

Attachment 5, Crops enterprises report, Tim Wiley

Evaluation of enterprise option and production systems for the Wiluna irrigation project

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Enterprise and crop selection

Soil and water resources are available to develop irrigation enterprises for the Martu people at Wiluna. There is a wide range of potential crops that could be grown. This desktop study will evaluate options against a set of criteria that reflect the ultimate goals of the Wiluna project and Martu people.

While a particular crop may grow at Wiluna, it may not be sustainable in the long term if it is not compatible with the culture and environment of Wiluna. A particular crop would need to be profitable, but must also provide jobs that are enjoyable and personally rewarding for local people.

Goal

Sustainable, locally run enterprises and rewarding employment for Martu people based on the utilisation of ground water resources

This must include..

- *Flexible labour requirements that is compatible with family and cultural commitments of Martu people.*
- *Meaningful, enjoyable and personally rewarding jobs.*

Selection criteria

Potential enterprises are to be assessed against criteria appropriate for the region, resources and people. Each potential enterprise will have strengths and weaknesses. Crops will be assessed against a set of criteria relating to issue of economic, social and environmental significances for Wiluna and the Martu people. Ultimately the Martu people will make the choice of enterprises. This report will help to guide the Martu through that decision making process. Their input into the assessment process is crucial.

It is recommended that the assessment of this report is reviewed in consultation with the Wiluna people. In particular their input into the social issues is vital.

The project will have two phases. The first phase will be pilot projects run by the families on their blocks at Wiluna. The aim will be to set up smaller scale enterprise to test, develop and refine different crops. During this phase the local families will...

- a) Identify the best options,
- b) Develop the skills, knowledge and confidence to grow these crops and
- c) Develop markets for their products.

This experience will allow them and their financiers to move to the second phase of large scale production with more confidence. The key aim of the first phases is to understand and manage the risk associated with full-scale production.

The following desktop study by necessity contains many assumptions. It is critical that these assumptions are tested in the pilot phase. An evaluation plan must be developed for the first phase of the project to ensure that learning and continuous improvement occurs.

The first phase will also include the growing of a cash crop on land retained by the Wiluna Development Corporation to generate income to support the corporation.

This assessment will help to identify annual crops with the least risk and the best prospects for profit in the short term. There will be other enterprises identified that may meet the long-term objectives, but about which there is more uncertainty. The uncertainty is due to these options being novel or less well developed in their agronomy, or because markets are not yet mature.

It is recommended that small scale trials be started in the first phase to assess and developed the more innovative enterprise options.

Funding for this R&D work could be sourced from other industry or government bodies

'Peak oil' and climate change mitigation.

Wiluna is ~ 1,000 km from Perth which is the key WA market place and source of supplies for horticulture in WA. Wiluna has a disadvantage compared to many other horticultural districts in WA due to the high transport costs. Increases in the price of oil / fuel will have a proportionately bigger impact on transport costs than other regions. Oil price also impacts on the cost of most of the inputs into agriculture. In particular Nitrogen fertiliser price is directly linked to fossil fuel prices as it is manufactured from natural gas.

Most analysts believe the world is at, or near, 'peak oil'. 'Peak oil' is the point where the global supply of oil starts to fall below the global demand for oil. As the short fall gets larger the price of oil will start to rise more rapidly. Some analyst believe the world's largest oil field in Saudi Arabia only has 20 to 30 years of 'cheap' oil left. Once this supply starts to dry up the price of oil will increase many fold.

The Wiluna enterprises must be developed as a very low input system or they will not be economically sustainable once there is the inevitable, and dramatic, increase in fossil fuel costs.

In response to human induced climate change it is very likely there will be a price put on the emissions from burning fossil fuels. This will further increase the costs of oil-based products and transport on Wiluna enterprises.

Three strategies are required to reduce the risk due to peak oil and a price on carbon pollution.

A priority should be given to...

1. *Produce that has a higher price per kilogram.* This would mean that the transport cost per \$\$ of product sold would be lower, and thus less vulnerable to increased energy and emissions costs. Any on site value adding will also be of benefit.
2. *Sourcing inputs and selling produce locally.* The fly in – fly out miners are a potential market for Wiluna produce. A survey should be conducted on the fresh produce required by caterers at local mines. In addition miner's kitchen waste could be composted reducing the need for imported fertiliser. One Wiluna mine is already considering composting their kitchen wastes.
3. *'Organic' or low input production systems.* There are challenges to 'organic' farming, but there are also premiums in the market. There is also an emerging market in Europe for produce with a low 'carbon foot print'. It would be desirable to model the emissions of various enterprises in the detailed planning phase for the project and to implement systems for estimating emissions once production starts. Some preliminary discussions have been held with researchers at Curtin University who are pioneering Life Cycle Assessment (LCA) of green house gasses in broad acre agriculture.

Low input production systems

Traditional production systems require large inputs of energy, nutrients and chemicals to maximise yields and quality. Low input systems rely on natural processes to reduce the need for fertilisers, water, weed control, pest control and cultivation.

Integrated Pest Management (IPM)

Intensive agriculture uses chemicals to kill insect pests, disease and weeds. While these chemicals can be very effective, over uses inevitably leads to chemical resistance in the pests. Integrated Pest Management is based on a detailed understanding of the pest life cycle so that a range of strategies can be targeted to have the maximum impact. Pesticides may be used but at lower rates of less toxic chemicals in a carefully targeted way. A key to IPM is creating the conditions that favour the natural predators of the pest. Insecticides and fungicides are not selective and take out beneficial insects and fungi. IPM encourages mixtures of plant species rather than monocultures to provide habitat for predators.

Nutrients

Locally produced organic fertilisers could supply nutrients and improve the soil fertility by increasing soil carbon levels. This results in improved water and nutrient holding potential. These carbon based fertiliser also feed the soil biology, which is essential for soil health.

Rotations and mixtures of plants

Including legumes in crop rotations or as companion plants can reduce nitrogen fertiliser. The legume may either be 1) an annual, which is grown as a break crop, 2) an herbaceous perennial that can be cropped over or 3) a woody perennial grown in alleys.

Mixtures of plants, or 'polycultures', may be achieved either in time (i.e. crop sequences) or in space (mixed plantings). The more species in a mix the more complex the ecosystem is. This can create challenges in agricultural ecosystems as the decision-making becomes more complicated. With careful planning it may be possible to increase the complexity of a system while limiting how complicated the management becomes.

Research generally shows that the best monoculture crop will be more productive than a polycultures in the short term. However, long-term trials show that the mixtures become more productive over time. Mixtures are also more resilient in adverse conditions. This resilience not only applies in a biological sense but also in economic terms. Having multiple products reduces the risk of price variability that can occur in any single crop. Having multiple crops also increases labour and equipment efficiency, as the management of any individual crops is inevitably concentrated into specific times in the season.

Plant species can compete with each other in mixed plantings. However certain mixes of plants species can also complement each other. It is this principle that is exploited in 'permaculture'. A system called 'pasture cropping' is being developed in the Mid West region where winter growing grain crops are being planted over summer active / winter dormant perennial grasses. It has been found that some perennial grasses can increase the availability of nutrients and organic carbon in their root zone by 3 to 5 fold. This results in the companion annual crop growing better than it would on its own. There is also some evidence to suggest that the perennial grasses may actually increase the moisture supply of the annual crop, rather than reduce it through competition.

It may be possible to apply the principles of pasture cropping to growing annual vegetable crops over perennial pastures. Of particular interest is the perennial legume Siratro. This legume is very winter

dormant, but has exceptional drought tolerance in summer. Siratro could possibly be cropped over in winter when it is dormant and then used for grazing stock in summer with minimal irrigation.

'Alley farming' is a system where annual crops are grown in 'alleys' between rows of woody perennials. The perennials can be a crop in their own right while providing shelter from wind and habitat for predators.

Water use efficiency

One of the biggest costs in irrigated agriculture is the cost of pumping water. The cost for power to pump water at Wiluna could increase substantially over time. The old Wiluna irrigation used flood irrigation. While flood irrigation is cheap in terms of infrastructure costs it is inefficient in using water due to evaporation. There can also be considerable losses of water with sprinkler systems. Drippers have the lowest evaporation loss but are more expensive. As fuel prices rise drippers will become more attractive.

Dripper systems combined with sophisticated soil moisture and weather monitoring systems will minimise water use and maximising crop yields. 'Partial root zone watering' can make plants more droughts tolerant. A horticulturalist south of Carnarvon is using 'open hydroponics' to virtually eliminate evaporation from the soil.

'T tape' is used as a disposable dripper system for annual vegetable crops. 'Netafin' is a long lasting dripper system that has been used for permanent crops, but not for annual crops as it can be damaged during crop planting. Wheat farmers are now using satellite guidance system that are accurate to 20 mm to sow, spray and fertiliser their crops. This guidance system could allow Netafin to be used in annual vegetable crops.

Currently electricity in Wiluna comes from a diesel-fired generator at high cost. Local miners have their own natural gas fired generated attached to gas pipeline not far from the Wiluna irrigation block. The project should investigate the possibility of this gas-fired generator supplying the electricity.

Soil biology

Soils that are alive with life are naturally more fertile. Increasing the amount and diversity of soil biology will give soils greater natural nutrient supply, pH closer to neutral, increased water holding capacity, more moderate soil temperatures, increased soil organic carbon and greater capacity to break down toxic chemicals. Improved soil biology will reduce the needs for inputs and improve crop health and vigour.

Practise that with stimulate soil biology include....

- Increased ground cover
- Reduced cultivation
- Less soluble fertilisers
- Organic fertilisers
- Crop diversity and rotations
- Legumes in the rotation
- Continuous green plants rather than fallow
- Perennial plants, particularly perennial grasses
- Reduced pesticide and fungicide use
- Biological stimulants such as compost teas.

These practises should be integrated into the cropping systems at Wiluna as much as possible.

Cropping systems that retain ground cover will be essential to minimise the effects of extreme temperatures at Wiluna.

Table 1; The effect of ground cover on soil temperature at Badgingarra over the 2002/03 summer. (Tim Wiley, Department of Agriculture & Food WA).

	Bare earth	Dry grass	Live Rhodes grass	Live Kikuyu & clover
Average temp	31.4	29.4	28.2	22.0
Highest temp	63	53	47	33
Lowest temp	13	17	17	17
Temp range	50	36	30	16
Hours above 40 C	555	332	25	0
% above 40 C	26	16	1	0

It has recently

been discovered that some perennial grasses can dramatically increase the amount of nutrients available within their root zone. This affect is exploited in a new system called 'pasture cropping'. This is where winter growing grain crops are planted over summer active – winter dormant perennial grasses. The perennial grass do not act as a 'weed' to the crop, rather they actually boost the crop growth and reduce the need for fertiliser. It may be possible to exploit this in horticulture by growing winter vegetable crops over summer dormant perennial grasses. Also there is a tropical perennial legume called 'Siratro' that is even more winter dormant than these grasses and is more drought tolerant. As a legume Siratro would also fix nitrogen to be used by the crop. Siratro has been grown successfully under irrigation on two stations at Carnarvon.

Table 2; Available nutrients a) between and b) within, the root zone of Green panic plants on deep yellow sand at Balla, WA from 10 paired samples with ~ 1 m between plus and minus panic roots. (Tim Wiley, Department of Agriculture & Food WA, 2008)

	Outside of panic root zone (no perennial roots)	Within panic root zone (with perennial roots)
Available P (Colwell ppm)	21	71
Nitrate N (ppm)	4	2
Ammonium N (ppm)	2	3
Organic Carbon (Walkley Black %)	0.24	1.04
Potassium (Colwell ppm)	44	150
Sulphur (ppm)	2.7	7.9
pH CaCl	5.8	7.1
pH water	6.4	7.8

Assessment criteria

ria for enterprises

Potential enterprises have been assessed against a set of criteria reflecting, economic, environmental and social issues relevant to Wiluna. Scores were given for each criteria on a 1 to 5 basis, with 5 being these most favourable.

Not all the data was available for all the crops. Gross marginal analysis was available for some crops. However these gross margins came from a range of sources that were done in different regions and

in different years. This means that yields, prices and costs used may not be comparable. A much more detailed analysis for Gross Margins and Return On Investment should be done in business case study.

Principles for sustainable enterprises

Crop productivity

Markets

Price

Water use efficiency

Energy efficiency

Soil fertility

Cropping flexibility

Labour distribution

Diversity

- Markets
- Long term economics and energy costs
- Labour

Ecosystems

Biosecurity

Input costs

Potential for 'organic production'

Transport costs

Perish ability

Processing requirements

Value adding

Potential for clashes with cultural commitments

Cultural significances

Job satisfaction

Personal growth and empowerment

Crop productivity

The productivity of crops is determined by their suitability to the soil types and climate of Wiluna. The climate of Wiluna was compared to the other main horticultural regions in WA north of Perth and to Alice Springs to the east.

Predictions of climate change suggest that Wiluna will get hotter, but there is less certainty about changes in rainfall. Higher temperatures will mean more heat stress in summer but more favourable growing conditions in winter. However the high winter temperatures also means less chilling hours that are required for some stone fruit crops.

Generally the soils at the Wiluna site are well suited for horticulture. However some fertilisers and amendments may be required for certain crops.

Social considerations

The culture of the Martu people is different in many ways to the broader white community. Martu people have responsibilities to their families and their law that may over ride the management requirements of particular crop enterprises. Also their culture means that some enterprise and types of work will be more interesting and enjoyable to them than others. Potential enterprises should be assessed in relation to these cultural differences. While a framework for that assessment is suggested here, the detailed assessment should be done by the Martu people themselves during the detailed business planning to follow up this scoping report.

Social assessment of crop options

- Interest of local people in the crop
- Diversity of skills required
- Current knowledge of crop within community
- Level of 'ownership' by all family members
- 'Comfort levels' of management tasks
- Opportunities to work together as family groups
- Cultural considerations
- Others?????

The climate of Wiluna compared to Alice Springs, Carnarvon, Geraldton, Moora and Perth
Comparisons of climate between Wiluna and other horticultural regions will help to indicate which crops should grow well at Wiluna. A comparison of climates also indicates potential differences in crop planting or harvesting times. There could be 'windows' when Wiluna can supply produce into the Perth market when other horticultural districts can't. There will be price premiums if Wiluna can supply the market at times when there is limited competing produce.

Conclusions

- *Harvesting times for crops at Wiluna are likely to fall between Carnarvon and Geraldton.*
- *Annual crops that are susceptible to heat stress should not be grown in Wiluna during summer.*
- *Perennial crops should be selected for heat tolerance.*
- *The Alice Springs experiences of heat tolerance of crops are the most applicable to Wiluna.*
- *Winter annual crops should be less limited by low temperatures at Wiluna compared to Alice Springs, Moora and Perth.*
- *Winter annual crops and perennial crops should be selected for frost tolerance.*
- *Alice Springs experience with frost damage to crops is not applicable to Wiluna.*
- *Irrigation systems at Wiluna should be capable of supplying almost all of the crop's water requirements without relying on rainfall.*
- *Less irrigation will be required at Wiluna than at Carnarvon or Alice Springs.*
- *More irrigation will be required at Wiluna than at Geraldton or Perth.*
- *Peak irrigation demand will be higher at Wiluna than for the other irrigation districts.*
- *Wiluna has few cloudy days.*
- *Alice Springs has solar radiation and cloud cover that is most similar to Wiluna.*
- *Wiluna has low humidity.*
- *Fungal leaf diseases of crops at Wiluna will be less important than for other districts.*
- *Winds at Wiluna are generally low, and of little significance.*

Wiluna location

The Latitude of Wiluna (26.59⁰ S) is further north than Geraldton, Moora and Perth, but south of Alice Springs and Carnarvon. Carnarvon is closest in Latitude to Wiluna being only 1.7⁰ further north. Latitude affects solar radiation and day length.

Wiluna has a similar attitude (521 m) to Alice Springs (546 m), but is significantly higher elevation (by 318 to 517 m) than the other WA sites. As a consequence night-time temperatures at Wiluna will generally be lower than the other WA districts.

Climate

Wiluna has a typical inland desert climate with...

- Low and variable rainfall
- Low humidity
- Low wind
- High sunshine
- Very hot summers
- Mild winters but with low minimum temperatures

Of the surrounding horticultural centres Alice Springs has the climate, which is most similar to Wiluna. Wiluna has more 'very hot' days in summer but less very cold days / frosts in winter. Wiluna should need less irrigation water than Alice Springs.

Carnarvon varies from Wiluna in that Carnarvon is more humid year round, evaporation is higher from May to September but lower in spring, its much windier, maximum temperatures are in lower summer, temperatures rise more slowly in spring, minimums are higher in winter and it does not have frosts.

Daily maximum temperatures averaged over the whole year are higher in Wiluna than the other districts. Alice Springs is the most similar being only 0.5 C cooler on average. Alice Springs has the same number (173) of moderately warm days with temperature above 30 C. However the number of hot days and very hot days is significantly higher for Wiluna than for all of the other districts. Wiluna has an average of 103 days with maximums above 35 C and 31 days above 40 C. Again Alice Springs is the closest in terms of hot and very hot days.

- *Annual crops that are susceptible to heat stress should not be grown in Wiluna during summer.*
- *Perennial crops should be selected for heat tolerance.*
- *Alice Springs experiences of heat tolerance of crops are the most applicable to Wiluna.*

The high temperatures combined with low humidity in summer means that crops in Wiluna will be subject to more heat / moisture stress than at Alice Springs, and much more than the coastal regions.

- *The irrigation systems at Wiluna will need to have the capacity to supply a higher rate of water than at Alice Springs to deal with the more extreme water stress in summer.*

Daily minimum temperatures, averaged over the whole season at Wiluna are higher than Alice Springs, Geraldton, Moora and Perth, but lower than Carnarvon. Geraldton is the closest to Wiluna in terms of annual minimum temperatures.

- *Winter annual crops should be less limited by low temperatures at Wiluna compared to Alice Springs, Moora and Perth.*

The number of chilling hours (< 7C) are not given by BoM but are likely to be in the range of 300 to 400 hours based on other Murchison centres.

Frost will occur at Wiluna in winter with an average of 11 days with minimum temperatures below 2 C and 5 days with ground temperatures below -1 C. Alice Springs has significantly more frost than Wiluna (41 days with ground temperatures < -1 C). The other WA districts rarely suffer from frosts.

- *Winter annual crops and perennial crops should be selected for frost tolerance.*
- *Alice Springs experience with frost damage to crops is not applicable to Wiluna.*

Some summer crops will not germinate if the soil temperature is too low. The 9.00 am soil temperature is often used to define the minimum temperature for these crops. This data are not available for Wiluna. The daily average temperature can be used as an estimate for the 9.00 am soil temperature. For crops that can germinate below 20 C average temperature (e.g. sweet corn),

sowing can be done earlier in spring at Carnarvon compared to Wiluna or Alice Springs. For crops that require temperatures above 20 C (e.g. watermelons) seeding can be done slightly earlier at Wiluna and Alice Springs compared to Carnarvon.

Wiluna (256 mm), Carnarvon (277 mm) and Alice Springs (278 mm) have significantly less annual rainfall than Geraldton (449 mm), Moora (459 mm) and Perth (781 mm). Also, rainfall is more variable between seasons at these sites compared to the more southern WA districts. Extreme droughts can occur at Wiluna. Wiluna has very few wet days, which is similar to Alice Springs and Carnarvon.

- *Irrigation systems at Wiluna should be capable of supplying almost all of the crop's water requirements without relying on rainfall.*

-

Annual evaporation at Wiluna (2,409 mm) is lower than all other districts except Perth. Evaporation at Wiluna is significantly less than Carnarvon (2,638 mm) and Alice Springs (3,176 mm). The rainfall deficit compared to evaporation is substantially larger at Carnarvon (+ 248 mm) and Alice Springs (+767 mm) than at Wiluna. Rainfall deficits at Geraldton (-156 mm) and Perth (-890 mm) are less than at Wiluna.

- *Less irrigation will be required at Wiluna than at Carnarvon or Alice Springs.*
- *More irrigation will be required at Wiluna than at Geraldton or Perth.*

Wiluna has more solar radiation than Geraldton, Moora or Perth, but less than Carnarvon and Alice Springs. Alice Springs and Carnarvon have 4% more solar radiation for the year than Wiluna. Geraldton and Perth have substantially more cloudy days than Wiluna.

- *Wiluna has few cloudy days.*
- *Alice Springs has solar radiation and cloud cover that is most similar to Wiluna.*

Humidity at Wiluna is considerably less than for the coastal districts of WA. Humidity at Wiluna is similar to Alice Springs. Low humidity combined with very high summer temperatures means there will be more water stress of crops at Wiluna than at other sites.

- *Wiluna has low humidity.*
- *Peak irrigation demand will be higher at Wiluna than for the other irrigation districts.*
- *Fungal leaf diseases of crops at Wiluna will be less important than for other districts.*

Wind speeds at Wiluna are moderate, and comparable with Alice Springs. Average winds speeds are substantially higher at Carnarvon and Geraldton. Extreme winds that can cause damage at Carnarvon and Geraldton are rare at Wiluna, but are still possible during summer thunderstorms. Cyclonic winds that occasionally devastate Carnarvon do not occur at Wiluna.

- *Winds at Wiluna are generally low, and of little significance to Wiluna.*

Markets and prices

(With information supplied by Allan Diver, Canningvale Markets)

The profitability of agricultural enterprises is driven by price and yield. Prices are determined in the market place by supply and demand. Today consumers expect ('demand') fruit and vegetables to be available on a year round basis, and are willing to pay for it. Seasonal factors will affect the supply of produce.

Wiluna will have an advantage over the main southwest growers in being able to supply produce out of season. However the horticultural production in the north of WA has been expanding in recent times so there is less variability in supply to the main market of Perth than there used to be. Wiluna will be competing with Carnarvon with most products. But there will still be price premiums before the southwest producers begin harvest.

The demand for fruit and vegetables is growing rapidly. This is due to population growth in Australia and to access to overseas markets increasing. Major droughts in the Murray Darling are reducing eastern states production and thus increasing the demand for WA produce. These fundamentals mean that prices are likely to increase over time.

As well as supply and demand the other key factor-affecting price is quality. Quality products sell, and attract good prices even when supply is high. High quality WA produce can be sold into international markets at high prices.

Wiluna enterprises must focus on quality to ensure good prices even when there are plenty of competing products in the market.

Wiluna has soils and climates that are suitable for growing most fruits and vegetables. Priority should be given to those crops that consistently give high quality produce. Wiluna had a reputation for its excellent quality citrus. Wiluna oranges and mandarins were always sold in to premium markets

The Perth grocery market is dominated by Coles and Woolworths (much more than any other state). These two retailers focus on low price, high turnover produce. The prices they pay to growers usually leaves low margins for the growers. Smaller specialist fruit and vegetable retailers share the rest of the Perth market. They focus on premium products attracting higher prices. Wiluna producers should target these specialist retailers.

Wiluna growers should develop an ongoing relationship with a marketing agent who will focus on the higher paying specialist retailers in Perth.

A dedicated marketer could also look at developing export market opportunities for Wiluna produce. Including the fly in – fly out miner workers there are about 1,600 people who live or work in the Wiluna shire. Wiluna producers could develop a local market by liaising closely with mine site caterers.

Crop options

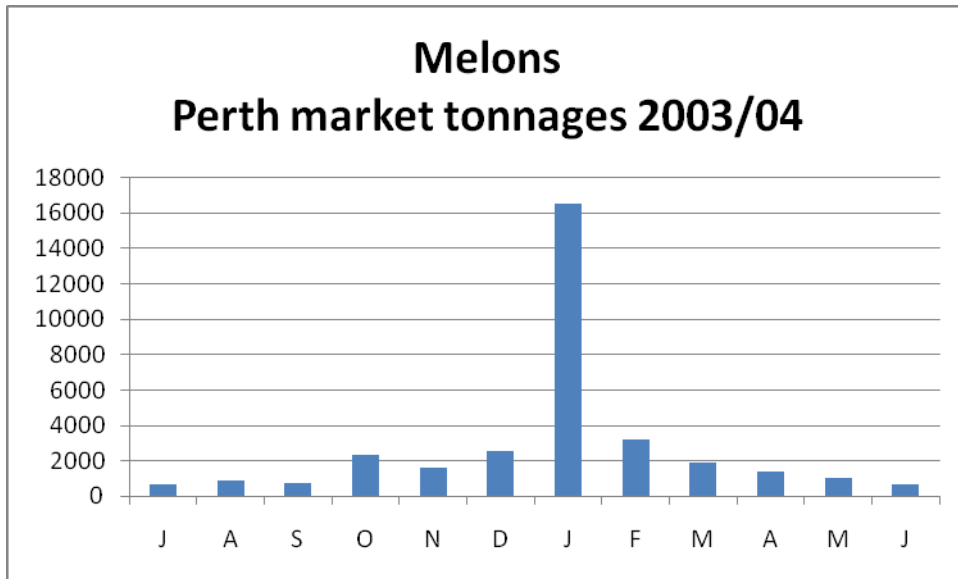
Watermelons

Watermelons should grow well at Wiluna. They will compete directly with watermelons from Carnarvon. Wiluna watermelons should be harvestable in December and have about a 4 to 6 week window before Perth producers come on line. Wiluna may be able to get product into the market slightly earlier than Carnarvon due to spring temperatures rising slightly faster and allowing earlier planting. Wiluna also has a slightly lower freight cost than Carnarvon.

Prices in the Perth market will be in the range of 50c to \$1.00 /kg. The higher prices (80c to \$1.00) should be achievable as long as the quality is good.

Rockmelons

Rock melons have been grown at Wiluna in the past. Crops achieved both high yields and high quality. Early summer markets for rock melons should deliver around \$2.00 each or \$16 /carton. Rockmelons have an advantage over watermelons in that the freight costs (\$/kg) will be lower. There are very good exports markets available to WA rock melons in Asia and Europe. These markets pay premium prices for premium products.



(Watermelons & rock melons)

Table grapes

The demand for table grapes continues to grow. December prices for new varieties of table grapes will be in the vicinity of \$15. Higher prices can be achieved for export quality fruit. There has been an expansion in table grape production in Carnarvon, but this may not be able to keep up with the demand for quality products.

Pumpkins

Perth market gardeners grow summer pumpkin crops to clean up their paddocks ready for winter vegetable crops. They grow earlier maturing varieties like Butternuts and Queensland Blue. They mostly avoid the later maturing Japanese pumpkins as these prevent them getting their winter crops in earlier enough. There should be an opportunity for Wiluna to produce Japanese pumpkins when the supply is low. Pumpkins have the advantage in that the picking and storage window on farm is much larger than for most fruit and vegetables.

Sweet corn

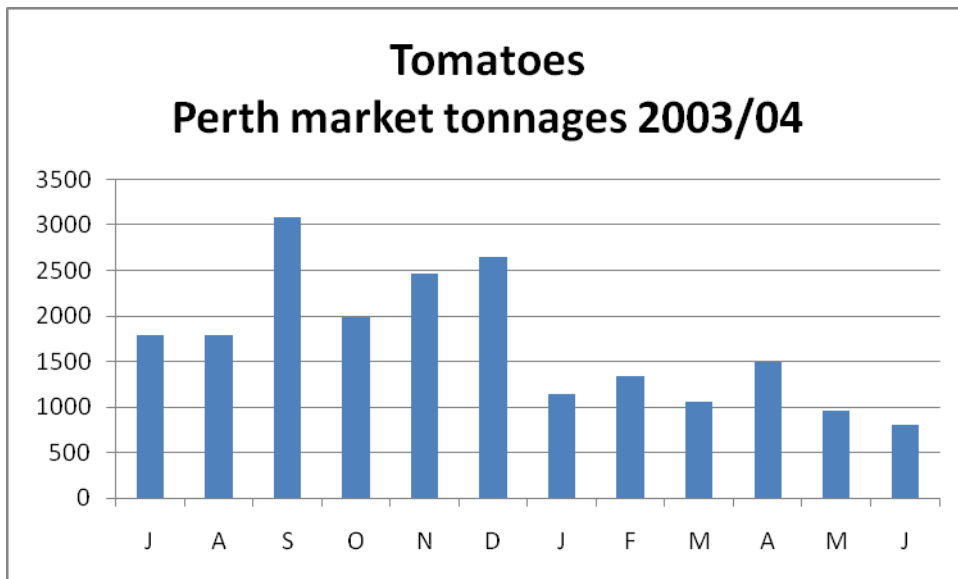
There is a niche market for sweet corn delivered to Perth in early summer. However there have been large producers at times in the Carnarvon and Kimberly regions.

Sweet potatoes

Currently almost all of the sweet potatoes in the Perth market are imported from the east at a freight cost of around \$6 /kg. Wiluna should be able to supply the Perth market. Sweet potatoes have an advantage as there is flexibility in the timing of harvesting.

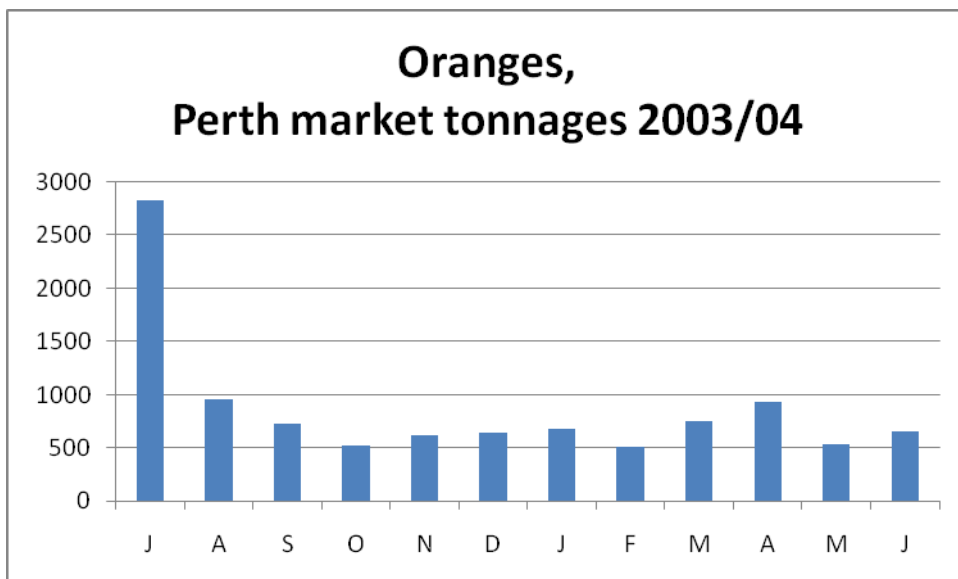
Tomatoes

Geraldton and Carnarvon have been the main suppliers of tomatoes over the cooler months. There is now little production coming from Geraldton. In recent times the quality tomatoes from Carnarvon has declined considerably. Quality tomatoes from Wiluna should attract good prices.



Citrus

Wiluna has produced very high quality citrus fruit in the past. This citrus was almost all sold in to premium retail markets. However the high prices didn't always end up in the hands of the growers at Wiluna. Wiluna citrus should perform well in premium export markets.



Fresh dates

WA imports all of its fresh dates from overseas. The growth in migration from Middle Eastern countries has created a significant market in WA that will pay high prices. Dates grow very well in the dry Wiluna climate. Older date varieties took a long time to come into production. Newer varieties produce much earlier.

Other products

There is a range of alternative and none food crops that could be grown under irrigation at Wiluna. With most of these there is very little data on production and yields in WA. Some of these options should be tested as small pilot projects to evaluate their yield and management. These trials could possibly attract funding from government, industry and commercial partners.

Oil crops

Biodiesel can be made from the seeds of canola (a winter annual crop) and from certain shrubs that have high oil content seed. It is not yet known how these oil seed crops will yield under irrigation in WA. However there is considerable interest from industry (and potentially local miners) in investing in these types of crops. Large-scale production should not be considered until the economics has been assessed from local trials.

Sandalwood

Sandalwood is a very high priced product that grows naturally in the Wiluna area. Bush picking under licence occurs around Wiluna. The local variety is much more expensive than the Indian sandalwood that is being grown under irrigation in Managed Investment Schemes at Kununurra. Unfortunately these MIS schemes can be so large that they flood the market and cause prices to crash. This may well be the case with sandalwood in the medium term. However local sandalwood integrated in to irrigation bays in an alley farming system may add environmental and economic benefits in the longer term.

Bush tucker

There is growing interest in bush tucker crops for specialty markets. Wiluna people have also expressed interest in growing their traditional foods under irrigation. While the agronomy is in its early stage of development, the long-term market prospects are very good. Some bush tucker crops such as bush tomatoes are already under cultivation in other regions. There is interest from some local people in cultivating cogla.

Bush medicine

Medical researchers at St Charles Gardiner Hospital are starting to demonstrate that bush medicine plants like gooberoo have real healing properties. There may be a high value market for these traditional medical plants. Virtually nothing is known of the agronomy of these plants. There are also traditional aboriginal IP ownership issues to be negotiated across tribal region boundaries.

Native shrub and tree seed crops

There is a high value market for native plant seeds for rehabilitation of mine sites and biodiversity plantings on farms. Currently seed is picked from the bush. Irrigated seed nurseries should supply higher yields at lower costs with better quality seed. This seed could be value added by growing seedlings. These tree and shrubs could be integrated into vegetable crops in an alley farming layout. 'Bare rooted seedlings' of native shrub and tree

Native shrubs and trees are planted as potted seedlings usually at a cost of \$1 per seedling or more. 'Bare rooted' seedlings are sown at high density in irrigated plots. These seedlings are harvested by blade ploughing the roots and pulling seedlings from the ground. This technology has been used for tagasaste and pines with seedlings being produced at only 10% to 20% of the cost of potted seedlings.

Native grass seed

Native grass seed is harvested opportunistically from the bush and is very high priced. These perennial grasses could be grown under irrigation for seed harvesting. In addition they could be grazed and 'pasture cropped' by planting winter growing vegetable crops. These perennial grass would provide ground cover and improve the soil fertility under perennial tree crops.

Exotic perennial grass seed crops

The use of C4 perennial grasses is expanding rapidly in the agricultural regions of WA. Currently all the seed is imported from Queensland and northern NSW. New varieties of some of these species

are being bred by the Department of Agriculture & Food WA and will be released for commercial seed production in the next few years. Wiluna could become a the major centre for producing WA seed requirements.

Lucerne hay

Lucerne is a perennial legume that puts nitrogen back into the soil and provides high quality hay. The distance from the main markets around Perth would make Wiluna production uncompetitive due to transport costs. However it may be competitive in local markets, and Wiluna is a similar distance from Kalgoorlie as are the Perth producers.

Cereal hay

Cereal hay could be grown as a break crop in vegetable rotations or under tree crops. Cereal hay would only be competitive in supplying local stations.

Grazing stock on mixed perennial pastures

Wiluna stations suffer from variable feed supplies from their rangeland pastures. Irrigated pastures could value add station cattle and sheep, and supply strategic feed for station's breeding stock. Many of the older aboriginal men were stockmen on stations and they would like to see their skills passed on to the younger generation. A live stock enterprise based on irrigated pastures at Wiluna could become the centre for training young people for working with livestock. Carefully designed mixed species pastures could also provide seed, habitat for predators to control diseases and pests, improve the fertility of the soil and the possibility of over cropping with vegetable crops.

Carbon farming

Perennial crops can sequester carbon in their vegetation and the soil. This could generate additional income through the sale of 'carbon credits'. There will also be premiums in the market for produce that come from systems with a low, or no, 'carbon foot print'.

Comparison of enterprise options

The possible enterprises have been assessed against multiple criteria. The ratings have been combined to allow a more holistic comparison of these options. Vegetable crops generate good cash flows in the short term and have the flexibility to be changed in response to short term market fluctuations. However when longer term trends (eg energy prices) and social factors are taken in to consideration perennial crops rate better. In particular those enterprises which include native plants rate the most highly.

Japanese pumpkins, watermelons and rock melons rate the most highly of the annual crop options.

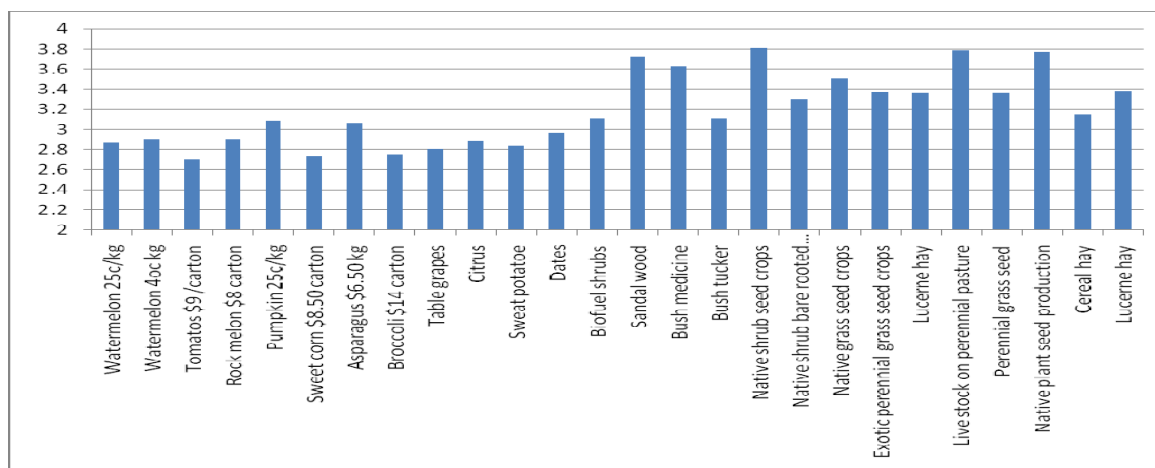
Sandal wood and cropping systems containing native plants for either seed, bush tucker or bush medicine are the most attractive of the perennial crops.

However there is limited knowledge of how to grow these native plants in commercial irrigation. These options should be tested and refined on a small scale before going into full production.

The early irrigation scheme proved that Wiluna can produce high quality citrus fruit that can attract a premium in the market.

This assessment must be presented to the local Wiluna people for their consideration. They may well put a different rating on these options. In the end it will be their decision as to what they grow. But this report should help to better inform their thinking.

Figure ; Combined ratings for enterprise options (score of 1 to 5)



Appendix 1

Climate data of yearly averages for Wiluna, Alice Springs AP, Carnarvon, Geraldton, Moora and Perth AP

(Data from Bureau of Meteorology)

Table 1.1; Site details from Bureau of Meteorology (BoM)

	Wiluna	Alice Springs AP	Carnarvon	Geraldton	Moora	Perth AP
Commencement date of records	1898	1940	1945	1941	1897	1944
BoM code for site	013012	015590	006011	008051	08091	009021
Latitude	26.59	23.80	24.89	28.80	30.60	31.93
Longitude	120.23	133.89	113.67	114.70	116.01	115.89
Elevation (m)	521	546	4	33	203	15

Table 1.2; Temperature (degrees C)

	Wiluna	Alice Springs AP	Carnarvon AP	Geraldton	Moora	Perth AP
Maximum temperature	29.2	28.7	27.1	25.8	25.6	24.4
Highest temperature	46.9	45.2	47.8	47.7	45.5	46.7
Number of days >= 30	173	173	85	80	96	74
Number of days >= 35	103	89	26	36	43	26
Number of days >= 40	31	15	6	9	9	4
Minimum temperature	14.2	13.2	17.1	13.6	11.9	12.1
Lowest temperature	-2.3	-7.5	2.4	0.5	-1.4	-1.3
Number of days <= 2 C	11	30	0	0.2	4.6	2.2
Number of days <= 0 C	2.4	12.4	0	0	0.4	0.2

Daily ground minimum temperature	13	9.7	15.2	11.5	-	10
Lowest ground temperature	-7.2	-12.4	-2.7	-4.7	-	-3.6
Number of days ground min. temp. <= -1 C	5.1	41.3	0.3	0.7	-	0.9

Table 1.3; Rainfall (mm)

	Wiluna	Alice Springs AP	Carnarvon AP	Geraldton	Moora	Perth AP
Annual rainfall	256	278	227	449	459	781
Highest rainfall	712	783	557	843	790	1165
Lowest rainfall	49	82	75	197	203	480
Decile 1 monthly rainfall	118	125	107	312	336	611
Decile 5 (median) monthly rainfall	224	238	207	445	453	785
Decile 9 monthly rainfall	423	455	351	610	595	962
Highest daily rainfall	125	205	103	109	143	132
Number of days of rain	42	43	40	87	92	113
Number of days of rain >= 1 mm	29	29	25	60	60	87
Number of days of rain >= 10 mm	7	8	6	13	12	27
Number of days of rain >= 25 mm	1.6	2.2	2	2.8	1.9	5.3

Table 1.4: Rainfall deficits

	Wiluna	Alice Springs AP	Carnarvon AP	Geraldton	Moora	Perth AP
Mean rainfall (mm)	256	278	227	449	459	781
Daily evaporation (mm)	6.6	8.7	7.2	6.7	-	5.6
Rainfall deficit	-2,153	-2,898	-2,401	-1,997	-	-1,263

Table 1.5; Wind speed (km/hr)

	Wiluna	Alice Springs AP	Carnarvon AP	Geraldton	Moora	Perth AP
Daily wind run in Km	-	253	528	467	-	394
9am wind speed	11	11	21	19	8	14
3pm wind speed	11	15	26	24	10	19

Maximum wind gust	-	174	178	143	-	124
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Table 1.6; solar energy

	Wiluna	Alice Springs AP	Carnarvon AP	Geraldton	Moora	Perth AP
Daily solar exposure (MJ/(m*m))	21.5	22.3	22.3	20.7	20.1	19.2
Number of clear days	186	199	211	164	126	139
Number of cloudy days	61	63	50	80	60	107
9am cloud cover (oktas)	2.2	2.4	2.6	3.2	3	3.6
3pm cloud cover (oktas)	2.7	2.8	2.2	3.1	3.3	3.7
Daily sunshine (hours)	-	9.6	-	-	-	8.8

Table 1.7; Humidity

	Wiluna	Alice Springs AP	Carnarvon AP	Geraldton	Moora	Perth AP
9am temperature	21.4	20.5	22.1	20.1	18	17.7
9am wet bulb temperature	14.1	12.8	17	15.2	13.9	13.8
9am dew point temperature	6.9	4.9	12.8	11	10.3	10.4
9am relative humidity (%)	44	42	59	61	64	65
3pm temperature	28.1	27.9	25.3	24.1	24.5	23
3pm wet bulb temperature	16.7	15.6	19.2	17.2	16.3	16
3pm dew point temperature	5.2	3.4	14.9	11.8	9.6	10.2
3pm relative humidity (%)	27	25	55	50	44	48

Table 1.8; Rainfall variability (mm)

	Wiluna	Alice Springs AP	Carnarvon AP	Geraldton	Moora	Perth AP
Mean rainfall	256	278	227	449	459	781
Decile 1 monthly rainfall	118	125	107	312	336	611
Decile 5 (median)	224	238	207	445	453	785
Decile 9 monthly rainfall	423	455	351	610	595	962
8 Decile range (80% of years)	305	330	244	298	259	351
8 Decile range as % of annual average rain	119%	119%	107%	66%	56%	45%

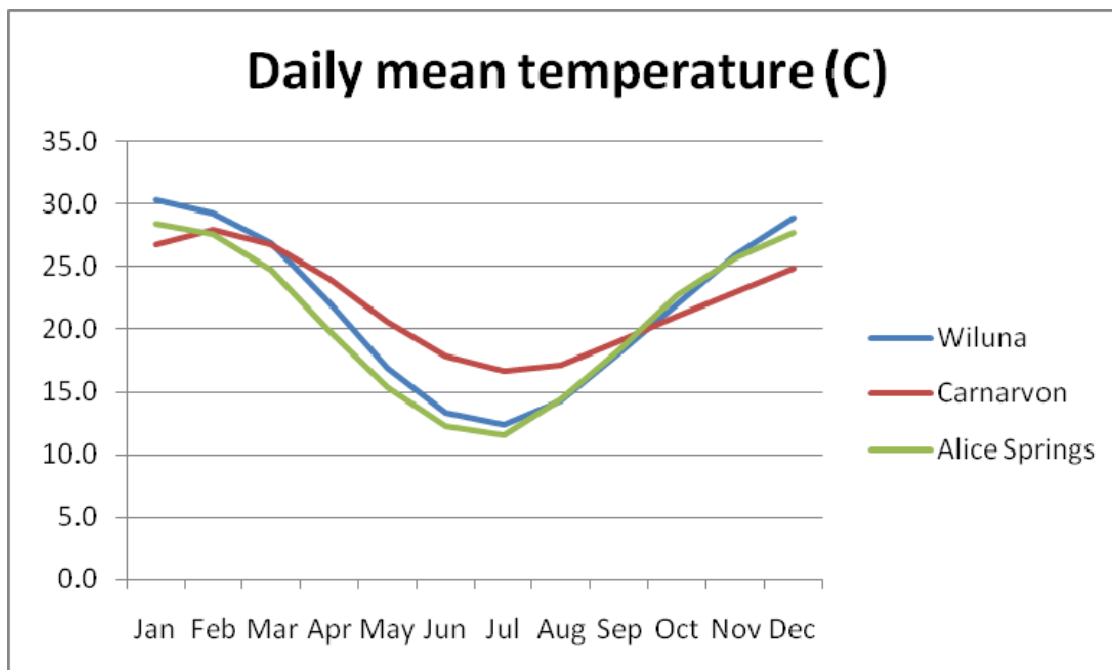


Table 1.9; Number of chilling hours and annual rainfall

chilling hours, = number of hours under 7.2°C.

Site	Chilling hours	Annual rainfall
Wiluna		
Bullsbrook	419	693 mm
Carnamah	469	392 mm
Carnarvon	123	256 mm
Cue	464	224 mm
Dalwallinu	551	357 mm
Dandaragan	496	598 mm
Eneabba	332	517 mm
Geraldton	310	468 mm
Jurien	305	560 mm
Kalbarri	223	383 mm
Meekatharra	437	218 mm
Mingenew	410	414 mm
Moorra	551	461 mm
Morawa	483	580 mm
Mount Magnet	469	234 mm
Mullewa	446	337 mm
Nabawa	446	455 mm
Northampton	296	429 mm
Paynes Find	519	270 mm
Perenjori	533	382 mm
Shark Bay	169	215 mm
Wongan Hills	610	349 mm
Yalgoo	501	209 mm
Yetna	396	480 mm

Table 2.1; Comparison of Bureau of Meteorology (BoM) site details with Wiluna

Site	Wiluna	Alice Springs AP	Carnarvon	Geraldton	Moora	Perth AP
Latitude (^o S)	26.59	+2.79	+1.70	-2.21	-4.01	-5.34
Longitude (^o E)	120.23	13.66	-6.56	-5.53	-4.22	-4.34
Elevation (m)	521	+25	-517	-488	-318	-506

Table 2.2; Comparison of Temperatures with Wiluna

	Wiluna	Alice Springs AP	Carnarvon AP	Geraldton	Moora	Perth AP
Mean maximum temperature	29.2	-0.5	-2.1	-3.4	-3.6	-4.8
Highest temperature	46.9	-1.7	+0.9	+0.8	-1.4	-0.2
Mean number of days >= 30	173	0	-88	-94	-78	-99
Mean number of days >= 35	103	-13	-76	-67	-60	-76
Mean number of days >= 40	31	-17	-25	-23	-23	-28
Mean minimum temperature	14.2	-1.0	+2.9	-0.6	-2.3	-2.1
Lowest temperature	-2.3	-5.2	+4.7	+2.8	+0.9	+1
Mean number of days <= 2 C	11	+19	-11	-10.8	-6.4	-8.8
Mean number of days <= 0 C	2.4	+10	-2.4	-2.4	-2	-2.2
Mean daily ground minimum temperature	13	-3.3	+2.2	-1.5	-	-3
Lowest ground temperature	-7.2	-5.2	+4.5	+2.5	-	+3.6
Mean number of days ground min. temp. <= -1 C	5.1	+36	-5	-4	-	-4

Table 2.3; Comparison of Rainfall with Wiluna

	Wiluna	Alice Springs AP	Carnarvon AP	Geraldton	Moora	Perth AP
Mean rainfall	256	+22	-29	+193	+203	+525
Highest rainfall	712	+70	-156	+131	+78	+453
Lowest rainfall	49	+33	+27	+149	+154	+431
Decile 1 monthly rainfall	118	+7	-11	+193	+217	+493
Decile 5 (median) monthly rainfall	224	+14	-17	+222	+229	+561

Decile 9 monthly rainfall	423	+32	-72	+187	+172	+539
Highest daily rainfall	125	+80	-22	-15	+18	+7
Number of days of rain	42	+1	-1.4	+44.9	+49.6	+71.4
Number of days of rain >= 1 mm	29	+0.4	-3.6	+31.2	+31.5	+58.1
Number of days of rain >= 10 mm	7	+1.1	-0.4	+6.2	+5.2	+20
Number of days of rain >= 25 mm	1.6	+0.6	+0.4	+1.2	+0.3	+3.7

Table 2.4; Comparison of Rainfall deficits (mm) with Wiluna

	Wiluna	Alice Springs AP	Carnarvon AP	Geraldton	Moora	Perth AP
Mean rainfall	256	+22	-29	+193	+203	+525
Daily evaporation	6.6	+2.1	+0.6	+0.1	-	-1
Annual evaporation	2,409	+767	+219	+37	-	-365
Rainfall deficit	-2,153	-745	-248	+156	-	+890

Table 2.5; Comparison of Wind speed (km/hr) with Wiluna

	Wiluna	Alice Springs AP	Carnarvon AP	Geraldton	Moora	Perth AP
9am wind speed	11	-0.1	+9.8	+7.9	-2.4	+3.2
3pm wind speed	11	+4.2	+15	+13.5	-0.3	+8

Table 2.6; Comparison of Solar energy with Wiluna

	Wiluna	Alice Springs AP	Carnarvon AP	Geraldton	Moora	Perth AP
Daily solar exposure (MJ/(m*m))	21.5	+0.8	+0.8	-0.8	-1.4	-2.3
Number of clear days	186	+13	+25	-22	-60	-48
Number of cloudy days	61	+3	-11	+19	-1	+47
9am cloud cover (okas)	2.2	+0.2	+0.4	+1	+0.8	+1.4
3pm cloud cover (oktas)	2.7	+0.1	-0.5	+0.4	+0.6	+1

Table 2.7; Comparison of Humidity with Wiluna

	Wiluna	Alice Springs AP	Carnarvon AP	Geraldton	Moora	Perth AP
9am temperature	21.4	-0.9	+0.7	-1.3	-3.4	-3.7
9am wet bulb temperature	14.1	-1.3	+2.9	+1.1	-0.2	-0.3
9am dew point temperature	6.9	-2	+5.9	+4.1	+3.4	+3.5
9am relative humidity (%)	44	-2	+15	+17	+20	+21
3pm temperature	28.1	-0.2	-2.8	-4	-3.6	-5.1
3pm wet bulb temperature	16.7	-1.1	+2.5	+0.5	-0.4	-0.7
3pm dew point temperature	5.2	-1.8	+9.7	+6.6	+4.4	+5
3pm relative humidity (%)	27	-2	+28	+23	+17	+21

Wiluna climate compared to Alice Springs AP, Carnarvon, Geraldton, Moora and Perth AP

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Mean number of days >= 35	103	-13	-76	-67	-60	-76
Mean number of days >= 40	31	-17	-25	-23	-23	-28
Mean minimum temperature	14.2	-1.0	+2.9	-0.6	-2.3	-2.1
Lowest	-2.3	-5.2	+4.7	+2.8	+0.9	+1

temperature						
Mean number of days <= 2 C	11	+19	-11	-10.8	-6.4	-8.8
Mean number of days <= 0 C	2.4	+10	-2.4	-2.4	-2	-2.2
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Number of days of rain >= 25 mm	1.6	+0.6	+0.4	+1.2	+0.3	+3.7

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9am wet bulb temperature	14.1	-1.3	+2.9	+1.1	-0.2	-0.3
9am dew point temperature	6.9	-2	+5.9	+4.1	+3.4	+3.5
9am relative humidity (%)	44	-2	+15	+17	+20	+21
3pm temperature	28.1	-0.2	-2.8	-4	-3.6	-5.1
3pm wet bulb temperature	16.7	-1.1	+2.5	+0.5	-0.4	-0.7
3pm dew point temperature	5.2	-1.8	+9.7	+6.6	+4.4	+5
3pm relative humidity (%)	27	-2	+28	+23	+17	+21

Appendix 2

Criteria used for assessing enterprise options

Limitations to achieving potential yield

Climate suitability

- Temperature
- Humidity
- Frost tolerance
- Chill factor

Soil suitability

- pH
- Toxicities
- Nutrient requirements

Potential pests and diseases

Markets

Harvest timing and seasonal price variability

Timing of crop for market shortages

Local markets vs. export markets

Price

- \$/kg (e.g. freight)
- \$/ha
- \$/l
- \$/hour of labour

Water use efficiency

- l/ha
- l/\$\$ produce
- Drought tolerance of perennial crops (i.e. can crop be put on to low 'maintenance' watering)
- Drip vs. sprinkler vs. flood irrigation

Energy efficiency

Assumption is that fossil fuel energy costs will increase dramatically over the next two decades – peak oil

- Water use efficiency l/ha (energy costs of pumping water)
- \$ /kg of produce trucked out (i.e. high value /kg produce has much lower transport costs)
- Kg inputs trucked in
- Kg N fertiliser /ha (i.e. N fertiliser directly linked to oil price)
- L fuel / ha
- Refrigeration requirements

Soil fertility

Nitrogen fertiliser requirements

Crop increases or decreases in soil fertility

Potential for legumes in rotation

Potential for over cropping perennial legumes or grasses to increase soil fertility

Flexibility of harvest

Length of harvest window for crop

Flexibility of timing of planting and harvesting the crop

Flexibility of crop rotations

Annual vs. perennial

Years to full production of perennial crops

Compatibility for companion cropping

Specialisations of machinery for cropping and processing

Labour distribution

Distribution of workload over the year (more even is better)

Flexibility of timing of management tasks

Job satisfaction

Level of input in to decision making by staff

Opportunities for staff to learn

Diversity of task in crop production (i.e. wider range of job types to allow more people to participate)

Level of physical effort required

Culturally significance of crop

???

Diversity

- Markets
- Long term economics and energy costs
- Labour

Ecosystems

Susceptibility to pest and diseases (i.e. need for chemicals)

Diversity of plant types

Hosts for pest predators

Perenniality of plants

Biosecurity

Potential insect threats

Potential disease threats

Potential to eradicate new disease or insect infestation

Cultural commitments

Flexibility of

- planting
- watering
- harvesting

i.e. how long could a practise be delayed without averse affects in response to people's commitments to sorry business etc

Clashes of major crop management with cultural commitments of Martu people

Inputs

\$/ha

Reliance on oil based inputs

Potential for 'organic system'

Soluble fertiliser requirements

Nitrogen requirements

Insect and disease tolerance

Legume, or allowing legume in rotation

Mycorrhizal compatibility

Biosecurity

Potential disease threats

Potential insect threats

Transport costs
Refrigeration
Perishability
\$/kg

Processing requirements
Level of on site processing
Specialisation of processing equipment
Cost of processing equipment
Potential for value adding

Value adding
Opportunity to value add locally

Perish ability
Shelf life without refrigeration
Shelf life with refrigeration
Spoilage rates

Cultural significances
Local native species
Management task have traditional basis
Opportunities for local art / artefacts
Opportunities for communal / group tasks
Opportunities for father/son, mother/daughter tasks

Personal growth and empowerment
Diverse task that suit a range of local people
Opportunities for staff to control / make decisions over their jobs

Economic
Initial capital out layer (\$/ha)
Time to first harvest
Operating costs (\$/ha, \$/kg)
Income (\$/ha, \$/kg)
Gross margin (\$/ha, \$/l water)
ROI
Transport & marketing costs (\$/kg)
Energy costs (\$/kg)
Risk, sensitivity analysis

Environmental impacts
Chemical use
Pest and disease risks
Habitat value
Soil carbon / soil biology impact

Appendix 4

Gross Margins

	Watermel on 25c/kg	Watermel on 40c kg	Tomatoes \$9 /carton	Rock melon 90 c/kg	Pumpkin 25 c/kg	Sweet corn \$8.50 carton	Asparags \$6.50 kg	Broccoli \$14 carton	Table grapes \$12.50 kg
Price	\$ 0.25	\$ 0.40	\$ 0.90	\$ 0.90	\$ 0.25	\$ 0.50	\$ 6.50	\$ 1.75	\$12.75
Gross Margin \$/ha	\$1,800	\$5,821	\$5,320	\$1,612	\$1,557	\$1,036	\$1,883	\$ 2,275	\$ 3,934
Gross Income \$/ha	\$7,500	\$12,000	\$45,000	\$15,200	\$ 6,250	\$ 8,500	\$20,010	\$11,200	\$21,000
\$/ML of water	\$ 233	\$ 728	\$ 887	\$ 403	\$195	\$129	\$ 235	\$375	\$ 280
Water use efficiency ML/ha	8	8	6	4	8	8	8	6	8

Note - the prices quoted may no reflect the current WA market