entrance. This is achieved by incorporating the retaining wall, entrance steps to the main door and part of the house and garage wall as part of the fence which effectively makes the driveway part of the external space.

The location of the fence around the house and along the gully is "give and take" which in rural tradition follows the landscape rather than straight line boundaries. The function of the reserves as public open space has been enhanced, future development options retained and approximate balance between enclosed and excluded land achieved.

The construction of the fence around the house is sawn hardwood rail with netting on quartered box posts. This is in keeping with the semi-rural nature of the locality and is a practical response to the many changes of direction and slope.

The less prominent long runs along the road reserves and gully are standard rural fence with box strainers, wooden line posts and star posts with netting, plain and barbed wire. Although pressure from large grazing animals is only occasional, barbed wire is a practical deterrent against children damaging fences by climbing on them.

Two 3.6m gates provide vehicle access to the internal vehicle track while a 1.2m gate provides pedestrian and slasher access to the gully reserve.

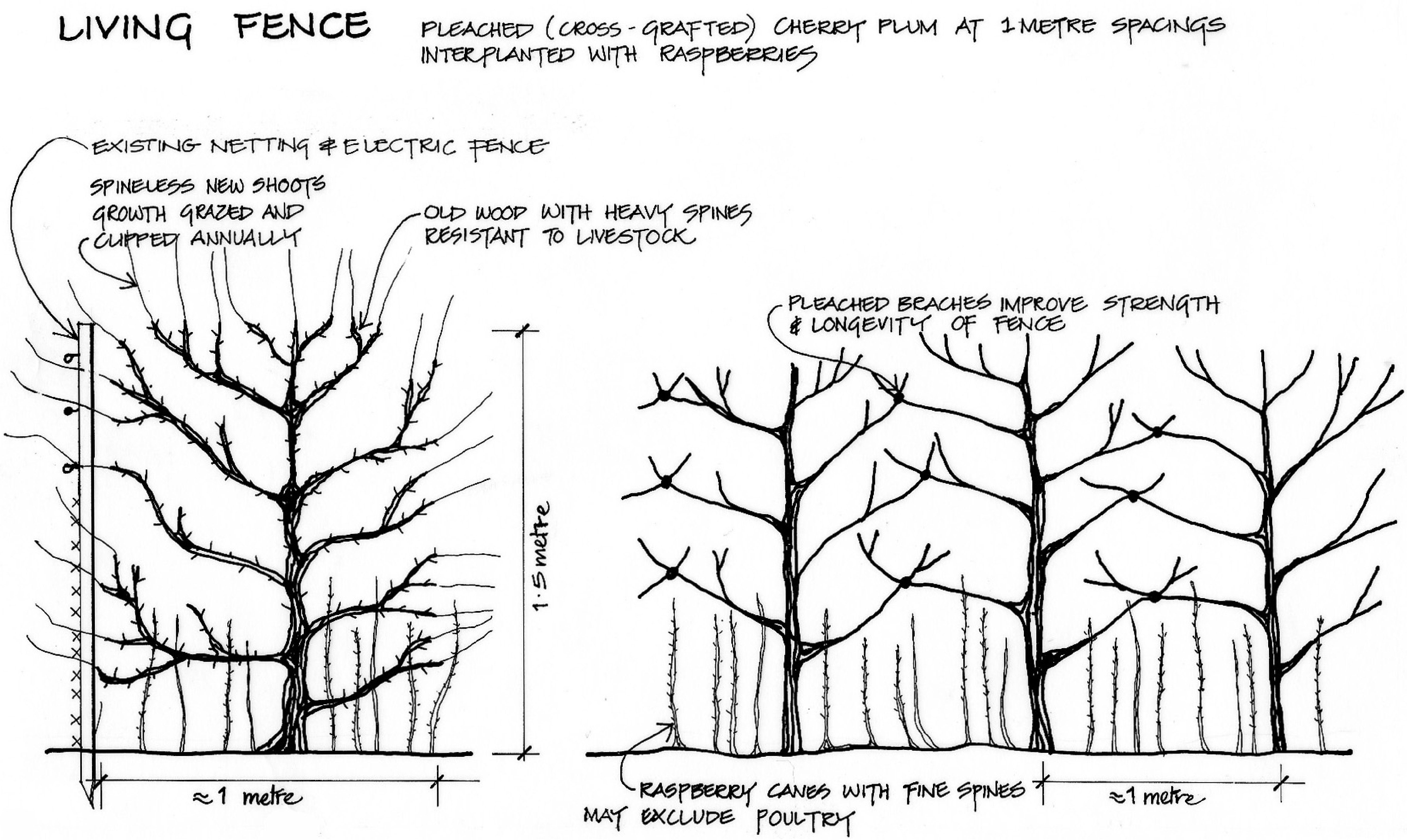
The first internal fence was needed to exclude poultry from the garden when foraging in the orchard. The first design was to fence along the top of the fill slope. Establishment of the summer garden below the deep litter yard and the red soil garden beyond the materials storage area led to a fence location which enclosed these important additions to Zone One as well as the steep slopes of the house fill slope where scratching by poultry would have created erosion. Pedestrian access into Zone Two from Zone One is via three pedestrian gates. Inside of this fence a hedge or living fence of close-planted cherry plum has been established which may one day become a stock proof barrier.

Netting boundary fence with trellising outriggers for grapes and bramble berries, vehicle gate and access track from McKinnon road reserve.

ACCESS & FENCING

The decision (1992) to plant a shelterbelt along the internal access road sacrificed the option for vehicle access along the rows of the northern orchard blocks. With it, the original concept of separately fenced orchard blocks for rotation of poultry and grazing animals made more sense and box corner posts were positioned for the current fence. The position of the poultry deep litter exit hatch had already made such a design possible. The design allowed dry weather vehicle access into the northern orchard block as far as the old pear tree.

It was not until 1994 that two 50m "Electranets" were set up between the posts and rotation access for the birds begun. The success and flexibility of this type of fence in controlling poultry (as well as foxes and livestock) is very impressive and well justifies the cost (A$360). We now plan to use this type of fence in combination with electric tapes to control grazing animals but plans will no doubt be modified by experience.



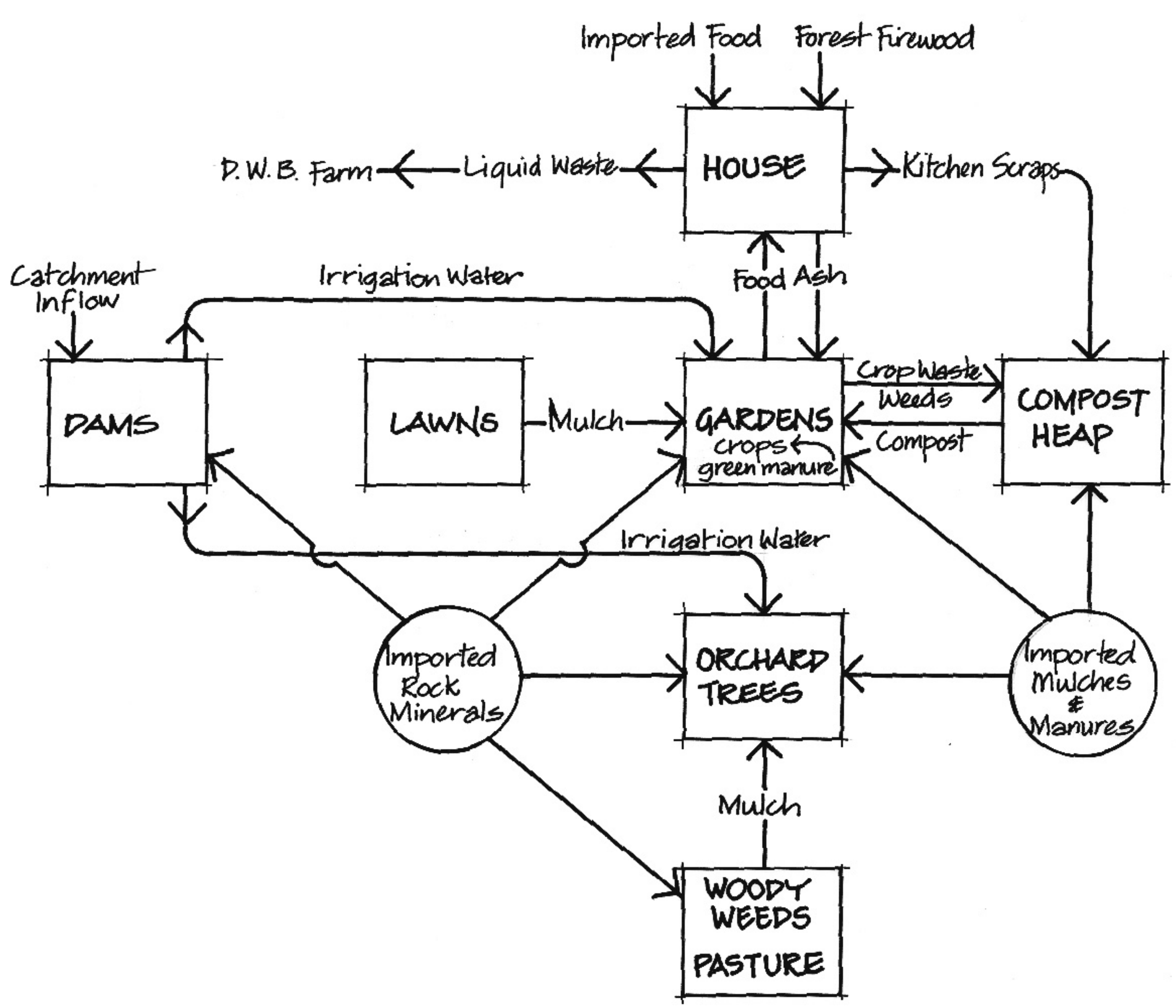
THE GROWING ENVIRONMENT

STRATEGIES

Any sustainable land use should aim to build "biological capital", given the depleted state of natural resources and the needs of future generations. The greatest stores of readily usable biological capital we can develop are trees and soil. Soil development is the most important aim of biological agriculture and is central to the ongoing development of this property.

However, an organic approach which "robs Peter to pay Paul" cannot be justified as sustainable. Importation of nutrients must be an investment in biological capital rather than a perpetual input necessary to maintain output. The first flow chart shows how imported nutrients have been used in combination with mechanically harvested and processed on-site materials to rapidly build soils. The second flow chart shows how animals and on-site productivity progressively replace imported and mechanically harvested organic matter to continue gradual building of biological soil capital and sustain productivity while reducing any risk of downstream pollution.

ORGANIC MATTER & NUTRIENT CYCLING
ESTABLISHMENT PHASE PRE - 1995



The major anomaly in the system is the legally required connection to the sewerage system. With appropriate systems, effective on-site use of effluent without pollution or health hazard would have been possible.

The implementation of the second phase of the strategy has been progressive and will take some years before it is all in place and several decades before the soil approaches its optimal state.

TECHNIQUES

The following techniques have been used in the implementation of the soil development strategy:

- **salvage of topsoil** from all earthworks for reuse on exposed surfaces and concentration of excess to provide extra soil depth in gardens.
- **reduction of runoff** by maintenance of total plant or mulch cover and where appropriate deep contour ripping.
- **woody weeds** are regarded as green manure crops which accumulate organic matter, fix nitrogen, and act as water and nutrient pumps. To reduce fire hazard, make the site more amenable for people and provide space for crops, woody and other weeds are progressively converted to mulch by seasonal slashing. Main on-site weeds slashed: blackberry, cape broom, gorse, broom, dock
- **progressive improvement of pastures** to outcompete woody weeds to increase nitrogen fixing and provide organic matter suitable for mulch and animal feed.This is achieved by elimination of rabbits (rabbit proof fencing), seasonal slashing, mineral fertilizers and future rotational grazing by tethered and penned animals.

As woody weeds, especially blackberry, are progressively controlled, some new pasture species have been sown, especially following rotational grazing and scratching by animals. Pasture species sown: lucerne, red clover, white clover, prairie grass, rye grass, tall fescue.

- **wood ash** from stoves is stored and used as a concentrate potash-rich fertiliser on gardens and orchard trees.
- **importation of ground rock fertilisers** to replace naturally lacking or depleted minerals. In the longer term use of these will decline. Main fertilisers used: Dolomite lime; 1 tonne used '88-90. Phosphate rock; 300 kg used '88-90.

SOIL DEVELOPMENT

David spreading rock phosphate and wood ash along potato planting lines, spring 1990 in Red soil garden. Heavy sheet mulch of spoilt lucerne hay (round bale unrolled in autumn as weed suppressing mat) used to establish garden and provide nutrients.

- **use of imported animal manures and mulches** where available and where risk of contamination is low for accelerated development of garden soils and orchard tree sites. Progressive reduction of these inputs is planned once true fertility is achieved. Main mulches and manures used: hardwood sawdust, grain and grass seedcrop straw, grass/clover hay, lucerne hay, sheep manure, stable manure.
- **use of green manure crops** in vegetable gardens for fixation of nitrogen, organic matter accumulation and conversion of imported minerals to organic form. Main green manures used: field peas, oats, mustard, buckwheat, comfrey
- **evergreen legume trees and shrubs as soil improvers:** nitrogen fixers, organic matter accumulators and nutrient and water pumps (reduced leaching and groundwater recharge). Site kept animal free during the tree establishment phase with rabbit proof fencing. Main soil improving species used: tagasaste, silver wattle, cootamundra wattle, catkin wattle, river casuarina.
- **progressively increasing use of animals** for energy efficient conversion of garden wastes, pasture and shrub forages to manure. The poultry deep litter system is the first step, recycling household and garden wastes. Grazing geese and tethered sheep or goats are future options.
- **partial recycling of human wastes:**
  a. a urine bucket in the house toilet (since 1991) provides a liquid nitrogen supplement to the vegetable garden with very low risk of disease transmission
  b. pan toilet in the garden shed using hardwood sawdust, output separately composted for 12 months prior to use on orchard (since 1993)
- **irrigation** (mainly stored runoff water) to accelerate breakdown of added organic matter and support of active soil life right though the growing season in gardens and orchard.

RESULTS OF THE FIRST DECADE

The results of the application of this strategy have been mixed. Firstly, the property has each year produced an increasing proportion of the household needs, and in recent years a seasonal surplus (mostly consumed in two week residential permaculture design courses).

Secondly, total plant biomass, soil organic matter levels, structure, water holding capacity and earthworm activity have improved in the intensively managed areas and over the property generally.

However, many health and disease problems have affected the fruit and nut trees, some resulting in deaths of trees. There have been similar problems with some crops in the intensively worked garden beds. Keeping qualities have often been poor. These problems have shown up after some years and I feel that although the original inputs got the system going they were not enough to overcome underlying deficiencies with:

a. transition to fruiting of the orchard trees and
b. intensive production from small areas of garden beds.

In addition to deficiencies:

a. applications of wood ash may have exacerbated imbalances of alkaline minerals
b. irrigation to achieve high yield from small areas and two very wet years ('92 and '93) may have contributed to increased leaching.

Comprehensive soil tests were not carried out at the start because I felt they would be difficult to usefully interpret given the diversity of soil conditions, prior modifications and crops grown. In retrospect such tests may have been worthwhile, but the variety of treatment since certainly makes any assessment problematic. In spring '94 pH tests of the red soil in the orchard interrow space showed results of 5.5, unchanged from tests done in 1985.

A number of different strategies are being tried or considered:

- further applications of appropriate mineral fertilizers and trace elements with control trees or areas to test diagnosis.
- leaf analysis to test for specific deficiencies.
- use of biodynamic composting and preparations.
- culling of some trees which have severe problems.

Rather than going into the details of these issues it is more relevant to understand the general lessons.

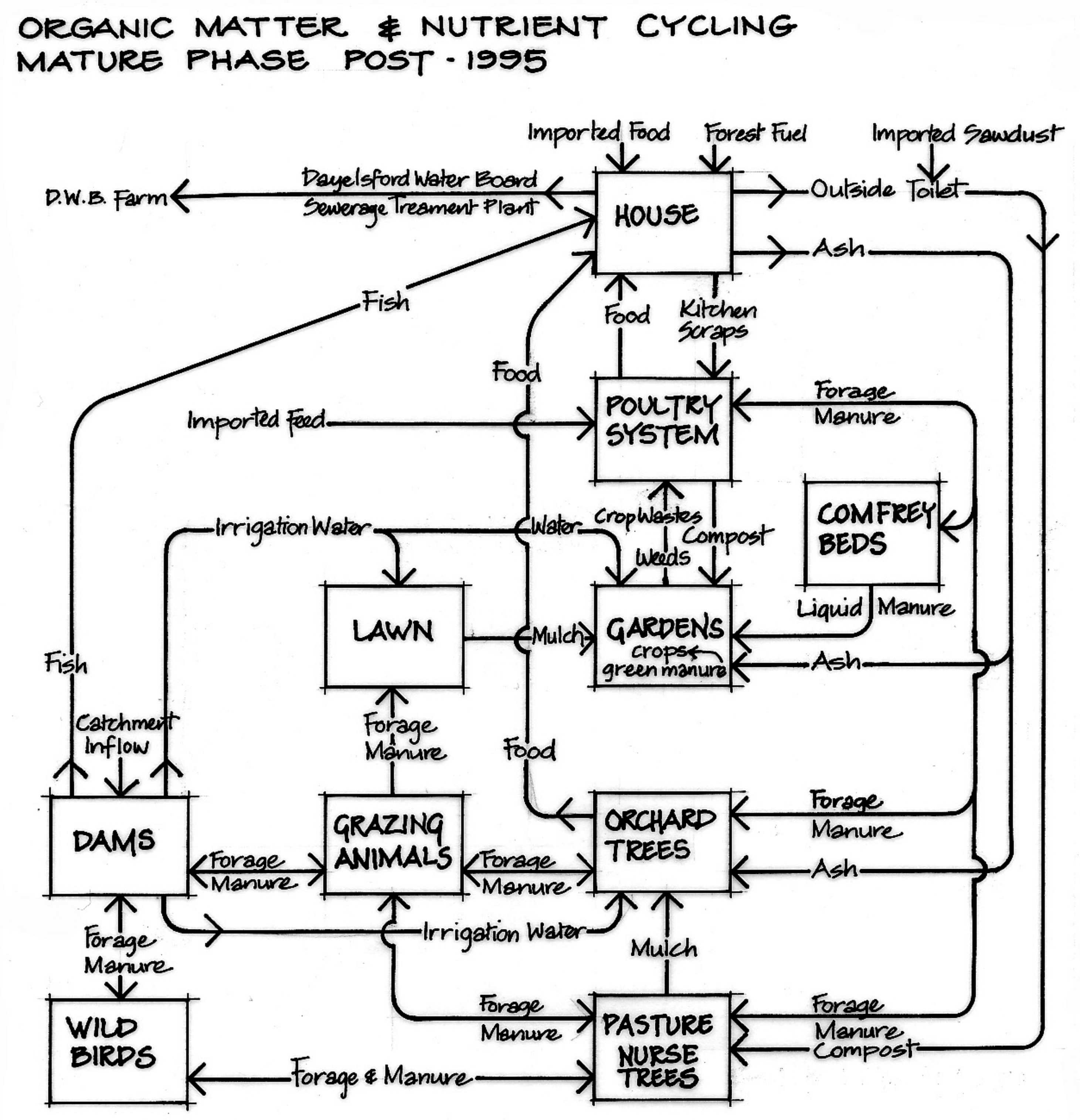
Firstly, my strong interest in physical design aspects of the project have led to less than adequate attention to these matters. It is very clear that having established a design framework for sustainable production, the key to achieving the potential will involve more focus on the traditional concerns of biological soil husbandry. This emphasises the complementary nature of permaculture to organic and biodynamic methods.

Secondly, the aim of intensive production with minimal use of inputs is something which may be very difficult to develop from a poor base. The inputs we have used seemed to us quite substantial but when compared with those commonly used by organic producers they are not. Quantities recommended by Jeavons for intensive production of vegetable from small areas are much higher than we have used.

Thirdly, the permaculture strategy of mixed wild seeding without major inputs has not been tried on this property to any great extent and may have been more effective at getting healthy trees and building soil than the reliance on selected cultivars of grafted nursery stock.

Su and Oliver harvesting deep litter compost autumn 1992. Bed frame on right covered with compost for screening before removal for placement on garden beds. Note heavy rot-resistant base boards to retain compost on sloping site and hatch in corner for exit of poultry to orchard free range.

Lastly, mineral deficiencies in systems supporting households with a high degree of self sufficiency can constitute a threat to health. In permaculture we are well aware of the weaknesses of modern food production systems, but we often forget that the consumption of a huge range of food products from good and varied agricultural land has been a great insurance against mineral deficiencies.



PERENNIAL PLANTING STRATEGY

While annual plants, especially vegetables, continue to provide important yields, it is the perennial plants which over time are providing an increasing proportion of the structure, functions and yields of our system. It is through the selection and placement of perennial plants that much of the design thinking of the system is expressed. Several factors have made planting of trees and other perennials a major part of the project:

- our mainly vegetarian habits make tree crops particularly important.
- my strong empathy and interest in trees and silviculture.
- the virtually treeless nature of the block when purchased.
- the opportunities to revegetate adjacent public land.
- the educational value in an arboretum of appropriate species and varieties for local conditions.
- a predominance of perennial plants, particularly trees, is a central tenet of permaculture.

The following general criteria have been used in species selection and placement of trees and other perennials:

- suitability for soils and climate have been tempered by the desire to experiment and to include marginal species to take advantage of microclimate niches. This provides the greatest buffer against seasonal variability and even climate change.
- low fire hazard species in general and particularly in the fire sector.
- general adherence to permaculture Zone One and Two selection criteria. Some specimens of species locally useful in more broadacre permaculture have been included and used more extensively in gully and road reserve plantings which correlate to the outer zones.
- use of suitable Australian native shrubs, especially local indigenous species, for shelter and screening functions to maximise small native bird and insect forage and habitat and visually harmonise with surrounding vegetation.
- where possible, siting of shelter and screening plantings on shallow or poorly drained soil.
- reservation of best soils for the most valuable and productive fruit and nut trees.
- inclusion of seedling fruit and nut trees where such stock give useful food. Grafting of local unnamed selections with good characteristics.

Above: *Mature asparagus fronds (left) and mature pods of scarlet runner beans right on arbor; both favourite perennial vegetables for us. In the background on pergola, for food and sun control, local heirloom Swiss Italian variety of Lambrusco type grape very well suited to cool and even wet summers. Used fresh and for juice and maybe wine when we have excess.*

Left: *Feijoa hedge backed by tagasaste provides a valuable mid winter fruit, red and white flowers and evergreen wind and fire shelter to house and intensive garden. Strawberries along lawn edge provide first fruit in spring.*

Right: *Oliver (carefully holding) open and unopened chestnut burrs with good sized nuts from young seedling tree, bearing for first time 1995. Chestnuts are a particularly important tree crop as they provide a staple carbohydrate food which can partially replace grains and potatoes in our diet.*

PERENNIAL PLANT FUNCTIONS AND USES

Shelter, shade, visual screening, fire protection, nitrogen fixing, soil conditioning, nutrient pumping, erosion control, wildlife attraction and habitat, and aesthetic values are some of the more important passive functions provided by perennial plants.

Food, mulch and animal fodder are the primary yields from perennial plants. Medicine, bee forage, timber, firewood and fibre are secondary yields.

The Perennial Species Index lists trees and other perennials planted on the property and adjacent road and gully reserve. It includes woody and herbaceous plants as well as ones which die back to a rootstock each winter (eg bulbs) but does not include annual species which were originally planted and have now become self seeding. (Most of these are included in the Herbarium List).

In permaculture, multiple function is the rule rather than the exception and the distinction between primary and secondary functions can be difficult. Nevertheless, the notion of primary functions is a useful concept around which planting strategies and designs can be organised.

Animal Fodder

Initially, self established vegetation on the site provided mulch and animal fodder, but this has been augmented and progressively replaced by more palatable and productive pastures, shrubs and trees. These will mostly be used to feed livestock as the need for mulch to control weeds and build up soil organic matter reserves declines. The main species planted for animal fodder are prairie grass, tall fescue, red clover, comfrey, tagasaste, Cootamundra wattle, catkin wattle, silver wattle and river casuarina.

Concentrate fodders (fruits, nuts, seeds and pods) are especially important for poultry and include slow-to-yield large trees. Drip irrigation and some fertilising have been used to establish these trees. The main concentrate species planted are honey locust, oak and cherry plum, as well as the hard seeded legume shrubs listed above.

Shelter and Screening

Shelter plantings are the most effective way to modify and improve microclimate and have also been used to provide visual screening from the road and neighbouring properties. The plants selected are generally hardy and low fire hazard. They include fast growing short-lived species (mostly nitrogen fixing legumes) and long-lived slower growing species which, in combination, generally provide soil improvement, some bee and insect forage, bird habitat and forage, aesthetic values, as well as fuel, fodder and timber. These plantings are generally unirrigated and unfertilised although they may be well mulched on more severe sites. Some hand watering aided establishment on the housesite cut slope.

Shelter and screen planting outside rabbit proof fence along Olver Street reserve. Mixed fast growing bushy acacia species with casuarina, banksia and melaleuca species behind. Golden and weeping willow (coming into leaf) and alders on drainage line between silt trap and main dam. Background shows main southern shelterbelt on Fourteenth Street of blue gums, blackwoods and bushy fire retardant species.

Food

Hepburn Permaculture Gardens can be described as a perennial food system since much of the harvested food, including vegetables, culinary herbs, fruit and nuts come from perennial plants. These food yields will increase in the future as the system matures.

Selection and experimentation for appropriate varieties to suit conditions and provide a diversity of yields (including over the season) have been important. Most perennials yielding food are named varieties propagated by vegetative means but also include seedling stock, especially where appropriate cultivars are not available.

Secondary functions of food plants include stock fodder (concentrates), aesthetics and medicinal uses. Food plants are almost all irrigated and given considerable additional nutrients in the form of manure and rock fertilisers as well as mulch. Once established, irrigation and fertilising of hardy species may be discontinued.

Aesthetic Values

There are some plants which have been selected and sited primarily for their visual or scent qualities though they generally yield food, fodder or perform other secondary functions. Some are irrigated and fertilised while others are not.

Medicinal

Medicinal values (for livestock as well as people) are significant for a few selected species but development of skill and interest in botanical medicine could potentially make use of many planted perennials.

Timber - Firewood and Fibre

In only a few cases have these yields been significant in selecting or managing plants because these yields are more appropriate in permaculture systems large enough to include a Zone 3 and 4. Most of the firewood harvested on the site will come from short lived nitrogen fixing trees and shrubs. Most of the large long-lived trees planted on the site, especially those planted in the gully (eg. walnut, chestnut, blackwood), have been pruned for good timber form.

Bee Fodder

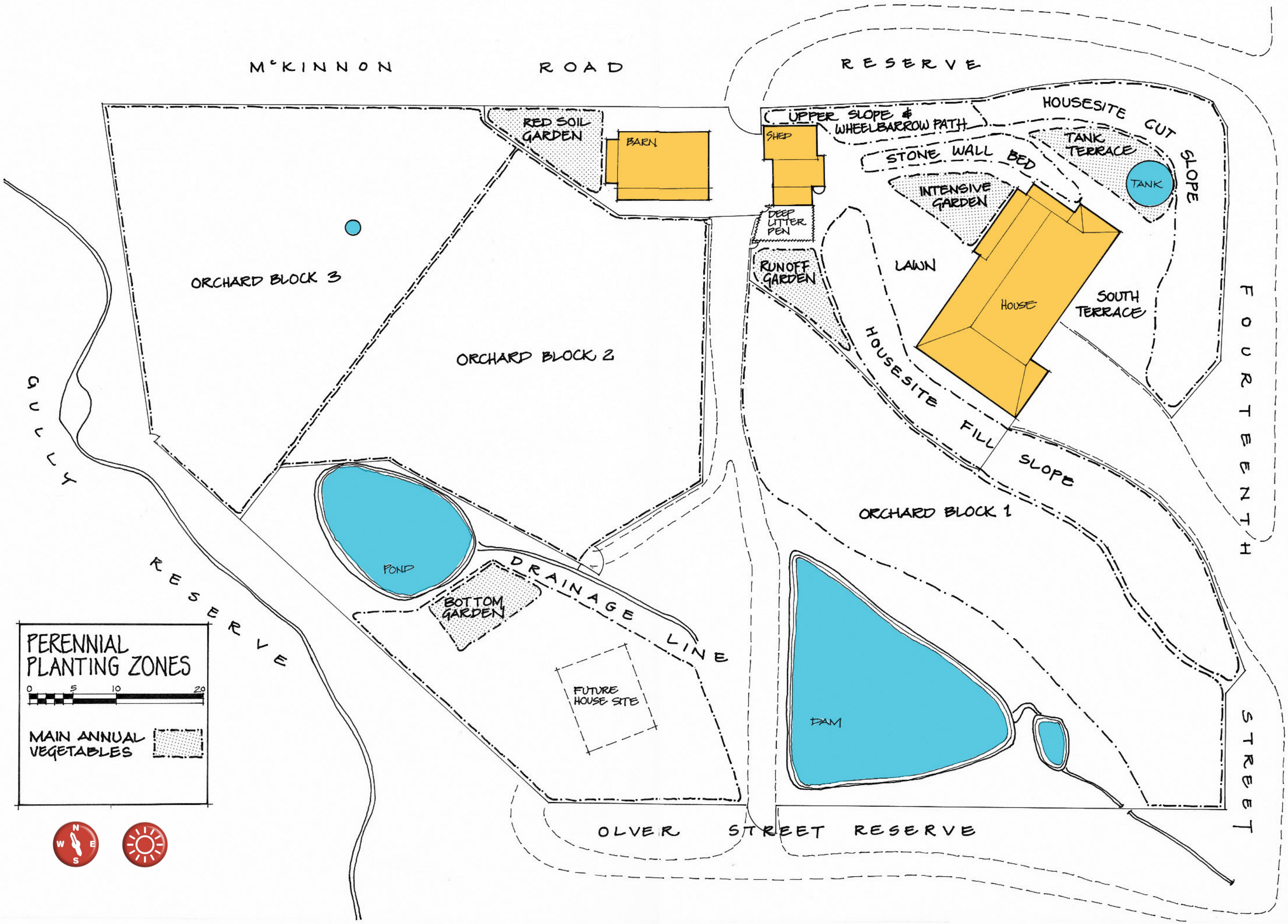
Bee forage is another indirect yield which is accumulating from many species. Of the species useful to bees, only those which are very numerous (clovers), large (eucalypts) or yield at critical times (tagasaste) are significant.

Wildlife Attraction and Habitat

These functions have been an important factor in selection of a few species, both native and exotic, but are secondary functions for many species.

Comfrey growing around young apple tree provides barrier to invading grass, loosens deep clay soils. Also living mulch and bee fodder or cut for liquid manure, poultry and livestock fodder and of course wonder first aid herb.

PLANTING ZONES



PLANTING ZONES

The planting zones, shown on plan, represent a combination of natural, land tenure, management and use characteristics, unique to the project but incorporating the permaculture zoning concept.

It is the space (design) and time (succession) relationships between plants which is even closer to the essence of permaculture than species selection. These relationships largely describe the zones and their progressive development.

Five zones are described here: cut slope of housesite; fill slope of housesite; barn surrounds; second house site; and drainage line (between the two dams). House garden and orchard are covered in more detail in the following sections.

CUT SLOPE OF HOUSESITE

This area is defined by the post and rail boundary fence which is constructed in a "give and take" manner along the McKinnon and Fourteenth road reserve boundaries. On the lower side the surface drain and main wheelbarrow path around the back of the header tank separate the slope from the first garden terrace.

Site and Soil Conditions

Mostly cut shale, sandstone with some areas of clay. Topsoil up to 150mm deep at tree planting sites only. The whole area is above the base level of the header tank so cannot be drip irrigated. N and W aspects. Very low productive potential.

Design Concept

A dense planting of fire and drought resistant, bird attracting and ornamental, and predominantly native species of low and moderate height to provide privacy screening from Fourteenth Street and some shelter against SW & SE winds. Canopy closure at an early age is being achieved which excludes grass, leaving a mulched surface. Some culling of quick growing species is intended. The planting represents a significant habitat for wrens, robins, pardalotes and honeyeaters which are excellent at controlling insect pests in nearby food gardens.

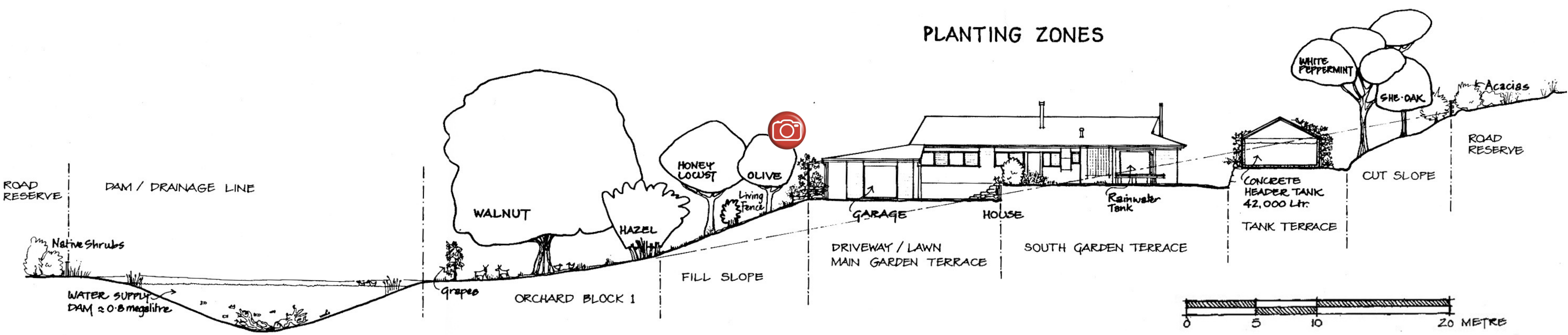
Survival and growth of low shrubs to the east of the house has been poor partly due to frost and winter waterlogging from seepage alternating with extreme summer drought. Only a few species have been found which meet the design criteria and will thrive in these conditions.

FILL SLOPE OF HOUSESITE

The fill slope is composed of shale covered in topsoil between 75 and 200mm deep on slopes of 14-27° while the area around the poultry deep litter yard has a deep but seasonally waterlogged sedimentary soil. Exposure to wind is high from both SW and NW winds. Aspect ranges from NW to SW with some shading on the southwest aspects by the building.

Design Concept

Primarily a shelterbelt around the house and garden against wind and fire. Secondly, a privacy screen from neighbouring land and public roads. Conversely the plantings soften the visual impact of the house when viewed from the main road.



Description and Results

Main slope planting consists of two rows of close planted, unirrigated tagasaste as quick shelter maintained as bushes to 3m. Three interplanted rows of slower growing irrigated food and animal concentrate fodder trees will eventually form the canopy of the shelterbelt. As the irrigated trees need the space and light the tagasaste will be progressively cut out over about 20 years. Near the house to the north west and west, fire and drought resistant, mostly evergreen species such as feijoa, olive and loquat have been used while to the south deciduous seedling fruit trees (nectarine, peach, fig, persimmon) and fodder trees (honey locust and oaks) predominate. Between these, slower growing fodder trees (casuarinas) have been planted as short rotation cull species for soil improvement and fuel.

Effective shelter to the house garden and visual screening from the main road were achieved in three years, mainly due to the rapid growth of the top row of tagasaste. However, there were substantial losses in the bottom row of tagasaste in the first winter due to "wet feet" from site runoff. The northern section of the lower row has since been replaced by the cherry plum hedge. Growth of the irrigated trees between the tagasaste has been good. Loquats have done best. Olives have grown well but have leant away from side shading, despite hard pruning of the tagasaste for mulch. With plenty of water and nutrients the feijoas now form a flowering and fruiting hedge.

View to Fourteenth Street from McKinnon Road, winter 1995, showing post and rail fence and now mature screen and shelter plantings on cut slope of housesite above header tank (roof visible.).

View from Newstead Road of house site, March 1987, showing planting marked by stakes on fill slope of housesite. Cut slope of housesite mulched with clippings and planted to screen shrubs and trees. White dots indicate the position of the post and rail fence, constructed late 1987.

View over poultry shed and deep litter yard, runoff garden, fill slope of housesite, lawn, raised timber beds and terrace gardens; most of the elements of this "Permaculture Zone 1" covering less than 0.1ha (1/4 acre).

Fill slope of housesite below driveway in spring showing double row of tagasaste and irrigated row of seedling nectarines and other fruit trees.

Around the deep litter yard the design becomes more complex with a summer seasonal garden occupying the deep moist soil. The winter waterlogging of this area has not been a problem for oat green manure crops except in very wet years. A diverter on the storm water would be useful in these years. Surrounding this garden and extending along the edge of the path inside the fence is a cherry plum hedge planted from seedlings germinating throughout the garden. As well as providing shelter, the close planting and pleaching[1] and hedging is intended to form a living fence as an animal barrier. The cherry plums are underplanted with raspberries and gooseberries to aid exclusion of poultry if the fence were to be removed in the future.

1. *pleaching: cross grafting of trees to form a single living structure*

BARN SURROUNDS

Gently sloping area. Soil is a very shallow stony basalt soil. Exposed to all winds.

A single row of tagasaste with seedling fig and coprosma interplants provide a fire resistant low shelter. North of this shelter hedge the red soil garden occupies an almost level area which is now well sheltered from the south and moderately sheltered from the east and west. It is a very productive and early garden. The very shallow soil over rotten basalt seems to have increased in depth from 150mm to over 200mm from the combined effects of stone removal, deep digging and tagasaste roots breaking the rotten rock and dramatically increased chemical weathering resulting from added water and organic matter.

Lopping of the tagasaste hedge for mulch has not been adequate to prevent moisture and nutrient competition with the vegetables so roots have been cut around the trees. With construction of the barn and establishment of road reserve and orchard shelter, progressive removal of the tagasaste is releasing nutrients for the vegetable garden.

Red soil garden with barn behind. Hot bed of composting stable manure with germinating rockmelons in early spring. Tagasaste along swale drain on left cut back hard for mulch and to reduce moisture competition and shade to garden.

SECOND HOUSESITE

The Olver Street, gully reserve and drainage line plantings have been designed to provide privacy and shelter to the site without blocking winter sun. Once the earthworks for the building are in place, planting of the garden will begin.

The vegetable garden site behind the geese pond has already been improved by green manure crops and is now being used as a late season garden to supply vegetables for our residential permaculture design course each year in February.

Garden at second housesite above geese pond planted to vegetables mainly for consumption during residential Permaculture Design Course February 1995. Right, compost heap and hedgrow of seedling apple and nectarine. Temporary electric mesh fence to exclude free ranging poultry.

DRAINAGE LINE

Site and Soil Conditions

The drainage line both above and below the main dam has deep, fertile, but seasonally waterlogged and flooded soils. Below the main dam some seepage and flushing of water supply filter maintains some permanent soil moisture.

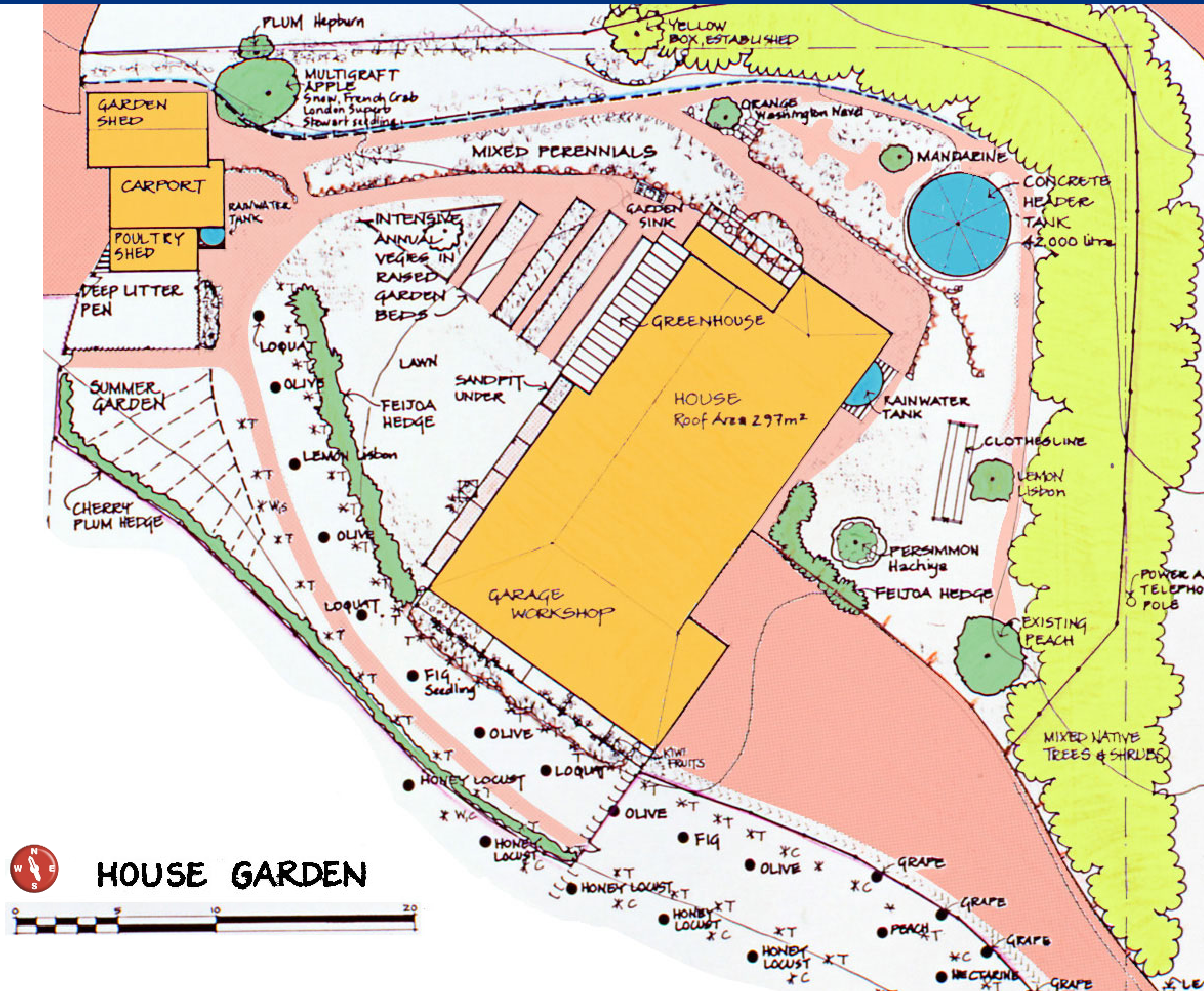
Design Concept

A planting of large deciduous trees suited to wet conditions to serve the following functions: erosion control, screening of the dam for swimming and a sense of separation between the two house sites, autumn colour, animal fodder, especially in drought, and a barrier to fire travelling up the gully. In addition a few swamp loving species such as New Zealand flax, irises and self established reeds and sedges will complete the design. Green pick for grazing animals in dry periods and foraging for ducks when wet will make these areas important parts of the total system. (See Aquaculture, for description of aquatic and water edge plantings.)

View from top of old Pear tree over dam in drought (January 1995). Orchard block 2 (foreground), orchard block 1 and fill slope of housesite (left of dam) .

Unusual summer flood down drainage line between dams. Oliver standing in trickle pipe flow, grassed spillway (right) also flowing. Willows and alders along drainage line. Orchard block 2 of stone and pome fruits on slope beyond with tagasaste and acacia interplants.

HOUSE GARDEN



Raised timber garden beds in October with newly planted seedlings covered by plastic and glass frost protectors. Beds covered in poultry deep litter compost and sown. North pergola with grapes still not in leaf.

SITE AND SOIL CONDITIONS

The garden consists of a series of terraces and platforms which make up the house site. The subsoil in most places is either bedrock shale or compacted shale fill. Small areas have a natural profile of clay over shale. The whole garden is growing on topsoil of varying depths which has been placed on the terraces. Behind retaining walls and in built up garden beds that soil is up to 400mm deep while under grassed areas it is as little as 75mm.

The formation of the housesite and the house itself have created some sheltered and shaded areas but generally the garden is exposed to sun and wind with only moderate frost risk. Plantings on the cut and fill slopes as well as the road reserves provide shelter as well as visual screening of the garden without compromising sun exposure to the intensive vegetable garden or winter sun exposure to the house. Views have generally been planted out to create a sense of enclosure except for the Elevated Plain escarpment view to the north.

DESIGN CONCEPT

The house garden is seen as a natural extension of the house living and work spaces. Built elements such as pergolas, stone and timber retaining walls combine with terraces to provide an architectural form to the garden, reminiscent of Italian hill gardens. The openness of the garden to the sun reflects the house design. The microclimates created around the house have been used to advantage and in particular extend the range of warm climate species.

Lawn

Lawns have been criticised by Bill Mollison and other permaculturalists as ecological disasters. While the facts and the sentiments of that argument are valid as a generalisation, lawns can be a functional element of permaculture. In this case the limited supply of topsoil has been concentrated in garden beds while the lawn only has 75 -100mm of topsoil. Sown to a mixture of grasses and clover with some lime to improve the structure of the underlying shale fill and rock phosphate to stimulate the clover, it has required no additional fertiliser. Watering in summer is minimal resulting in a partial browning in dry years. It is a low fire hazard element between the main shelter planting and the house. Full sun and indirect sky light to the house and vegetable garden is ensured by the position of the lawn. The lawn is mown infrequently which reduces fuel usage and ensures deeper root growth for healthier growth and abundant mulch. The finely divided, high nutrient, seed free mulch is ideal for use on the intensive vegetable garden.

The main function of the lawn is a moderately hard wearing, level outdoor play area for children and space for outdoor parties etc. Raising of chicks on "clean" grass is an additional use of the lawn. Rotational grazing by caged rabbits or Guinea pigs is a future option.

Intensive Vegetable Garden

Timber sided rectangular beds are a literal and functional extension of the greenhouse garden bed. The raised design and location are very convenient for intensive gardening. The free draining soil is more suitable for winter vegetables but is also very handy for early plantings of tender spring vegetables which require frost covers. This small area (40m^2 in actual beds) can produce most of the family's vegetable needs. The gardening style is geometric and close planted. Green manure crops, mineral fertilisers, lawn clippings, compost and dilute urine have all been used to maintain fertility. Hand watering is efficient and convenient.

Compost from the deep litter system has been a major source of nutrients, generally spread in spring after composting to reduce weed seeds and as a heat absorbing layer for sowing of seed. After 5 years of intensive gardening some deficiencies have been noticed. As well as addressing these with mineral fertilisers, other more recently developed gardens are providing more of the needs.

West pergola in spring with Chinese gooseberries beginning to shade garden and terrace from afternoon sun.

Pergolas

The building design includes three pergolas. The north pergola supports overhead grape vines which act as a seasonal extension of the house eave to shade the north glazing and outdoor terrace from indirect and afternoon summer sun. The west pergola supports trained chinese gooseberries vertically and overhead to protect the terrace from afternoon summer sun. The east pergola supports overhead grape vines which act as an eave extension to protect the kitchen windows from morning summer sun. Built up garden beds have been constructed to provide deep soil over the shale fill to support vigorous vines. Careful training and pruning ensure good fruit production and a permanent woody structure in grape and chinese gooseberry vines which rapidly leaf out in late spring to give effective shade and readily shed leaves in late autumn.

Dry Stone Wall Bed

This highly accessible garden bed has deep topsoil but is very free draining and prone to summer dryness. It is planted to a mixture of herbs, perennial vegetables such as asparagus, tree onions, flowers and self sown vegetables. Deep litter compost is often spread in autumn. The path/gravel drain below the wall is planted to moisture loving creeping herbs such as pennyroyal, mint and Vietnamese mint.

South Terrace

This area is partially shaded in winter by the house and is exposed to SW winds. The soil varies from 75mm over cut shale to deep soil near the timber retaining wall. The shallow soil supports a small lawn while the deeper soil is planted to a perennial food garden with an ornamental emphasis near the main entrance to the house.

A "Hackiya" Persimmon is the focus of the terrace garden. Feijoa and quick interplants form an evergreen hedge along the retaining wall to protect the house entrance from SW winds up the drive. Chilean guava are an aromatic and shade tolerant extension of that hedge around the large stone seat at the entrance. Blueberry bushes occupy the east and south edges of the garden.

The clothes line is of a similar construction to the pergola design and is set on the south bank where it is exposed to full winter sun and SW winds without the full force of strong winds.

Upper (Water Tank) Terrace

This area has deep topsoil but no subsoil over solid rock. The terrace was the site of the first vegetable garden but has been partially planted to perennials. The tank is surrounded by trellis which supports an ornamental grape and jasmine on the south west, climbing rose on the west, grape on the north west and passionvine on north east. Black and red currants and various ornamentals grow on the south and east sides. The north side is arranged as a series of keyhole raised garden beds designed between the main wheelbarrow path, tank and stone retaining wall. Clipped bay and two citrus trees are the focus of the design taking advantage of the sheltered and sunny position. Herbs and ornamentals occupy the droughty edge of the stone wall while annual vegetables are planted in the rich soil of the keyhole beds.

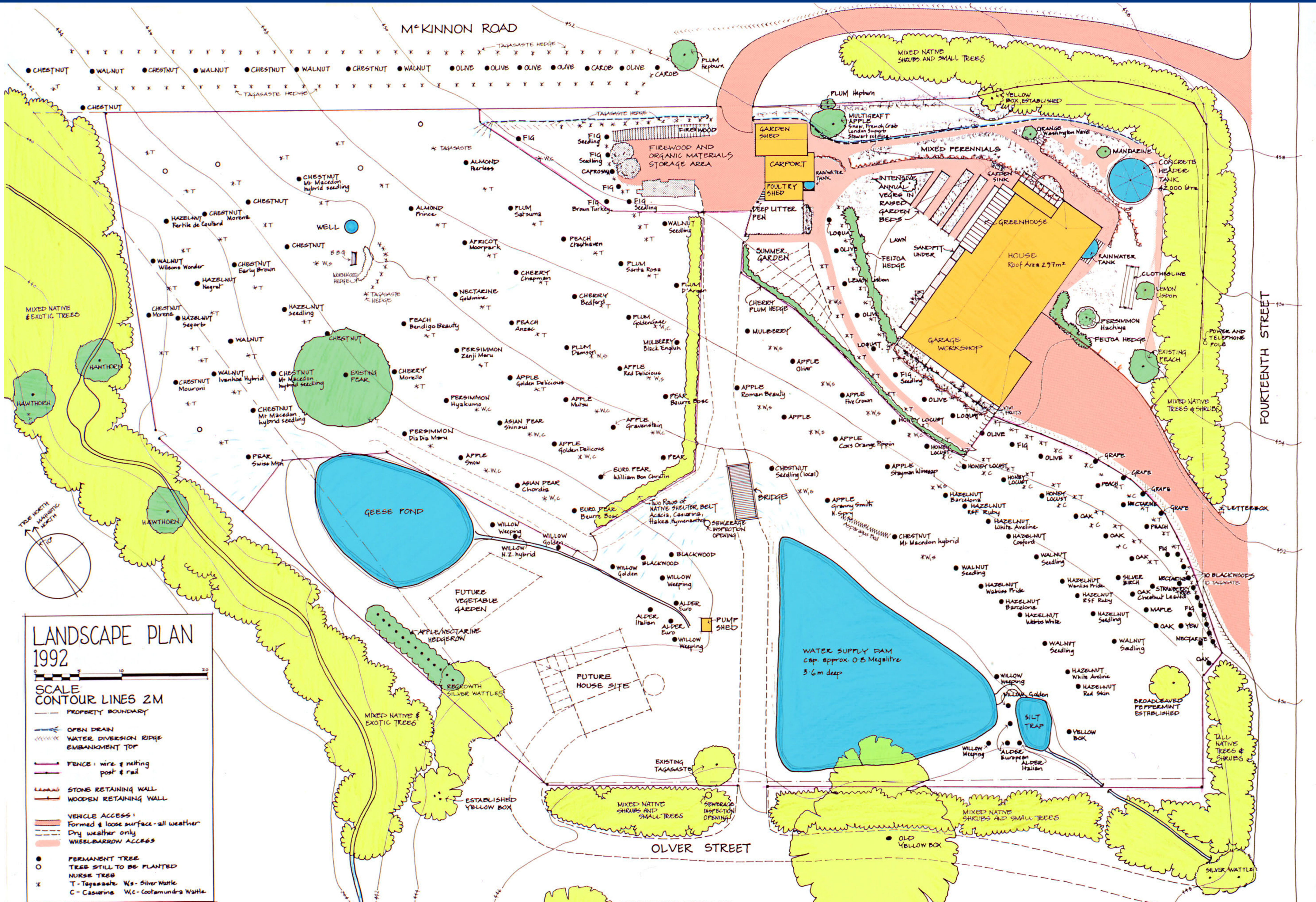
Maintenance of water to vegetables in this garden is difficult in dry seasons. However, the convenience, and freedom from late spring frosts, continues to make this a valuable vegetable garden area. Many types of vegetables such as lettuce, fennel, silver beet and potatoes regularly self seed in this garden and are an important contribution to household supplies. Deep litter compost is often spread in autumn. It produces a dense germination of lush weeds (chickweed, nettle, fat hen etc) vegetables (silver beet, lettuce, parsley, carrot etc) and some trees (cherry plum, nectarine, peach, apple and pear). Selective weeding can produce useful food, green manure crops and trees for planting out elsewhere.

Wheelbarrow Path Bed and Upper Slope

This raised bed is also very accessible and is planted to strawberries, raspberries, blackcurrants and roses on drip irrigation. Beyond this bed is a grassed strip between the path bed and a bed along the fence where bramble berries and grapes are trellised. Mowing the grass area provides mulch to the adjacent beds. A wild apple next to the shed has been regrafted to several unusual varieties while a cherry plum on the fenceline has been reworked to a local variety.

Productivity of the berries is dependent on regular watering during most years. Drainage of irrigation water into the drain, before the bed is fully moist, is a problem here, as with the other terraces and raised beds, but the convenience for daily picking makes effective productivity from this bed high (and accessible to small children-the most effective grazers / harvesters of soft fruit).

March 1991 - Sheet mulching to extend the run-off garden started the previous spring. Thick growth of grass, clovers and weeds covered with cardboard after deep watering. Timber flitch forms edge. Job partly complete to show layers: 50mm of stable manure compost, lime (about a 100 gms per m^2), 50mm of partly composted tree chippings.


McKINNON ROAD
OLVER STREET
FOURTEENTH STREET
LANDSCAPE PLAN
1992
SCALE
CONTOUR LINES 2M
PROPERTY BOUNDARY
OPEN DRAIN
WATER DIVERSION RIDGE
EMBANKMENT TOP
FENCE: wire & netting
post & rail
STONE RETAINING WALL
WOODEN RETAINING WALL
VEHICLE ACCESS:
Formed & loose surface - all weather
Dry weather only
WHEELBARROW ACCESS
PERMANENT TREE
TREE STILL TO BE PLANTED
NURSE TREE
T - Tagasaste W.s - Silver Wattle
C - Casuarina W.c - Cootamundra Wattle
GEESE POND
WATER SUPPLY DAM
Cap. approx. 0.8 Megalitre
3.6m deep
SILT TRAP
HOUSE
Roof Area 297m²
GARAGE WORKSHOP
GREENHOUSE
GARDEN SHED
CARPORT
POULTRY SHED
DEEP LITTER PEN
FIREWOOD AND ORGANIC MATERIALS STORAGE AREA
CONCRETE HEADER TANK 42,000 litres
RAINWATER TANK
MIXED PERENNIALS
INTENSIVE ANNUAL VEGIES IN RAISED GARDEN BEDS
SUMMER GARDEN
LAWN
SANDPIT UNDER
FEIJOA HEDGE
CHERRY PLUM HEDGE
CLOTHESLINE
POWER AND TELEPHONE POLE
MIXED NATIVE SHRUBS AND SMALL TREES
MIXED NATIVE & EXOTIC TREES
MIXED NATIVE TREES & SHRUBS
TALL NATIVE TREES & SHRUBS
FUTURE VEGETABLE GARDEN
FUTURE HOUSE SITE
APPLE/NECTARINE HEDGEROW
BRIDGE
PUMP SHED
WELL
BBQ
HAWTHORN
EXISTING PEAR
EXISTING TAGASASTE
ESTABLISHED YELLOW BOX
OLD YELLOW BOX
BROAD LEAVED PEPPERMINT
BROADLEAVED PEPPERMINT ESTABLISHED
SILVER WATTLES
LETTERBOX
10 BLACKWOODS
TAGASASTE HEDGE
CHESTNUT
WALNUT
OLIVE
CAROB
PLUM Hepburn
FIG
HAZELNUT
ALMOND
PEACH
CHERRY
NECTARINE
APPLE
PEAR
PERSIMMON
ASIAN PEAR
MULBERRY
LOQUAT
LEMON
MANDARINE
GRAPE
OAK
WILLOW
ALDER

SITE AND SOIL CONDITIONS

The aspect of the orchard is predominately westerly and moderately exposed to south and north winds, exposure having increased since mature trees across Fourteenth Street were felled. The lower areas fringing the gully are fairly sheltered. However, these areas are prone to harder and more frosts than the upper slopes. Soils vary from deep but compacted loam over deep sedimentary clay in the southern section through a transition to chocolate loams in the northern section. These chocolate loams vary from very shallow and rocky at the top of the slope to deep at the bottom.

STRATEGIES

Size

The orchard includes nearly 100 deciduous fruit and nut trees (leaving aside the evergreen olives and loquats along the house site fill slope). Most home orchards consist of only a few trees. The desire to grow the bulk of the family's annual consumption of fruit and nuts and the fact that fruit and nuts comprise a large part of the family's diet suggested a larger orchard. Although large yields from single mature trees can be expected, the size of the orchard reflects an aim of achieving self sufficiency in fruit and nuts in less than ten years.

The role of the property as an arboretum of useful tree crops and the expectation of some possible income from sale of fruit were also factors in the size of the orchard.

Mixed species and varieties

A diversity of species and varieties is necessary for a diverse and year round diet. It also insures against seasonal failure of one or more species, provides some long term insurance against untreatable serious disease and even climate change. In addition a mixed species orchard maximises the total productivity of a site with diverse soils and microclimate.

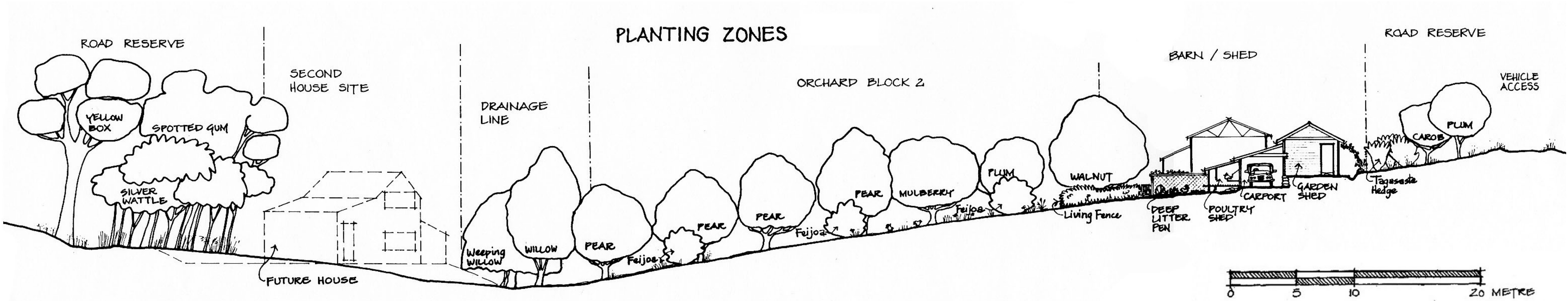
Grouping the species together to suit soil and microclimate and pollination simplifies the management compared to a random mixture. However, it is the minimum intervention organic approach to orchard management which should prevent the orchard becoming a liability rather than an asset. Failure to thrive, or difficult pest or disease problems will lead to the replacement of some trees with varieties which have proven themselves onsite and are in demand by the household or local markets. Thus some of the original nonfunctional diversity will be reduced as the system is refined by culling.

ORCHARD DESIGN

Layout and Spacing

The orchard is laid out as approximate contour lines of trees 6-7m apart. Food tree spacing along rows is 6-7m with nurse (pioneer) shrub interplants between each food tree. These spacings allow adequate light and air movement between the trees and for intercropping and underplanting at least in the early years. Siting of food trees reflects soil and microclimate suitability, pollination and management groups. The orchard is divided into three irrigation blocks with separate drip and microspray circuits.

The northern block is mostly large nut trees: chestnuts, walnuts and hazels grafted on Turkish (non suckering tree) hazel stock. These hazels also form a pollination group. While the basic pattern has been maintained, the topography is steep and varied and the well, hut site and old pear tree are within its bounds. Consequently, it is likely to develop as more of a nut grove without intercropping or underplanting which would inhibit harvesting nuts. Late spring frosts have been a severe problem at the bottom of this block (the best soil on the whole property) due to a frost damming effect created by topography and trees in the gully. In some years only the hazels have been unaffected.



The middle irrigation block has the greatest diversity of soils and is planted to a wide variety of fruit trees with pome fruits predominant to the south on the clay soils and stone fruit predominant to the north on the volcanic soils. Wind exposure from the south is being belatedly reduced by the 1992 planting of the two row native shelterbelt.

South of the shelterbelt and vehicle access track is the most recently planted section, mostly old apple varieties on heavy and seasonally wet clay soils. A special layout has been used in the most southern section which has been planted to hazels and walnuts.

Pollination of hazels in Australia is not well understood but the group of varieties planted in this block are known to bear nuts when planted together. In addition their strongly suckering bush form makes them less suited to growing as a tree. Consequently they have been close planted (2m) to form short hedges of 3 varieties each, between walnuts at 8m, without any nurse shrubs, in two parallel orchard rows. While the walnuts will eventually shade out the hazels, this will take many decades due to time taken for the former to reach maturity and the relative shade tolerance of the latter. In addition, possible topworking of the seedling walnuts to a selected variety could further delay the shading.

The road reserve plantings around the head of the drainage line have created a wind sheltered sun trap with low incidence of spring frosts. This still unplanted site may be appropriate for wind and spring frost sensitive species such as persimmon which have not been very successful in the red soil orchard. Pecans may also be possible here.

David carrying cut grass to mulch hazels and walnuts in orchard block one.

TREEFORM

Where possible the food trees have been trained to a "standard" form with branching at about 1m similar to traditional orchards in Europe. Retraining of nursery stock which is mostly trained to an "open vase" or "modified central leader" has been necessary in most cases and resulted in less than the ideal standard tree. Standard form maintains options for grazing of stock under the trees during the growing season, underplanting and intercropping.

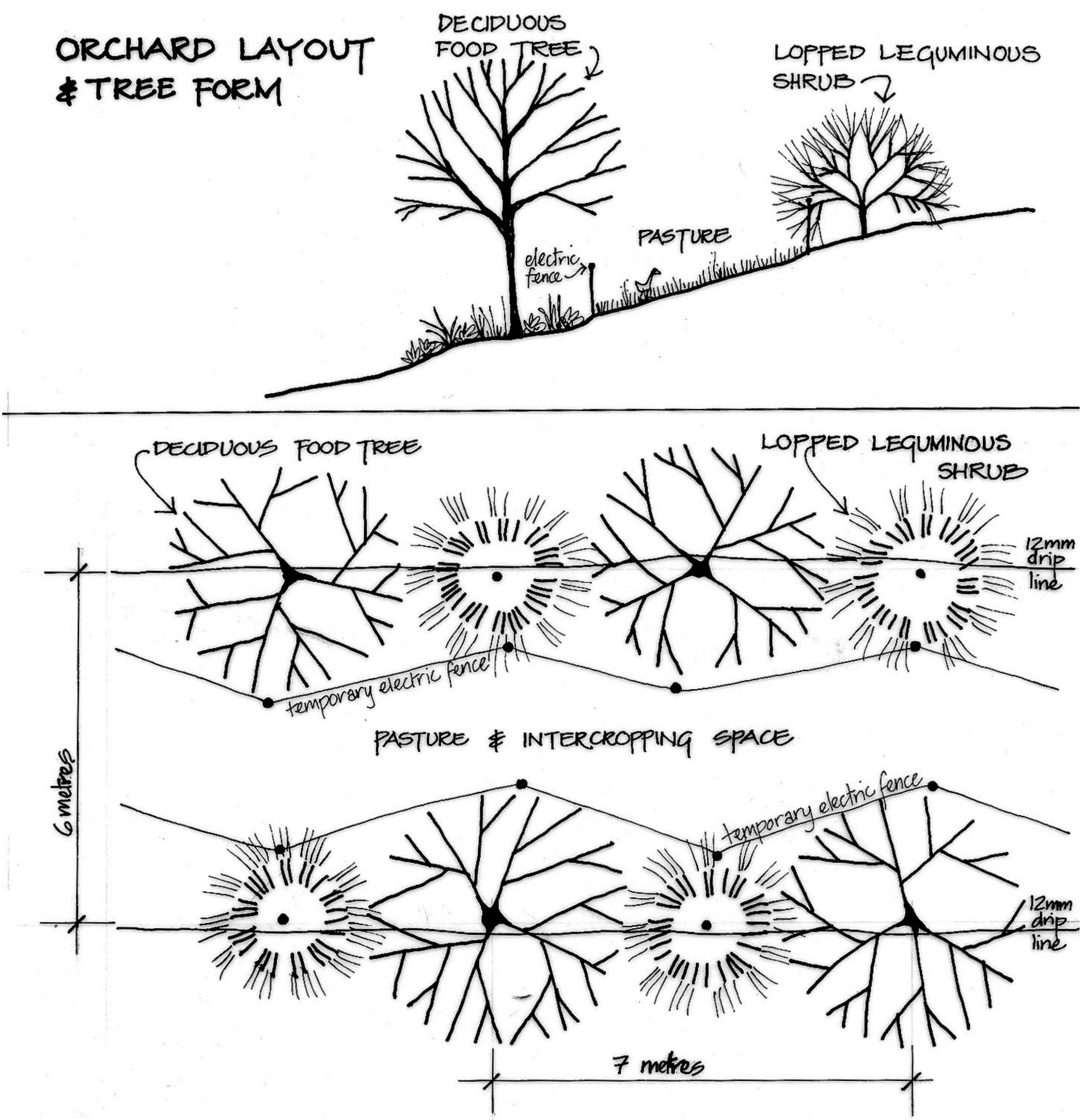
One problem with the standard form has been exposure of the trunk to sun scorch. Whitewash is the traditional solution in the Mediterranean. We have also found that retaining side shoots or rootstock suckers (cut back) until the canopy shades the trunk is also effective.

The pruning has been mainly to establish general tree form. On some trees we have used wire forms and weights to create weeping form which stimulates fruiting buds and reduces vertical growth. On some young apples we are trying Allen Gilbert's method which aims to develop a minimal pruning weeping tree form but begins with several years of very hard pruning before the resulting vertical shoots bend over.

William pear with central leader and weeping branches formed by combination of tie downs and weight of fruit. High fruit beyond reach of ladder is generally taken by cockatoos.

TREE STOCK

Most of the trees are commercially grown trees purchased from the Victorian Tree Crop Nursery. A few have been grown on the property and grafted. Rootstocks are not known for all the grafted trees. Most of the non commercial varieties of apple planted on the poorer soils are on Granny Smith seedling while most of the commercial varieties are on Northern Spy rootstock which produces a smaller tree and is resistant to woolly aphid.



VARIETIES

Selection of varieties reflected availability, a desire to experiment and incomplete information as much as careful design. However, a few general principles have been applied:

- suitability for cool climates
- fruit flavour and keeping qualities are more important than appearance and transportability.
- natural vigour and pest resistance rather than high yield.
- suitability for drying more important than bottling.
- a sequence in ripening.

This has meant a bias toward older varieties and away from newer varieties suited to commercial production.

LEGUMINOUS SHRUB INTERPLANTS

The inclusion of pioneer leguminous shrubs throughout immediately distinguishes the orchard from most others. These fast growing evergreen species are planted on a 6 x 7 metre grid in the tree rows between the food trees. They serve the following functions:

- quickly providing a matrix of shelter throughout the orchard for the young food trees.
- attracting insect eating birds, bees and useful insects.
- reducing the transmission of pests and diseases between adjacent related food trees.
- providing nutrient rich fodder for grazing animals and/or mulch for adjacent trees and nitrogen released from roots following browsing or cutting.
- provide high protein seed for free ranging poultry.

The main species used is tagasaste which has the ideal growth form, is excellent at attracting native birds and has a high fodder value. On more poorly drained sites, Cootamundra wattle and silver wattle were planted. Their finely divided foliage readily breaks down and as natives are likely to support some insect life not attracted to tagasaste. The silver wattles are from local seed source. However, both these species may not respond well to lopping and some of the silver wattles have been severely attacked by caterpillars. Catkin wattle is very fast growing on the property and responds well to lopping. Since 1992 it has been progressively planted to replace some of the other wattles. Its leaves are reputed to be high in minerals. Wirilda is another species which may be tried in the future.

Management of nurse shrubs

Management of the interplants is essential if the above benefits are to result without adverse effects on the food trees. The management regime being implemented is as follows:

- drip irrigation to assist rapid establishment in the first few years.
- regular lopping in spring and autumn to establish woody bush form at 2m (with regrowth to 3m) to reduce moisture and mineral nutrient competition with food trees, provide green fodder and/or mulch and release nitrogen from root decay.
- transfer of dripper to adjacent food tree to reduce growth rate once mature woody form is established.
- possible removal of nurse shrub for firewood once canopy of food trees severely shades shrubs and they become and obstruction to harvesting.

David lopping tagasaste in orchard block two for mulch and poultry scratching deterrent around adjacent fruit trees.

The useful life of the nurse shrubs[1] is expected to be in the order of 15 to 20 years by which time underplanting of the food trees will be achieving many of the nurse functions.

Branch mulch harvesting from these and other pioneer species on the property has produced 1 - 2 tonnes/annum for the last few years. This material has been perfect for deterring excessive poultry scratching around trees, a problem which has been more severe than I expected due to the slope of the land.

Pastures and Intercrops

Most of the interrow space in the orchard will be used for grazing animals. Once the process (described in the Soil Development notes) has controlled weeds and improved the soil fertility adequately, specific areas may be developed for field crops. The moderate slopes in the main orchard block with chocolate and transitional soils and the near level fertile soils in the southern block are suitable for field crops. Likely crops include grains, linseed and sunflowers (primarily for poultry feed) potatoes, corn, field peas, broad beans and other dried legumes. Chicken tractor systems[2] may be practical on the flattest areas.

Underplanting

Around each food tree the soil has been enriched by manuring and heavy mulching during the first few years. These sites, partially shaded by the canopy, represent a potential gardening environment where minimum maintenance species can be grown.

They are being progressively planted to species which have a beneficial effect on the deciduous food trees and exclude grass growth which is antagonistic to most trees. Extra irrigation water may be needed for some to thrive while others will take advantage of seasonal moisture when the trees are dormant. In the development of a system characterised by beneficial interactions between plants these underplantings represent a successional stage beyond the use of leguminous shrubs to establish the orchard. This is an example of a guild[3], which should be developed around important food trees.

The following types of plants are being tried:-

- Insect attracting species; particularly umbelliferae species such as fennel, tansy, dill and parsnip which support Tachynid and other small predatory wasps. These insects parasitise codling moth and other serious pests.
- Spring bulbs; such as daffodil, narcissus and hyacinth which flower before the trees leaf out and die back in summer.
- Spike roots; such as comfrey, daikon, globe artichoke and dandelion which suppress grass, aerate subsoils, yield mulch and maintain cool moist conditions in the topsoil encouraging earthworms.
- Nitrogen fixers; such as field peas, tick beans and clovers.
- Soft ground covers; such as nasturtium which provide a living mulch.

Underplantings need to be able to survive orchard livestock. Observations so far suggest rotational foraging by poultry will be necessary for many umbelliferous and leguminous species to become naturalised under the trees. The same will probably apply with grazing animals.

Removal of the nurse bushes will also provide enriched grass free planting sites. At this stage feijoa seems the most likely species to plant on these sites for the following reasons:-

- It is well suited to climate, is tolerant of partial shade and is evergreen making some use of water in the winter.
- It produces a winter fruit with commercial potential which is not attractive to pest birds.

1. *nurse shrubs : plantings to shelter and aid establishment of more valuable tree crops.*
2. *chicken tractor: enclosure of poultry at high densities on a vegetable cropping area to remove weeds, cultivate and fertilise prior to sowing (see* Permaculture: A Designers Manual *for designs)*
3. *guild: a mutually beneficial association of plants and animals (see* Permaculture: A Designers Manual*)*

LIVESTOCK

ANIMAL STRATEGY

Animals have not been a major part of the system to date for the following reasons:-

- Our largely vegetarian diet makes minimal use of animal products.
- The absence of any strong emotional attachment to animals.
- The permaculture principle of establishing soil building and animal forage systems first and then introducing animals once the system can support them without damage and without excessive inputs from outside.

However, animals are essential to the maturation of any permaculture system. Apart from diversifying the available yields they perform essential functions of vegetation control, nutrient recycling, pest control and mechanical tasks such as shredding and ploughing.

David with the 8hp. self propelled and geared slasher which since 1987 has converted brambles, shrubs and grass to mulch for trees and worm food to improve the soil and has allowed rapid establishment of tree systems without risk or the costs of guarding from grazing livestock. Poultry on free range consume a significant amount of green feed and add valuable fertilizer to the orchard.

The strategy involved several elements:-

- Complete exclusion of rabbits and other animals to allow unrestricted planting and full growth of biomass for soil improvement and mulch.
- A poultry deep litter system to replace composting as a way of converting garden and household wastes and providing a supply of eggs.
- Introduction of fish and suitable birds to the dams.
- Introduction of animals to the orchard to replace slashing, use tree fodder, accelerate nutrient cycling, consume fallen fruit and pest insects and provide additional sources of manure for the gardens.

POULTRY DESIGN

Poultry are our primary animals because they:-

- Provide eggs which we regularly use and can barter.
- Efficiently convert surplus garden wastes and pests into high nutrient manure.
- Cause minimal damage on free range in young orchard systems.

The first stage involved the construction of the house and deep litter yard as part of the garden shed complex. The house is small (2x1.2m) but is adequate for 1 - 2 dozen birds. There are three nest boxes mounted on the wall with a hatch for collecting the eggs from the carport space. A slatted floor high off the ground allows manure to fall through where it can be raked out for use as a concentrated fertiliser on the gardens.

Attached to the house is a small yard (4x5m) which is maintained as deep litter. The netting roof excludes foxes and ravens (egg stealing) while beans and other vines provide some shade in summer. Bruising of pungent herbs such as wormwood growing against the netting helps repel lice, and the birds push through a wormwood bush on leaving the yard. A self waterer from the adjacent tank ensures the birds have a continuous supply of fresh water.

This system has been very effective in providing the birds with a good foraging environment, recycling wastes and providing the main source of nutrients and humus to the vegetable gardens. Proper management is the key to making the system work.

Deep Litter Management

Crop wastes, weeds and kitchen scraps are added to the straw base and grain is fed in the yard to encourage scratching. The location of the yard encourages casual harvesting of lush weeds, snails and other titbits from the gardens for the birds.

Anaerobic condition in winter and spring is the main problem. This is unhealthy for the birds, smells, slows breakdown of fibrous material and most importantly leads to loss of valuable nitrogen. In cool wet climates this can be avoided by:-

- Cutting all long tough material such as corn stalks into 300mm lengths to assist in turning wet material.
- Turning, heaping and addition of dry straw following heavy rain in winter and spring.

This management maximises the action of the manure (tiger) worms which naturally invade such material. These are most important in the rapid breakdown of the compost. Thus the deep litter system can be considered a worm farm. The large amount of material added in autumn prevents the birds scratching to the base. Worm populations develop rapidly. Poultry eat large numbers of worms (protein content is 78% dry weight) during and following turning but the resulting aeration increases worm numbers.

Su turning deep litter in early spring with hens flocking around to catch abundant tiger worms, a significant protein supplement for egg laying birds.

As material dries off in the summer, the looser material allows poultry to eat a high proportion of the worms before they migrate or die. (These worms are of less use in garden soils where other species of earthworms are predominant). Through summer the birds dust bathe in the dry material and in early autumn we screen the material through a bed frame to harvest 3-5m^3 of compost which is spread on the gardens and/or allowed to compost further for use in spring. Coarse material remaining provides the start (including worm egg cases) for the next year's deep litter.

Concentrate feed

For birds to lay eggs they require a diet high in protein and carbohydrate. While a deep litter yard combined with some free range in a mature orchard will supply some of the diet, supplementary feeding will still be needed. Grains and oilseed crops are ideal concentrate supplements. While it is not practical or economic to grow these for human consumption, they are obvious elements in any field crop rotation and can be fed to poultry without threshing or husking. Sunflowers and linseed have already been grown in small quantities for this purpose.

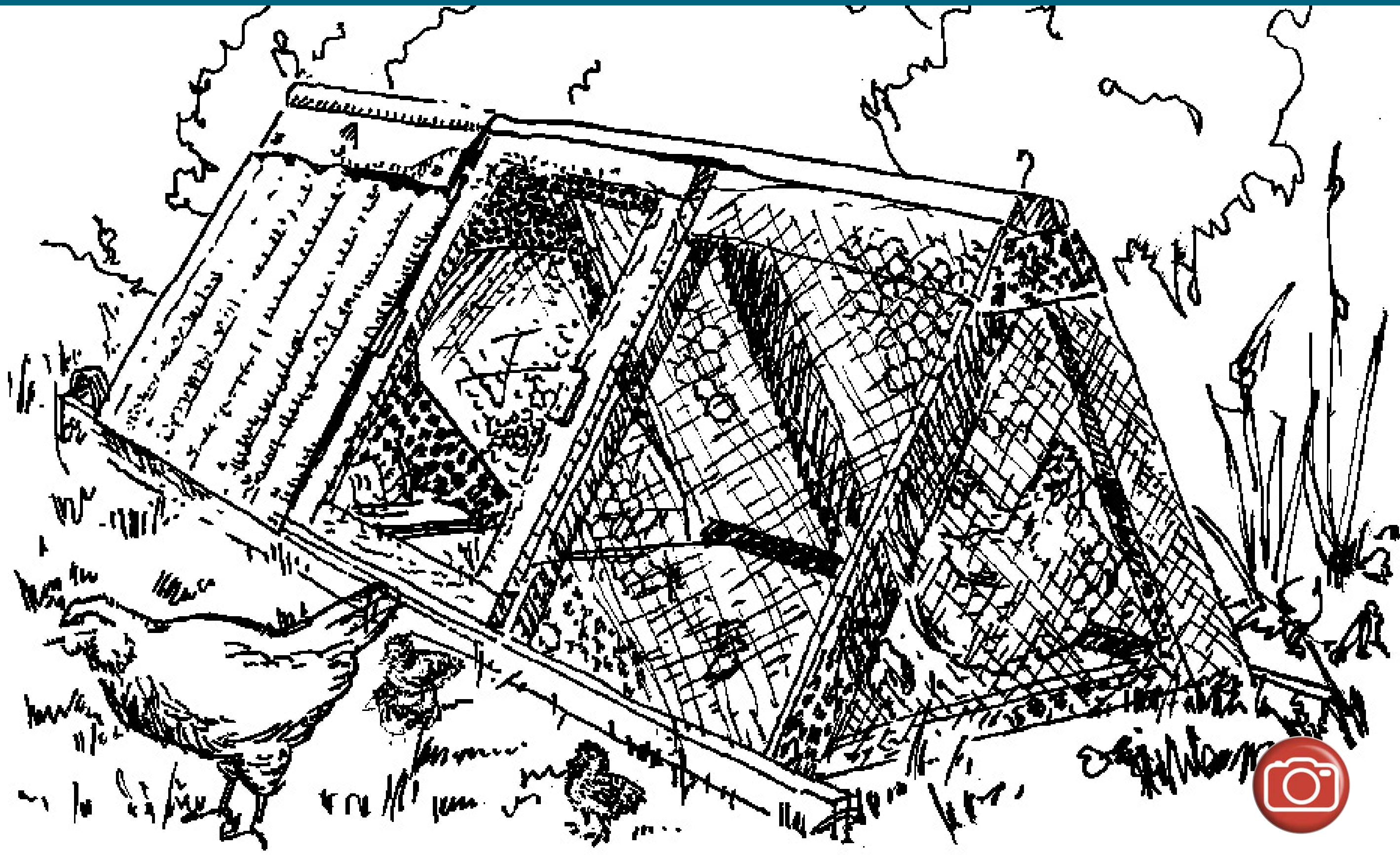
When birds go off the lay in winter they can be partially fed on lower value feeds such as potatoes. In the longer term low grade nuts and acorns may provide alternative feeds. The bulk of concentrate feed is still imported, mostly feed grade wheat from a nearby organic farm. Waste from the local health food shop, restaurant and a pasta maker have also contributed valuable feed from time to time.

Egg yields

Our consumption of eggs is not high (6-8/week average) but with our system and Su's interest we have found 18-20 hens is optimal. Over the last few years egg production has been approx 2800/annum so our consumption is only 10-15%. The remainder are given away and sold.

The quantity of bought wheat has been about 750kg/annum which cost A$225, this being about half the value of the eggs produced. It will be interesting to see over the next decade whether the total production and quantity of bought feed changes significantly with better flock management and maturation of the free range and onsite feed production, or whether we will reduce numbers of birds as other animals are added to the system.

Su and Oliver harvesting deep litter compost autumn 1992. Bed frame on right covered with compost for screening before removal for placement on garden beds. Note heavy rot-resistant base boards to retain compost on sloping site and hatch in corner for exit of poultry to orchard free range.



Movable A-frame on lawn with "Granny Black" broody and chicks free ranging under supervision.

MANAGEMENT OF BIRDS

Choice of birds is partly a matter of personal preference but permaculture principles suggest selecting birds which are good foragers with moderate egg and meat qualities. Birds bred for maximum egg production need a regular supply of prepared feed and are generally poor foragers. Black Australorp has been our choice. The flock was started with four birds from a good egg laying strain and an unrelated rooster to give outcrossing vigour in breeding.

A good rooster is an essential part of the system. He will scratch deeper than the hens but let them feed first, alert the hens to predatory birds and if necessary defend the flock, as well as fertilise the eggs without excessive harassment of the hens. Some people suggest fertilising increases the quality of eggs as food apart from allowing chickens to be raised.

We have since added some Black Australorp/New Hampshire crosses which have been very hardy, good egg layers (and personality!) but these lighter birds are able to fly over fences and are prone to an inability to refeather after moulting.

Su has taken responsibility for the poultry and has developed a considerable attachment to "her girls". Raising chickens allows maintenance of the flock, entertainment and education for children and an occasional source of meat from male cockerels. Preparedness to kill birds naturally follows from keeping a rooster. Culling of birds not laying is also necessary to prevent feed requirements from escalating. Su makes the decisions, I do the job and we all pluck.

A moveable "A-frame" is used to isolate a broody hen and allow her to raise the chicks free from harassment on the lawn (free from risk of any disease or parasites in the flock). Once chicks are 10-14 days old and before the broody causes too much mayhem in the garden, the A frame is moved into the orchard where they can free range in the morning before the flock is let out. Gradually the young birds are integrated into the flock before having to join it permanently. Generally three batches of chicks are raised each year.

Orchard Free Ranging

Confinement to deep litter is a humane and workable system of husbandry but only taps a small proportion of available forages on the property. A small lifting gate allows the birds to range in the orchard where they can glean green feed, seeds including tagasaste, fallen fruit, insects and worms as well as distribute manure.

Free ranging has been restricted in the early years because of the problems of birds scratching around heavily mulched young trees. Now the trees are well established and mulched with stones and branches. Underplanting to species such as comfrey and bulbs is also providing protection.

Recent subdivision (spring '94) of the orchard with light weight electric mesh fencing has allowed the long-planned rotation of birds from the northern volcanic soil areas in winter (good dust bathing) to the southern and drainage line clay soils in summer (good green feed). It has also increased protection during the day from foxes.

Chooks free ranging along internal grassed access track (orchard block 2) contained by Electranet moveable fence. Two row internal orchard shelter plantings on left side of mesh.

OTHER ANIMALS

Kimon(16) and Oliver(2) spring 1988 with geese on trial in newly planted orchard and green manure strips of oats and field peas. Damage to newly planted fruit trees lead to abandonment of the trial.

STRATEGY

Decisions on other types of animals, numbers and methods of management have been slower to happen but geese on free range, tethered goats on loan and a small flock of ducks have been trialled.

Ducks

Currently a small flock of ducks is enclosed with temporary electric mesh fencing with a small moveable house around the pond which is enclosed. One reason for keeping ducks is to breed ducklings which can be free ranged in parts of the garden in winter and early spring to reduce slugs and snails which are one of the greatest problems for our spring vegetable plantings.

Geese

Geese are ideal grazers for the orchard, preferring grass to other plants and causing minimal damage to established fruit trees. The reliability of green feed along the drainage line in dry summers and the availability of the pond make the property well suited to geese. One of the light egg laying breeds such as Chinese Brown Geese would be ideal. These can be raised for weeder geese in unpalatable field crops (especially alliums). The electric mesh fencing could be used to exclude them from the main dam during the swimming and irrigation season as is done now with the ducks.

Larger livestock

A few sheep or goats could be run in the orchard to completely replace slashing and utilise available grass, shrub and tree fodder. Rotational grazing between the tree rows as indicated in the orchard layout diagram seems the best option at present. The simplest solution might be a flock of sheep on brief agistment once a year. The most productive option would be a pair of milking goats.

Although goats can be quite destructive if given free access to trees, a number of factors make them the logical choice:-

- Their preference for eating dock and blackberry (the two most persistent perennial weeds in the orchard) as well as tree and shrub fodder which we have in abundance and their use in helping to control blackberry on the adjacent public land.
- The work required for frequent moving is better paid back through the valuable yield in milk.
- Milking goats can be good pets with personality.
- Milking and shedding in bad weather allows accumulation of manure which can be collected for use on gardens.

Until recently, other priorities, our lack of skills with animals, fear of damage to trees and cheap supply of local unpasteurised milk have inhibited us from taking up this option.

FUTURE SCENARIOS

Maturation of the orchard (20 years+) with less pasture growth and progressive removal of nurse fodder shrubs and increasing yields of fruit and nuts could make pigs an attractive option. However erosion hazard on steep slopes will probably preclude free range pigs. As the forest along the gully matures black wallaby are likely to become more common. They could be allowed to periodically graze the orchard with low netting across the gate to the gully to exclude rabbits.

Maturation of the tree canopy is also likely to be accompanied by a possum problem.

A dog on range in the orchard may be the most effective way of keeping the problem in check as well as controlling any rabbits which manage to find their way into the orchard. So far, predatory birds seem to have caught any rabbits which have got into the orchard.

The most severe pest problem in the orchard is cockatoos and parrots. At present, kites resembling predatory birds, humming tape and strategic use of nets on some trees are being used to some effect. If the old pear tree can be encouraged to fruit every year its decoy effect is quite useful while it remains the largest tree in the orchard. In the long term, another bird is probably the best solution. Trained predatory birds (falconry) have proven effective in some commercial orchards and vineyards while white pigeons are reputed to keep away white cockatoos.

AQUACULTURE

STRATEGY

Producing food from water bodies is commonplace in other parts of the world but the general abundance of fish from wild systems has done little to encourage aquaculture in Australia, except for high energy monocultures of high value species such as trout.

Several factors suggest aquaculture should be a significant part of this system.

- The large winter flows through the property bring with them considerable nutrients, organic matter, worms and insects.
- Two dams increase options for management, including separation of species.
- The pipe through the wall of the main dam allows easy drainage down to the sump for cleaning out any fish stock.
- Yellow box stumps with contorted roots provide shelter for fish from predatory cormorants.
- Lining of the dams with topsoil and absence of grazing animals for the first 8 years has allowed a mature edge of Juncus and Cyperus to develop. These support abundant insect life and these species survive the seasonal level fluctuations.

Yabbies from the dams caught in butterfly traps are a regular part of our diet in summer. Blackbirds caught in rat traps to protect berry crops are used as bait.

Dam drained in April 1995 (following drought) to harvest fish and prepare for earthworks to increase storage volume. Floating platform resting on tree stump (fish habitat). Floating styrene boxes with compost growing water chestnuts.

Plants

Mat rush and other self established species brought in by native ducks are increasing the diversity of the water edge and providing clean entry points for swimming. Self established cumbungi has been removed from the dam and planted in the silt trap which it completely filled, thus improving its water filtering capacity. Harvesting for weaving and mulch has been carried out. We did transfer some curly pondweed (Potamogeton sp.) from the local creek to the lower dam but no systematic investigation of aquatic species suitable for introduction to the dams has been done so far.

In the last few years water chestnuts given to us have been propogated in the greenhouse and in 94/95 have been grown outside. Several systems are being tried:-

- Bath tub in the red soil garden.
- Small pond ($2m^2$) dug into the clay bank behind the lower dam.
- Polystyrene boxes (with potting mix) floating in the silt trap and main dam.

Yabbies

Yabbies quickly became established in the dams following filling and within a few years were causing seepage problems due to burrows in the wall. Intensive harvesting of the main dam and silt trap in the summer of 1989/90 with nets and traps yielded over 150 eating size yabbies. Since then regular late spring/summer harvests of yabbies have been higher than this.

Fish

The previous year Vernon Howell, who stocks many dams in the area, introduced a small number of brown trout to both dams and redfin perch to the main dam. These fish came from naturalised populations in local streams. Two good eating fish of each species were caught with a fly rod and the yabbie trap while others eluded all efforts. Yabbies are a significant part of the diet of both species along with aquatic and aerial insects. Harvests of fish have been variable but the average yield of yabbies and fish would be equivalent to 400kg/ha of water/annum.

MANAGEMENT ISSUES

Apart from the structural problems caused by yabbies, several management issues are worth noting.

The nature of the local clays combined with yabbie activity maintains a high turbidity during the summer and this leads to severe stratification of water temperature which in turn is not good for comfortable swimming or for the health of fish. Swimming itself is a partial solution to the stratification by mixing the warm and cold layers.

Water quality in the main dam declines through the irrigation and swimming season so more frequent clean out of the pump filter is required.

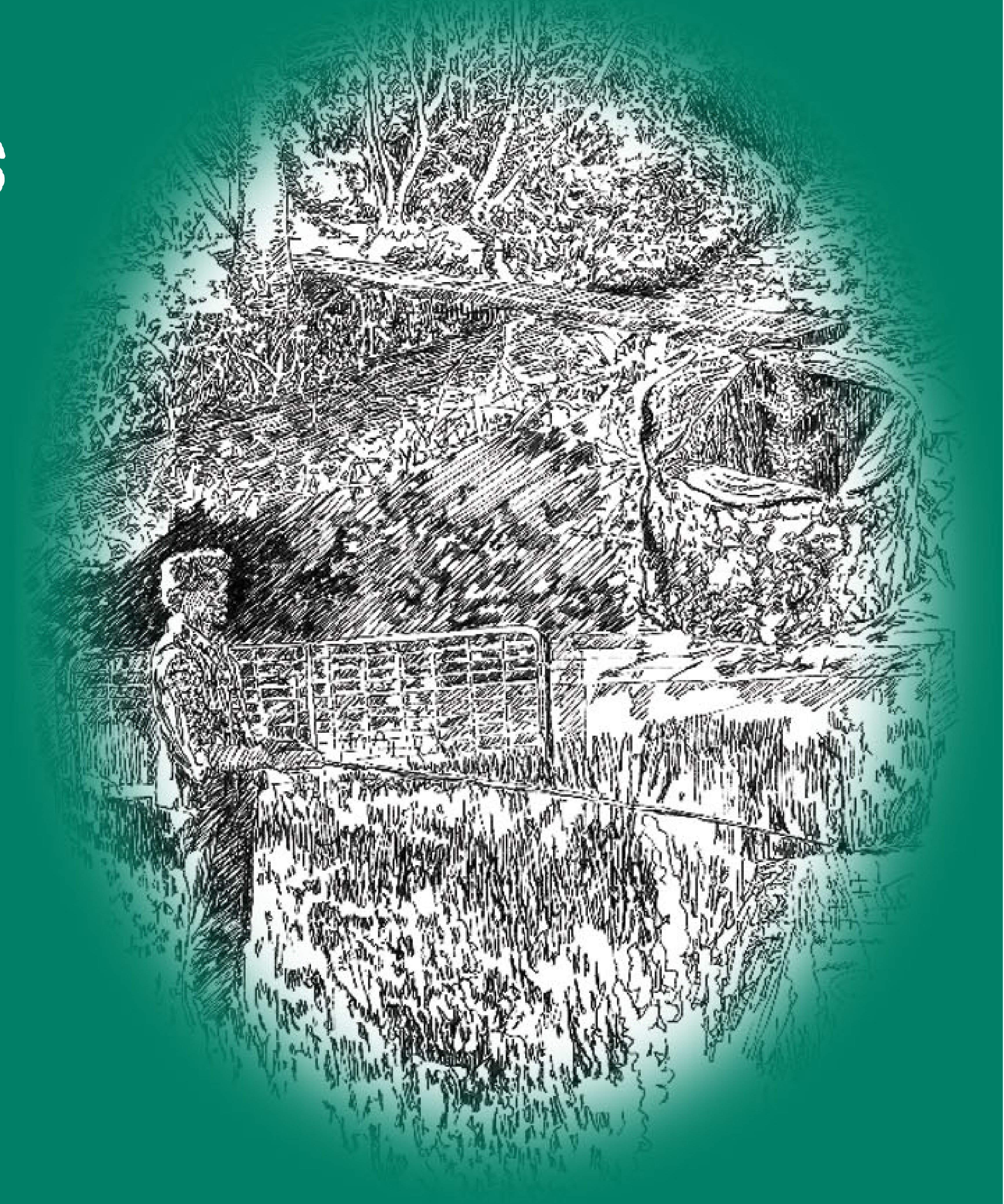
In spring '94 massive populations of mosquito larvae led to severe filter clogging to such a degree that pumping was not practical. A lack of tadpoles (major predators of mosquito wrigglers) seems to have been the problem which, in turn, was probably due to the presence of six ducks over the winter, for the first time. The ducks certainly layed very well but the eggs were difficult to collect from the island and in the end a swimming fox extended this food chain one more step by eating two of the ducks.

This example illustrates that integrated systems are complex and a cascade of problems can result from attempts to integrate everything. The original logic of two dams increasing options for separation of some species has proven to be valid.

The lower dam appears to be much more eutrophic than the large dam. This may be related to the red soil bank on one side. Extensive growth of pond weed in December '93 was harvested for mulch for the adjacent garden. It has since disappeared. In February '94 algal blooms appeared, and again in December '94. Some of the nutrient rich water was pumped out for gardens in the drought of '94/95. Ducks on the dam ate some of the algae.

Better management of the already productive aquatic systems on the property awaits further research. Like the issue of grazing animals, other priorities have led to less than optimal development of aquaculture but valuable knowledge has been built up by the casual observation and "do little" approach.

BEYOND THE BOUNDARIES



STRATEGY

Planting of trees and other work on the road reserves surrounding the property have been an integral part of the development of the site. In permaculture site design language these areas function as "Zone Three" dominated by planted but unirrigated trees and shrubs as well as mown and grazed pasture. Further away along the gully reserve which connects the property to Hepburn Regional Park, steep slopes and massive brambles make a less intensive "Zone Four" approach more realistic. Here managing what grows wild may be more important than designed plantings.

This work has been done within a framework of informal approval by the local authorities. Our own efforts have in many ways been inspired by the work of Vernon Howell. Vernon had been active planting trees before we arrived and since then has provided leadership in what has become a major but quiet community forestry project involving many people; kilometres of foot tracks, bridges and thousands of trees. All of this work has been informal and unfunded. Vern's approach in managing natural systems is classic permaculture and we use the "gully" project as a demonstration site during our Permaculture Design Courses.

While the ecological/permaculture objectives of this work have been slow to spread, the example of community management of public land has inspired several projects by other groups including the restoration of the Hepburn Swimming Pool on Spring Creek.

The following objectives have been used to guide the planting on the immediately adjacent public land:-

- Reverse decline in habitat value of locality in recent years and provide wildlife corridors to the regional park.
- Reduction of annual grass and woody weed growth and reduction in fire hazard by shading and competition.
- Siting to avoid the problems for possible extension of roads or reticulated services.
- Provide visual screening between houses while maintaining solar access to existing and likely future houses.
- Improve general appearance of public land and pedestrian access to regional park.

Right: *Vernon Howell clearing blackberry brambles with slashhook for tree planting along Spring Creek.*

ROAD RESERVES

DESIGN GUIDELINES

Planting on road reserves with potential to be developed as streets (Olver and McKinnon) has been restricted to 5m strips adjacent the property. This allows 10m for the construction of the road surface, table drains and slopes and a 5m planting strip on the other boundary.

Use of large trees on Fourteenth, Olver and McKinnon Streets has been limited. Where they have been used, shading of neighbouring properties, placement of powerlines and other services as well as options for future felling have been considered.

Preference for low fire hazard species.

Low maintenance, unirrigated plantings in most cases.

FOURTEENTH STREET

Construction of the street in the 1960s produced a steep unconsolidated fill slope of shale and clay across the gully which regenerated to cape broom and blackberry, and a few silver wattles near the pipe under the road. The upper section adjacent the house site was compacted in-situ clay and shale covered in cape broom and gorse. Powerlines are on the other side of the street except for the pole and line servicing the house.

Design Concept

Screen plantings to complement house slope screen plantings and provide shelter to the house site and orchard from SW winds. Also to extend native vegetation grid along road reserves.

Description

On the steep road slope across the gully, taller plantings to shade out the blackberries have been planted. Silver wattle and blackwood at close spacings have been used. Specimens of self sown silver wattle, blackwood and yellow box growing in the cape broom have been protected.

Clearfelling of mature yellow box trees on vacant land on the other side of the road had exposed the house and orchard to cold SW winds. Consequently (spring '89) a row of close planted blue gums has been added closest to the road. Thinning and final felling of these trees was carefully planned prior to planting. They are already a major feature of the site and are providing good shelter over the south orchard.

OLVER STREET

Excavation of material to construct Fourteenth Street and installation of the trunk sewer have exposed and compacted clay along the road reserve adjacent the property. The gully crossing in the southern corner of the reserve is wet and anaerobic. The large yellow box tree is a striking feature along with other mature trees on the far side of the reserve.

Fourteenth Street shelterbelt on road embankment previously covered in cape broom and blackberry. Blue gums only six years old now provide effective shelter over orchard as well as damming cold air drainage, thus reducing growing season frost risk in orchard block one. Blackwoods and fire retardant shrubs on slope below provide low shelter and suppress blackberries.

Design Concept

Screen planting to give privacy at the dam (swimming) and the second house site and reinforce existing native vegetation.

Description

A three row screen planting incorporating the yellow box tree between the gully and the gate onto the dam wall to replace the screening provided by existing cape broom on the far side of the reserve. At the gully a dense planting includes large eucalypts to provide screening from houses overlooking the dam and housesite and complete a sun trap formed around the southern end of the orchard with the Fourteenth Street plantings. One of the consequences of this planting has also been the diversion of cold air drainage down Olver Street reserve leading to reduced incidence of frost in the sun trap.

Behind the second house site natural regeneration of yellow boxes and peppermint gums has been protected to provide screening from houses along the main road and complemented by shrubs.

MCKINNON ROAD

The soil along the upper sections of the reserve is shallow over shale and sandstone grading to deep clay behind the shed. Beyond the gate there is the transition to shallow basalt. The reserve is generally sunny and very exposed to N and NW winds.

Design Concept

Low plantings to screen neighbour's house and extend native shrub habitat without blocking sun to house on the southern section. Along the north a low fire hazard food and fodder producing belt which will shelter but not overshadow the orchard from the north east.

Description

A three row planting between the small yellow box tree and the shed to extend the cut slope plantings. A mature height of 2m will ensure maximum sun exposure to the garden and the view of the Elevated Plain escarpment from the house. Around the gate an arc of shrubs connects to a cherry plum (now grafted) and forms a small space used for materials storage adjacent the gate.

Beyond this point are two rows of tagasaste sheltering an irrigated row of olives, walnuts and other species. Spraying of blackberries on the other side of the reserve by a neighbour in 1993 resulted in a severe setback to the tagasaste and showed the extreme sensitivity of this species to herbicides used for woody weed control. The neighbour has since planted a single row of mixed deciduous and evergreen trees along his side of the road reserve.

Winter 1990. Oliver(4) by drip irrigated chestnut planted 1988 on volcanic soil of gully reserve. Orchard block 3 inside rabbit proof boundary fence. Some planted blackwoods and and willows visible between blackberry brambles.

Same view as left, summer 93/94 showing established canopy of blackwoods, bat willows. Not visible are underplanted oaks, walnuts, bunya pines, myrtle beech and understory shrubs. Suppression of blackberries improving every year.

GULLY RESERVE

Public land connecting the property to the Hepburn Regional Park.

Site and soil conditions

Very diverse with shallow and deep chocolate loams, anaerobic clays and some mullock generally with good mulch layer from woody weed cover, high level of rabbits and some wallaby browsing.

Design guidelines

- Plantings in the gully have aimed to achieve a low fire hazard canopy to shade out blackberries and other woody weeds in the shortest possible time.
- Because of the deeply incised nature of the gully, there is little concern about shading of neighbouring properties. The only likely development of the gully reserve is a walking track down into the Hepburn Regional Park. Consequently large trees have been widely used.
- Because of the rugged and blackberry covered nature of the gully, planting began as opportunistic, individual plantings, but since then several techniques have been trialled, including rolling down whole patches of blackberry and mass planting at high densities (1 - 2m spacings).

Use of native species has been more limited than on the road reserves for the following reasons:

- The already exotic nature of the gully with willows, blackberry and hawthorn. The mostly moist conditions and rich soil have considerable potential for exotic species and conversely few natives can effectively shade out the blackberries in these conditions.
- The importance of developing an effective barrier to any fire funnelling up the gully into the town. Few large native trees are suitable.
- Browsing pressure from wallabies and the inaccessible nature of the gully have made planting of poplars and willows from sticks the most effective technique.

Species

Blackwood has been the main native species used but some very fast growing eucalypts including Eucalyptus globulus, E. ovata and E. botryoides have been included to provide quick cover before being thinned to reduce fire hazard.

Yunnan poplar, silver poplar, cottonwood, bat willow, Italian alder, sycamore and European ash have been the main exotic pioneers used (See website).

On the best sites some higher value successional species have been planted including bunya pine, oaks, chestnuts and walnuts, usually with tree guards, but still subject to wallaby pressure.

APPENDICES

DEVELOPMENT TIMELINE

1985

	Land purchased

1986

January	Site cleaned up and tractor slashed
February	Town water connected to lot 9
March	Housesite earthworks with D7 bulldozer
	Stone retaining walls, topsoil on terraces with tractor
	Footing trenches with backhoe
April	Strip footings boxed and poured
	McKinnon access track aggregate spread
May	Fill slopes sown with pasture seed
	Chestnut tree planted for Oliver's birth
June	Mains power connected to meter box.
August	Sewer connection installed up to house foundations.
	Garden shed, concrete water tank constructed
	House foundation walls laid
September	Town water main laid to house and outside taps
	Driveway retaining walls constructed
	Cut and fill slopes planted with shelter trees and shrubs
Nov-March	House mudbrick walls laid

1987

March	House roof framed and clad
	Main dam dug with D7 bulldozer, pump intake pipe installed
April	Pump house built, dam walls sown with pasture seed mix
September	Geese pond dug with D3 bulldozer and backhoe
	Topsoil stockpile moved onto house platform
	First vegetable garden planted along stone retaining walls
September	Orchard tree rows cultivated and sown to green manure crops
October	Pump installed and poly main to concrete tank
Nov-May	House windows, doors, internal walls, floors, ceilings, linings, insulation, electrical, plumbing and telephone

1988

January	Boundary rabbit proof fence constructed
May	Move into house
July	Orchard plantings, first stage (60 fruit and nut)
	Road reserves and gully plantings, first stage.
August	Raised wooden garden beds built and filled with topsoil
	First major vegetable garden planted
	Grape pergola constructed
November	Irrigation system and drip irrigation installed
	Lawn sown over newly spread topsoil

1989

March	External paving around house laid
	First fruit and nuts from orchard
	Dams stocked with trout and redfin
April	Wood heater and slate steps installed
July	Orchard plantings second stage (20 fruit and nut trees)
	Frost -8°C kills some orchard interplants
Sept-Nov	Gully and road reserve plantings (100 trees)
	Screen and shelter planting including blue gums on 14th Street
November	Poultry house and yard, triangle raised garden bed and kiwi fruit pergola built
	Runoff garden established using plastic mulch for couch grass

DEVELOPMENT TIMELINE

1990

January	Goats tethered for blackberry control trial in orchard
	Fish and yabbies first harvested from dams
March	First formal guided tour of Melliodora
April	Poultry deep litter compost first harvested
	Deep ripping for orchard and road reserve plantings
	Red soil garden established with lucerne sheet mulch
June	Major clearing and tree planting along gully
	Last area of blackberry and broom within fence slashed
	Sink splash back and bathroom shower recess for certificate of occupancy from Council
July	Orchard plantings third stage (apples & chestnuts)
	Peak flood event, large trout caught against fence
September	Three row native planting McKinnon & Olver
December	Cottage (bottom) garden established (potatoes)

1991

March	Runoff garden extended with cardboard sheet mulch
April	First air photos of property
	Ripping for McKinnon tagasaste shelterbelt
May	Dam emptied after very dry season to harvest fish
	Netting fence between zone one and zone two built to exclude poultry on free range.
September	Tagasaste two row shelterbelt planted on McKinnon

1992

April	Office-living room dividing wall built
	Mid orchard shelterbelt site preparation
September	Mid orchard two row shelterbelt planted
	Tagasaste shelterbelt interplanted with fruit & nut trees.
September	Gully willows underplanted with oaks, bunyas etc
November	Windmill installed
	Poulty A frame first used for raising chickens
December	First summer overflow of dam spillways, fourth for year
	Rainfall for year (1058mm) well above average

1993

April	Barn constructed
July	Compost toilet and compost bays constructed
August	Erosion control work in gully
	First ducks
December	Rainfall for year (1175mm) highest for decades

1994

March-Sept	Property managed by caretakers while we are overseas
October	Electric fence subdivision of orchard & sowing of lucerne.
	Dolomite lime (1 ton) applied to orchard and gardens
	Boron applied to selected fruit trees and garden beds
December	Rainfall for year (580mm) nearly as dry as 1982

1995

January	Attack by dogs kills most hens and ducks, ducks not replaced
March	Dam drained after dry season
April	Shade house roof over barn compost bays
	Underground power connection to shed
August	First goat 'Feijoa'
October	Guinea pigs and rabbits introduced in cages on lawn

PERENNIAL SPECIES INDEX

Perennial species which have been deliberately planted or sown on the property and surrounding public land reserves are included and listed alphabetically by botanical name. Where appropriate, species identification includes cultivated varieties or provenances. In some cases identification is incomplete or varieties are identified by some personal or local designation. Some varieties and species included reflect availability and circumstances as much as conscious design criteria. Inevitably these lists will have additions and deletions over time.

For each species the main functions and yields are listed more or less in order of their importance in selecting, planting and managing that species or variety at Melliodora. Functions may change over time. For example, Tagasaste may be a shelter species but will become a major source of fodder as the system evolves. The same species planted at two different sites or systems may have different primary functions. The functions indicated in the species index are as follows.

MAIN FUNCTIONS

S	SHELTER AND SCREENING
A	ANIMAL FODDER
F	FOOD INCLUDING CULINARY HERBS
O	ORNAMENTAL (VISUAL AND SCENT)
T	TIMBER/FIREWOOD/FIBRE
B	BEE FODDER
W	WILDLIFE ATTRACTANT OR HABITAT
M	MEDICINAL

PLANTING ZONES

For each species one or more of eight planting zones is listed. The characteristics of these zones and the planting design for each is described in the Planting Zone notes.

H	HOUSE ZONE
F	FILL SLOPE
C	CUT SLOPE
B	BARN ZONE
O	ORCHARD
D	DRAINAGE LINE AND DAM SURROUNDS
R	ROAD RESERVES
G	GULLY RESERVE

BOTANICAL NAME	COMMON NAME	MAIN FUNCTIONS	PLANTING ZONE
Acacia baileyana	Cootamundra wattle	S, A, W, B	C, O, R
Acacia boormanii	Snowy River wattle	S	H, C, R
Acacia dealbata	silver wattle, local prov.	S, W, B	O, R
Acacia decurrens	early black wattle	S, A	O, R
Acacia floribunda	catkin wattle	S, A, B	O, R
Acacia howittii	sticky wattle	S	C, R
Acacia melanoxylon	blackwood, several prov.	S, T, B	C, R, O, D, G
Acacia pravissima	Ovens wattle	S	C, R
Acacia pycnantha	golden wattle	S	R
Acacia verticillata	prickly Moses	S, W	R
Acacia sp.		S	C
Acacia sp.		S	R
Acer pseudoplatanus	sycamore	S, T	G
Achillea millefolium	yarrow	M, O	H
Actinidia chinensis	**Chinese gooseberry/ kiwi**		
	Hayward	F, O	H
	Tomuri (male)	O, H	H
Allium canadense	tree onion	F	H
Allium schoenoprasum	chive	F	H
Allium fistulosum	Welsh onion	F	H
Allocasuarina verticillata	drooping sheoak	S	C, R, O
Alnus cordata	Italian alder	S	D, G
Alnus glutinosa	common alder	S	D, G
Anthemis nobilis	lawn chamomile	A	H
Araucaria bidwillii	bunya bunya pine	F, O, S, T	G
Arbutus unedo	strawberry tree	F, A	F
Armoracia rusticiana	horseradish	F	H
Artemisia absinthium	wormwood	S, M	F
Artemisia dracunculus	French tarragon	F	H
Arundo donax	giant reed	S, T	D
Asimina triloba	custard banana	F	O
Asparagus officinalis	**asparagus**		
	Mary Washington 500	F	H, B, O
Atriplex nummularia	old man salt bush	S	C, R
Banksia marginata	silver banksia	S, W	C, R
Banksia spinulosa	hairpin banksia	S, O, W	R

PERENNIAL SPECIES INDEX

BOTANICAL NAME	COMMON NAME	MAIN FUNCTIONS	PLANTING ZONE
Banksia ericifolia	golden banksia	S, O, W	R
Betula pendula	silver birch	O	F
Bromus unioloides	prairie grass	A	F, O
Buddleia salvifolia	butterfly bush	O, W	F
Bursaria spinosa	sweet bursaria	W, S	C, R
Callistemon sp.	bottlebrush	O, W	C
Castanea sativa	**Spanish chestnut**		
	EarlyBrown	F	O,R
	"Mt. Macedon"	F	O,R
	Morena	F	O,R
	Mouroni	F	O,R
	seedling	F	O,R
Casuarina cunninghamii	river sheoak	S, A, F, T	F, O, G
Casuarina glauca	swamp sheoak	S, A, T	C, F ,R
Ceanothus	**ceanothus**		
	A.T.Johnson	O, B	C
Ceratonia siliqua	carob	F, O	F, R
Chamaecytisus palmensis	tagasaste	A, S, W, B	B, O, F ,R
Cichorium intybus	chicory	A, F	H, O
Citrus limon	**lemon**		
	Lisbon	F, O	H
	Meyer Lemon	F, O	H
Citrus reticulata	**mandarin**		
	Imperial	F, O	H
Citrus sinensis	**orange**		
	Leng Navel	F, O	H
	Washington Navel	F, O	H
	Valencia	F ,O	H
Colchicum byzantium	autumn crocus	O	H, O
Coprosma repens	taupata	S, A	B
Cortaderia selloana	pampas grass	S, A	D
Correa lawrenciana	mountain correa	O	R
Correa	Dusky Bells	O	H
Corylus avallana	**hazels**		
	White Aveline	F	O
	Red Skin F. Ruby	F	O

BOTANICAL NAME	COMMON NAME	MAIN FUNCTIONS	PLANTING ZONE
Corylus avallana (cont)	Barcellona N.E. Vic.	F	O
	Cosford	F	O
	Wanliss Pride	F	O
	Webbs White	F	O
	Segorb	F	O
	Negret	F	O
	Fertile de Coutard	F	O
	seedling	F	O
Cyandra scolymus	globe artichoke	F	B
Cydonia oblonga	quince	F, O	O
Cyandra scolymus	globe artichoke	F	B
Cydonia oblonga	quince	F, O	O
Cymbopogon citratus	lemongrass	F	H (g/house)
Cyphomandra betacea	tamarillo	F	H
Dactylis glomerata	cocksfoot	A	F,O,D
Dahlia sp.	dahlia	O	H,F
Diospyros kaki	**persimmon**		
	Dia Dia Maru	F	O
	Hackiya	F, O	H
	Hyakumo	F	O, F
	Zenji Maru	F	O
Eleocharis dulcis	Chinese water chestnut	F	H, B, D
Echium candicans	pride of Madeira	B, O	H, C
Eriobotrya japonica	loquat	S, F	F
Eucalyptus botryoides	swamp mahogany	S, B, T	D, G
Eucalyptus globulus	Tasmanian blue gum	S, T, B	R, G
Eucalyptus kitsoniana	bog gum	S, O, B	R
Eucalyptus leucoxylon	yellow gum	O, S	R

MAIN FUNCTIONS

- **S** SHELTER AND SCREENING
- **A** ANIMAL FODDER
- **F** FOOD INCLUDING CULINARY HERBS
- **O** ORNAMENTAL (VISUAL AND SCENT)
- **T** TIMBER/FIREWOOD/FIBRE
- **B** BEE FODDER
- **W** WILDLIFE ATTRACTANT OR HABITAT
- **M** MEDICINAL

PLANTING ZONES

- **H** HOUSE ZONE
- **F** FILL SLOPE
- **C** CUT SLOPE
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PERENNIAL SPECIES INDEX

BOTANICAL NAME	COMMON NAME	MAIN FUNCTIONS	PLANTING ZONE
Eucalyptus lehmannii	bushy yate	O, S	C
Eucalyptus maculata	spotted gum	S, B, T	R
Eucalyptus ovata	swamp gum	S, B, T	D, G
Eucalyptus pauciflora	snow gum	O	C
Feijoa sellowiana	feijoa	F, S, O	H
Festuca arundinaceae	Demeter - tall fescue	A	F, O, D
Ficus carica	**fig**		
	Brown Turkey	F	B
	"Northcote"	F	F
	seedling	F	F
Forsythia viridissima	golden bells	O	H
Fragaria sp.	strawberry	F	H
Fragaria vesca	alpine strawberry	F	H
Fraxinus excelsior	European ash	S, T	G
Geranium sp.	scented geranium	O	H
Gingko biloba	maidenhair tree	O, F	F
Grevillea aquifolium	holly leafed grevillea	O	H
Grevillea barklyana	fern leaf grevillea	O	H
Grevillea	**grevillea**		
	Clear View David	O, W	C
	Gaudi Chaudi	O, W	C
Grevillea miqueliana		O, W	H
Grevillea rosmarinifolia	rosemary grevillea	O, W	C
Grevillea victoriae		O, W	R
Grevillea sp.		O, W	R
Grevillea sp.		O, W	R
Gleditsia triacanthos	honey locust	A, S	F, R
Hakea laurina	pinwheel hakea	S, O, W	C, R
Hakea suaveolens	sweet hakea	S, W	C, R
Hakea sericea	silky hakea	S, W	O
Hakea salicifolia	willow hakea	S, W, O	H
Hardenbergia sp.	**purple coral pea**		
	Happy Wanderer	O	C
Helianthus tuberosus	Jerusalem artichoke	F, A	D, O
Hemerocallis sp.	day lily	O	H
Humulus lupus	hops	F	F

BOTANICAL NAME	COMMON NAME	MAIN FUNCTIONS	PLANTING ZONE
Hymenanthera dentata	tree violet	S, W	O, R
Iris sp.	iris	O	H
Jasminum officinale	common jasmine	O	H
Jubaea spectabilis	Chilean wine palm	F	O
Juglans nigra	black walnut	F, T, S	G
Juglans regia	**Persian walnut**		
	Wilson's Wonder	F, T	F, O
	seedling	F, T	O, R, G
Juglans x	Ivanhoe hybrid	F, T	F, O
Kniphofia sp.	red hot poker	O, W	H
Laurus nobilis	bay laurel	F, O	H
Lavandula spica	English lavender	O, B	H
Ligusticum officinale	lovage	O, F	H
Lolium perenne	perennial ryegrass	A	O, D, H
Malus domestica	**apples**		
	Cox's Orange Pippin on Granny Smith	F	O
	Five Crown on GrannySmith	F	O
	Golden Delicious	F	O
	Gravenstein	F	O
	Mackintosh	F	O
	Mutsu	F	O
	Oliver	F	O
	Red Delicious	F	O
	Rome Beauty on Granny Smith	F	O
	Snow	F	O
	Stayman Winesap on Granny Smith	F	O
	Sturmer Pippin	F	O

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PERENNIAL SPECIES INDEX

BOTANICAL NAME	COMMON NAME	MAIN FUNCTIONS	PLANTING ZONE
Malus domestica (cont)	**multigrafted on wild seedling:**	F	H
	Laxton superb		
	James Grieve		
	Stewart seedling		
	Ida red		
Medicago sativa	lucerne	A, B	O
Melaleuca decussata	cross leaf honey myrtle	O, W	C, R
Melaleuca styphelioides	prickly paperbark	S, W	R
Melaleuca sp.	paperbark	S, O	R
Mentha canadensis	mint	F	H
Melissa officinalis	lemon balm	F, M, O	H, F, O
Mentha x piperita	peppermint	F, M	H
Mespilus germanica	medlar	F, O	G
Monstera deliciosa	fruit salad plant	F	H (g/house)
Morus alba	**white mulberry**		
	Shahtoot	F, A	O
Morus nigra	English black mulberry	F, A	O
Myoporum parvifolium	creeping boobialla	O	C
Myrtus ugni	Chilean guava	F, O	H
Narcissus sp.	daffodils	O	H, O
Olea europea	**olive**		
	Verdale	F, S	F, R
	Manzanillo	F, S	F, R
	Wallace	F, S	F
Origanum vulgare	wild marjoram	F	H
Oxalis crenata	oka	F	H
Passiflora cinibarina	native passionfruit	O	H
Phalaris aquatica	phalaris	A	F, O, D
Phaseolus coccineus	scarlet runner bean	F	H, B
Phormium tenax	New Zealand flax	O, T	H, D
Phyllostachys aurea	golden bamboo	S, O, T	H
Phyllostachys nigra	**black bamboo**		
	Bory	S, O, T	D
Pittosporum bicolor	banyalla	S	G, D
Polygonum odoratum	Vietnamese mint	F	H
Pomaderris aspera	native hazel or hazel pomaderris	S	G, D

BOTANICAL NAME	COMMON NAME	MAIN FUNCTIONS	PLANTING ZONE
Populus alba	silver poplar	S, A	G
Populus deltoidies	cottonwood	S	G
Populus yunanensis	Yunnan poplar	S	G
Prunus amygdalus	**almond**		
	Prince	F	O
.	Peerless	F	O
Prunus armenaica	**apricot**		
	Moorpark	F	O
Prunus armenaica x	plumcot	F	O
Prunus avium	**sweet cherry**		
	Bedford	F	O
	Chapman	F	O
Prunus cerasus	**sour cherry**		
	Morello	F	O
Prunus cerasifera	cherry plum	S, A, F, B	F
Prunus domestica	**plum**		
	D'Agen	F	O
	"Swiss Mt Ave" blue plum	F	H, R
	Golden Gage	F	O
	Damson	F	O
Prunus laurocerasus	Cherry Laurel	S,F	R
Prunus persica	**nectarine**		
	Goldmine Nectarine	F	O
	seedling	F	F,O
	peach		
	Anzac (white fleshed peach)	F	O
	Bendigo Beauty	F	O
	Cresthaven (yellow fleshed peach)	F	O

MAIN FUNCTIONS

- **S** SHELTER AND SCREENING
- **A** ANIMAL FODDER
- **F** FOOD INCLUDING CULINARY HERBS
- **O** ORNAMENTAL (VISUAL AND SCENT)
- **T** TIMBER/FIREWOOD/FIBRE
- **B** BEE FODDER
- **W** WILDLIFE ATTRACTANT OR HABITAT
- **M** MEDICINAL

PLANTING ZONES

- **H** HOUSE ZONE
- **F** FILL SLOPE
- **C** CUT SLOPE
- **B** BARN ZONE
- **O** ORCHARD
- **D** DRAINAGE LINE AND DAM SURROUNDS
- **R** ROAD RESERVES
- **G** GULLY RESERVE

PERENNIAL SPECIES INDEX

BOTANICAL NAME	COMMON NAME	MAIN FUNCTIONS	PLANTING ZONE
Prunus salicina	**multigraft Japanese plum**		
	Santa Rosa/Satsuma	F	O
Psidium cattleianum	cherry guava	F	H
Pyrus communis	**pears**		
	Beurre Bosc	F	O
	William bon Chretin	F	O
	Winter Nelis	F	O
	Packham's Triumph	F	O
.	"Swiss Mt Ave" on wild seedling	F	O
Pyrus calleryana	**Asian pear**		
	Chojura	F	O
	Shinsui	F	O
Quercus castaneifolia	chestnut leafed oak	S, A, O, T	F
Quercus cerris	Turkey oak	S, A, O, T	F
Quercus macrocarpa	burr oak	S, A, O, T	F
Quercus robur	English oak	S, A, O, T	F
Querecus spp.	oaks	S, A, T	F, O, R, G
Rhododendron	**white rhododendron**		
	Unique	O	H
Rosa rubiginosa	briar rose Clunes selection	F,M,O	H
Rosa spp.	**roses**		
	Cross of Malta	O	H
	bush rose	O	H
	bush rose	O	H
	climbing rose	O	F
	dwarf climbing rose	O	H
Rubus idaeus	red raspberry var.?	F	H
Rubus fruticosus cultivar	youngberry	F	B, H
	thornless youngberry	F	H
Rheum palmatum	rhubarb	F	B, F
Ribes grossularia var.?	gooseberry	F	F
Ribes nigrum var.?	black currant	F	H
Ribes rubrum	red currant	F	H
Rosmarinus officinalis	rosemary	F, O, B	H
Rumex montanus	French sorrel	F	H
Salvia officinalis	sage	F, M	H
Salvia sp.	pineapple sage	O, W	H
Salix alba	bat willow var.coerulea	S, T, B, G	
Salix babylonica	weeping willow	S, A, O, B	D
Salix caprea	goat willow	S, A, B	G
Salix matsudana x	New Zealand hyrbid	S, B, A, T	D
Salix vitellina	golden willow	S, A, O, B	D
Sambucus nigra	elderberry	F	G
Satureia montana	winter savory	F	H
Sechium edule	choko	S, F	H
Solanum frutescens	chili pepper	F	H (g/house)
Symphytum officinale	comfrey	A, M, B	H, O
Syringea vulgaris	common lilac	O	H
Taxus baccata	yew	O, F	
Thymus serpyllum	lemon thyme	F	H
Thymus vulgaris	thyme	F, M	H
Trifolium fragiferum	strawberry clover	A, B	H, D
Trifolium pratense	red clover	A, B	O
Trifolium repens	white clover	A, B	O, H
Typha latifolia	cumbungi	S, T, W	D
Vaccinium corymbosum	**blueberry**		
	Blue Rose	F	H
	Denise Blue	F	H
	3 varieties?	F	H
Viola odorata	violet	A	H
Vitis vinifera	grape		
	"Yandoit white"	F	
	"Yandoit red"	F	F
	"Carlton" (White Muscatel?)	F	H
Vitis lambrusca	"Hepburn passionfruit"	F	H

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HERBARIUM LIST (WILD PLANTS)

The diversity of wild plants is an important indicator of biological diversity and resilience in any permaculture system. Both native and exotic (foreign) species, noxious weeds and useful plants all contribute in this regard although our attitudes and management strategies to them may vary greatly.

This provisional plant list of species was surveyed early summer 1994/95 by Kale Sniderman. Follow up surveys will check for species missed and new naturalisations. The lists include annuals and perennials found on site (not including road reserves or gully) and believed to be naturalised (ie an established population of self reproducing plants). They include remnant indigenous plants, and those which have become established since european invasion.

* indicates species probably indigenous to the site

\# indicates species probably naturalized from intentional or unintentional introductions since 1986.

FERNS

	Asplenium flabellifolium (in well)	necklace fern
	Lastreopsis acuminata (in well)	shiny shield-fern
	Polystichum proliferum (in well)	mother shield-fern

HERBACEOUS ANNUALS AND BIENNIALS

	Agrostis capillaris	brown-top bent
	Aira cupaniana	hair grass
	Anagallis arvensis	scarlet pimpernel
#	Arctium lappa	burdock
	Avena alba	bearded oat
	Briza maxima	large quaking-grass
	Bromus catharticus	pairie grass
	Bromus hordeaceus ssp. hordeaceus	soft brome
	Bromus sterilis	barren brome
	Centaurium minus	common centaury
#	Chenopodium album	fat hen
	Cirsium vulgare	spear thistle
*	Cynoglossum suaveolens	sweet hound's tongue
#	Galium aparine	cleavers
	Hypochoeris radicata	flatweed
#	Juncus bufonius	toad rush
	Myosotis sylvatica	wood forget-me-not
#	Petroselinum crispum	parsley
	Polygonum aviculare	prostrate knotweed
	Silybum marianum	variegated thistle
	Sonchus oleraceus	sow thistle
#	Stachys arvensis?	stagger weed
#	Stellaria media	chickweed
	Trifolium campestre	hop clover
	Trifolium dubium	suckling clover
	Trifolium glomeratum	cluster clover
	Trifolium subterraneum	subterranean clover
	Verbascum virgatum	twiggy mullein
	Veronica sp.	speedwell
	Vicia angustifolia	narrow-leaf vetch
	Vicia hirsuta	tiny vetch
	Vicia sativa	common vetch
	Vulpia myuris forma megalura?	foxtail fescue

HERBACEOUS PERENNIALS

*	Acaena agnipila	sheep's burr
	Acetosella vulgaris	sheep sorrel
	Anthoxanthum odoratum	sweet vernal-grass
*	Carex inversa	sedge
	Crepis vesicaria ssp. haenseleri	dandelion hawksbeard
	Cyperus eragrostis	umbrella sedge
#	Cyperus tenellus	
	Dactylis glomerata	cocksfoot
*	Danthonia racemosa	wallaby grass
*	Elymus scabrus	common wheat grass
*	Epilobium billardierianum ssp. cinereum	variable willow-herb
#	Festuca arundinacea	tall fescue

	Geranium sp.	
#	Helianthus tuberosus	Jerusalem artichokes
	Holcus lanatus	Yorkshire Fog
*	Juncus sp.(dam)	rush
*	Juncus sp.(creeping, dam)	rush
	Lolium perenne	rye-grass
#	Lythrum hyssopifolium	hyssop loosestrife
	Medicago arabica	spotted medic
	Mentha spicata	spearmint
	Myosotis discolor	
*	Oxalis sp.	soursob
	Paspalum dilatatum	paspalum
	Phalaris sp.	canary grass
	Plantago lanceolata	ribwort plantain
	Poa compressa	flattened meadow grass
	Rumex acetosella	sorrel
	Rumex crispus	curled dock
	Symphytum officinale	comfrey
	Taraxacum officinale spp. agg.	dandelion
	Trifolium repens	white clover
#	Trifolium pratense	red clover
*	Typha latifolia	bulrush

WOODY PERENNIALS

*	Acacia dealbata	silver wattle
#	Chamaecytisus palmensis	tagasaste
	Cytisus scoparius	English broom
*	Eucalyptus melliodora	yellow box
*	Eucalyptus radiata	narrow-leaf peppermint
	Genista monspessulana	Montpellier broom
	Prunus cerasifera	cherry-plum
	Rubus fruticosus spp. agg.	blackberry
	Rosa rubiginosa	sweet briar
	Ulex europaeus	gorse

HOUSE GARDEN LIST

(Species so far restricted to the house garden)

ANNUALS AND BIENNIALS

	Arctotheca calendula	capeweed
#	Barbarea sp.	winter cress
#	Borago officinalis	borage
#	Buglossoides arvensis	corn gromwell
#	Calendula officinalis	calendula
#	Epilobium ciliatum	glandular willow-herb
#	Euphorbia peplus	petty spurge
#	Fagopyrum esculentum	buckwheat
#	Foeniculum vulgare	fennel
#	Fumaria officinalis	common fumitory
#	Lactuca sativa (cultivar)	lettuce(Mrs. Higgins)
#	Medicago sp.	medic
#	Poa annua	winter grass
#	Portulaca oleracea	purslane
#	Urtica urens	small nettle

HERBACEOUS PERENNIALS

#	Cichorium intybus (cultivar)	chicory
#	Melissa officinalis	lemon balm
#	Oxalis purpurea	large flowered wood sorrel

WOODY PERENNIALS

#	Malus sylvestris	apple
#	Prunus persica	peach and nectarine

* indicates species probably indigenous to the site

\# indicates species probably naturalized from intentional or unintentional introductions since 1986.

BUSHFIRE SAFETY PROCEDURES

EXTREME FIRE HAZARD DAYS

(Dry conditions December-March, hot northerly wind)

1. Water garden early morning
2. Turn off electric fence.
3. Close all windows and NW clerestory vent in office.
4. Fill pump with fuel and if header tank is below 20,000litre run pump. Refill pump with fuel.

WITH BUSHFIRE THREATENING

(Strong wind, low visibility and haze)

1. Everyone dress in overalls or woollen pants, long sleeved shirt, leather boots. Outside wear work gloves, woollen scarves, hard hats and goggles.
2. Move doormats, paper, boxes, kindling and other combustibles indoors (workshop or shed). Weigh down any loose plastic or metal sheeting.
3. Check gutters are clear of leaves and block gutters with old rags.
4. Move south garden hose, SW fire hose and aluminium extension ladder into workshop. Move step ladder into house. Fix 1/2" hose to greenhouse outlet and fill knapsack sprayer.
5. Close underfloor and greenhouse vents, undercroft door, check all windows, close all curtains. Turn on greenhouse sprayers.
6. Set up rose sprinkler on Red soil vegetable garden and turn on shed spray circuit and all drip circuits.

AS FIRE APPROACHES

(Thick smoke, falling burnt leaves)

1. Close 50mm gate valve (blue) and check sight gauge tube stopcock is open at concrete header tank.
2. Start pump (choke on, pull and choke off, if doesn't start, check switch is on and fuel is on). Run at full revs.
3. If time allows, open vehicle gate to dam wall.
4. Attach spray gun to 3/4" hose at shed and test by wetting down house roof and outside paving.
5. If time allows, load fire rake, chain saw, 44 gallon drum with tap and galvanised buckets onto truck and move round to south of house, leave gate open and keys in ignition.
6. Fight fire from radiant shelter of shed sprayers retreating to house via greenhouse with hose when necessary.
7. Patrol house checking clerestory and ceiling with torch. Check workshop from east side door when safe. (Do not open office or workshop doors). Use knapsack sprayer if necessary.
8. Once fire front has passed check eaves and roof using extension ladder and long hose off SW tap.
9. Once house is safe, check shed, firewood stacks, fences, tree mulch. Turn off pump and any burnt drip circuits. Open tank valve and turn on all drip circuits.
10. Recheck house then take truck to help neighbours with first aid kit, blankets, knapsack and 1/2" hose.

INPUTS & YIELDS AT MELLIODORA

Labour, material and capital requirements to establish permaculture systems are commonly criticised in permaculture.

Low output of commercial or useful yields is also another criticism sometimes made of permaculture systems. At Melliodora there has been no attempt to maximise immediate yields or income directly from the property or even to develop any particular primary production enterprise.

Our main focus has been to reduce the need for inputs, increase the yield potential of the land and generate information useful in designing further permaculture systems.

However, input and output figures are one important indicator of the performance and success of the design systems described in this book. Precise records have not been kept for all inputs and yields but the following figures give the general picture to date.

MAJOR INPUTS

Labour:	Inputs in property development, management and harvesting since 1989 about 3 person days/week (mostly our own)
Water:	Town supply - average annual consumption 200 kilolitres Dam supply - average annual consumption 500 kilolitres
Electric power:	average daily use: under 2 kiloWatt hours
Bottled gas usage:	less than 10kg/annum
Petrol use 93/94:	slasher, brushcutter, pump: 150litres
Firewood use:	approx 7tonne/annum
Mulch and manure from off site:	In recent years 2 - 4tonnes/annum
Fertilisers:	Dolomite limestone average use 200kg/annum Rock phosphate average use 10kg/annum Seaweed concentrate average use 4lits/annum
Poultry feed:	Organic wheat 750kg/annum

CAPITAL INVESTMENT

Phase One:	**Building and Estabishment 1986-1988**	
	House	A$62,000
	Land development	A$13,000
Phase Two:	**Consolidation 1989-1995**	
	House	A$20,000
	Land development	A$8,000
	Total to date	A$103,000

Oliver (6) harvesting huge pontiac potatoes from second housesite garden winter 1992.

Brown trout and redfin perch caught during draining of dam April 1991.

SOME YIELDS TO DATE

Complete household supply of vegetables and eggs since 1990

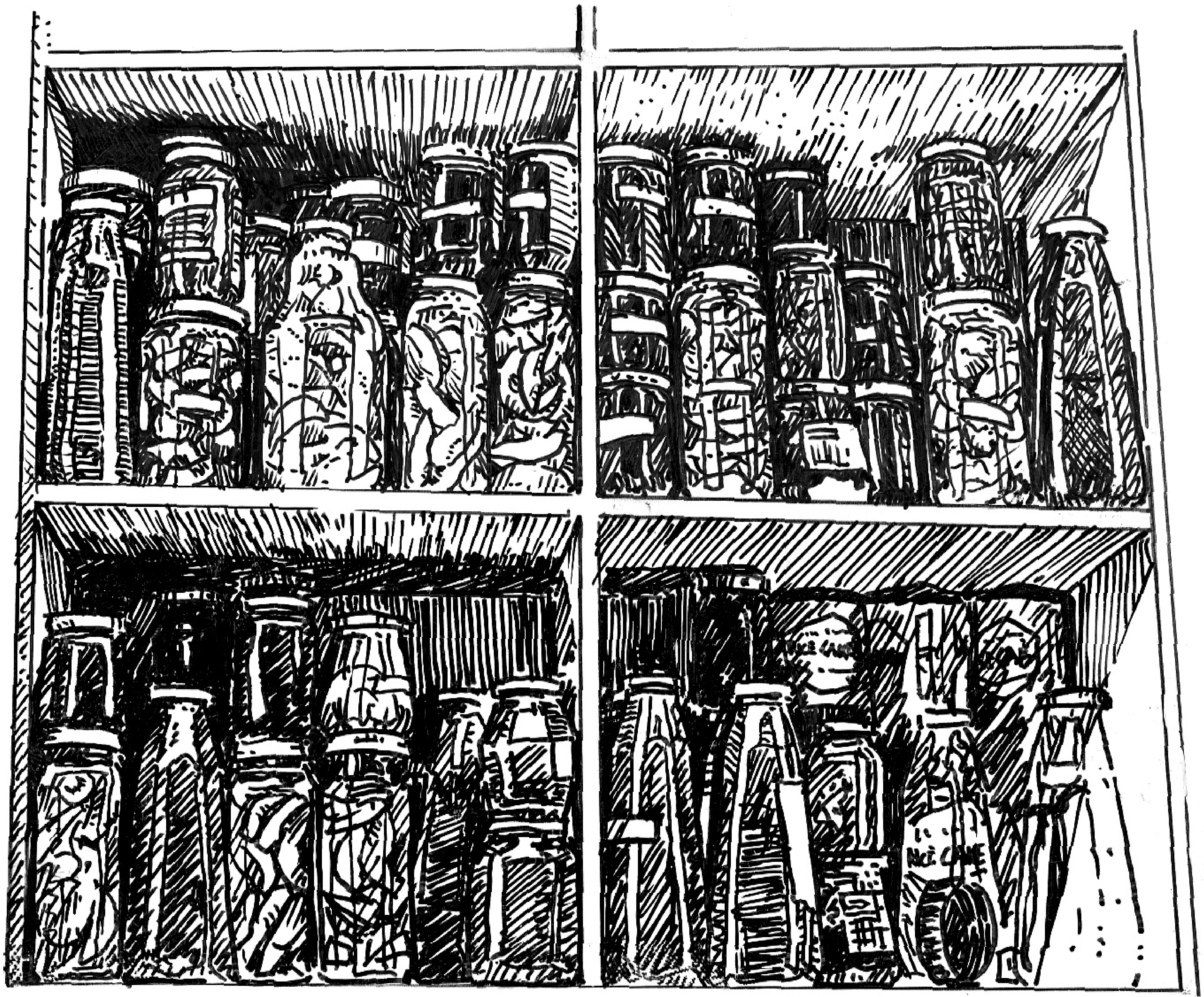
Eggs: approx 2800/annum in recent years, most bartered or given away

Majority (increasing) of animal protein, fruit and nuts, dried legumes

1995 fruit harvest about 360kg (cockatoos about 500kg)

Catering ingredients consumed in a two week residential Permaculture Design Course held each February (catering for 30 people): value A$300-400

Plant and seed stock: sold, bartered, given away or planted on public land, annual value A$150-250



Bottled fruit, tomato sauce and jams from 92/93 season harvest.

REFERENCES & RESOURCES

GENERAL REFERENCES

The following books are referred to in the text, provide more detailed information about some subjects in the book, provide general information about permaculture or we have found particularly useful in developing the property.

Mollison, B. **Permaculture: A Designers Manual** Tagari 1988

Mollison, B. Slay, R. **Introduction to Permaculture** Tagari 1994

Ballinger, R. & Swaan. H. **Vegetable Gardening in South Eastern Australia**. Caxton Press 1982

Baxter, P. & Tankard **Growing Fruit In Australia** Mc Millan Melb. 1990

Fanton, M.& J. **The Seed Savers' Handbook** Seed Savers Network 1993

Gilbert, A.Yates **Green Guide to Gardening** Angus & Robertson 1981

Glowinski, L **Complete Book of Fruit Growing in Australia** Lothian Publishing Melb. 1991

Hollo, N. **Warm House Cool House**. Choice Books 1995

Jeavons, J **How to Grow More Vegetables than you ever thought possible on less land than you can imagine** Ten Speed Press California 1979

Kern, K. **The Owner Built Home**. Charles Scribners Sons New York 1972

Kourik, R. **Designing and Maintaining Your Edible Landscape Naturally** Metamorphic Press 1986.

Nelson, K.D. **Design and Construction of Small Earth Dams** Inkata 1985

Pearson, D. **The Natural House Book**. Angus & Robertson 1989

Romanowski, N. **Farming in Ponds and Dams.**

Schoknecht, N.R. **Land Inventory of the Loddon River Catchment: A Reconnaissance Survey** Department of Conservation, Forests & Lands 1988.

Simpfendorfer, K.J. **Introduction to Trees for South Eastern Australia.** Inkata Press Melbourne 1975

Weir, R.G. & Cresswell, G.C. **Plant Nutrient Disorders 1: Temperate & Sub-tropical Fruit & Nut Crops.** - **Plant Nutrient Disorders 3: Vegetable Crops**. Inkata Press 1993

PERIODICALS*

Earth Garden - R.M.B. 427, Trentham Vic 3458

Owner Builder - pub. V.& R. Andrews, 66 Broadway Dunolly, Vic.3472

Soft Technology - pub. Alternative Technology Ass. 247 Flinders Lane, Melbourne.

** These are original reference from the book and may no longer be current.*

LOCAL PERMACULTURE GROUPS WITH NEWSLETTERS*

Permaculture International Journal - PO Box 6039, South Lismore, NSW 2480, 066 22 0020

Permaculture Melbourne - (03) 9853 6828

Green Connections (Pc & Landcarers) - PO Box 793, Castlemaine, 3450
Phone/fax (054) 705 040

NURSERIES & SEEDS*

We have purchased plants or seeds from the following suppliers.

New Gippsland Seed Farm - P.O.Box 1, Silvan Vic 3795, Phone (03)737 9560

Diggers Seeds - 105 La Trobe Pde., Dromana Vic 3936, Phone (059) 871 877

Eden Seeds - 21A Sandy Ck. Rd., Gympie. Qld 4570

Dragonfly Aquatics - R.M.B. AB 366, Colac Vic 3250, Phone (052) 366320

Flemings - Monbulk Vic 3793, Phone (03) 756 6105
Largest producers of fruit and nut trees. Catalogue has good information on available varieties.

Hillander Herbs - R.M.B. 299 Sunraysia Hwy., Redbank Vic 3478, Phone (054) 677 283
Fruits, nuts and berries

Victorian Tree Crop Nursery - Warragul. Vic 3820, Phone (056) 268 311

MANUFACTURERS & SUPPLIERS*

Green Harvest - 52 Crystal Waters MS 16, Maleny Qld 4552, Phone (074) 944 679
Natural pest control agents, tools, seeds etc. Mail order catalogue.

Gundaroo Tiller. - P.O.Box, Gundaroo N.S.W. 2620, Phone (06) 236 8173
Cultivation hand tools & "Electranet "fencing.

Sure Gro - 2 Plane Tree Avenue, Dingley. Vic 3172, Phone (03) 9558 1060

Southern Cross Machinery Pty Ltd - P.O. Box 46, Sunshine. Vic 3020
Catalogue includes useful irrigation information and tables.

THE SECOND DECADE

DEVELOPMENT TIMELINE

1996

April	Mudbrick infill of barn N.W. wall
December	First kid goat, construction of milking stall

1997

March	Deepen dam, bridge construction and leveling of cottage site
June	Stone wall garden bed reconstruction
October	First comprehensive (Albrecht) soil tests
November	Trial application of hydrated lime

1998

August	First complete application of lime and trace elements recommended by soil tests

1999

April	First good olive harvest
	Second application of lime & trace elements
May-Oct	Caretakers
October	Introduction of 6 geese
November	Electric guards around orchard trees and replacement goats 'Tansy' and 'Betony'

2000

January	Albrecht soil tests
April	Third application of lime & trace elements
June	First biodynamic compost
September	Oak underplanting of driveway slope
	Albrecht soil tests
November	Thinning of blue gums on Fourteenth Street
	Planting of first Avocado & Macadamia

2001

April	Installation of Bosky combustion stove
August	Extension of red soil garden within temporary fence
December	Last rabbits not replaced

2002

April	Geese pond wall partial rebuild and deepening, new stone spill structure
	Laserlight replacement of clear roof on east pergola
September	Construction of permanent fence around expanded red soil garden

2003

July	Culling of eucalypts behind silt trap, expansion of bamboo plantings
October	Re-surfacing gravel driveway

2004

January	Progressive repair and repaint of external timber
	Re-laying of outside paving and partial exterior mud re-render
April	Roof insulation retrofit
May	Double glazing clerestory
June	Caretakers
August	PV power installation
November	External wall mud re-render completion

2005

January	Linseed treated mudbrick in shower recess replaced with slate

Since writing the book, animals have become a more important part of the development and management of Melliodora. This reflects the animal strategy outlined in the main text and Su's growing interest, confidence and joy in working with animals.

December 1996 Oliver (with Little Olive) Su and Eugenio feeding Feijoa in newly constructed milking stall over compost bay in barn

MILKING GOATS

The introduction of milking goats as a permanent part of our system has been the most important part of this process.

Milking goats have allowed us:

- to better manage excess pasture, blackberry and tree growth with less use of machinery
- provided milk for fresh consumption, yoghurt, soft (ricotta style) cheese and more recently hard cheeses.
- become pets with individual character as well as herd behaviour which has been a source of interest, delight and at times, anguish.

We started with one Toggenburg goat (Feijoa) in 1995. After birth of her kid, Little Olive in 1996, we began milking. In December 1996 we constructed a small goathouse and milking stall over one of the compost bays in the barn. This provided winter shelter, a rack for above ground feeding of lopped tree fodder and a accumulation of manure under the slatted timber floor (for later composting).

A fenced holding yard below the goat house has been partially constructed.

Foraging was mostly on tether within the orchard and on the adjacent road reserves. Initially control of excess grass was less than we expected because of;

- only two goats
- the abundance of cut tree fodder
- the course nature of the tall fescue dominated pasture.

In addition we did not escape the usual problems of damage to fruit and other trees.

Despite the abundance of cut tree fodder, the goats continued to favour bark eating and avoided close grazing the pasture. This was probably due to soil structure and mineral balance problems, which began to show up in late 1990s, brought on by excessive use of dolomite lime and wood ash in the early years.

More intensive soil testing and corrective measures have gradually improved the situation.

Tree Fodder

The living haystack value of the tagasaste, catkin wattle, willow, cherry plum and other tree fodders established in orchard and shelter plantings during the development of the property cannot be underestimated in making the integration of goats a successful and ongoing part of Melliodora.

Lopping tree fodder (about 1 tonne/annum for two goats) in the 1990s fitted in exactly with the need to cut back these species to avoid excessive competition with fruit trees and avoided the need to buy hay for either winter or summer feeding.

Winter 1998. Su with Feijoa on lower road reserve helping to control Blackberry and Pampas grass.

Tagasaste is our most important tree fodder. With a protein content of over 24% it contributes greatly to milk production, allows the goats to avoid the increased parasite load from close grazing of pastures and is available through the winter (especially for overnight feeding in the stall).

However we also discovered one of the hazards in overfeeding Tagasaste. In the winter of '98 Little Olive died of unknown causes after a long illness despite attention by vets and loving care from Su and Oliver. Later investigation showed that an ailment called Tagasaste Staggers has been identified in Western Australia where cattle have been fed pure diets of broadacre tagasaste crops for about a decade. If our experience is any guide goats appear more susceptible to this condition, on a less than pure diet. These days we always alternate winter feeding of tagasaste with catkin wattle and other somewhat less palatable tree fodders.

In 1999 we also lost Feijoa (probably to snake bite when on adjistment on another property while we were away travelling in northern Australia).

November 1999 - Su with Betony and Tansy tethered to bridge with tall spring growth in orchard. Note electric guards around trees to allow partial tree ranging of goats

A Small Saanen Herd

In late 99 we started again with two new goats Tansy (Saanen) and her mature kid Betony (Saanen/British Alpine cross). Both have since had twins. Poppy and Peach, the remaining two after tether accidents, complete our current flock of four goats which has been stable for two years.

Tether accidents have taught us the limitations of use of tether but spared us the need to act to cull two kids. We consumed the beautiful meat and Oliver tanned the hides.

Milking goats without certified breeding such as ours have a number of disadvantages. There is little option to sell offspring and if you don't want to see your darling kid turn into a lonely neurotic on the end of a tether as lawn mowers then the freezer is a better resting place.

The milk yield from our goats (2 litres/day) while adequate for our needs, is low compared to top milking goats. Also their teat size and temperament make finding alternative milkers difficult.

On the other hand we have been blessed with a milk supply which is sweet without any trace of the goaty taste that has turned so many people off goats milk. Although this may be partly due to feed and environment, genetics does play a part. It appears that selection has been less than effective at weeding out goaty flavour from certified milking goat stock to the extent that even commercial goats milk is sometimes tainted in this way.
I cannot think of a worse advertisement for a product which is, in general better for human consumption than cows milk. We have had the repeated experience of persuading guests and neighbours to just try our milk despite negative experiences with goats milk in the past. In almost every case, they are surprised and delighted.

Containment and Tree Protection

Managing four goats on the property has required extensive use of electric tape fences, and increased use of the road reserves for both tethering and temporary electric paddock. Our small herd of four well fed goats, with plenty of attention and extra tree fodder, have been content to mostly stay within four wire temporary fences, even though they are capable of jumping over. Perhaps better training when young would make moving the animals around the property and neighbouring road reserves an easier task, with less undesirable browsing of trees.

By establishing permanent electric guards around the apple and interplant legumes in Orchard Block 1 we have been able to create a semi permanent paddock with various configurations to include the cottage site, dam wall and spill way and even goose pond. Some of these layouts provide a home paddock of almost one third of the property. A few planted trees have been sacrificed in this minor rationalisation. Perhaps more important some of our slow growing plantings of oaks and other desirable trees have been lost or had setbacks from unsupervised (and at times supervised) goat browsing. On the other hand, established and unpalitable fast growing eucalypts and other less desirable species on the road reserves have not been adversely affected by goats.

Growth of orchard trees especially in block two has made interrow electric tape strip grazing by goats impractical. In areas grazed regularly by goats, blackberry and gorse have been almost eliminated while they remain elements in the slashed pasture in areas where only chooks and geese are on range.

Carrying Capacity

Tree fodder cut for goats now includes a wider range of species but those listed above remain the most important. Between 2 and 4 tonnes is the current estimate for cut tree fodder each year. The stick and branch residue from this harvest far exceeds our need for kindling, so much of it is burnt in autumn equinox and winter solstice bonfires.

We have never purchased bulk feed for the goats even in the latest 2002/2003 drought.

Small amounts of chaff and bran provide a base for supplementary feeding of kelp, minerals and apple cider vinegar during the morning milking. Fallen fruit, especially apples are a significant supplement in late summer and autumn while purchased carobs are used as “lolly” reward supplements. Gradually increasing yields of honey locust pods and acorns suggest these will be significant supplements in the future.

GEESE

After loss of ducks to foxes, we returned to the original plan of using geese as a grazing bird in orchard. Since 1999 between 6 and 12 geese have complemented the goat grazing of pasture and significantly reduced the need for slashing. Gradually the geese have reduced the rank fescue dominated tussock pasture to a close grazed ground cover with continuous fertilising by their copious manure, and reduced competition with fruit trees. After early losses to foxes, we have found that if the geese have access to one of the dams, they are safe from foxes. Efforts to raise goslings however have failed despite cages over geese siting on eggs. Ravens have killed our goslings two years running. Assuming the geese succeed in raising young we will need to cull geese each year to maintain an appropriate stocking rate.

September 2000 - Mother goose with newly hatched goslings in nest outside chook deep litter yard. Attendant gander calling the other geese as witnesses. All of this hatching was later lost to fox attack.

Although short green grass needed by grazing geese has been lacking over recent dry summers, fallen fruit provides an abundant supplement, which the geese avidly consume. In the process they provide a more effective control over codlin moth than our hens who only consume small quantities of premature fallen fruit.

While geese in the orchard has been a success, their presence had reduced one of our options for productive underplanting of fruit trees. Winter active globe artichokes appear to be very palatable to geese who destroy my established stock of orchard plants.

RABBITS AND GUINEA PIGS

In 1995 we inherited some "pet" short faced (dwarf) rabbits which became lawn mowers in cages. We did eat some of the prodigious offspring but large meat breeds would have been more sensible in terms of return for effort (and the taking of life) for food gained. About the same time we also experimented with caged and free range guinea pigs within the garden area as lawn movers. With better designed housing for fox and dog protection, I believe free range guinea pigs to maintain lawns without mowing may be worth trying again in the future.

LESSONS LEARNT FROM THE INCREASED NUMBERS AND TYPES OF LIVESTOCK

Living Haystacks and Carrying Capacity

As mentioned in the original Animal Strategy notes, the intensification of livestock in the orchard has been successful in converting more of the burgeoning tree and pasture biomass to soil humus able to feed our food producing plants without excessive use of machinery and fertilisers. The support of four goats (two milking) 6 geese and 2 dozen hens, on less than a hectare of available pasture and tree fodder (including road reserves) which also produces an abundance of fruit is testament to success of the permaculture development strategy

In addition surplus manure captured in the poultry deep litter, goat house litter and to some degree, harvesting of geese camps, has provided significant fertility to maintain the intensive "zone one" gardens.

Management of poultry, geese and goats with electric tape, netting and tethers has been complex. Sometimes the design solutions and active management have failed to optimise use of feed, protection of dams from excessive fouling by geese and prevention of excessive scratching by hens.

In retrospect it may have been better to design the layout of the property with a lower degree of integration. For example a smaller orchard of fewer more intensively managed trees (partly due to the pest cockatoo problem) and two small permanent grazing paddocks for goats with fringing tree fodder. Rather than pursuing any radical redesign we may sacrifice some further trees to allow simpler layouts of electric fencing. It is certainly true that without protection, goats will eliminate the most desirable and palatable trees from mixed plantings, leaving the tough fast growing and less palatable species to dominate. These species tend to be non-food producing, more fire hazardous trees and shrubs which have limited value in intensive permaculture designed systems.

Soil Structure and Mineral Balance

Soil structure and mineral balance remain important issues in determining the degree to which animals will damage trees seeking minerals in bark, the ability of the soil to resist pugging in wet conditions, and the ground's ability to hold more available and soluble nutrients in animal manure. The improvement in the mix and quality of our pastures has the potential to enhance the carrying capacity of the property, while better holding the cycling fertility from losses in runoff, leaching and gassing off. Until we see these improvements we will not further increase livestock numbers.

Better balance of minerals in our tree and pasture fodders may even allow less rigid control of goat grazing and browsing. Our soil tests in 1997 and 98 showed deficiencies of trace elements, most notably manganese. Although these deficiencies have been corrected by mineral applications an excessively high pH (alkaline) continues to restrict the adequate availability to plants. Manganese is known to concentrate in the bark of trees so the voracious appetite of our goats for bark may reflect this general deficiency.

The larger lesson from this and other experiences in managing Melliodora, is that the link between soil mineral balance and fertility on the one hand, and a whole raft of design and management issues, is so great that it emphasises the priority of soil development. Balanced and fertile soil is a powerful system that allows a wide range design and management strategies to work. Even apparent crude designs and haphazard management can work if the soil is working. But soil is also so complex and mysterious that achieving and maintaining fertility and balance remains a highly uncertain process, where simple recipes based on a particular experience or theory do not necessarily translate when applied to another site and context.

COOL CUPBOARD

Standard Design

Interest in alternatives to refrigeration reflects concerns about energy consumption, chemical refrigerants and food quality.

The following design and specification are based on experience in construction, use and monitoring of cool cupboards at Melliodora as well as a previous one in southern NSW (see Permaculture in the Bush). It also reflects experience and advice in the design and construction of many others over 20 years. Calculations by a refrigeration and air conditioning engineer may slightly improve performance and more precisely indicate minimum sizes.

Fresh food including fruit, most vegetables, cheese, butter and eggs can be (better) stored for reasonable lengths of time at temperatures of 10-15° C. Dry goods such as flour, nuts muesli, processed grains, dried herbs etc will also keep longer at these temperatures. More perishable goods such as cooked food, yoghurt can be stored for a few days. Drinks at cool cupboard temperatures are healthier than cold drinks.

Cool cupboards can be built to suit storage needs including bulk harvests from garden and orchard. In combination with other traditional preserving (drying, bottling pickling, smoking etc) a cool cupboard can reduce the need for refrigeration and freezing to that provided by an under bench fridge. Cool cupboards should be an integral element in house design and construction where autonomous power supply limits electricity use.

Principles

The design combines evaporative cooling of plants and water with thermal mass cooling from the earth (14°C in southern Australia) to maintain cool temperatures for food storage throughout the year.

The design relies on a thermosyphon effect to draw cool air in from the underground duct. Air within the upper cupboard and more particularly the metal flue pipe, rises as it warms from heat infiltrating from the room, roof space and outside air. The air drawn into the cupboard from the concrete duct is at background earth temperature. Air drawn into the duct from the outside is precooled by passing through a shade house.

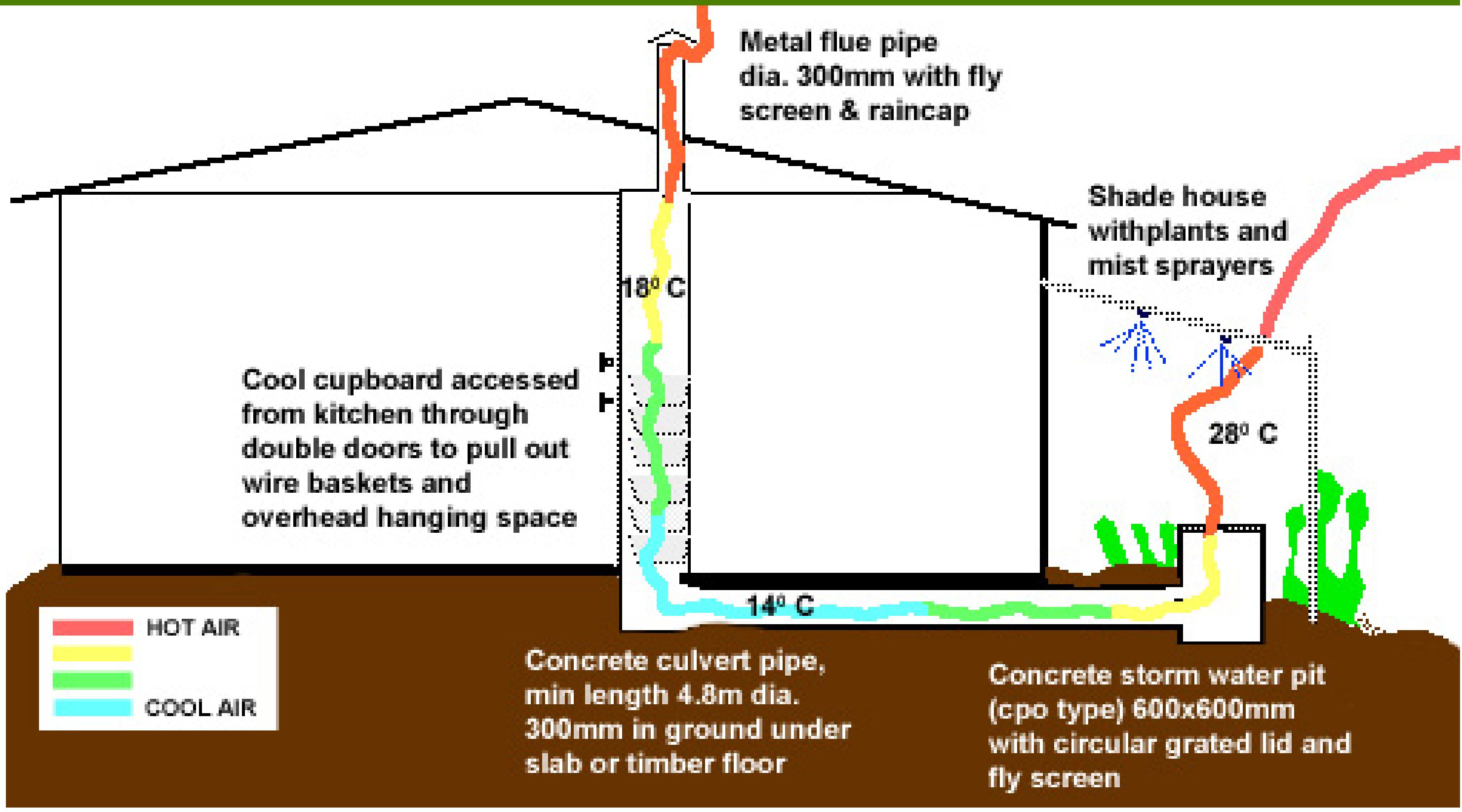
DESIGN FACTORS AFFECTING PERFORMANCE

Air Flow

The flow of cool air over the food from underground maintains a low temperature and also inhibits the development of molds characteristic of stagnant air storage.

The thermosyphon effect is quite weak so constriction in the flow of air must be avoided.

Small even multiple ducts have a higher surface area, increasing the friction and preventing



air flow. Sharp bends and multiple bends also inhibit air flow. So far experience suggest 300mm dia. inlet and outlet venting is necessary.

Solar chimney (tall flue pipe painted black and exposed to the sun) or active (rotating) exhaust vents may allow duct sizes to be reduced somewhat. Cupboards in high ceiling houses can be expected to draw better than those in low ceiling houses.

Although a continuous flow through is desirable, the optimum rate to balance precooling of the air in the earth duct and cooling of the food by air flow is not known. Excessive flow rates can easily be slowed with use of damp hessian screens over the intake to gain greater evaporative cooling.

Duct Insulation

In open conditions, depth to stable background temperature maybe 1m or more depending on soil type, moisture and ground cover.

For ducts sited underneath concrete or brick floors an insulating layer of 200mm of dry gravel over the duct should be adequate so long as the house is insulated and the floor over the duct does not receive any direct sun in summer.

Earth floors are better insulators and if 200mm thick may not require any additional insulation

Greater coverage may be necessary for ducts under suspended floors even assuming the crawl space is enclosed by masonry walls and has minimal venting from shaded areas.

Where depth of coverage is a problem better insulating materials such as vermiculite or polystyrene may be required.

MATERIALS AND CONSTRUCTION OPTIONS

Duct materials and length

Reinforced concrete pipes used for road storm water drainage make an ideal duct because;

- low volatile gas emissions and toxicity
- durability and strength
- combination of thermal mass and conductivity
- readily available in a range of sizes in 2.4m & 1.2 m lengths with socketed ends.

A 4m long boxed concrete duct has performed well but 4.8m is recommended to allow slightly longer air residence time and flexibility in cupboard siting on internal walls.

The duct should be bedded on a slight slope away from the cupboard to allow any flushing of the duct should it prove necessary to remove internal dirt or worse still rodents which may enter from either end.

Cheaper and semi flexible plastic ducting with spirally bound wire (used for concrete pier boxing and other uses can be used as an alternative to masonry ducts. Although gassing off from plastics may be undesirable, constant air flow means levels will always be low.

Cool cupboard at Melliodora with epoxy coated wire baskets holding garden produce and purchased food stuffs.

Intake Material and Siting

A vertical air intake allows air to be drawn from above ground level with minimal risk of soil, debris and water entering the duct. Where possible the intake should be larger in cross section than the duct to compensate for the restriction of right angle junctions and should include a sump below the duct level to collect any debris or water which may enter the system. A drain hole into well drained soil or ag. pipe is advisable.

Concrete is the ideal material for the above reasons and standard storm water pits such as the Rocla circular punch out type are ideal.

A 600mm X 600mm tall pit sunk to just above ground level can provide a 150mm deep sump for a 300mm dia duct pipe with 150mm coverage of earth. A removable galvanised grate with metal flywire added will exclude rodents and most insect pests.

Where plastic ducting is used, a recycled food grade plastic barrel (150-200lits) makes a good intake.

The intake should be on the south or south east side of the house and preferably be enclosed in a shade house containing moisture loving plants. Without the cooling effect of a shadehouse and/or dense vegetation, the earth duct may need to be much longer to cool the air to background temperature.

Deciduous vines (such as kiwi) or seasonal climbers (eg scarlet runner beans or choko) are ideal to enclose a shadehouse and yet allow free flow of air in winter.

Mist sprayers for use in hot weather, ponds, fountains and other water features will all add to cooling effects especially in dry low humidity conditions typical of southern and inland Australia.

Water tanks, especially overhead ones can provide additional cooling thermal mass to the shade house which can also be integrated into the the house design as an outdoor living area for summer and source of cool air for the house on summer evenings.

Cupboard Design and Size

Standard kitchen joinery construction such as melamine coated Kraftwood or similar material is ideal (cleanable white reflective surface). Although materials which gas off chemicals should be avoided, constant air flow in the cupboard means this is much less important than in closed cupboards.

The base of the cupboard is best constructed as a waterproof cement rendered sump without sharp corners (for easy cleaning) which drains to the earth duct pipe.

Wire or mesh shelves or baskets for food storage allow air flow through and around the stored food. White epoxy coated wire baskets on roller bearing tracks are ideal but may need to be of a more robust construction than those used for clothes storage. Baskets should be removable for cleaning.

Cupboard dimensions should be constructed to suit available basket dimensions and to suit kitchen design and needs.

A double cupboard with two columns about 500-600mm wide by 400-500mm deep each can be supplied by a single air intake 300-375mm diameter.

Doors (at least 20mm thick) should latch firmly and be as well sealed as practical. Separate doors for occasional access to the overhead upper section of the cupboard space are advisable.

Vent Pipe

Standard galvanised sheet metal flue pipe 300mm dia with suitable rain cap, flywire screen and roof flashing are suitable.

If ceiling height and thus cupboard are standard and roof space modest, a flue pipe of at least 1.8m may be advisable to ensure adequate draw.

Optimising Performance

Earth ducts generally need to be installed very early in the house construction process, sometimes before foundations and cannot be changed. However some elements are amenable to tuning after construction.

Flue pipes can be easily extended, painted matt black or extractor fans added to improve draw especially during hot weather.

Mist sprayers, more plants, ponds and hessian screens can be added to increase evaporative precooling if prevailing air humidity allows. Terra cotta pots of water can be placed in the intake sump.

Concerns about humidified air causing mold are unfounded if air flow is adequate. However permanent damp with the earth duct can lead to off odours and contribute to the risk of mold in the cupboard.

Foods requiring coolest temperatures should be stored in lower baskets. In double cupboards separation of foods giving off moisture from those requiring drier conditions can be achieved.

Gas from ripening fruit will tend to accelerate ripening in fruit stored above.

Possible Improvements

A secondary duct which draws in outside air during the winter can allow lower winter temperatures in cool to cold climates than achievable through the earth duct.

Integral design of a small fridge within a cool cupboard would reduce energy needed for refrigeration and centralises all perishable food storage. Heat exchange coils for the fridge would need to be mounted external to the cupboard. In summer, this would be a way of venting hot air from the back of the fridge out of the house. If heat exchange coils were mounted high in the cupboard, this would increase the draw of cool air from the earth duct, without raising the temperature near the stored items or in the house.

Comments and Feedback

Feedback is invited to improve this design based on performance of similar or different designs. Please email us at info@holmgren.com.au

In particular engineering computations which may validate or change the critical specification such as duct size and length are sought.

Double column cool cupboard with 300mm diameter metal flue pipe through attic space.

HEATING AND PASSIVE SOLAR DESIGN

WOOD COOKING AND HEATING UPGRADE

In 2001 we purchased a second hand (5 yr old) Bosky wood cooking stove to replace our 20 year old Everhot. While the Everhot was still in reasonable condition, the Bosky offered the potential to run three hot water room radiators in addition to continuing to provide all our hot water. The longer and deeper firebox can take wood up to 400mm while the Everhot needed wood cut to 300mm

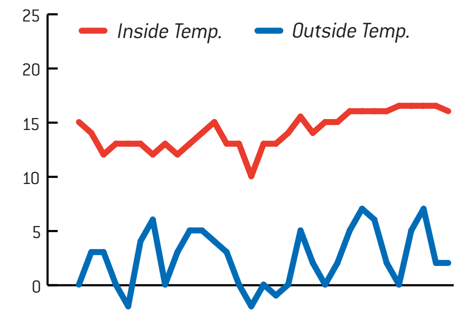
Su and visitors using Bosky wood fired cooking stove. Plates warming on wrought iron rack above fold down hot plate insulated cover which serves as splash back when stove is in use.

We also hoped to get less creosote build up and pollution and greater efficiency in wood use than we had managed with the Everhot.

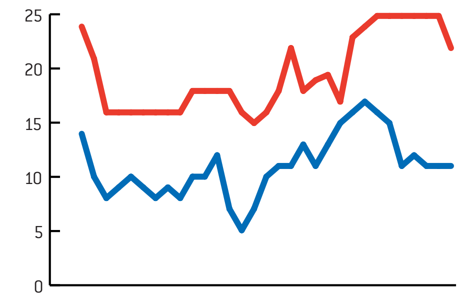
After three years of continuous use, we are yet to clean out the flue; an indication of how clean the Bosky burns. With the grate in the high (summer position) the stove generated ample hot water for our needs although running room radiators will no doubt demand the low grate position and more wood to generate adequate hot water. Despite the sophisticated controls, managing oven temperature has been quite difficult and the quantity of wood burnt has not been less than the Everhot. We are measuring wood use again and so far have averaged 200kg/week in mid winter. Annual consumption is estimated to be about 6.3 tonnes.

Our use of firewood in the back up wood heater has averaged around 2 tonnes/annum, used mostly in July and August. Our plan to install room radiators to replace the back up wood heater is yet to be done, but replacement and upgrading of the roof insulation and clerestory double glazing provided the opportunity to remove the heater flue. Consequently we have had no supplementary heating during winter 2004 (other than the small amount radiated from the cooking stove hot plates and open oven door). In the longest runs of cloudy weather (in 16 years) the house was rather cool but it was rarely below 14 degrees C.

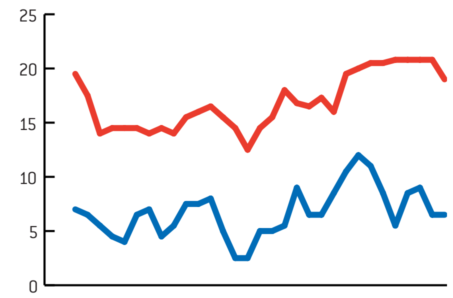
DATE	SUNSHINE	INSIDE TEMP. (°C)			OUTSIDE TEMP. (°C)			DIFFERENCE	COMMENTS
August	approx.	min	max	av.	min	max	av.	in temp.	
1	20%	15.0	24.0	19.5	0.0	14.0	7.0	12.5	
2	0%	14.0	21.0	17.5	3.0	10.0	6.5	11.0	
3	0%	12.0	16.0	14.0	3.0	8.0	5.5	8.5	
4	0%	13.0	16.0	14.5	0.0	9.0	4.5	10.0	
5	10%	13.0	16.0	14.5	-2.0	10.0	4.0	10.5	
6	0%	13.0	16.0	14.5	4.0	9.0	6.5	8.0	
7	0%	12.0	16.0	14.0	6.0	8.0	7.0	7.0	
8	0%	13.0	16.0	14.5	0.0	9.0	4.5	10.0	
9	0%	12.0	16.0	14.0	3.0	8.0	5.5	8.5	
10	10%	13.0	18.0	15.5	5.0	10.0	7.5	8.0	
11	10%	14.0	18.0	16.0	5.0	10.0	7.5	8.5	
12	10%	15.0	18.0	16.5	4.0	12.0	8.0	8.5	
13	0%	13.0	18.0	15.5	3.0	7.0	5.0	10.5	
14	0%	13.0	16.0	14.5	0.0	5.0	2.5	12.0	
15	0%	10.0	15.0	12.5	-2.0	7.0	2.5	10.0	"blinds not drawn, stove not lit"
16	80%	13.0	16.0	14.5	0.0	10.0	5.0	9.5	
17	90%	13.0	18.0	15.5	-1.0	11.0	5.0	10.5	
18	60%	14.0	22.0	18.0	0.0	11.0	5.5	12.5	
19	70%	15.5	18.0	16.8	5.0	13.0	9.0	7.8	
20	50%	14.0	19.0	16.5	2.0	11.0	6.5	10.0	
21	100%	15.0	19.5	17.3	0.0	13.0	6.5	10.8	
22	80%	15.0	17.0	16.0	2.0	15.0	8.5	7.5	
23	100%	16.0	23.0	19.5	5.0	16.0	10.5	9.0	
24	70%	16.0	24.0	20.0	7.0	17.0	12.0	8.0	
25	100%	16.0	25.0	20.5	6.0	16.0	11.0	9.5	
26	90%	16.0	25.0	20.5	2.0	15.0	8.5	12.0	
27	90%	16.5	25.0	20.8	0.0	11.0	5.5	15.3	
28	0%	16.5	25.0	20.8	5.0	12.0	8.5	12.3	
29	0%	16.5	25.0	20.8	7.0	11.0	9.0	11.8	
30	0%	16.5	25.0	20.8	2.0	11.0	6.5	14.3	
31	70%	16.0	22.0	19.0	2.0	11.0	6.5	12.5	
AVERAGE	**36%**	**14.2**	**19.6**	**16.9**	**2.5**	**11.0**	**6.7**	**10.2**	



Minimum August Temperature (°C)



Maximum August Temperature (°C)



Average August Temperature (°C)

INSULATION UPGRADE

In the book I mentioned the limitations of roof insulation and its effects on the thermal performance of the house. In the mid 1980's R2.5 insulation was recommended for our climate and that was the highest performance batt we could install in the south cathedral ceiling. Also we followed CSIRO research at the time suggesting that, in cold climates, building foil was better placed under insulation to control moisture from the house entering the roof space rather than the traditional use as a sarking under the roof. We now believe this was a bad idea.

Over the years the passive solar performance of the house appeared to decline with less retention of heat in long runs of cloudy weather in winter. We believe the primary reason was due to rodent activity creating nests and compacting the insulation. The rule of thumb that a 5% gap in batt insulation results in a 50% reduction in performance was particularly relevant because the non standard roof truss spacing had required many smaller cut sections of batt, increasing the risk of movement and gaps.

Michael O'Brien fixing galv bracket to batten. Note condensation staining on battens.

Other related problems strongly suggested the need to lift the roof sheeting and replace the insulation.

- Rodents had on two occasions caused power failure by eating through wiring (a serious concern).
- Without sarking under the roof sheeting, condensation drip may have degraded insulation performance and threatened roofing batten durability.
- On going health concern about exposure to fibreglass (both from entering the roof space for maintenance and from the firestop strips under the flashings entering the gutters).

Newly installled cellulose (left) and old fibreglass batts (right) prior to removal. Note cavity and gaps caused by rodents in batts

Although we decided many years ago to replace the insulation, the magnitude of the job combined with uncertainty about the best alternatives delayed this project until April 2004.

We decided to use loose fill cellulose insulation which has been widely used in the ecological building and mainstream building fields for many years. It is deflocculated paper from recycled telephone directories treated with borax as a fire retardant and rodent repellent. It has very low embodied energy in manufacture and is low health hazard. It is generally installed by blower which fluffs up the insulation and reduces the total amount of insulation needed to fill a given space and so reduce cost. In Europe it is often installed as a moderately compacted material in walls and sloping roofs.

In the north sloping roof a depth of 145mm (to the top of the rafters) was possible giving a R3.2 rating. In the south sloping roof 125mm was possible giving an R2.8 rating. In the flat ceiling we also used 125mm.

In the smaller vertical sections of wall connecting flat and cathedral ceiling areas we used R3.0 polyester batts. The good sag resistant characteristics of polyester batts compared with wool batts was an important consideration balancing its higher embodied energy of manufacture.

Cellulose loose fill insulation 125mm deep in flat laundry ceiling (front) west bedroom and clerestory cathedral cavities (behind) with polyester batts (R 1.5) on vertical plaster and mudbrick connecting walls prior to fixing of foil sarking.

For sarking over the battens we used standard, double sided, reflective insulation foil.

For rodent proofing we used a number of different materials and techniques to compartmentalise the roof so that any rodents managing to get into one section could not spread to another. 6mm square galvanised mesh, cornice plaster, mud mortar, and wood plus metal flywire in the roof corrugation ends to replace the fibre glass firestop.

For the following reasons we decided to do the whole job ourselves with paid help from a friend (experienced renovator/builder) rather than pay a professional insulation contractor;

- Prior knowledge of how the roof flashings and sheets were assembled
- Need to do a section at a time to avoid risk of rain made it difficult for an insulation contractor to quote on the job
- The care needed in identifying rodent pathways and nests, full and safe removal of fibreglass including vacuuming dust and blocking of all existing and potential rodent pathways.

The extra labour in hand fluffing and consequent extra cellulose required to fill spaces was the cost of ensuring a good quality and stress free result.

We found an extensive network of rat trails and nests which contained many stone fruit nuts from fruit trees up the 30m from the house and eaten wiring insulation in two places.

It was also sobering to discover that 16 years of condensation from the roof had been sufficient (mostly over the bathroom) to allow loosening and rusting of otherwise very secure nailing as well as rusting of roofing screw threads. We added galvanised brackets to reinforce batten fixing and replaced rusted screws to maintain the integrity of the wind resistant design.

Su and Tony Soccio unrolling foil sarking over roofing battens. Note cardboard apple packing sheets used as baffles to contain cellulose in insulated section.

The spreadsheet shows the materials, quantities, labour and costs for the whole project

ROOF SECTION

	Area(m²)	Depth(m)	Volume(m³)	Comments
Front roof	43.25	0.150	6.488	
Back roof	107.00	0.125	13.375	flat and sloping + trim roof and east end wall
Window headers	3.45	0.100	0.345	
Bedroom east end ceiling	8.50	0.125	1.063	
Total Area	**162.20**		**21.270**	

INSULATION MATERIALS

Cellulose bags	**Number**	**Weight (kg)**	**Total (kg)**	
	54.0	12.00	**648.00**	
Installed density (kgs/m³)			**30.47**	
Polyester			**Coverage(m³)**	
16 batts R1.5 1170*580	2.0	0.72	8.29	"Ceiling space mudbrick walls, bedroom plaster short wall"
8 batts R3.5 1170*430	1.5	0.54	2.33	Sloping trim roof
Total Coverage			**10.63**	

PROJECT COSTS

Materials	**Units**	**Unit cost A$**	**Cost A$**
Cellulose	54.0	$18.25	$986.00
Polyester batts R1.5 1170*580	2.0	$41.00	$82.00
Polyester batts R3.5 1170*430	1.5	$36.00	$54.00
Foil Sarking 100m*1.35m	3.1	$95.66	$297.00
Rodent mesh 915mm	20.0	$6.00	$120.00
Fasteners & hardware			$360.00
Tip fees (3 utes fiberglass)			$45.00
Sub-Total			**$1943.00**

LABOUR

	Hours	**Rate A$ p/h**	**Cost A$**
Builder	52.0	$17.00	$884.00
Helper	48.5	$14.00	$679.00
Owners *unpaid*	59.0	$17.00	$1003.00
Sub-Total			**$1563.00**
Total Project Cost			**$3506.00**
Total Project Value *including owners labour*		**$4509.00**	

CLERESTORY DOUBLE GLAZING.

During the house design process we considered the relative merits of curtains or double glazing to insulate the clerestory against greater winter heat loss from rising warm air and excess gain due to the very small eave. We decided to see how it performed without either. After the first year it became clear that double glazing using a second sheet of second hand glass would be the best and cheapest solution (summer overheating was not a problem). If that glazing was 6mm, it would also give added protection against large flying debris in a severe bushfire.

By the mid 1990's, the double glazing was planned (as noted in the book) but for various reasons it didn't happen until May 2004 shortly after the roof insulation replacement.

Over those years the cost of manufactured double glazing has dropped substantially but it was still easier and cheaper (and less embodied energy) to use an additional sheet of second hand 6mm glass on the inside. We had the glazier pre-drill the sheets top and bottom with a 6mm hole to allow experimenting with different arrangements to eliminate condensation.

After installation and temporary sealing of both top and bottom holes in dry autumn conditions, there has been only minor condensation fog after build up of very warm clerestory air on sunny winter days.

UNDER FLOOR DAMP

An impression that the mudbrick floor was not as warm as it used to be correlated with problems of water seeping into the undercroft space and obvious signs of damp in the concrete block footing walls (below the damp course). Although there is no evidence of damp actually in the floor or walls, it is possible that damp in the ground has wicked up into the scoria/crushed rock/sand bedding below the vapour barrier. This would allow greater heat loss from the floor to the ground because damp ground is a better conductor than dust dry ground. Conductivity into damp ground under any thermal mass floor (eg concrete) is generally accepted because it has advantages in dissipating excess heat gain in summer and winter loss of heat at slab edges to outside air is seen as more important than loss to the relatively warm ground (about 14°C). I believe losses into damp ground can be significant in a house such as ours where;

- a thermal mass floor receives substantial direct solar gain in winter
- thermal breaks and/or insulation stop losses at edges
- a cool climate reduces the summer cooling advantages of under floor conductivity.

Although we have made various attempts to find and halt the source of damp, nothing has so far been successful.

Second sheet of 6mm glass fixed over 10mm bead to form double glazed panel with existing 6mm external glass. Note wooden blocks to clamp glass until silicon sealant dries.

THERMAL PERFORMANCE EVALUATION

Our records of inside (open plan living space) and outside temperatures and sunny days for August show the performance with the above improvements but without having solved the colder floor problem. These results are particularly interesting because the house had no supplementary heating (other than that radiating from the cooking stove running about 10hrs/day). Consequently the average 10 degree difference between inside and outside temperatures can be largely attributed to passive solar gain in a month where sunshine levels were about one third maximum.

Although these temperatures are not within the generally accepted comfort zone, the radiant energy provided by the very high thermal mass makes the house more comfortable than these air temperature measurements suggest.

The relatively low house temperatures in the first half of the month may also be a carryover from record low sunshine levels in both June and July which appeared to leave the substantial thermal mass of the house much colder than any previous winter.

Thermal performance of the house is also slightly affected by our habit of opening bedroom windows at night for fresh air resulting in substantially lower bedroom temperatures which must affect the rest of the house somewhat by infiltration and radiant heat loss.

FIVE STAR RATING

In recent years computer software has been increasingly used to simulate house heating and cooling requirements and is now the basis of the building design controls in the state of Victoria requiring a 5 star rating on new houses. “First Rate” developed by the Sustainable Energy Authority of Victoria is the most widely used software for this rating of houses.

“First Rate” generated very poor ratings for mudbrick and rammed earth houses because of the very low R value (0.4) assigned to measure insulation value of earth. Consequently the environmental status of earth has been radically downgraded in the minds of regulators, architects, builders and owner builders and it is harder to design a earth walled house to meet the new standards.

These issues were discussed at a local event called the Great Sustainable Building Debate in 2002 run by Solar Sisters[1]. Four local houses were assessed for environmental criteria using a variety of techniques and approaches by different experts. The First Rate result for our house was 1.5 stars much to the embarrassment of the rater who agreed with the other experts that Melliodora appeared to be the most thermally efficient house assessed.
While the low rating was partly due to the low R value assigned to mudbrick it was also due to several other limitations of First Rate in evaluating non standard houses;

1 www. solarsisters.com.au

- the inability to evaluate houses with as much glazing as Melliodora[2]
- the inability to evaluate the greenhouse
- the assumption that bedrooms are heated spaces
- my belief that radiant heat and passive solar gain potential is not well modeled

A more recent and creative interpretation of the house design using First Rate[3] that;

- simulated (albeit roughly) the greenhouse performance
- allowed for increased R value assigned to mudbrick of 0.65 in partial recognition of its dynamic insulation value[4]
- included roof insulation upgrade and clerestory double glazing

gave a result of 4 stars. Most of this change could be attributed to including the greenhouse which is in accord with our intuitive understanding of how the house works.

My criticism of First Rate has been somewhat muted by this result but it is still well short of our experience that the house is more comfortable and requires less heating than most 5 star houses. The energy requirements for heating and cooling generated by First Rate were suspect in both the amount of energy it suggested we needed and the fact that much of it was for summer which we never need.

Despite these limitations, this case does show how results generated (at least for unconventional designs) are very dependent on the experience and interpretations made by the user of the software.

For our house to be built under the second stage (July 2005) of the new Victoria energy efficiency standards we would need either a better reading from more sophisticated modeling using different software or professional assessment that the house design did meet the new standards. It is one thing to gain that assessment based on real life performance of an existing house but quite another to get an opinion that a proposed design will work when the software says it will not. Alternatively, the same house built with exterior walls of double cavity mudbrick (or brick), or insulated timber frame would achieve a rating well in excess of 5 stars. However these options would all have higher cost, environmental impact and/or maintenance requirements.

The fact that environmentally motivated regulation tends to suppress the most progressive innovation in any field at the same time that it lifts the floor of standard practice is not confined to this example but is a general pattern which emerges in land development controls, recycling regulation, food standards and many other areas which impact on sustainability.

2 *North facing glazing is 36% of heated floor area. First Rate is suitable for houses with up to 25% glazing in any one direction. NatHERS, a more sophisticated simulation program is recommended for buildings outside the parameters of First Rate. So far we have not managed to get an assessment of Melliodora using NatHERS*
3 *Toby Channing*
4 *now included in First Rate*

ELECTRIC POWER USE AND SOLAR POWER

In the original book we recorded an electric power use under 2 kilo Watt hours per day, a figure so low that an experienced solar power installer insisted it was not possible if we were running a fridge.

Since those early years, electric power use has gradually increased to between 4 and 5 kWhrs/day (still well below typical household use). The main reasons for the increase have been;

- continued increase of use of computers including a large CRT screen although recent use of laptops has at least moderated this increase.
- purchase of a second hand chest type freezer which is housed in the garage.
- change from a household of two adults, young child plus visitors to two adults, teenager/adult and increasing numbers of visitors.

Refrigeration has probably been the greatest contribution to the rise in energy consumption but it has not been as large as might be expected for the following reasons;

- temperatures in the garage are close to outside average temperatures in winter and almost as cool as the house in summer.
- switching off the under bench fridge in mid winter in favour of the cool cupboard and emptying the freezer for a short period in January-February has also reduced the increase.

New energy efficient fridges and freezers would also reduce demand but the embodied energy in new production and waste from discarding old but still functional equipment may not be justified on environmental grounds.

For several years we have been purchasers of "Green power" and in 2003 decided to take advantage of the subsidy for grid connected domestic power production using photovoltaic panels. However, it was not until August 2004 that we had Origin Energy install a 1050 watt, seven panel photovoltaic array and inverter at a net cost to us of A$9,600. Origin Energy's estimated annual power production is 1533kWhrs (4.2kWhrs/day)

Production and use figures for the first few weeks of winter operation are as follows;

- Average daily production 3.1 kWhrs[5]
- Average daily use 4.9 kWhrs[6]
- Net demand from grid 1.8 kWhrs

Production and use for the last two weeks of September (mid season) are as follows;

- Average daily production 4.1 kWhrs
- Average daily use 3.9kWhrs
- Net daily surplus to grid 0.2kWhrs

240 volt inverter and isolation switches mounted on mudbrick wall in workshop. Wiring conduit from panels on roof chased into mudbrick. Note fresh mud mortar covering wiring conduit on right leading to meter box switchboard

We are aiming at achieving a net surplus of power from the system by some efficiency gains and reductions in power demand over the next year.

Although the Federal government rebate, Renewable Energy Certificates and green power sales premiums make the system more financially attractive, very low power prices (relative to Europe and Japan for example) means the financial pay back period is between 10 and 20 years. However global energy peak and resultant changes in public policies over the next decade could change the situation.

While the net energy gains[7] from PV power may be marginal compared to current sources of non-renewable power and some renewable sources because of the embodied energy in the equipment and infrastructure, I think PV power may still be an appropriate environmental technology to make better use of existing electricity network infrastructure.

5 *Relatively high number of sunny days (for August)*
6 *Higher than usual due to intensive computer use, extra person plus power tool use.*
7 *An Emergy (embodied energy) evaluation of a PV power plant in Austin Texas in 1991 showed a net emergy yield ratio of 0.43 (a substantial net loss) but system design, array support infrastructure, maintenance and admin represented 2/3 of the total emergy input. My current guesstimate is that PV domestic systems may have a true emergy return around 1.5 while wind on good sites is probably 2.5 and forest biomass about 4.5 (coal fired power is about 4.5). For more on 'emergy' see* Permaculture: Principles and Pathways Beyond Sustainability.

Installation of photovoltaic panels on north roof. Note mounting rails and wiring switch box visible prior to placement of final panel.

For example small domestic systems can make use of existing electric supply and building infrastructure as well as maintenance by owners. The administration costs should be covered as a by-product of existing electric service contracts. In this way domestic grid feedback PV systems improve the energy return from the existing network rather than providing major new sources of net energy.

The practical downside of grid feedback is that it does not provide back up power.

Although back up power is an important issue with increased dependence on electricity for critical functions and doubts about future reliability of the grid, it is of less concern for us, because most essential functions such as cooking, water heating and space heating and even perishable food storage are not totally dependent on electricity. In the most critical dependent area of computers for communication, laptops provide back up for short term power failure.

August 1995 - Oliver with Feijoa, our first Toggenberg on lead reaching to eat praire grass seed heads in orchard.

October 1996 - Caged rabbits and hen and chicks in. A-frame on spring growth of lawn.

October 1996 - Electranet and electic tapes used to control goat grazing and chook foraging in lane between orchard and shelterbelt.

December 1996 - Oliver (with Little Olive) Su and Eugenio feeding Feijoa in newly constructed milking stall over compost bay in barn

Dam deepening March 1997 increasing capacity from 0.8 to 1.0 Megalitre, repairing yabbie holes and building up cottage site.

March 1997 - Newly constructed vehicle bridge from salvaged timber (telegraph poles and Fryers Forest chainsaw ripped thinnings and deepened dam with new jetty in background.

Cottage site works March 1997 - Fill from dam deepening used to build up site.

June 1997 - Reconstruction of stone wall with cement mortar after removal of all perennials and careful weeding of bent grass rhizomes. With excellent access, good deep soil and better moisture retention, this bed is now used for annual vegetables. Winter season digging over several years allowed removal of last bent grass. Steps provide better access to wheelbarrow path above and a garden seat. Stone pillars at top allow long garden hose to be dragged without damaging crops.

September 1997 - Daffodils established under peach tree.

November 1997 - View from greenhouse door under grape pergola with gladioli, lavender (in flower) and rosemary in tank terrace. Black cabbage, mandarin and grapes behind.

1999 - Visitor from the Solomon Islands inspecting first good olive crop, one which requires little irrigation or fertiliser.

Driveway October 1999. Poles, firewood, bark and chipped tree heads in driveway from 2nd thinning of 14th St shelter bluegums.

February 2000 - T tape drip irrigation line for watering newly planted vegetable in reconstructed stone wall garden bed after harvesting early potatoes. Note outside sink supplied by town water.

November 1999 - Su with Betony and Tansy tethered to bridge with tall spring growth in orchard. Note electric guards around trees to allow partial free ranging of goats.

February 2000 - Oliver cast netting to check for red fin. Note loss of reeds around dam (compared with earlier photos) due to yabbies browsing. Tansy, Betony and kids grazing between orchard trees protected by electric guards and tapes.

June 2000 - Biodynamic compost making workshop

September 2000 - Mother goose with newly hatched goslings in nest outside chook deep litter yard. Attendant gander calling the other geese as witnesses. All of this hatching was later lost to fox attack.

April 2003 - Hard lopping of crack willow on gully slope for goat fodder, firewood, walking track access and sunlight to established Bunya Bunya Pine. Tansy teathered on blackberrys in background.

April 2003 - David at his desk.

April 2003 - Oliver ready to head off on his road bike.

April 2003 - Established shelter, shade and fodder plantings around dam at end of drought.

April 2003 - Established hazel and walnuts in Orchard Block 1 protected from goats by electric tape. Established trees behind on housesite fill and cut slopes forming part of suntrap around dam.

April 2003 - View from barn roof showing growth of Feijoas replacing Tagasaste shelter around house and tall shelter Blue Gums along Fourteenth Street.

April 2003 - View over housesite fill slope below driveway at end of drought with established evergreen and deciduous fodder trees now dominating early plantings of seedling fruit trees and tagasaste.

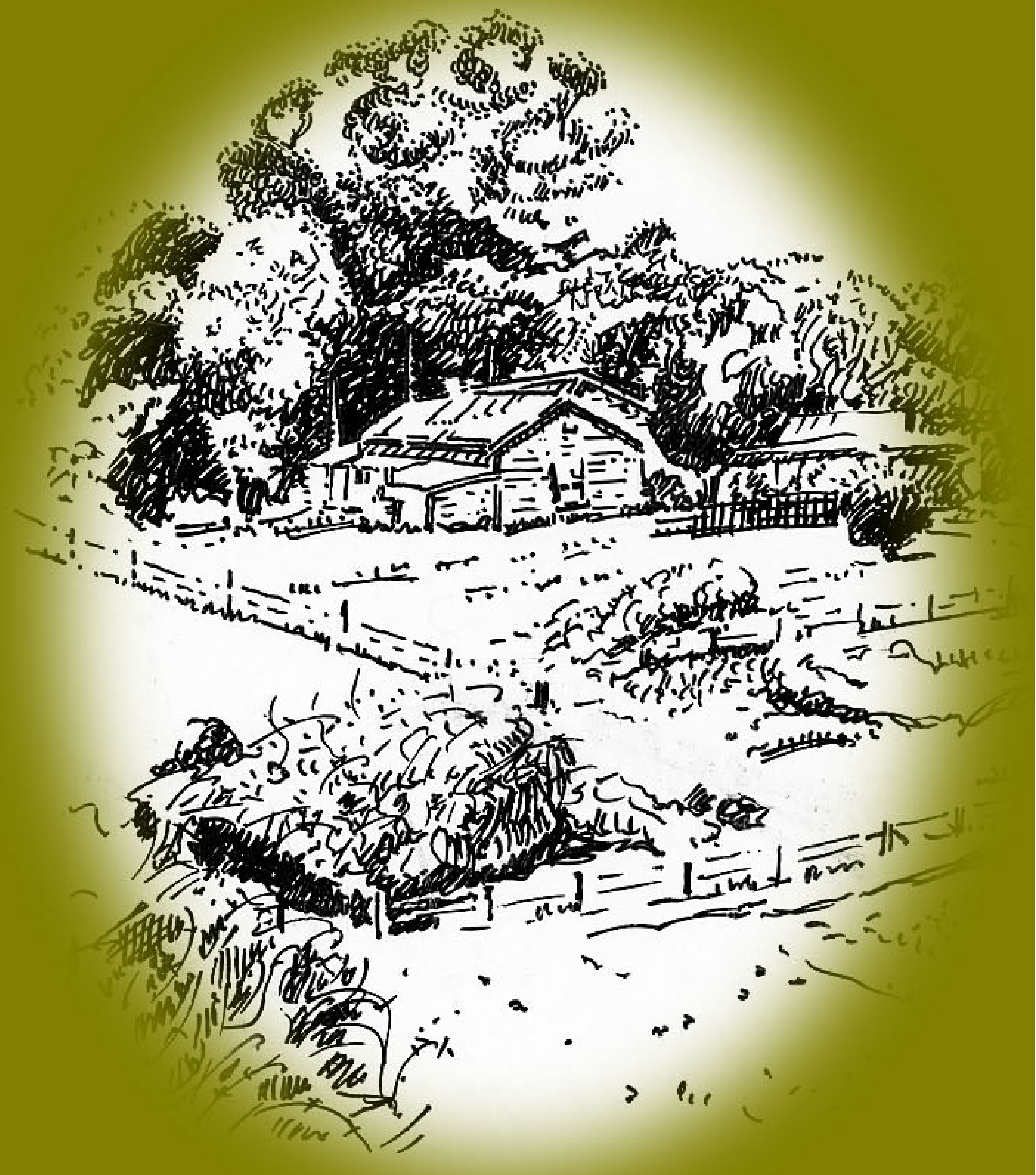
April 2003 - Geese eating fallen apples at the end of drought in same part of established orchard as 1988 photo.

April 2003 - View from same position as original photo of established hazels and walnuts with property fence corner in front of Fourteenth Street shelter plantings.

April 2003 - View down Olver Street reserve with shelter planting along boundary (right) shading vehicle access track and almost obscuring mature Yellow Box. Young yellow box left, retained after clearing cape broom with goats. Su in background near gate onto dam wall.

April 2003 - View over dam at end of drought to netted apple trees left, and nut trees, right, in Orchard Block 1 with housesite fill slope mixed planting almost completely obscuring house roof. Fourteenth Street shelter plantings behind.

CATALOGUE

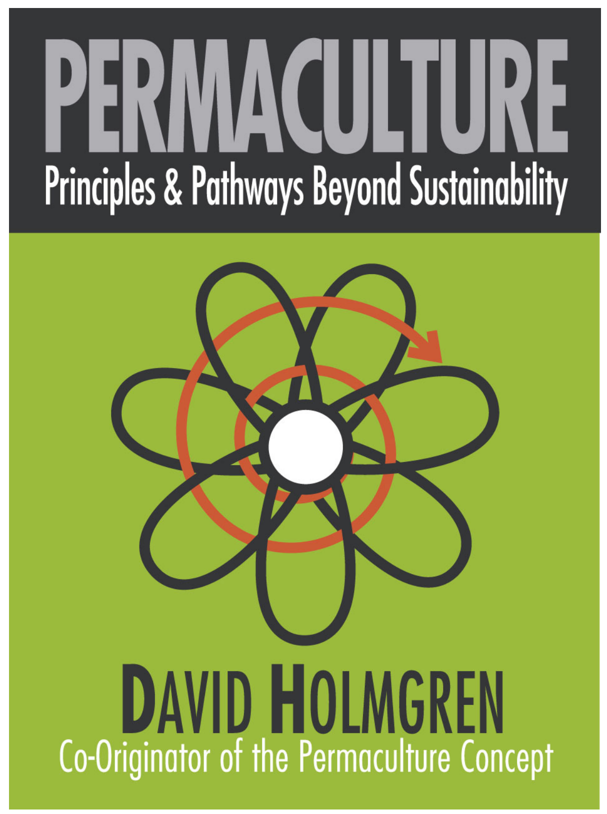


CURRENT TITLES IN PRINT

We publish a limited number of permaculture books authored by David Holmgren, the co-originator of the internationally acclaimed Permaculture concept of sustainability, first presented in Permaculture One (published 1978).

- Permaculture: Principles and Pathways Beyond Sustainability (Now available)
- David Holmgren:Collected Writings 1978-2000
- 'Melliodora' Hepburn Permaculture Gardens

PERMACULTURE: PRINCIPLES & PATHWAYS BEYOND SUSTAINABILITY



This book uses permaculture principles as a framework for an empowering but challenging vision of creative adaptation to a world of energy descent. David Holmgren builds on the extraordinary success of the permaculture concept (which he co-originated with Bill Mollison 25 years ago) and the global permaculture movement, to provide a more cerebral and controversial contribution to the sustainability debate.

- 320 pages, graphics and design principle icons
- Available from the publisher and selected bookshops

"If the 'Permaculture Principles that David Holmgren discusses in this extremely important book were applied to all that we do, we would well on the road to sustainability, and beyond." Professor Stuart B. Hill

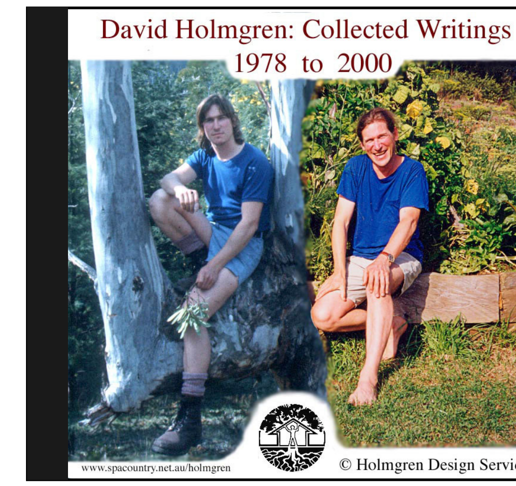
CONTENTS:

Introduction •What Is Permaculture? • Popular and academic reactions • Ethical and Design Principles

Ethical Principles • Care of the Earth • Care of People • Distribute Surplus and Set Limits to Consumption and Reproduction

Design Principles • Observe and Interact • Catch and Store Energy • Obtain a Yield • Apply Self Regulation and Accept Feedback • Use and Value Renewable Resources and Services • Produce No Waste • Design From Patterns To Details • Integrate Rather Than Segregate • Use Small and Slow Solutions • Use and Value Diversity • Use Edges and Value The Marginal • Creatively Use and Respond To Change

DAVID HOLMGREN: COLLECTED WRITINGS 1978-2000



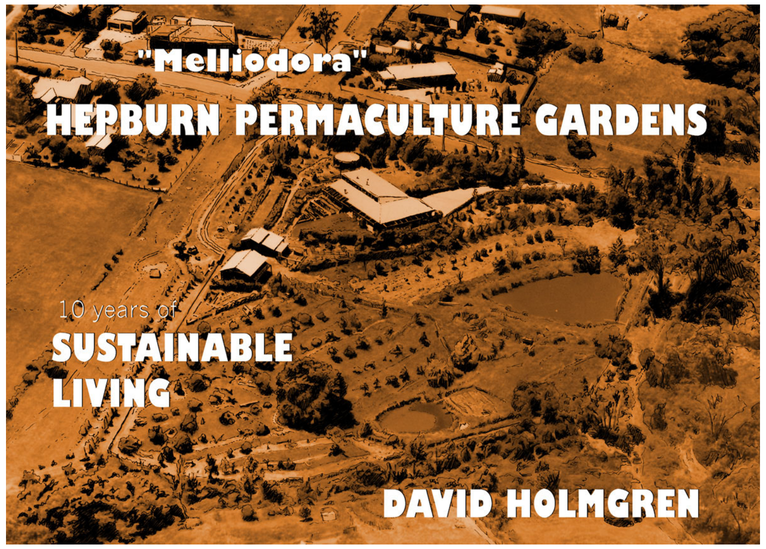
This collection of magazine articles, conference papers, public lectures, book reviews and other work by David Holmgren provide a deeper insight into the thinking behind the Permaculture concept and its many applications. The publication of the Collected Writings on CD provides source material from the co-originator of the Permaculture concept. Together they trace the ongoing evolution and explanation of the permaculture concept to a wide range of audiences by its lesser known author.

They will be of particular interest to permaculture teachers and practitioners and provide a glimpse of some of the ideas which have contributed to the long-awaited major new book, Permaculture: Principles and Pathways Beyond Sustainability.

The CD also contains some biographical photos which relate to the articles and some further references to the Holmgren Design Services and other websites.

This CD is Windows and Mac compatible and requires a web browser and a pdf reader such as Acrobat Reader (already installed on most computers and available free over the internet from www.adobe.com).

'MELLIODORA' HEPBURN PERMACULTURE GARDENS



Melliodora: Ten Years of Sustainable Living Book Review by Ian Lillington, Permaculture International Journal

When I first heard about Permaculture I thought it was for large acreages in the sub tropics. My first visit to David Holmgren's and Su Dennett's place in 1989 entirely changed my thinking. Here was a passive solar house and a food production system on one hectare, in a cool climate, in a town. It worked: the house was warm in winter, cool in summer and the land provided all the vegetables and most of the fruit for the family!

Throughout the 10 year history of the project, David has kept detailed records and photos, which have been collated into a very unusual book. It has A3 size landscape pages, so at a single opening it covers your desk! Each spread has a theme - such as house design, orchard, or animals with maps, plans photos and text.

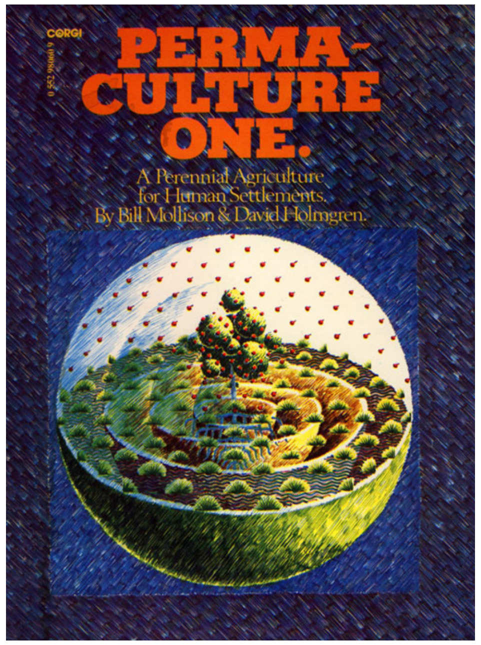
The book was written inside the property it is describing - it's a kind of autobiography. It was written over a five year period, and with property now "established", the text has been revised with the benefits of hindsight. It is ideal for anyone seriously interested in sustainable living - both at a practical level and with a good dose of Holmgren holistic thinking.

The meticulous detail allows the reader to trace the development of the property from the purchase of a steep weed-infested site, through the early stages of blackberry slashing, dam construction and tree planting to the "finished" product of family home, office, workshop, greenhouse, and integrated living systems with perennial plants and a range of animals fulfilling many functions.

Hepburn is in central Victoria, 470 metres above sea level, in the Great Dividing Range, north of Melbourne. It is an arboretum for cool climate Permaculture and the book has an extensive species list (over 170 listings)

Twenty years on from the first draft of "Permaculture One", this book shows that Permaculture works...."

PERMACULTURE ONE: A Perennial Agriculture for Human Settlements. By Bill Molison and David Holmgren



This seminal work first published in 1978 and translated in 7 languages, was the book that launched the Permaculture concept and movement. It is both the original statements of the theory by the co-authors and a useful text on cool climate self reliant land use and living. Includes an extensive species index of plants for cool temperate regions.

FORTHCOMING TITLE

WEEDS OR WILD NATURE: Migrant Plants and Animals in Australia

NEW BOOK IN THE PIPELINE PROMISES TO BE CONTROVERSIAL

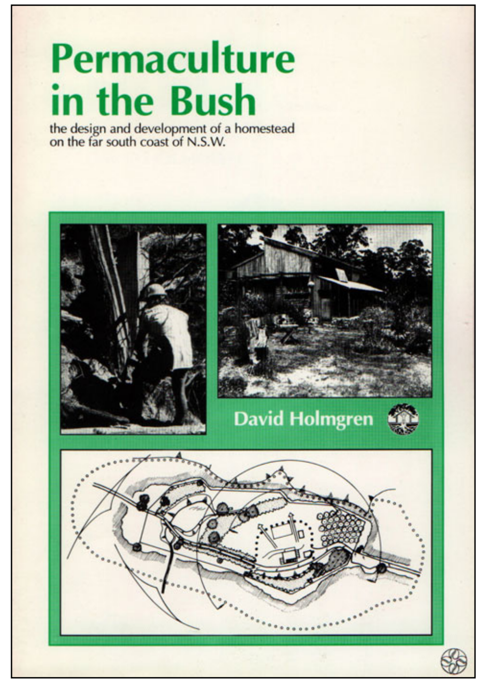
For over twenty years David Holmgren has observed, researched, discussed and debated the controversial issue of what is an environmentally progressive response to weeds and pests. Over the last five years he has been working on a book (WEEDS OR WILD NATURE: Migrant Plants and Animals in Australia) which gives a positive and empowering portrait of our relationship to nature and lays out a clear challenge to the emerging environmental orthodoxy about the evils of plant and animal naturalisations.

For an introduction to David's perspective on this subject, the article Weeds or Wild Nature is a good start (published in the Permaculture International Journal issue 61 in 1997). Articles 1, 18 and 20 in the Collected Writing CD also explore this subject while the theoretical foundations for these perspectives are explained in Permaculture: Principles & Pathways Beyond Sustainability

For an example of the application of these ideas to practical management of mixed urban fringe streamside vegetation see report by David Holmgren Upper Spring Creek Restoration Project Management Report on Daylesford Regional Landcare Group web site.

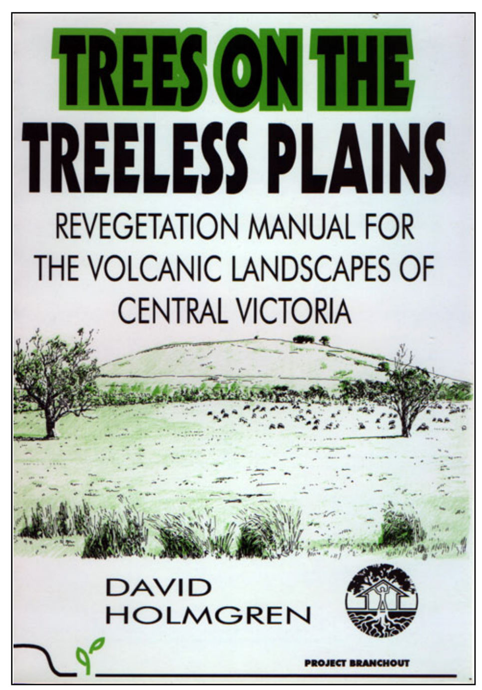
OUT OF PRINT TITLES

PERMACULTURE IN THE BUSH: The Design and Development of a Homestead on the Far South Coast of NSW



For those familiar with the basic concepts of permaculture, this case study design show how the principles have been applied to the inevitably unique conditions of a particular site and locality by permaculture's foremost practitioner. It provides information about a permaculture site, otherwise only accessible through local residential permaculture design courses. This small book is packed with technical information on land assessment, earthworks, water supply, soil improvement, passive solar and fire resistant design adaptable to a range of situations but especially for people developing bush properties.

TREES ON THE TREELESS PLAINS: Revegetation Manual for the Volcanic Landscapes of Central Victoria



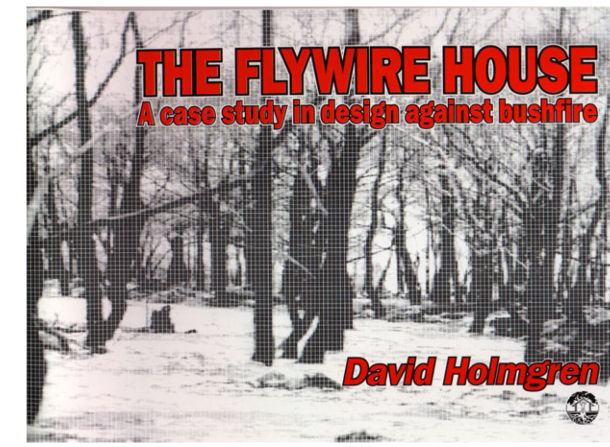
Soon to be an eBook

This design manual is a result of years of research and observation into the role and potential of trees and shrubs on farms. It addresses the transformation of broader farm landscapes through the application of permaculture principles to revegetation. The manual includes revegetation strategies and design solutions relevant to increasing and diversifying farm productivity while stabilising the landscape. It also address the public land on roadsides, stream sides and reserves.

The case study approach of the manual uses the volcanic landscapes as a focus to describe land types, local native species and to provide strategies, design solutions and species lists. It is directly relevant to some of the most valuable agricultural land in Victoria including the extensive Western Districts. A comprehensive species index of native and introduced trees and shrubs with proven performance provides a ready guide to species selection for different situations and purposes. For private and public land managers of the volcanic landscapes this manual is an essential reference.

For a wider audience concerned with revegetation, this book provides a design system approach and principles applicable everywhere to assist in the development of local strategies and design solutions.

THE FLYWIRE HOUSE: A Case Study in Design Against Bushfire



This small book is packed with information about the principles and practice of fire resistant, landscape and house design in ways in which are energy efficient, sustainable and productive: the essence of permaculture. It takes the form of a case study design for a property burnt out in the catastrophic Ash Wednesday fires of 1983 in the Dandenong Ranges of Victoria. This work has been applied in many designs by Holmgren Design Services including Melliodora. The ideas are applicable to all fire prone regions.

Please let us know if you are interested in out-of-print titles by emailing us at info@holmgren.com.au as this will help us plan re-prints.

HOW TO ORDER

Check our website for pricing and payment options www.holmgren.com.au

Cheque or money orders can be made out to:

Holmgren Design Services
16 Fourteenth Street, Hepburn, Victoria 3461, Australia

Email us for inquiries about discounts on bulk orders: info@holmgren.com.au

N.Z. distribution

- Living Lightly: Principles & Pathways, Melliodora, Collected Writings CD

U.S.A. distribution

- Chelsea Green: Principles & Pathways, Melliodora
- Permaculture Activist: Collected Writings CD, Principles & Pathways

U.K. distribution

- Permanent Publications: Principles & Pathways, Melliodora, Collected Writings CD

THE SEASONAL CYCLE

Early December - Grass at hay stage with second cutting of orchard underway after extended spring rains, dams full.

December - Past frost risk, kiwi begins shading west pergola.

New Year - Early cucumbers and beans in greenhouse begin shading and cropping.

Mid January - Watering raised beds with basil and staked tomatoes beginning to crop.

January - Hot dry weather with water level in dam falling from irrigation and evaporation. Early stone fruit harvest time.

February - Early apples ripening, brambles and blackcurrants foreground finished harvest, a little moisture stressed

Late March - Dam water level very low after irrigation season, time of harvesting fish.

Late March - Deep litter yard after harvest of compost, pampas grass as straw base for winter.

April - Pears with autumn colours from early frosts.

May - Tagasaste, the nitrogen fixing living haystack of goat fodder in flower soaks up winter moisture in dormant deciduous orchard.

June - Slashing and pruning in gully and orchard with help from goats

July - Winter frost

August - Fog over dam on frosty morning with wattle blossom and first shoot of weeping willow.

Late August - Turning the deep litter in wet conditions for aerations. Hens feasting on surplus manure worms. Background, evergreen tagasaste soaking up surplus soil moisture.

Early September - Plum in blossom (grafting time), apple still dormant, early bramble berry in full leaf.

Early October - Raised beds almost completely cleared of winter's growth with soil exposed to sun to warm new plantings of lettuce, carrot, radish etc.

Late September - Spring flood in gully with crack willow in full catkin

October - Slashed grass between orchard rows with comfrey in flower under apple tree in leaf and blossom

October - Week old chicks with broody hen in A frame on lawn

November - Main grass cutting season, grass used for mulching garden and fruit trees