



Open Hydroponics : Risks and Opportunities Stage 1

**3rd December 2004, Mildura, Workshop
Report**

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Acknowledgements

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Workshop Aim

The aim of the workshop was to:

- Update and discuss the results of the project with team members, affiliated contributors and nominated stakeholders
- Develop recommendations for stage two of the project

Workshop Outline

A full outline of the program and attendees is provided in appendix A. To provide all participants an opportunity to view an operational Open Hydroponics System, Yandilla Park, Matinez Open Hydroponics Technology (MOHT) citrus orchard was visited in the morning. The formal proceedings of the workshop commenced at 10 a.m. at the Mildura Grand hotel. The following presentations were made to outline the current findings of the project:

- General principles and literature review: Steven Falivene (NSW DPI)
- Water, nutrient and salt balance: Ian Goodwin (DPI Vic)
- Impact on water supply: David Williams (NSW DPI)
- Ecological risk assessment: Robert Faggian (DPI Vic)

Richard Stirzaker (CSIRO) provided a supplementary presentation of his experiences with Open Hydroponics in South Africa. All presentations were followed by about 10 minutes of question time to query and discuss the findings.

The discussion and planning session of the workshop occurred after lunch. This session was facilitated by Jayne Sunbird (Sunbird Enterprises) and focused on discussing the findings and developing a plan for stage two of the project. The first part of the session conducted a S.W.O.T. analysis on the current knowledge and state of Open Hydroponics. A three-part gap analysis was then conducted. The first part of the gap analysis identified the unknowns and deficiencies, the second part identified strategies to address these unknowns and deficiencies, and the third part grouped the strategies into main headings. Following the gap analysis a short presentation was made outlining the project teams recommendations for stage two of the project. The project team recommendations were incorporated into the strategies developed by the group and these were prioritised in order of importance. The workshop concluded with a short discussion of the next steps for the completion of stage one of the project.

Workshop Sessions

Farm Visit

A farm visits to Yandilla Park MOHT citrus orchard (farm 8) occurred from 7:30am to 9:45am.

The main injection facilities were first inspected. All participants were able to get a good overview of the kind of infrastructure required for a large sized orchard. Of special interest were the numerous occupational health and safety requirements for the storage and handling of fertilisers and chemicals.



Figure 1: Workshop participants inspecting fertigation equipment

The orchard was visited and the participants were able to inspect mature trees. The root zone underneath one of the trees was surface excavated and a high density of roots were found directly under the dripper (Figure 2). The main portion of roots was observed to extend 25 to 30 centimetres radially from the dripper outlet.



Figure 2: Soil excavation under the dripper of a navel tree managed by MOHT

Participants were taken to a field lysimeter (Figure 3). The lysimeter is being used to monitor drainage.



Figure 3 : Field lysimeter at Yandilla Park MOHT orchard to monitor drainage

Project Findings Presentations

A series of presentations outlining the main findings of the project were presented at the indoor session of the workshop. A copy of the presentations is provided in appendix C. More detail of the information presented during these sessions can be sourced from the individual reports; Literature Review, Water Nutrient and Salt Balance, Water Supply Assessment and Ecological Risk Assessment. The following is a brief summary of the presentations.



Figure 4 : Participants attending the indoor session of the workshop

Literature Review

The literature review outlined the main principles and practices of Open Hydroponics production. The review was not meant to validate any of these practices, but only present them in an unbiased manner. Since minimal printed information is available about Open Hydroponics, the majority of information was sourced by discussion with Open Hydroponics consultants and farm inspections. The literature review highlighted that Open Hydroponics is a very intensive programme that requires a high degree of skill to operate and manage. All Open Hydroponics orchards in Australia currently use a consultant to provide direction and assistance in management. Even though growers use consultants, a high degree skill is required by the grower to conduct the daily management practices for Open Hydroponics (fertiliser mixing, injection rate timing, computer operation, irrigation scheduling, etc). Increased levels of production have been reported in overseas experiences, however it is difficult to conclude the possible production gains in Australian conditions and whether all, or parts of an Open Hydroponics production system contributes to productivity improvements.

Water Nutrient and Salt Balance

Simulated case studies of the irrigation requirement, drainage, soil water content, nutrient leakage and salt accumulation in the root-zone of a hypothetical Open Hydroponics citrus orchard in a Sunraysia were presented. The soil water balance method and the assumptions employed in this study were explained. The tree water use model used in the soil water balance was discussed in considerable detail because of the sensitivity of irrigation, nutrient leakage and salt accumulation to tree water use. Two Open Hydroponics designs were presented. The first consisted of a single drip line with closely spaced emitters. The second design consisted of twin drip lines with emitters spaced further apart. The effects of continuous, daytime (12 and 14 h) and pulse (1 h on 0.75 h off) irrigation on drainage and root-zone soil water content were compared. Simulations highlighted the need for flexible management and appropriate design to match tree water use so drainage is minimised and periods of water stress are avoided. Pulse irrigation appeared to have advantages because the frequency of pulses can be altered according to tree water use. An Open Hydroponics triggered to irrigate when the soil water content reached a threshold was presented and discussed. The conclusion was that such a system is ideal but difficult to implement.

A best practice continuous nutrition program for citrus was used to simulation nitrate accumulation in the root zone over a 12-month period. A range of tree uptake efficiencies was compared. Predictions showed that at 90 % uptake approximately 60 kg/ha of nitrate remained in the root zone. This compared with 6-fold more nitrate at 40% uptake. Suggestions were made about the potential leakage of nitrate from the root zone during rainfall events. Similarly root zone salinity was simulated based on the nutrition program and irrigation water salinity. Results presented showed the build up of salt above the threshold for yield decline in citrus even at 100 % uptake efficiency. Leaching fractions from 5 to 8 % (depending on uptake efficiencies) at each irrigation were calculated to maintain root zone salinity below the yield decline threshold.

Ecological Risk Assessment

Ecological Risk Assessment (ERA) is the process of defining and quantifying risks to non-human biota and determining the acceptability of those risks. The aim of ERA is to contribute to the protection and management of the environment through scientifically

credible evaluation of the ecological effects of human activities. Important components of an ERA are 1) defining what 'the environment' is; 2) devising methods to characterise the state of the environment and quantify changes and 3) determining what constitutes a significant change and 4) evaluating the importance of uncertainties/assumptions in the risk assessment.

During Stage 1 of the project, a workshop on Ecological Risk Assessment (funded by the National Program for Sustainable Irrigation) was held (October 20th 2004) to explore the benefits of ERA to Open Hydroponics Scheme decision-making (in conjunction with Professor Barry Hart, Monash University and Dr Terry Walshe, the University of Western Australia). Workshop participants identified a number of direct or indirect factors resulting from Open Hydroponics that have the potential to affect local ecosystems (for example, turbidity, salinity, pH and nutrients). However, while many common risks and hazards were agreed upon, other more disparate risks were also identified that were based more on personal experience than scientific data. This served to highlight the difficulty in identifying risks in an ecological system and in evaluating the importance of uncertainties and assumptions when background data may be incomplete.

One means of characterising and quantifying uncertainty is with a Bayesian Network. Bayesian Networks are graphical models that find probabilistic relationships among variables within a system to facilitate decision-making with probability data. Bayesian Networks are used to estimate the probability of an event or effect on a system, based on observations of the pre-existing state of the system, and are capable of utilising both qualitative and quantitative data.

Data generated at the ERA workshop was used to create a number of conceptual models, which identified the relationship between a single potential hazard, the Open Hydroponics and the assessment endpoint and enabled a simple risk assessment to be conducted on the impact of Open Hydroponics. It is recommended that these simple assessment models be expanded to incorporate all significant risks and therefore provide the framework for the development of a Bayesian Network for Open Hydroponics ecological risk assessment.

Water Supply Assessment

Four regions were surveyed for the ability of water service providers to meet Open Hydroponics water requirements. The water service providers surveyed were Lower Murray Urban and Rural Water Authority (Interviews were conducted at the former Sunraysia Rural Water Authority, Irymple, Victoria); Western Murray Irrigation Limited; Dareton, New South Wales; Goulburn-Murray Water, Tatura, Victoria and Murrumbidgee Irrigation, Leeton, New South Wales. The main conclusion of the survey was that a high majority of horticultural properties could be supplied with water to operate Open Hydroponics. However the ease in which the water can be supplied is dependent on the delivery system within the district.

Western Murray Irrigation has a completely pressurised system and with some minor changes to water ordering programs, Open Hydroponics could be used on all horticultural properties delivered by the system. It was identified that over two thirds of the irrigators in the Lower Murray Irrigation scheme were private diverters and could therefore access

water with reasonable confidence. Horticultural enterprises on a channel system had a higher degree of difficulty to meet Open Hydroponics water supply demands, however a high proportion of channel systems could meet Open Hydroponics if water ordering was slightly modified in management and coordination to accommodate Open Hydroponics orchards. The study identified that it should not be a problem if only a few growers or if all growers adopted Open Hydroponics within a channel system. A problem may exist when only a portion (30-70%) of growers adopted Open Hydroponics within a channel system. A more detailed investigation is required to study the hydrology and engineering complexities of the adoption of Open Hydroponics within a channel system.

The study also highlighted that a water supply risk management strategy will need to be adopted by growers. Breakdowns and stoppages due to maintenance of the system will cause a disruption in water supply. On-farm water storage was identified as one strategy to address this risk if constructed and sited correctly to minimise seepage and evaporation.

South Africa Experience

The session ended with a presentation by Richard Stirzaker (CSIRO Canberra) of his experiences in South Africa with Open Hydroponics. Richard discussed the adoption of Open Hydroponics by a number of horticultural enterprises. The main impact of the adoption of Open Hydroponics was that it raised the grower's awareness of the implications of their cultural practices. The growers began to question the performance of their practices and most importantly began to measure their performance. Measurements included yield, fertiliser application and water application. This measurement was seen as a major improvement because the growers were now able to quantify their production system. Since the growers had a common interest in Open Hydroponics, it brought them together to discuss issues and identify solutions collectively. One of the benefits that Open Hydroponics brought to these growers was that it developed a mechanism where they could identify problems and work through appropriate solutions.

Planning Session

S.W.O.T Analysis

The S.W.O.T. analysis was conducted to generate some broad thinking of issues with Open Hydroponics. The analysis provided background information for the GAP analysis.

Strengths

- User feedback is that it works
- Open Hydroponics – good start for collection of information
- Potential to reduce spatial variability – removes the effects of soil variability
- Works in low rainfall areas
- Efficiency in water use (claimed) – more tonnage with same water
- Driver for best practice management
- Driver for improved irrigation methods
- Drip irrigation has good credibility
- Forces users to think and talk quantitatively with both water and nutrition
- Forces integration of all aspects of crop management.

Weakness

- Got to get everything right ie system design, management
- Does not work in wetter areas (high rainfall)
- Initial cost
- Lack of nutrition knowledge
- Grower skills need to be higher
- Complex, needs intensive management
- Planning for a reliable water supply
- No requirement to adhere to a farm dam standard
- MOHT is intellectual property and is privately owned

Threats

- Failure of farm dams (on farm water storage)
 - o Leakage and seepage losses (economic and environmental cost)
- Divergence of ideas from science and industry
 - o New theories of crop management and physiological mechanisms
 - o Mystery of Open Hydroponics is a key part of consultant business
- If we do nothing will there be half baked attempts with resulting problems
 - o Bad reputation for a good system due to poor practice
 - o Environmental impact (but is it any worse than any other system that is poorly run?)

Opportunities

- Improve productivity in Australian horticultural crops
- Addresses “triple bottom line”
- Expansion to other irrigated crops
- Potential to increase quality
- Improve knowledge with both Australian research and extension in the area of Open Hydroponics and fertigation.
- Encourage and develop new management tools
 - o Growers conducting their own “demonstration” trials to fine tune their system (e.g. apply half and double the water and fertiliser rates to a small number of trees to check if the normal rates are appropriate)
 - o Learning tool
- Forces scientists to think more holistically

Issues raised by the group

- Perhaps we should not duplicate existing work and research between private and public sector.
- Conduct experiments on work already underway in the private sector by identifying key research questions

Gap Analysis

Gap Analysis Pt 1 – Unknowns and Deficiencies

What are the unknowns and deficiencies (knowledge, experience, understanding, risks etc) in Open Hydroponics principles and practices?

First Priority Gaps

1. No proper quantification of Open Hydroponics suitability/availability
2. Soil water interaction – water uptake theories
3. Soil nutrient interactions and crop uptake timings not understood
4. Nutrient leakage of Open Hydroponics as compared to other conventional systems
5. Do we need a new production model or is perfection of existing knowledge only required?
6. Need more science to clarify principles and terms,
 - o stay faithful until they are proven wrong. (we should not make claims until they are scientifically proven)
7. Open Hydroponics training for growers and extension officers
 - o Basic knowledge/daily management skills to manage Open Hydroponics
8. Independent economic analysis for Open Hydroponics benefit
9. Sustainability

Second Priority Gaps (Desirables)

1. Soil born pathogens – soil ecology and risk of promoting unfavourable pathogens
2. Nutritional effects on fruit composition
3. Soil structure decline
4. Open Hydroponics effect on heavier soils

Gap Analysis Pt 2 – Strategies

Identify a strategy/activity to address the unknowns/deficiencies (dot point only)

1. Consultation with water authorities to increase awareness. Work with a selected water authority to examine the ability of a district to gradually convert to Open Hydroponics under a range of conditions (compare pressure and channel systems).
2. Soil water interaction not properly understood.
 - i. Establish working partnership between research and Open Hydroponics consultants
 - ii. Pool skills and understanding on analysing real data on soil water and nutrient transport and uptake.
3. An assessment of the risk of soil borne pathogens under Open Hydroponics needs to be investigated.
4. Assess available data and get new data. Evaluate by modelling. Promotion and education of Open Hydroponics to change perception especially leakage.
5. On farm data collection. Critical review of anecdotal claims. Define potential crop yield by utilising existing growth modelling. Research station trials are only a second option if on-farm data collection and collaboration with commercial operators are unable to provide sufficient data.

6. Training - Develop and initiate a knowledge broker program on Open Hydroponics for raising grower awareness and skills. Define understanding and purpose of training and screening of growers
7. Trial on a heavy soil site. Collate existing knowledge of trials on options / alternatives eg peat
8. Undertake economic analysis
9. Establish communication links to collate nutritional audit data for comparison to conventional systems. Make recommendations on new knowledge requirement to funding bodies
10. Ecological Risk Assessment

Issues Raised by the Group

Minimal information is available on the nutrient uptake rates of various crops at key physiological periods and the effects of nutrition on fruit quality. Funding bodies should be alerted by written correspondence that the group identified an important need for more work on nutrient crop uptake so Open Hydroponics and other fertigation management programs can be better utilised to meet crop requirements.

Gap Analysis Pt 3 – Grouping of Strategies

Group the strategies into main headings (eg extension, commercial orchard research, research station trial, information review etc)

The grouping exercise was not conducted because a significant degree of grouping and prioritising of strategies was already conducted on the previous section. After ideas from the project team was presented (appendix B), a general discussion took place on the logical procedure for which the next steps should take place if stage two of the project proceeds. The order is as follows:

1. Form the working relationships between private and public sectors
2. Review existing knowledge
3. Generate new knowledge based on gaps / need
4. Awareness and promotion
5. Further work including second priority gaps

Appendices

Appendix A – Workshop Program

Open Hydroponics Workshop

9th December, 2004, Grand Hotel Mildura

Program

Attendance: Hugh Campbell (CSU), Arthur Edwards (Yandilla Park), Robert Faggian (VIC DPI), Steven Falivene (NSW DPI), Ian Goodwin (VIC DPI), Ian Matherson (Lower Murray Water), Michael Sautner (Western Murray), Gerrit Schrale (SARDI), Richard Stirzaker (CSIRO), Jayne Sunbird (Sunbird Enterprises), Clare Kellaiher (HAL representative), David Williams (NSW DPI)

8:00am	Departing Grand Hotel Mildura to visit the Yandilla Park MOHT (Possibility of a 7:30am start)
9:05am	Depart orchard to return to Mildura
9:45am	Arrive at Grand Hotel from Open Hydroponics tour
9:45am	Registration Rio Vista room Grand Hotel Mildura
10:00 – 10:10am	Group introduction and overview of project objectives and workshop plan and aims: Steven Falivene (NSW DPI)
10:10 – 10:35am	General principles and literature review: Steven Falivene (NSW DPI)
10:35 – 10:45am	Questions
10:45 – 11:05am	Water Nutrient and salt balance: Ian Goodwin (VIC DPI)
11:05 – 11:15am	Questions
11:15 – 11:30 am	Impact on Water Supply : David Williams (NSW DPI)
11:30 – 11:40 am	Questions
11:40 – 12:00am	Ecological Risk Assessment : Robert Faggian (VIC DPI)
12:00 – 12:10pm	Question
12:10 – 12:25pm	South Africa Experience : Richard Stirzaker (CSIRO)
12:25 – 12:30pm	Questions
12:30pm	Lunch
1:20 – 1:30pm	Introduction : Facilitator - Jayne Sunbird
1:30 – 2:00pm	SWOT analysis

2:00 – 2:45 pm	Gap Analysis Pt 1 – What are the unknowns and deficiencies (knowledge, experience, understanding, risks etc) in Open Hydroponics principles and practices in relation to stage 2?
2:45 – 3:00 pm	Gap Analysis Pt 2 – Identify a strategy/activity to address the unknowns/deficiencies (dot point only)
3:00 – 3:10pm	Tea Break
3:10 – 3:30pm	Gap Analysis Pt 3 – Group the strategies into main headings (eg extension, commercial orchard research, research station trial, information review etc)
3:30 – 3:45pm	Open Hydroponics Project Officers suggested recommendations (S. Falivene, NSW DPI)
3:45 – 4:20pm	Link workshop strategy plan with Open Hydroponics Project officers recommendations to form single list of strategies for Stage 2 of the project. Prioritise list.
4:20 – 4:30pm	Next Steps - Outline the outputs/activities for completion of stage 1 of the project and development of stage 2 project proposal.

Appendix B – Project Team Suggestions

Open Hydroponics Project

Suggested Recommendations by Project Team

Mildura Workshop, 9th December 2004

- Detailed **Ecological risk assessment** – basian networks, involvement with environmental policy makers and regulators
- **Information & Extension**
 - o Economic Analysis
 - o Technical information collation – production practices & management issues (study tour) & more detailed literature review of specific Open Hydroponics principles and hypothesis (eg. soil, water, crop physiology etc)
 - o Best Management Practice Guidelines, speciality courses, factsheet – basic competency in specific tasks for Open Hydroponics (mixing fertilisers, basic compatibilities, identifying problems). Need research trial to gain knowledge & experience
 - o Industry information – Update water service providers and other sectors of the industry with Open Hydroponics information - seminars and media
 - o More detailed information/investigation about water supply issues and on farm water storage practices
- **Research**
 - o **Commercial Open Hydroponics Orchards** (limited due to commercial sensitivities)
 - Yield and productivity
 - Measure deep drainage and nutrient content in drainage water (i.e. CSIRO/Yandilla drainage probe)
 - Irrigation scheduling – enviroscan
 - Tree water use – sap flow meter, infrared canopy temperature meter
 - Monitor soil moisture zones in within wetted area – logging tensiometer of single tensiometers
 - Soil analysis – EC, pH etc
 - o **Research Station** (suggested for Dareton ARAS)
 - Test selected hypothesis – eg. is Open Hydroponics different from IFP,
 - Include tests in Commercial orchard study
 - More intensively study selected detailed Open Hydroponics principles – eg. soil buffering capacity, nutrition practices
 - Opportunity to gain knowledge and experience for extension workshops, seminars and improve production practices. Start the learning curve!
 - Possible benefits to conventional horticulture

Appendix C – Presentations

Basic Principles & Literature Review

**Open Hydroponics
Risks & Opportunities**

**General Principles
Literature Review**



NATIONAL PROGRAM FOR
Sustainable Irrigation

Cooperative Research Centre for
IRRIGATION FUTURES

www.irrigationfutures.org.au

Introduction



- Just because we do not understand a principle it does not mean that it is wrong, or right
 - Let it be judged after adequate information, knowledge and understanding is gained.
 - If not all is understood, then investigate further

2

Introduction



- Full information in report – Draft only
 - seek your feedback
 - Information sourced mostly from discussions, seminars notes and a few research papers
 - Respect commercial sensitivity
 - The report presents the principles, does not validate the principles
 - basic interpretation is provided

3

Principles



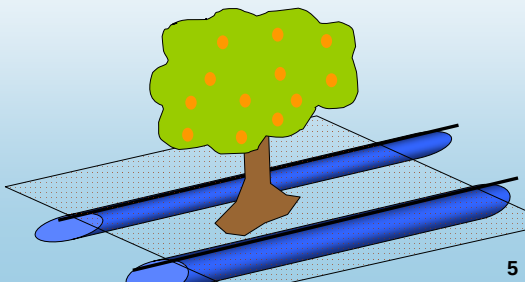
- Open Hydroponics Systems (OHS) is the adaptation of commercial artificial media crop production to field horticulture
 - Reduce the effect of the soil to store or supply nutrients and water. – Restricted root zone
 - Constantly maintaining soil moisture levels near or above field capacity
 - Providing a constant supply of nutrition (macro & micro) through a balanced nutrient solution.

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Conventional Root Zone



- Conventional wetted strip (20-35% soil volume)



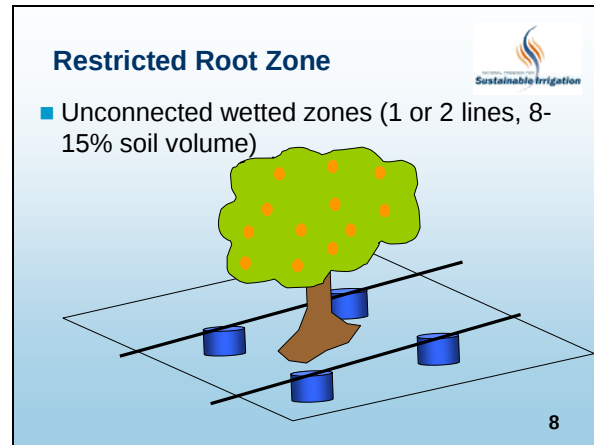
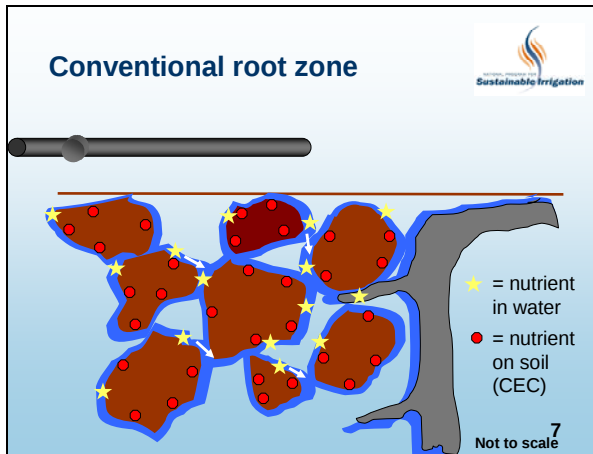
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Conventional Root Zone



- All soils have different abilities to store, buffer and release nutrients (CEC).
 - As nutrients are added to the soil solution, some nutrients “lock-up” to soil particles. Some of these nutrients are slowly released back into the soil solution, some are not released.
- Base soil fertility will contribute to nutrition and growth of tree.

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Restricted Root Zone

Purposes

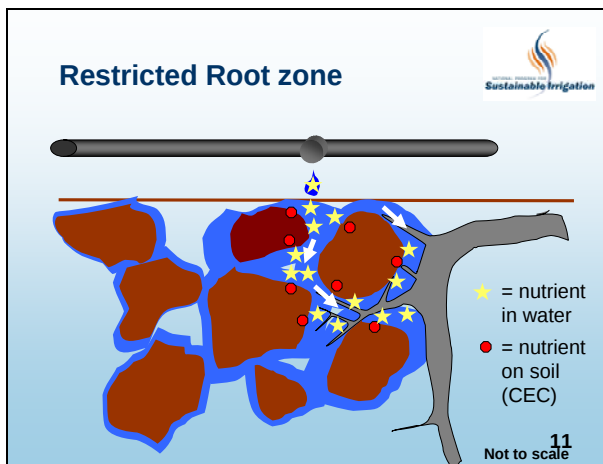
- Less soil volume; able to change nutrient concentrations and ratios in the soil solution – higher degree of nutrient control
 - Quicker change - manipulate nutrient ratios in the soil solution to suit/control physiological growth stages (i.e. drop N during fruit set etc.)

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Restricted Root zones

- Soil has reduced influence as a nutrient buffer and as a mine,
 - Applied nutrients/water are taken up by tree within the day. Need daily supply.
 - A greater emphasis on supplying all nutrients by fertigation (NPK & micro mix) – no mine/store.
 - Greater pH control
 - Sunraysia sandy soils well suited – low nutrient buffer capacity (CEC).

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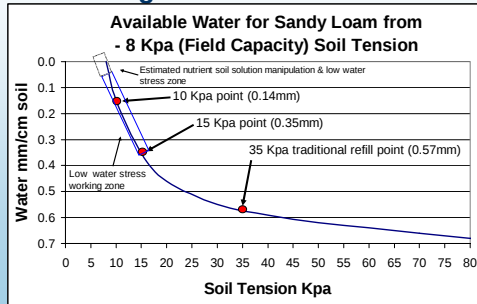


Water Management

- Keep moisture near, or above field capacity
- Why - Hydroponics
 - Work with the soil solution, not with the buffering capacity of the soil
 - Reduce buffering capacity of soil –
 - Other benefits of nil water stress
 - MOHT indicate that above field capacity (zero soil tension) better uptake water than F.C. (3kpa)

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Water Management



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Water Management

How to achieve high soil moisture levels

- Pulsing - Kruger
 - pulse irrigation 8-12 times per day when ever soil moisture levels reach 10%RAW.
- Continuous - MOHT
 - low application (0.5mm/hr) to meet daily demands (also use pulsing to meet plant water needs)
 - Aim to keep water near saturation,
 - supply enough oxygen – zones of wetness, low application, night drainage.
 - roots are healthy at Farm 8 directly under dripper

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Water Management

- High degree of skill to schedule irrigation
- All OHS growers use capacitance probe to monitor irrigations
- Current OHS farms are not using excessive water : 7-8ML/ha per annum
 - Possibly more efficient irrigation than conventional drip irrigators because of a need to intensively monitor soil moisture

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Nutrition

- Higher application rates to match and encourage higher vigour and productivity
- Since no soil mine of nutrients, higher emphasis on applying complete crop/tree removal rates.
- Supply a balanced mix of macro & micro
- MOHT emphasis ionic balance
 - energy for uptake & pH control

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Nutrition

- Optimum uptake conditions : always maintain high soil moisture for better movement and uptake of nutrients
 - Focus is on nutrients in the soil solution rather than nutrient held on soil particles
- pH buffering of water important to maximise nutrient uptake
 - P and most micro nutrients

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Nutrition

- Higher application rates have higher risk of nutrient imbalances (rough, colour delay)



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Publications



- Reviewed hydroponic, irrigation and fertigation research papers
 - Gave insight, but OHS is different
- Four papers dealing OHS
 - Bravdo – restricted root zone trial found benefits only very high yield, transition period
 - 2 x Kruger – higher yields, but early experiment show low yields for restricted root zone (same Bravdo)
 - Martinez – higher yields, soil saturation management & ionic balance

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Equipment



- System \$50,000 - \$100,000 for injection system only



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Intensive Fertigation Practices



- Other option using OHS principles, but less intensive
 - Conventional root zone
 - About 50% RAW irrigation
- Increasing in use and also reporting high productivity
- OHS should not be investigated in isolation
 - OHS is one option for growers in a number of systems with differing degrees of complexity. System needs to match grower skill level

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Risks



- Low water holding capacity / water supply during the day
- Soil effects (pH, salinity etc)
- Nutrient balance – crop quality
- Management – irrigation, nutrition & other

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Productivity



- Reported increase in productivity of yields 60-70t/ha
 - Difficult to properly assess since most from OS data in a different climate, soil, rootstock, planting density and variety.
- OHS in Australia – Yandilla since 1999
 - Reported a increase in average marketable yield through less alternate bearing
 - Still early days, but positive indications

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Hypothesis



- Does / how much, OHS provide greater net returns than IFP or other conventional practices?
- Many technical questions / unknowns
 - Soil buffering capacity soil, pH
 - Conventional vs restricted root zone
 - Water status: Saturation vs F.C. vs 50% RAW
 - Ionic balance

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Conclusion



- OHS is an exciting opportunity to promote production practices that will possibly improve productivity and increase water use efficiency
- Requires higher skill level management
- One choice from a variety of systems
- Only expertise is with commercial providers & overseas
 - little expertise by public researchers/extension in Australia

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Conclusion



- Need to build knowledge and understanding in Australia
 - Knowledge & training for growers and industry
 - Benefits to IFP and conventional
- Investigations on commercial OHS properties and research station trials to begin building a knowledge base in "Australia"
 - Further scientific studies, investigations

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Acknowledgements (NPSI funding)



- Contributors – consultants and growers
- Project Team
 - Ian Goodwin (VIC DPI), David Williams (NSW DPI), Dr Anne-Maree Boland (VIC DPI.)
 - In kind contribution from CRC IF affiliated institutions to provide studies, feedback, review and advice from appropriate officers : CSIRO, SARDI, CSU, Monash Uni, Melbourne. Uni

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Salt Water and Nutrient Balance

DEPARTMENT OF
PRIMARY INDUSTRIES



Water, nutrient and salt balance of OHS

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Objectives

Use simple models to simulate:

- seasonal on-farm water balance
- potential leakage of nutrients
- accumulation of salt in the root-zone

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Water balance

Water balance equation

$$TWU + E_s + R_{off} + D = Irr + R_e + (SWC_{t-1} - SWC_t)$$

TWU is tree water use
 E_s is soil evaporation (assume = 0)
 R_{off} is run-off (assume = 0)
D is below root-zone drainage
Irr is irrigation applied
 R_e is effective rainfall (assume = 0)
 SWC_{t-1} is root-zone soil water content at time t-1
 SWC_t is root-zone soil water content at time t

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Water balance

Simplified water balance equation

$$TWU + D = Irr + (SWC_{t-1} - SWC_t)$$

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Tree Water Use

Diurnal tree water use model

$$TWU = 1.1 f_i ET_o$$

TWU is tree water use (mm/h)
 f_i is simulated fractional radiation interception
 ET_o is reference crop evapotranspiration (mm/h)

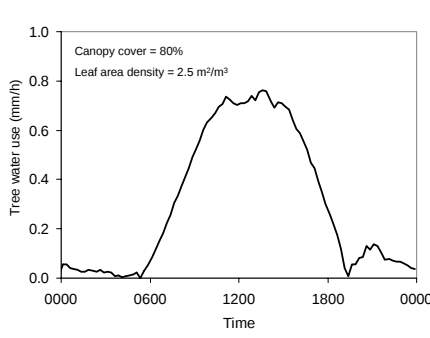
References: Goodwin 2004; Allen et al. 1998; Cohen 1991; Fuchs et al. 1987

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Tree Water Use



Canopy cover = 80%
Leaf area density = 2.5 m²/m³

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Simplified water balance equation

(1) if $Irr > (SWC_{Full\ Point} - SWC_{t-1}) + TWU$

- $SWC_t = SWC_{Full\ Point}$
- $D = Irr - TWU + (SWC_{t-1} - SWC_t)$

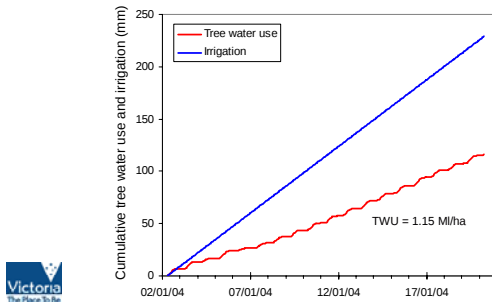
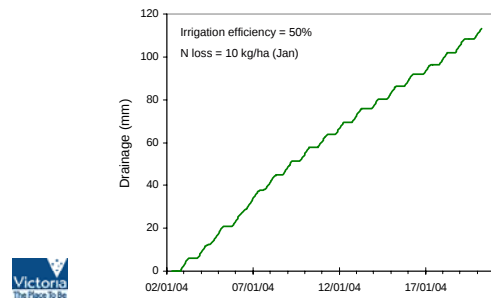
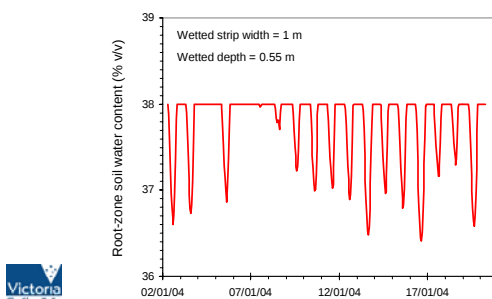
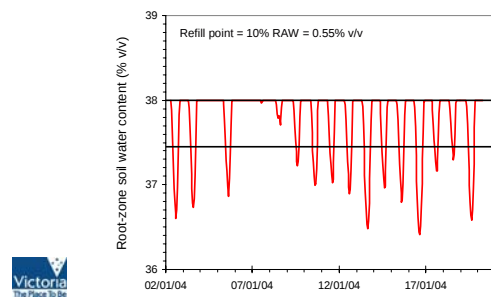
(2) if $Irr < (SWC_{Full\ Point} - SWC_{t-1}) + TWU$

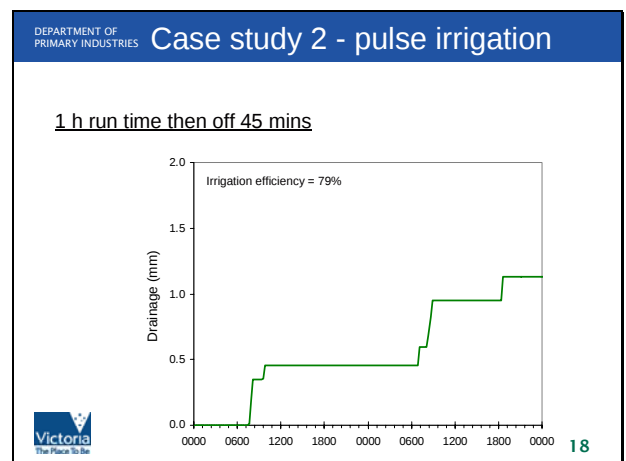
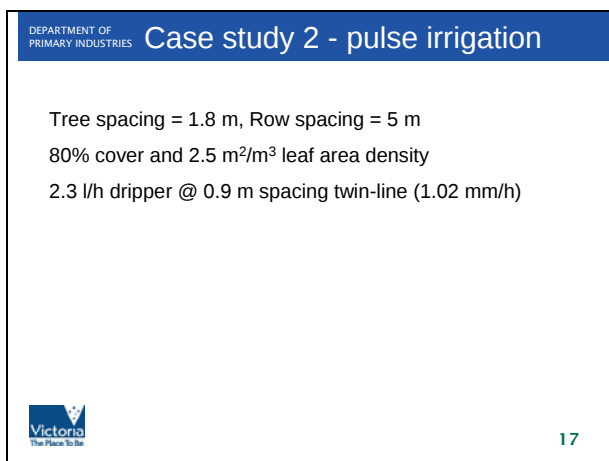
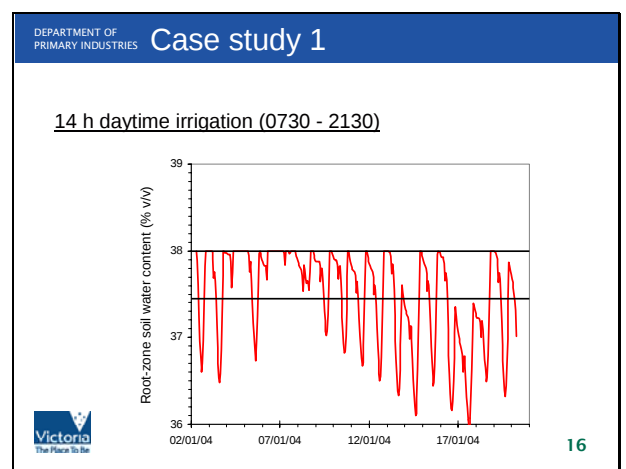
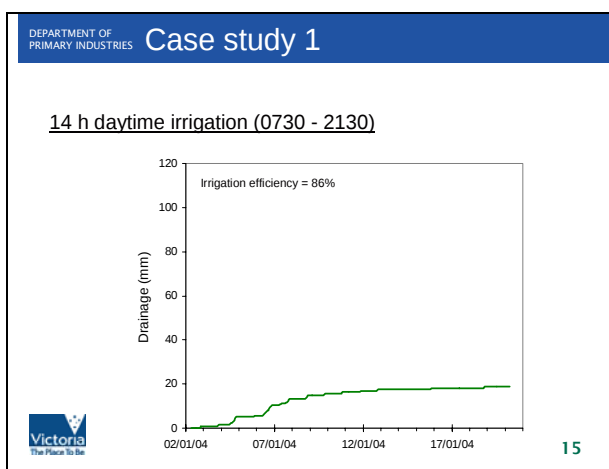
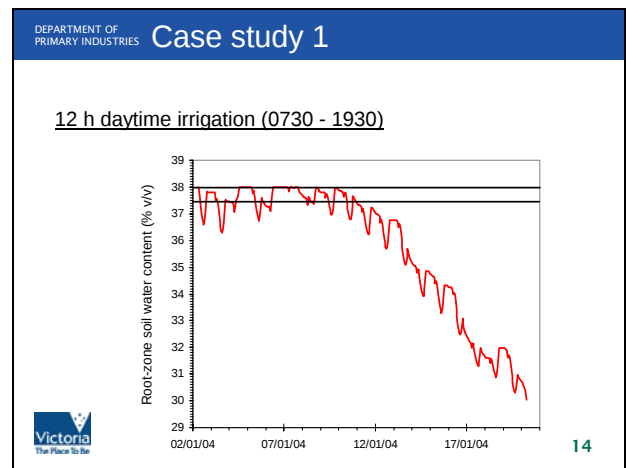
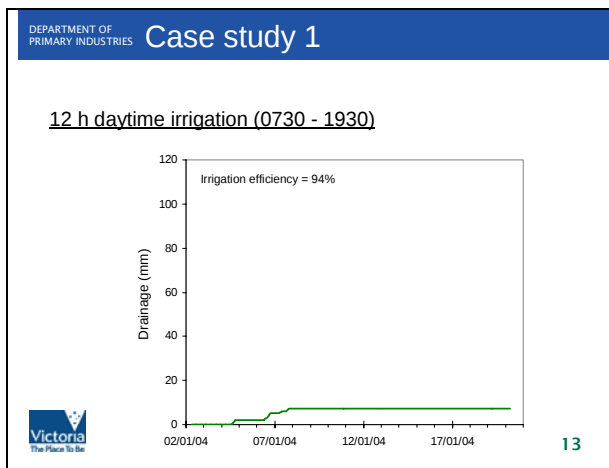
- $D = 0$
- $SWC_t = Irr - TWU + SWC_{t-1}$

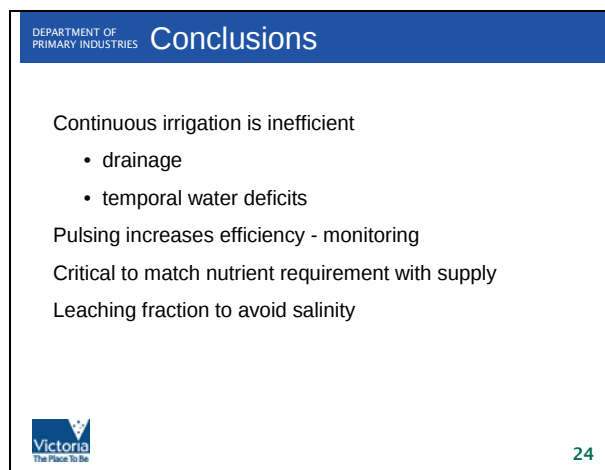
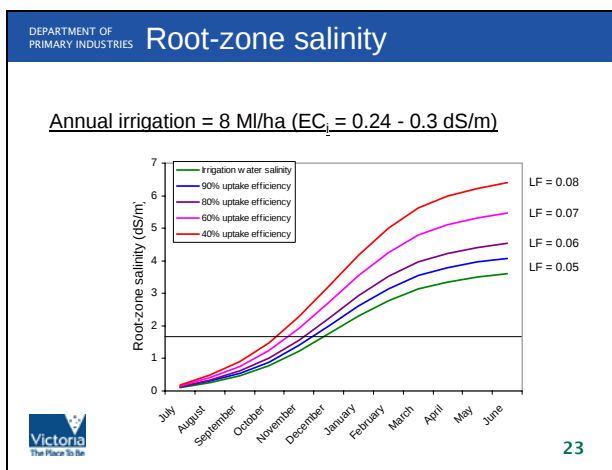
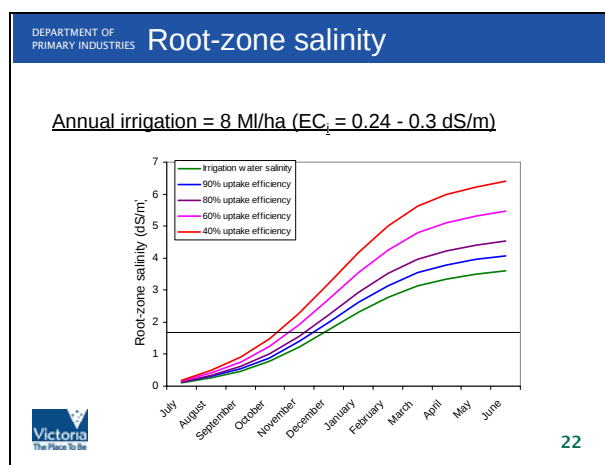
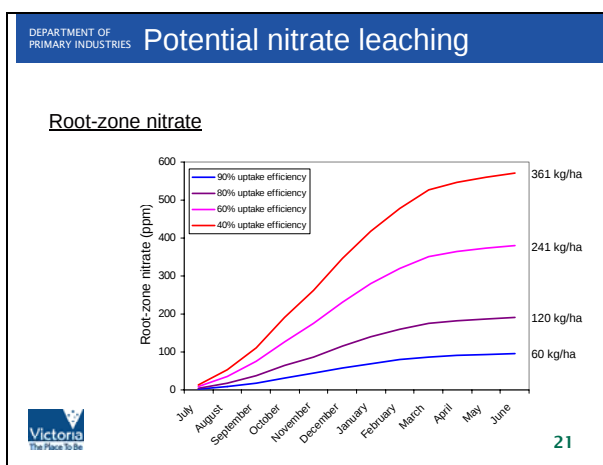
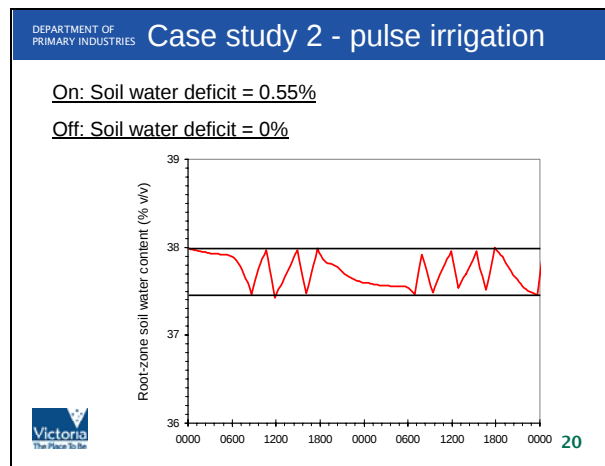
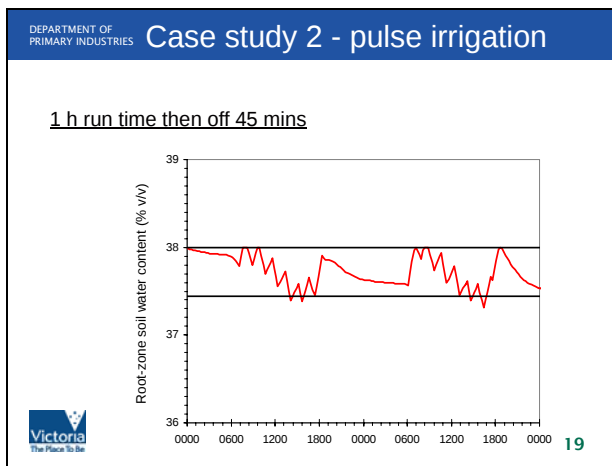
Tree spacing = 1.8 m, Row spacing = 5 m

80% cover and 2.5 m²/m³ leaf area density

1.6 l/h dripper @ 0.6 m spacing single-line (0.53 mm/h)

Continuous irrigationContinuous irrigationContinuous irrigationContinuous irrigation





Accurate estimates of diurnal TWU

Soil water deficits

Root distribution

Drainage and nutrient leakage

Root-zone salinity

Water Supply Impact Assessment

By David Williams, NSW DPI – Dubbo, December 2004.

What was the aim of the Assessment ?

- Assess the ability of irrigation suppliers to meet the irrigation supply requirements of Open Hydroponics users.
- Assess the requirement for on farm buffer storages.
- Assess the ability to supply subject to seasonal water requirements

How did we go about the assessment ?

- Interviewed a range of Water supply authorities including Western Murray, Lower Murray Water, Goulburn Murray Water and Murrumbidgee Irrigation
- We gave them an estimated supply requirement based on Citrus at Mildura of 0.065 ML/Ha/day (6.5mm Et equivalent). This was based on an application rate of 5mm/Ha/hr (slightly higher than industry) requiring about 13 hours of daily application.

We asked them questions including:

- What is your ability to apply this flow requirement ?
- How does this vary across your distribution system ?
- What are the impediments that you can identify and what solutions can you offer ?
- Will this situation change in the future and how ?
- How do your winter supplies vary ?

What did they say ?

(A summary of the main points)

- Level of risk irrigator is willing to work with
 - All irrigators are treated equal.
 - There is no preference for systems type.
 - Access cannot be guaranteed all the time. This is for all systems not just Open Hydroponics.
 - Water is available between 75% and 99% of the time depending on the area and the method of supply. Often 30 % of the customers are serviced at once in the traditional channel based schemes on a 20 to 28 day cycle.
 - Murrumbidgee Irrigation claims that 98% of water is currently delivered as per orders.
- Location of property in scheme.
 - Highest interest is in the farms with access to reliable volumes and availability of scheme water.
 - Supply channel buffering quite often negates the need for on farm storage.
 - Conversely , a farm at the end of a scheme channel or system would be more likely to require some form of supply buffering. If an Open Hydroponics

- o venture was started from scratch, then it would be highly likely that a site would be chosen in order to minimise the supply access risk.
 - o Some areas will have conflict issues with demand for water – solved by schedules, rosters or storages. Some are sorted by localised “self rostering”
 - o Happy customers with pressurised systems often means unhappy channel operators re working hours. Difficult to get the mix right.
 - o Some parts or whole schemes are set up for constant supply and have more potential to suit Open Hydroponics supply requirements eg GMW automated channel scheme and WM pressurised piped supply
 - o Open Hydroponics could be sited in most location within a scheme, subject to supply analysis and implementation of pre-emptive solutions
- Seasonal Access
 - o Minimal problems with access from August to May
 - o Variable to limited access May to August (open channel schemes)
 - o Piped scheme have good access nearly all year round.
- Storages
 - o Preferred to assist with buffering supply but not essential
 - o Useful when system is pushed through high demand and breakdowns
 - o Have the ability to take excess water (off cycle) from scheme
 - o Potential to leak if not constructed correctly
 - o No farm dam policies in most areas
- Other options
 - o Paying for a premium access right – Restricted by legislation (Vic)
- Future issues
 - o Lower Murray Water and Goulburn Murray Water saw the potential local expansion of Open Hydroponics to be low due to the small acreages of citrus in their areas.
 - o Increased conversion of open channels to piped schemes.
 - o Increased acceptance of pressurised irrigation systems on farm and a resulting improved supply service.
 - o Improved awareness thought studies like the one in GMW on supply difficulties.

Summary

- Supply risk assessment needs to occur in the planning process for Open Hydroponics development
- Mostly site specific and different for each individual farm.
- Needs to be assessed on a case by case basis.
- Some will require on farm buffer storages
- Suppliers are keen to meet the supply requirements of Open Hydroponics customers
- There are no restrictions with siting Open Hydroponics within schemes, but some sites are better suited than others
- Open Hydroponics customers will treated like any other customer.

Recommendations:

- Update potential Open Hydroponics irrigators and Water Service providers about supply risk assessment.
- Where farm dams are required, site selection, construction and management information is required to minimise losses seepage to groundwater.

Ecological Risk Assessment and Open Hydroponics

Ecological Risk Assessment and OHS

Rob Faggian, DPI Victoria

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Introduction

- Risk Assessments
- Ecological Risk Assessments
 - Steps, Advantages, etc
- Assessment Methods
 - Models, Bayesian Networks
- Outcomes from Stage 1
- Recommendations for Stage 2

2

Risk Assessments

- Process of assigning magnitudes and probabilities to the adverse effects of human activity on the environment
- Recognition that:
 - 1) The cost of eliminating all adverse affects is impossibly high
 - 2) Regulatory decisions must be made on the basis of incomplete scientific data

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Risk Assessments

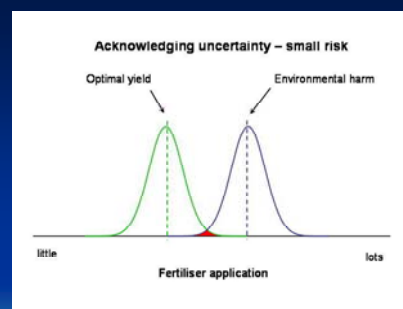
- Types of Risk Assessments
 - Environmental Impact Assessment
 - Hazard Assessment
 - Natural Resource Management
 - Ecological Risk Assessment
- Ecological Risk Assessment:
the process of defining and quantifying risks to non-human biota and determining the acceptability of those risks

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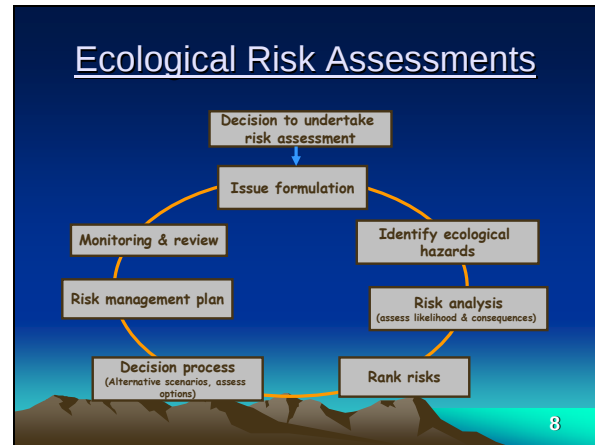
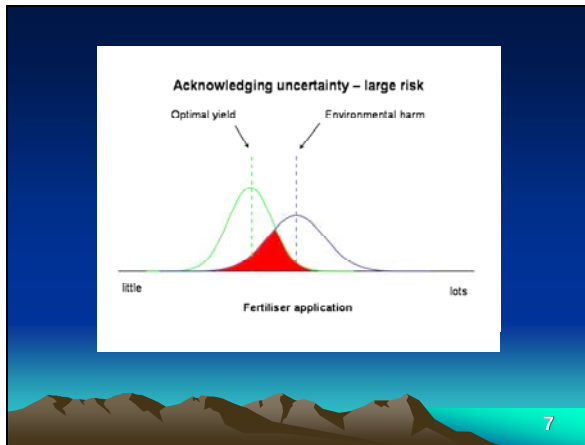
Ecological 'Risk' Assessments

- Risk = effects x probability
- If probability is 1 or 0, there is no risk
- Incorporates 'Risk Analysis'

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- ### Main Steps
- Define what 'the environment' is
 - Define the hazards/threats
 - Devise methods to measure current state of environment and quantify/predict changes
 - Evaluate importance of assumptions and uncertainties
 - Determine what constitutes a significant change to the environment
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- ### Critical Issues
- What 'end points' to use
 - Assessment and Measurement Endpoints
 - Biological and Societal Relevance
 - Unambiguous (e.g. soil health?)
 - Amenable to measurement
 - Susceptibility to hazard
 - Perceived versus actual risk
 - Subjective analysis
 - Qualitative (opinion) versus Quantitative (data)
 - What is acceptable risk?
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- ### Assessment Methods/Models
- Assessment methods can be physical (testing systems) and quantitative (statistical and mathematical)
 - The assessment method, or model, is used to simulate or simplify real-world processes and study them in compressed time.
 - Physical models, generally laboratory tests
 - Statistical Models, e.g. dose-response curves
 - Mechanistic models, describe the relationship between variables in terms of causal mechanisms (Bayesian)
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- ### Why use Models?
- Simplification real-world process and predictive
 - Allows the study of systems in compressed time, e.g. simulation, scenarios, prediction
 - Often used where too expensive, risky or slow to test a proposed change in real system
 - Allows us to justify decisions, clarify problems and identify important variables
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Challenges

$$\text{Risk} = \text{effect} \times \text{probability}$$

- What biological effects to measure?
- Ecological significance?
- How to handle multiple hazards?
- How to make risk assessments more quantitative?
- How to handle assumptions and uncertainties?

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Advantages of ERA

- Robust process
 - Rigorous & logical process (steps now well documented)
 - Internally consistent
 - Transparent
 - Assumptions & uncertainties clearly identified
- Outputs
 - Risk predictions (with probabilities)
 - Priorities for action, monitoring and research

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Summary of Critical Issues

- Incomplete data on biology of species
- Incomplete data on species distributions, dispersal, habitat quality, breeding triggers, etc
- Natural variations difficult to handle
- Uncertainties and assumptions difficult to handle

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How to achieve?

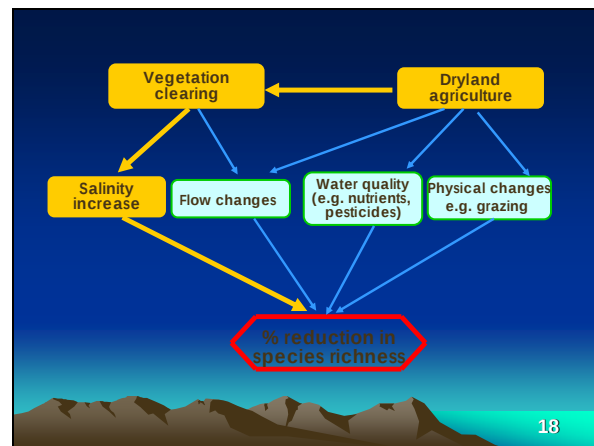
- Need predictive tools that are:
 - Rigorous, Unambiguous
- First, build conceptual models
 - System-specific models (local-scale)
 - 'Big picture' models (catchment-scale)
- Then, build predictive cause-effect (assessment) models = Bayesian Network

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Why use Conceptual Models?

- Helps to clarify and align thinking
- Enhances community engagement process
- Communicates any assumptions about cause and effect
- Helps to identify knowledge gaps and management intervention points
- Acts as forerunner to Bayesian Network

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Stage 1 - Findings

- Identified a range of potential hazards
- Episodic rainfall events
- Low river flows
- Fertilisers
- pH/nutrients
- Sediments
- Effects on aquatic organisms (fish, frogs, crustaceans, reptiles, blue/green algae, flora)
 - Changes in pathogen populations
 - Species diversity
 - Changes in competition/predation/interaction between flora and fauna

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Stage 1 - Findings

- Developed conceptual cause-effect models for each hazard
- Development of full ERA for OHS very complex



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Stage 2 - Recommendations

- Define community engagement process
 - Stage 1 findings driven by researchers
 - Need to include more diverse stakeholders
 - Processes already exist within CMA's?
- Develop Bayesian Network
 - Collaborate with Prof Barry Hart, Monash Uni
 - DPI building capability in ERA, BN

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Stage 2 - Recommendations

- Input data for BN
- Run several scenarios
 - Traditional vs OHS
 - Highly sensitive through to robust ecosystems
 - Review applicability to intensive horticulture
- Understand issues of scale
 - Farm vs landscape

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Ecological Risk Assessments



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Stage 2 - Recommendations

- Full ERA for OHS
- Timeframe: 2 years +
 - Model development alone requires 1 year
- Staffing: 1 full time scientist
 - Time split between B. Hart, I. Goodwin, R. Faggian ??
 - 80% DPI, 20% Monash ??

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