Aquaponics
for
Master Gardeners

2014 Statewide UH Master Gardener Conference

Larry Yonashiro
October 2014

Objective of this Class

To give the Master Gardener
the tools needed
to handle Aquaponics related calls
on the Help Desk.

Topics to be Covered

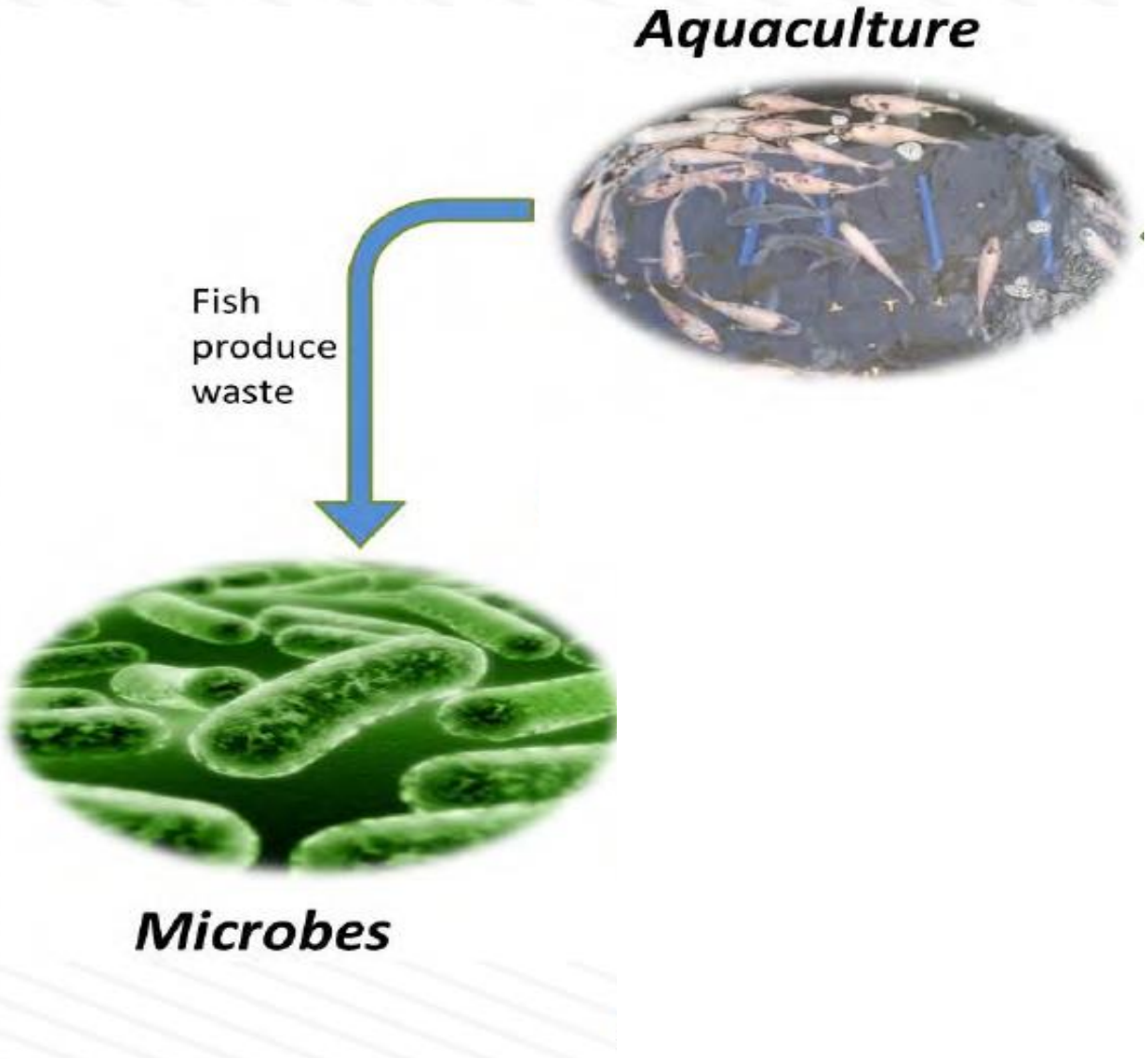
- Basic Concepts
- Types of Systems
- Nutrient Deficiencies & pH
- System Startup & Water Quality
- Troubleshooting Flowchart

Basic Components

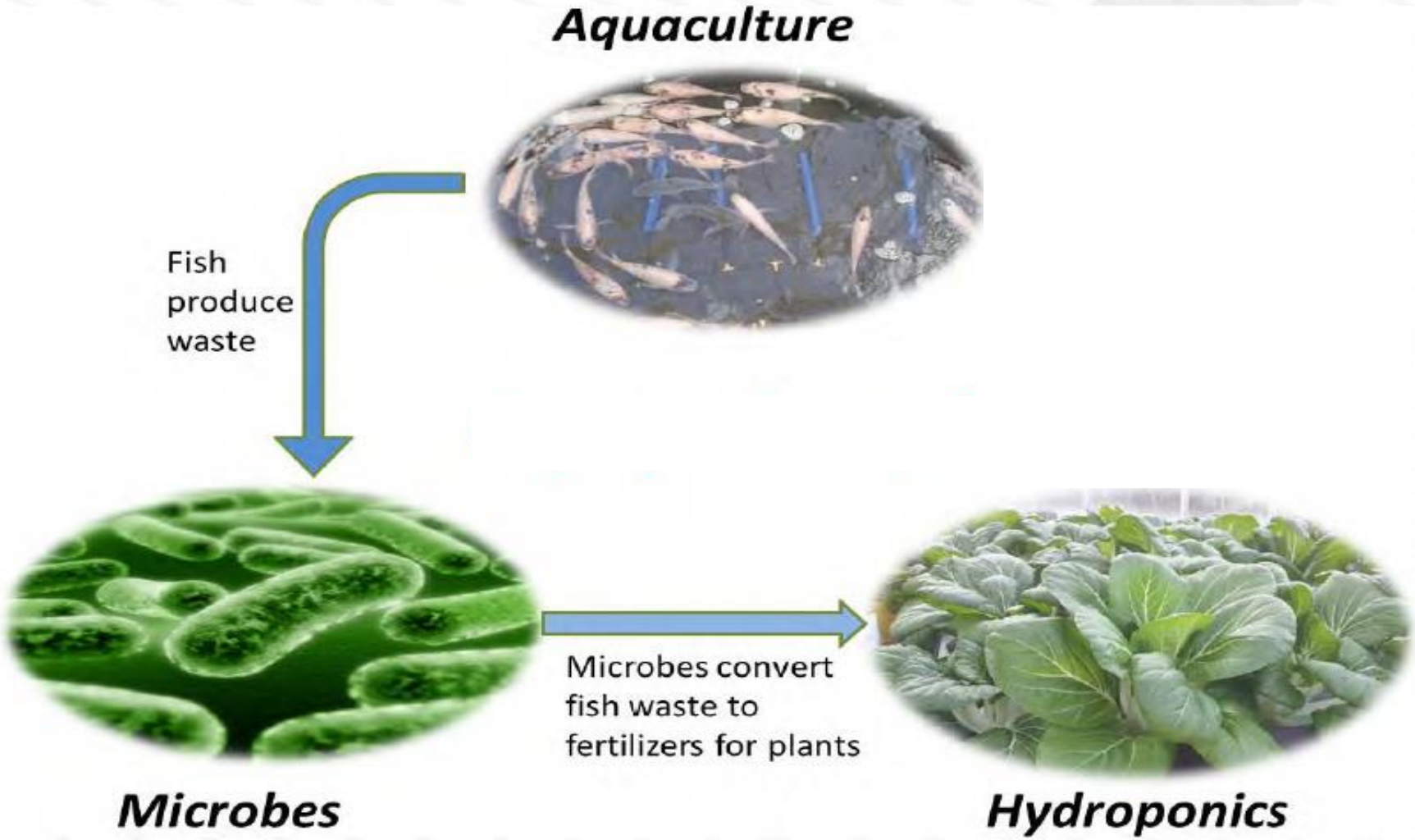
Basic Components

Aquaculture

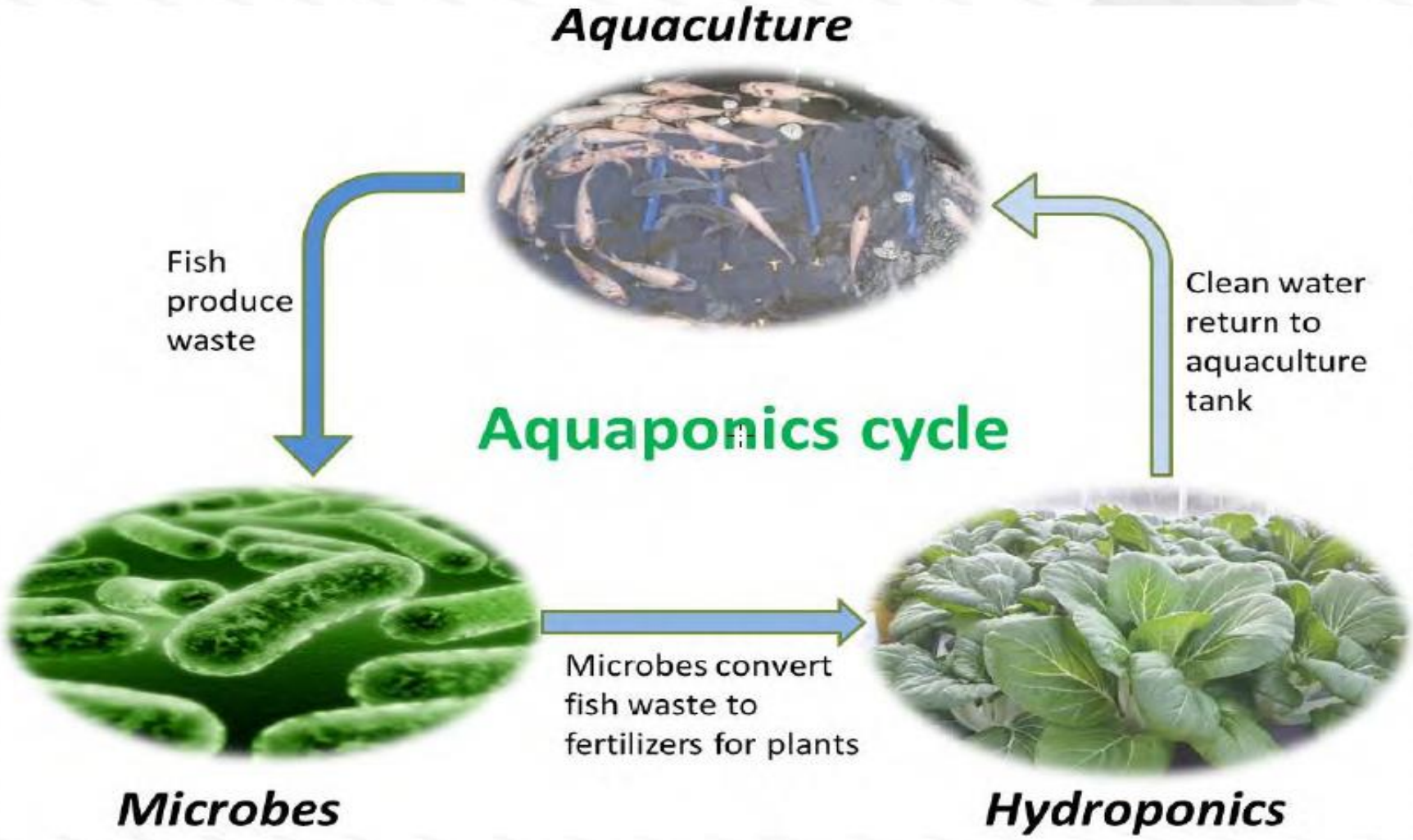
Basic Components



Basic Components



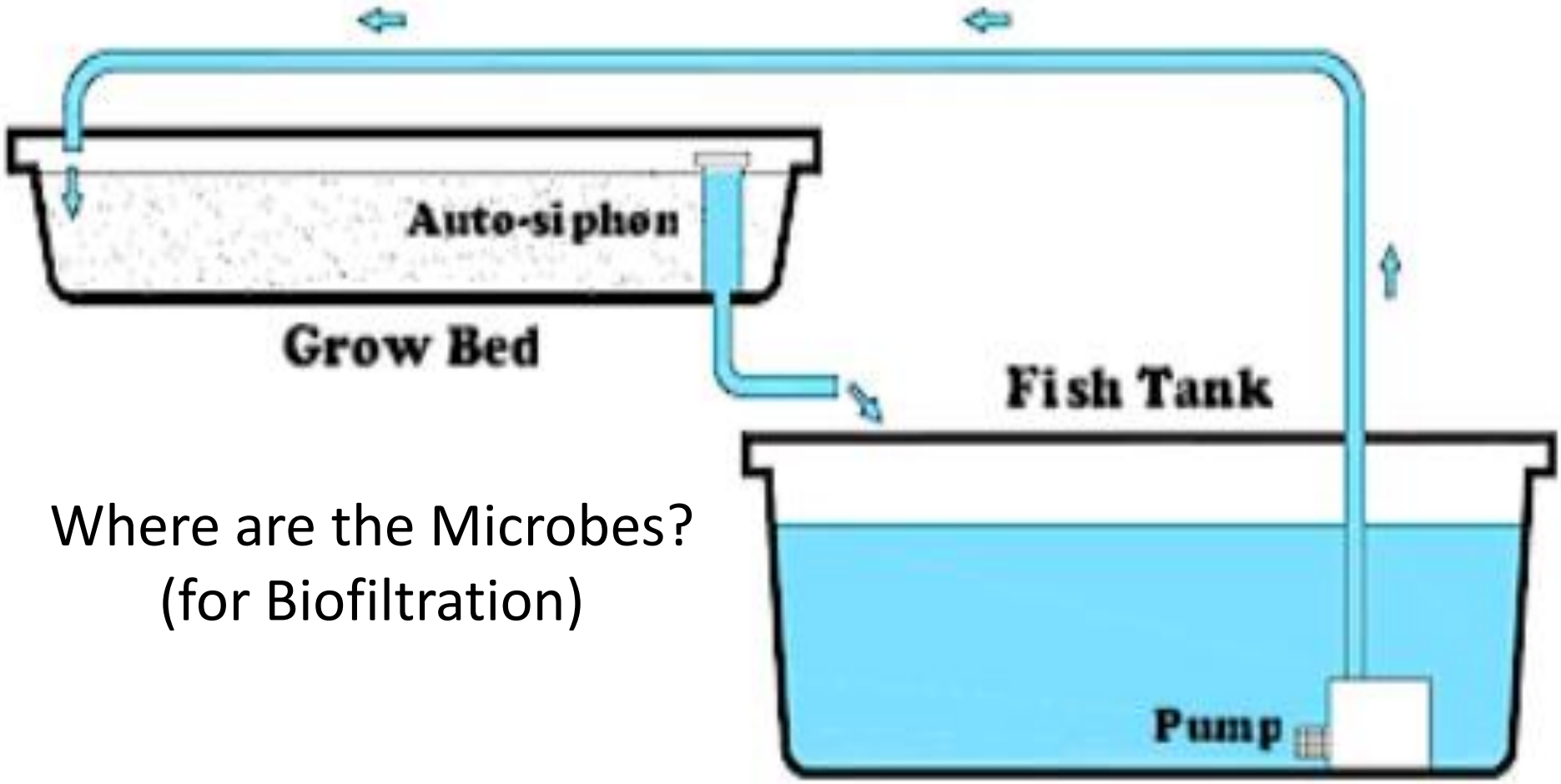
Basic Concept



Aquaponics cycle

http://www.ctahr.hawaii.edu/sustainag/workshop/downloads/Aquaponics-May2013/Hu.pdf

Basic System

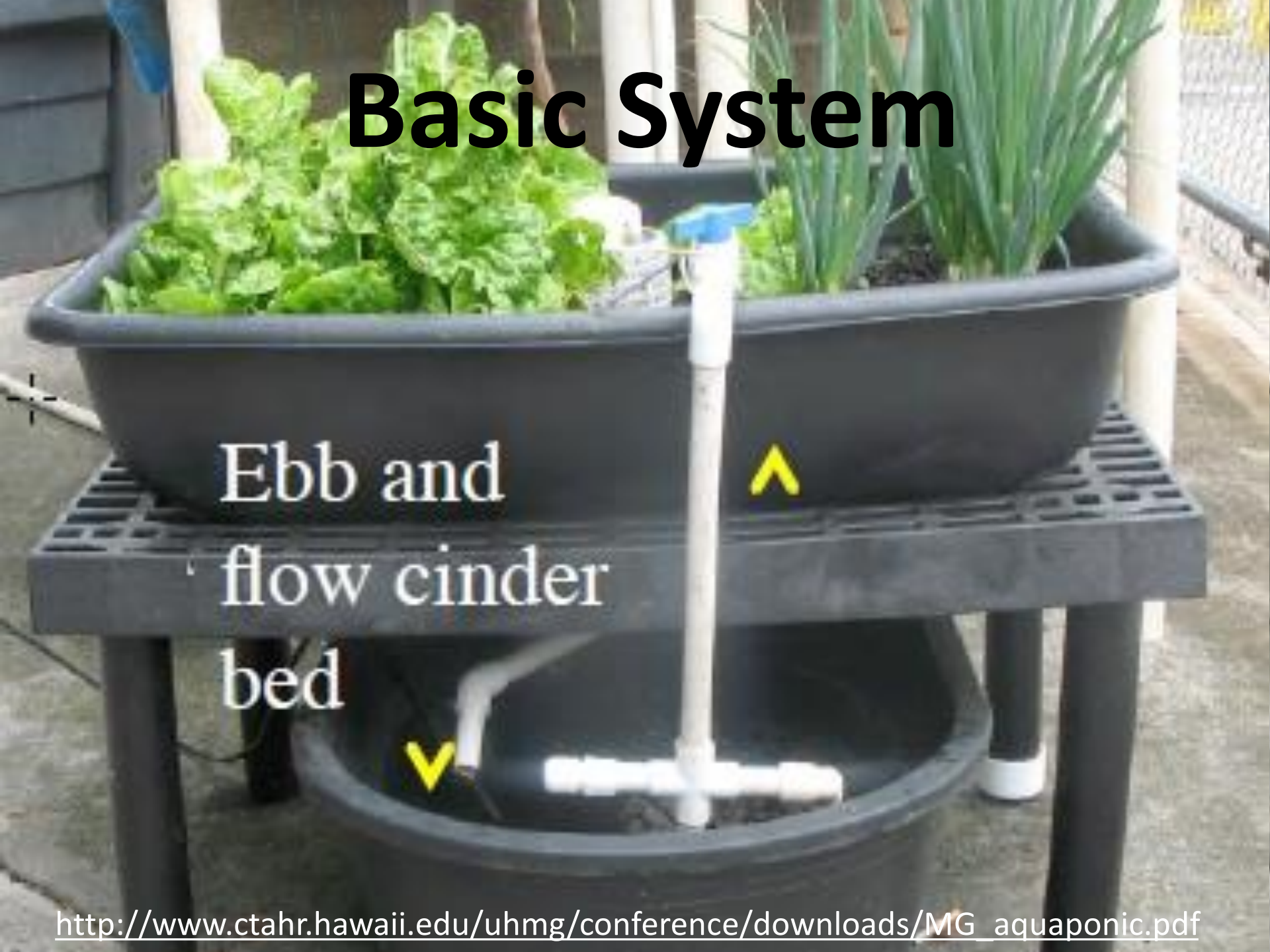


Where are the Microbes?
(for Biofiltration)

http://www.ctahr.hawaii.edu/sustainag/workshop/downloads/Aquaponics-May2013/Horner.pdf

http://www.ctahr.hawaii.edu/uhmg/conference/downloads/MG_aquaponic.pdf

Basic System



http://www.ctahr.hawaii.edu/uhmg/conference/downloads/MG_aquaponic.pdf

Types of Grow Bed Media

Flood & Drain (Ebb & Flow)

Black Cinder | Pea Gravel | Expanded Clay Balls (Hydrotons)

1. Three commonly used solid support media for ebb-and-flow aquaponic systems. Black cinder (left) and pea gravel (center) are produced in Hawai'i; the expanded clay balls (right) typically are imported from Germany.

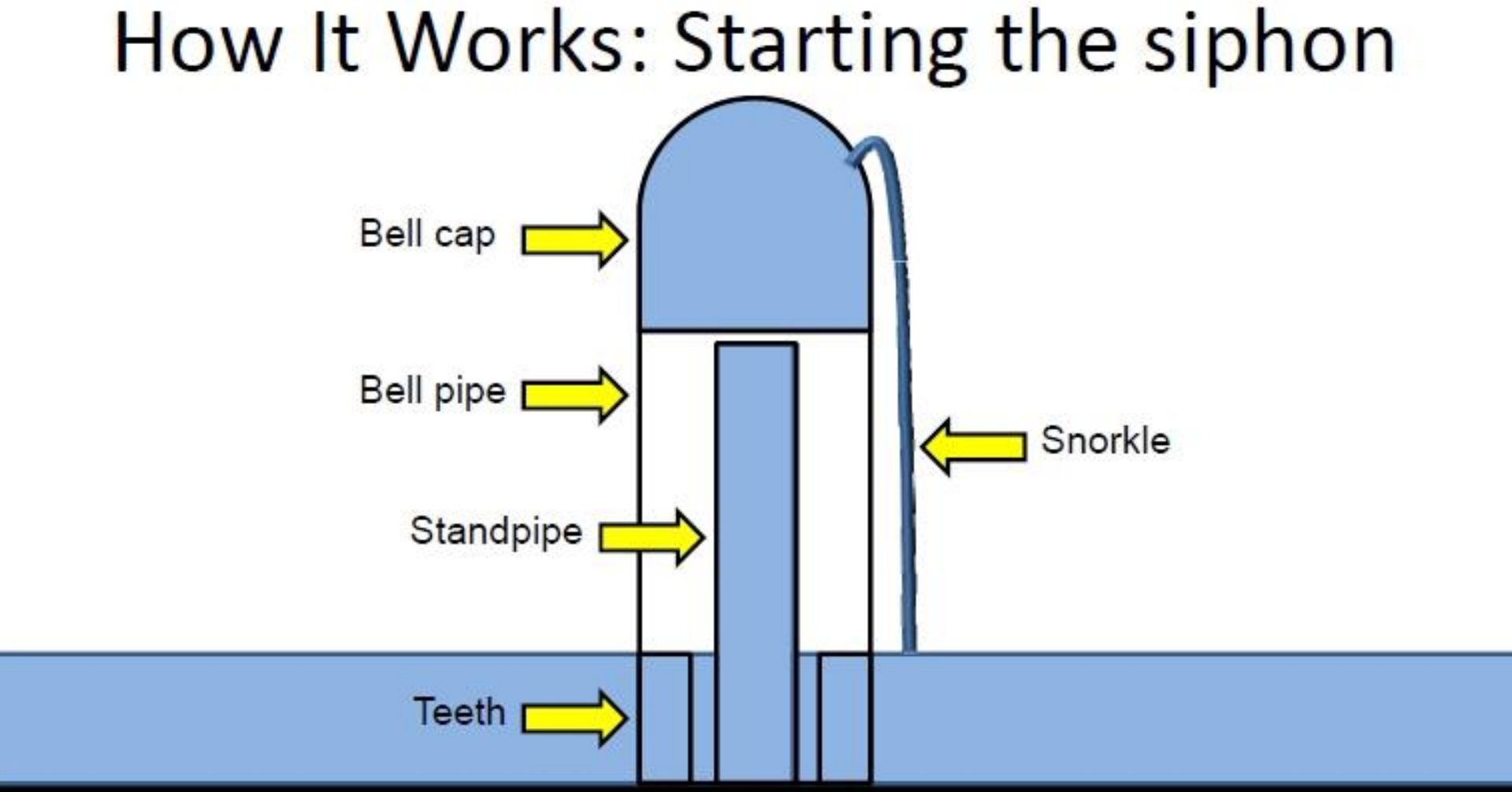
http://www.ctahr.hawaii.edu/oc/freepubs/pdf/bio-10.pdf

Flood & Drain (Ebb & Flow)
Bell (Auto) Siphon

http://www.ctahr.hawaii.edu/uhmg/conference/downloads/MG_aquaponic.pdf

Bell (Auto) Siphon Operation

Ebb & Flow (Flood & Drain)

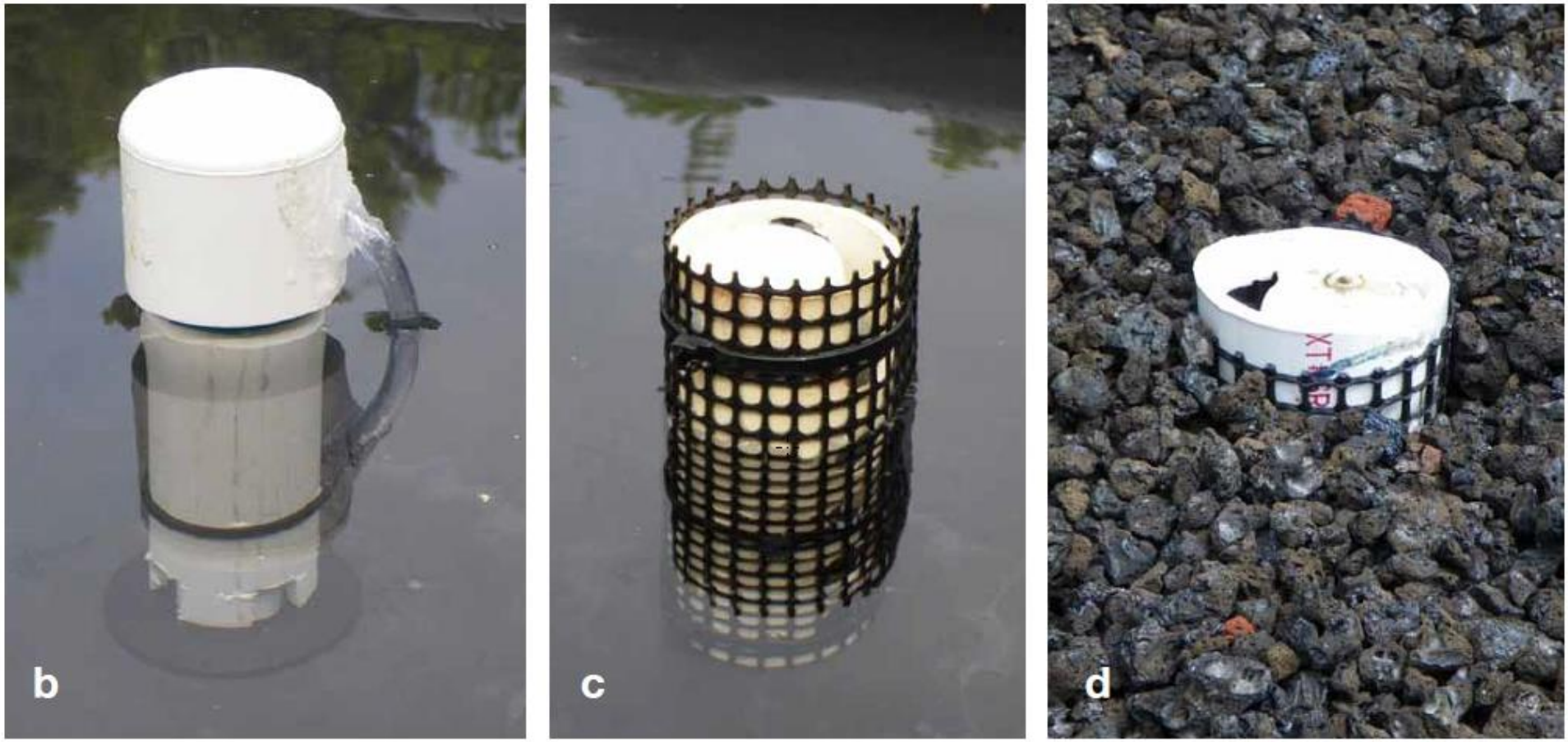


http://legacy.sip-hawaii.org/files/2A_Fox_aquaponics.pdf

Bell Siphon Installation In Tub

http://legacy.sip-hawaii.org/files/2A_Fox_aquaponics.pdf

Bell Siphon Test & Install



3b–d. The bottom of the bell cap is even with the height of the standpipe, and thus with the desired water level. This level should be predetermined so that when the gravel guard is installed (center) and the medium is added (right), the water level is 1–2 inches below the surface of the medium.

http://www.ctahr.hawaii.edu/oc/freepubs/pdf/bio-10.pdf

College of Tropical Agriculture
and Human Resources
University of Hawai'i at Mānoa

Biotechnology
June 2010
BIO-10

Construction of Automatic Bell Siphons for Backyard Aquaponic Systems

Bradley K. Fox,[1] Robert Howerton,[2] and Clyde S. Tamaru[1]
[1]Department of Molecular Biosciences and Bioengineering
[2]University of Hawai'i Sea Grant College Program

Aquaponics is a developing agricultural technology that is rapidly gaining worldwide popularity, both for commercial production and small-scale, backyard systems. The aquaponics concept involves integrating aquaculture and hydroponics, where fish wastewater is converting nitrogen in the effluent to forms suited to the plants' nutrient uptake.

Flood-and-drain cycling in ebb-and-flow aquaponic systems can be controlled by electronic timers, which regulate the activity of water pumps, or by non-

http://www.ctahr.hawaii.edu/oc/freepubs/pdf/bio-10.pdf

End of Discussion on Basic Concept / System

Next: Types of Aquaponic Systems

Types of Aquaponic Systems

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- Ebb and flow (reciprocating)
  - Hydroponic support media (gravel, clay balls, cinder, etc.)

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  - Polystyrene sheets

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  - Rain Gutters
  - Pvc pipe

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- Raft aquaponics
  - Polystyrene sheets
- Nutrient Film Technique (NFT)
  - Rain Gutters
  - Pvc pipe
- Three Components
  - Rearing tank
  - Biofilter
  - Hydroponic component

http://legacy.sip-hawaii.org/files/2A_Fox_aquaponics.pdf

NFT

Flood & Drain (Ebb & Flow)

Floating Raft (DWC)

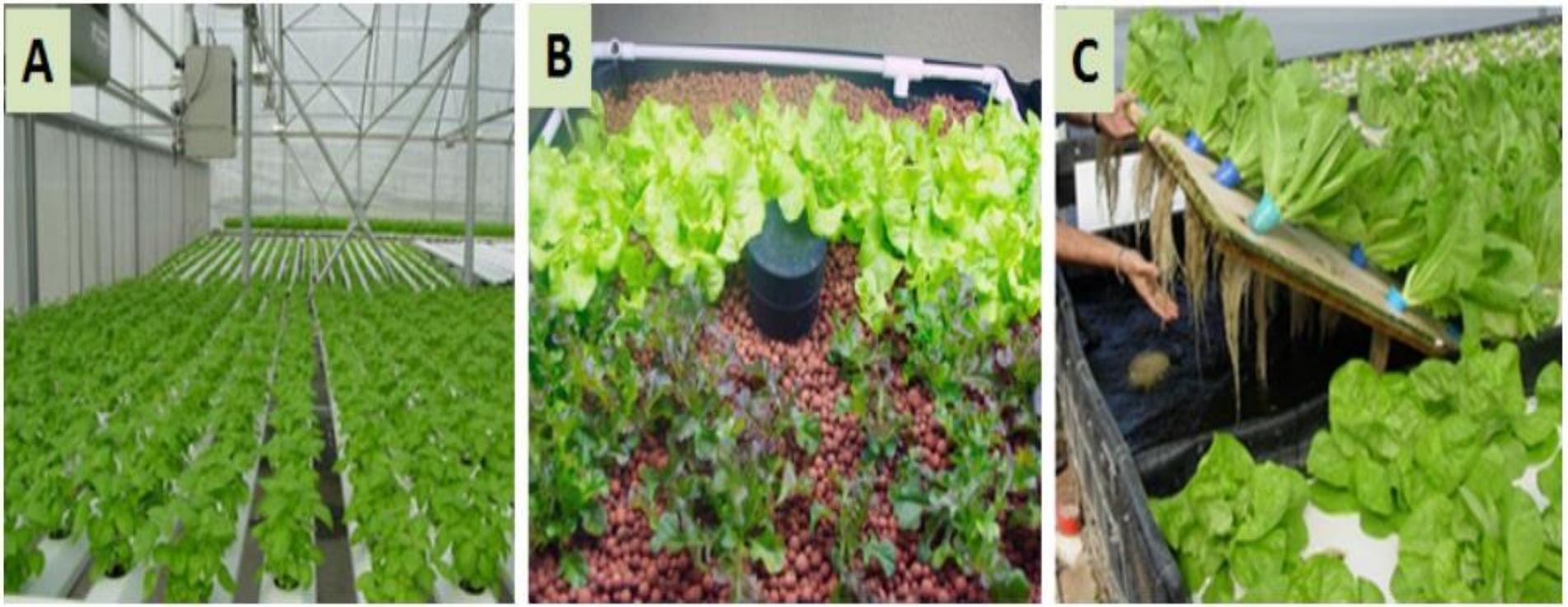


Fig. 2 Different hydroponic designs. (A) NFT; (B) flood and drain; (3) floating raft.

http://www2.hawaii.edu/~khanal/aquaponics/design.html

Vertical Towers

http://www.ctahr.hawaii.edu/sustainag/workshop/downloads/Aquaponics-May2013/Primavera.pdf


University of the Virgin Islands
Dr. James Rakocy
Floating Raft Design
Deep Water Culture (DWC)


Backyard DWC System
Maui, Hawaii

Net Pots


Coir
60/40
Vermiculite


Root


Net Pots in Floating Rafts


Floating Raft

Types of Systems

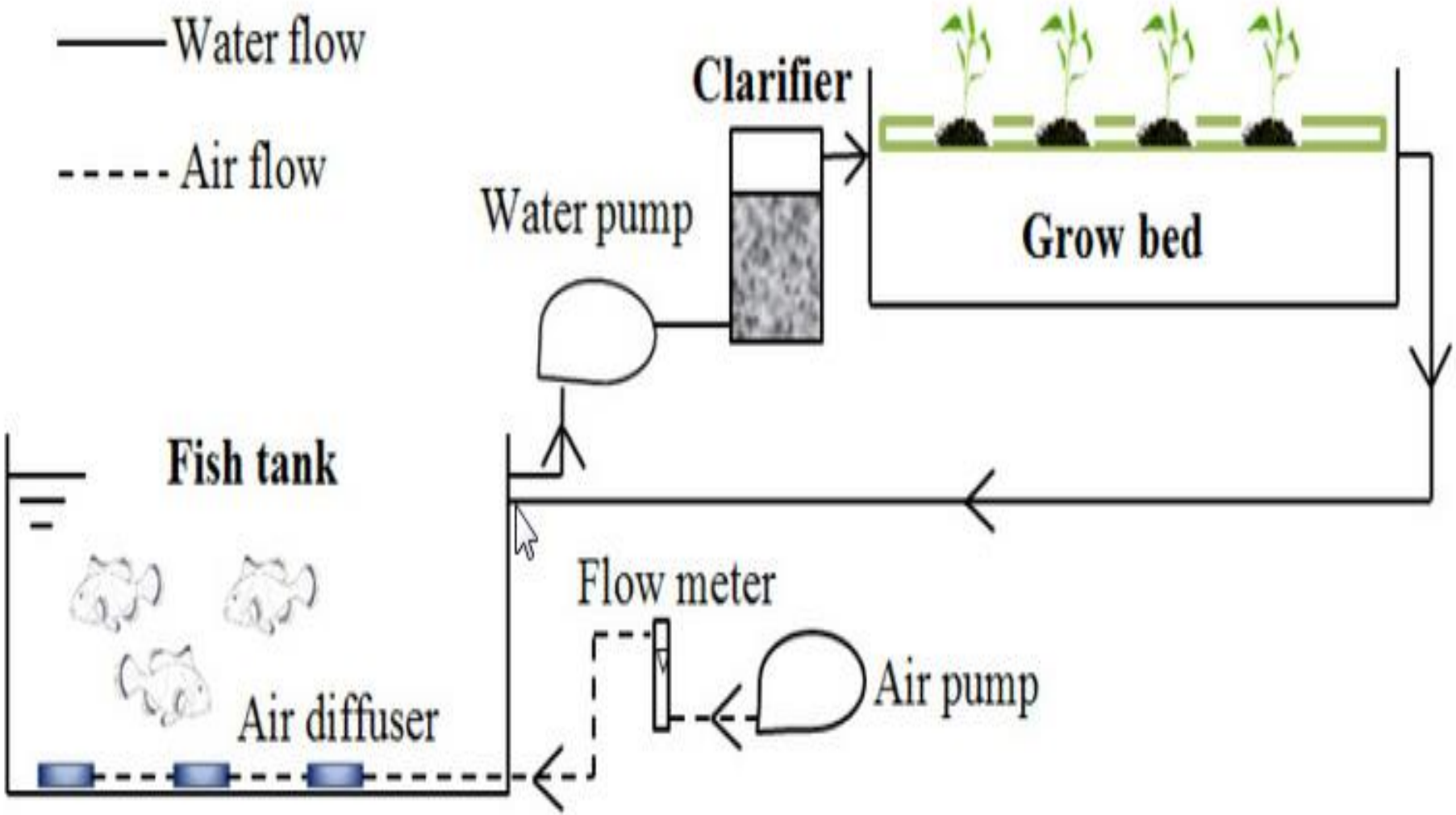
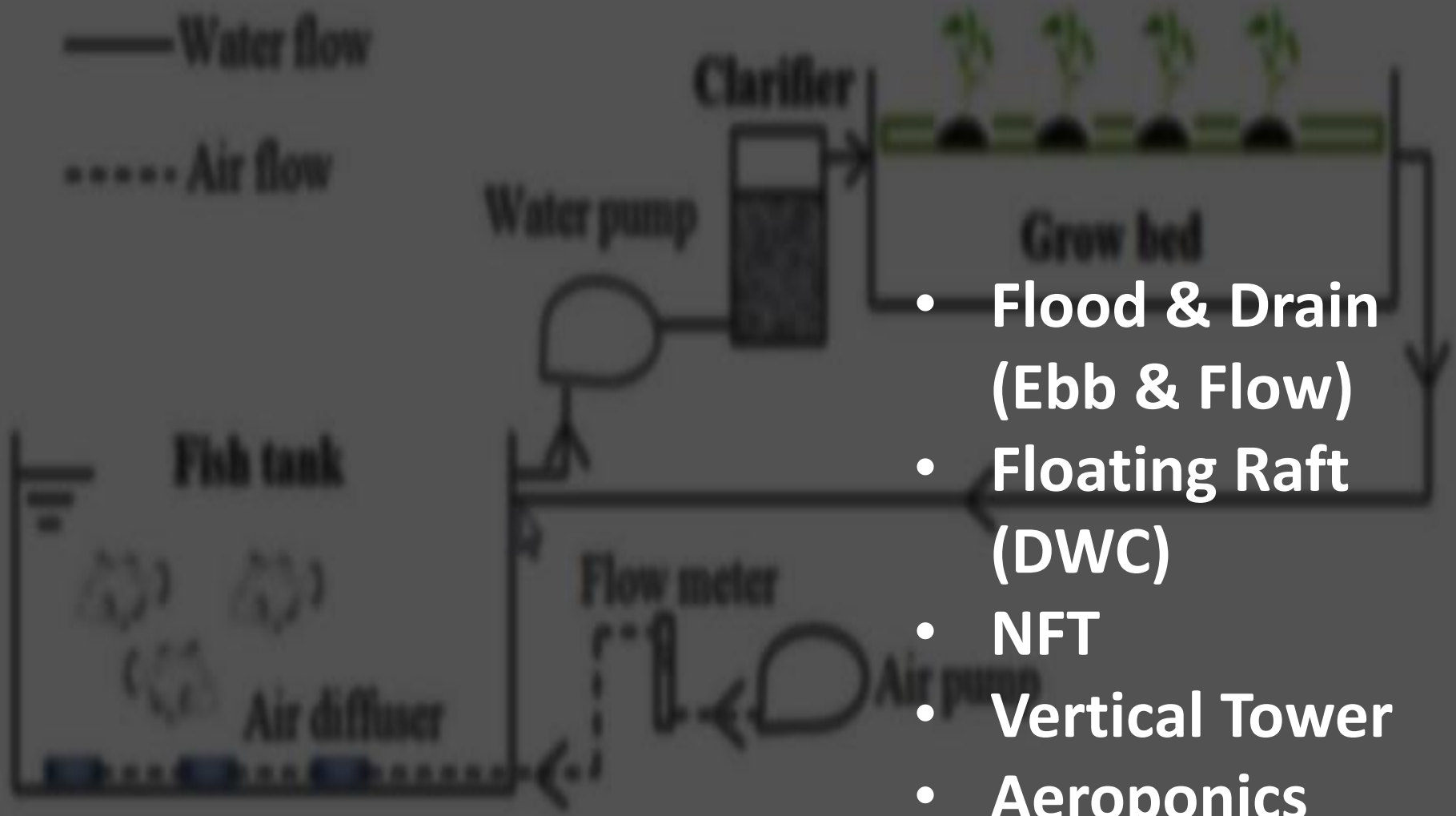


Fig. 1 Schematic diagram of an aquaponic system

http://www2.hawaii.edu/~khanal/aquaponics/

Types of Systems



- **Flood & Drain (Ebb & Flow)**
- **Floating Raft (DWC)**
- **NFT**
- **Vertical Tower**
- **Aeroponics**

Fig. 1 Schematic diagram of an aquaponic system

http://www2.hawaii.edu/~khanal/aquaponics/

Student Project – Ebb & Flow

http://www.ctahr.hawaii.edu/uhmg/conference/downloads/MG_aquaponic.pdf


Ebb & Flow
Floating Raft
http://www.ctahr.hawaii.edu/uhmg/conference/downloads/MG_aquaponic.pdf

Ebb & Flow Floating Raft NFT

Darrel Tanaka,
Kailua Elementary

Windward
Community College,
Aquaculture
Complex

http://www.ctahr.hawaii.edu/uhmg/conference/downloads/MG_aquaponic.pdf

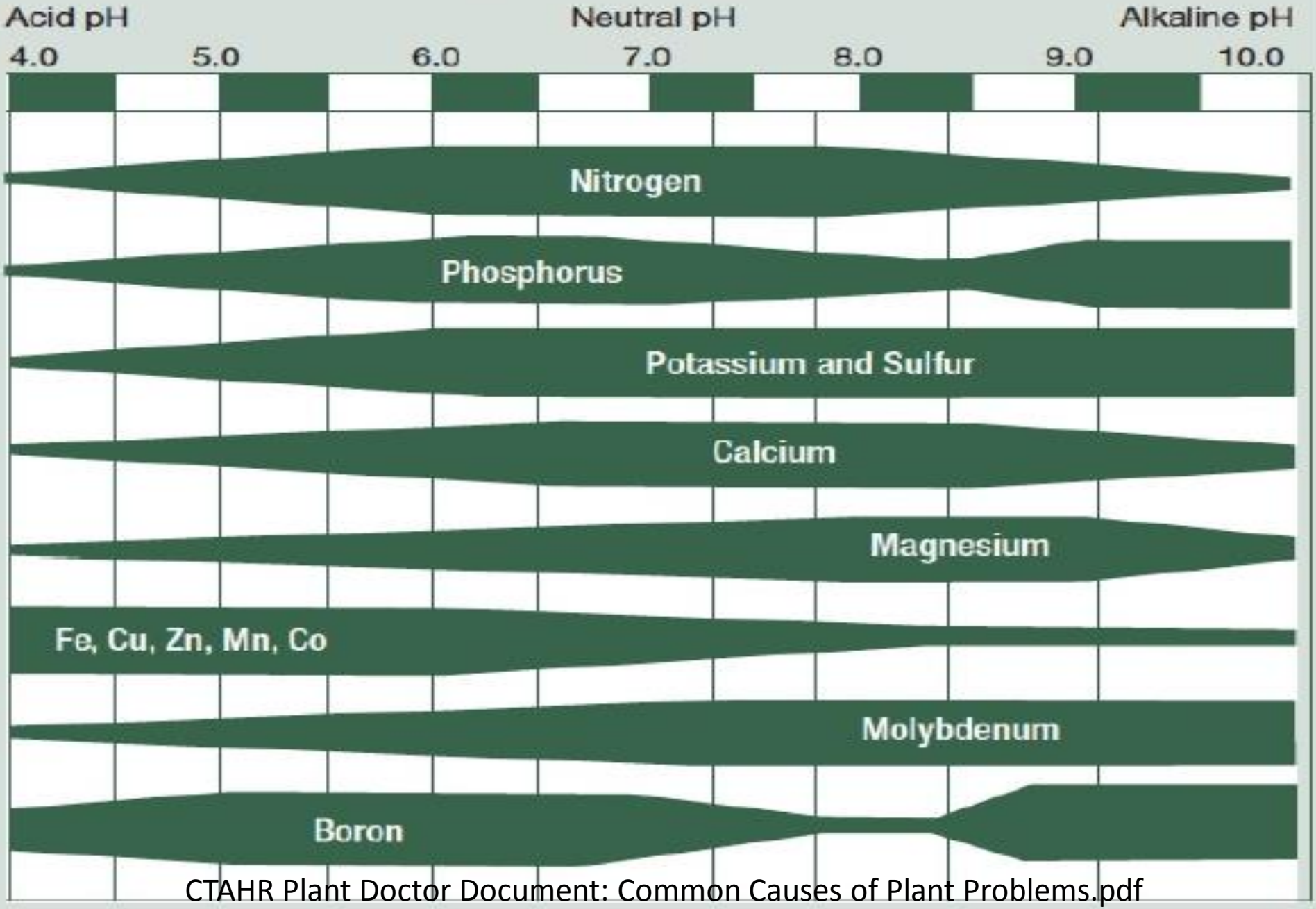
End of Discussion on Types of Systems

Next: Nutrient Deficiencies & pH

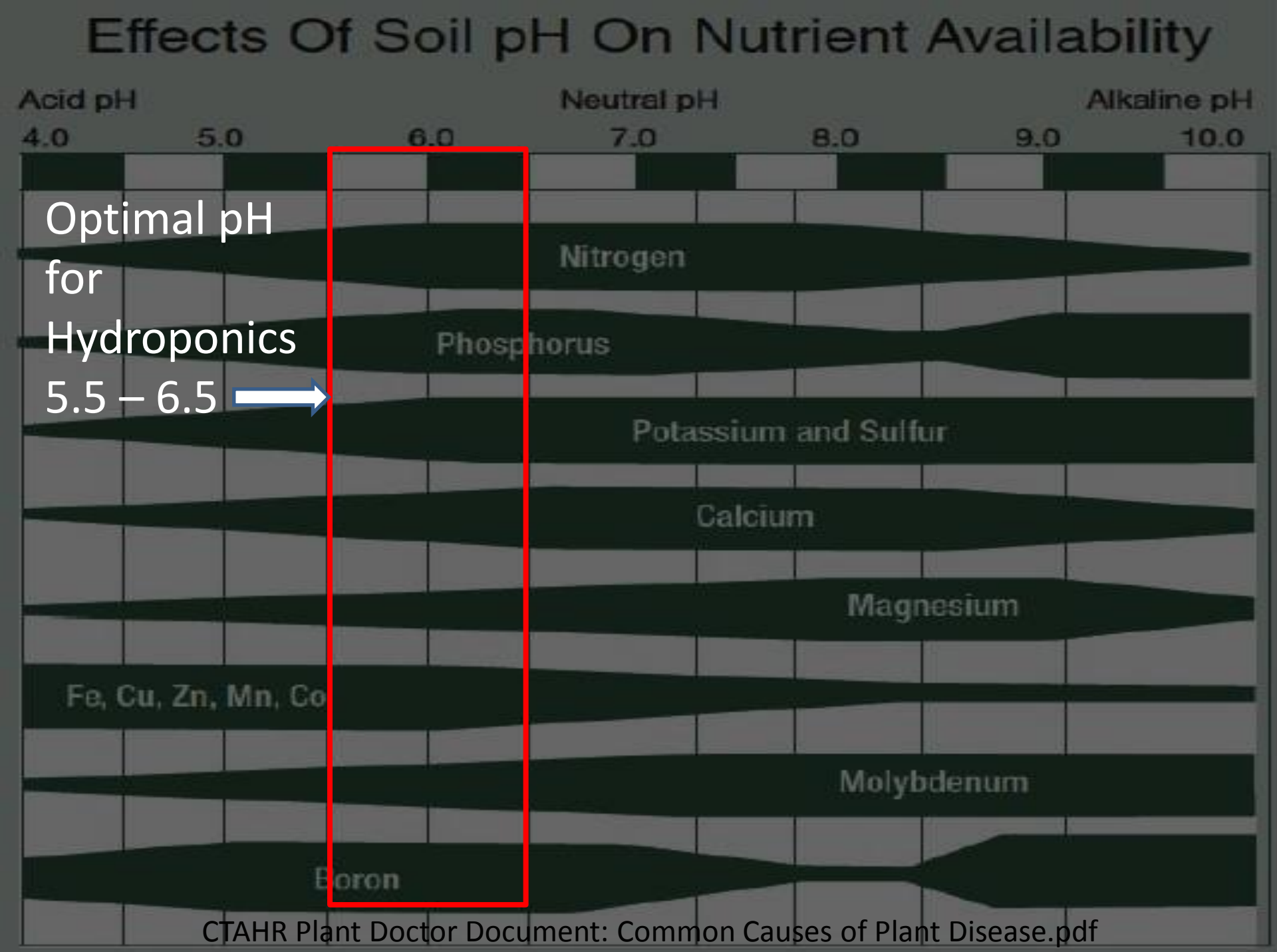
Nutrient Deficiencies in Aquaponics

"Aquaculture effluent typically supplies 10 of the 13 required plant nutrients in adequate amounts, with only Ca, K and Fe needing supplementation."
(Dr. James Rakocy)

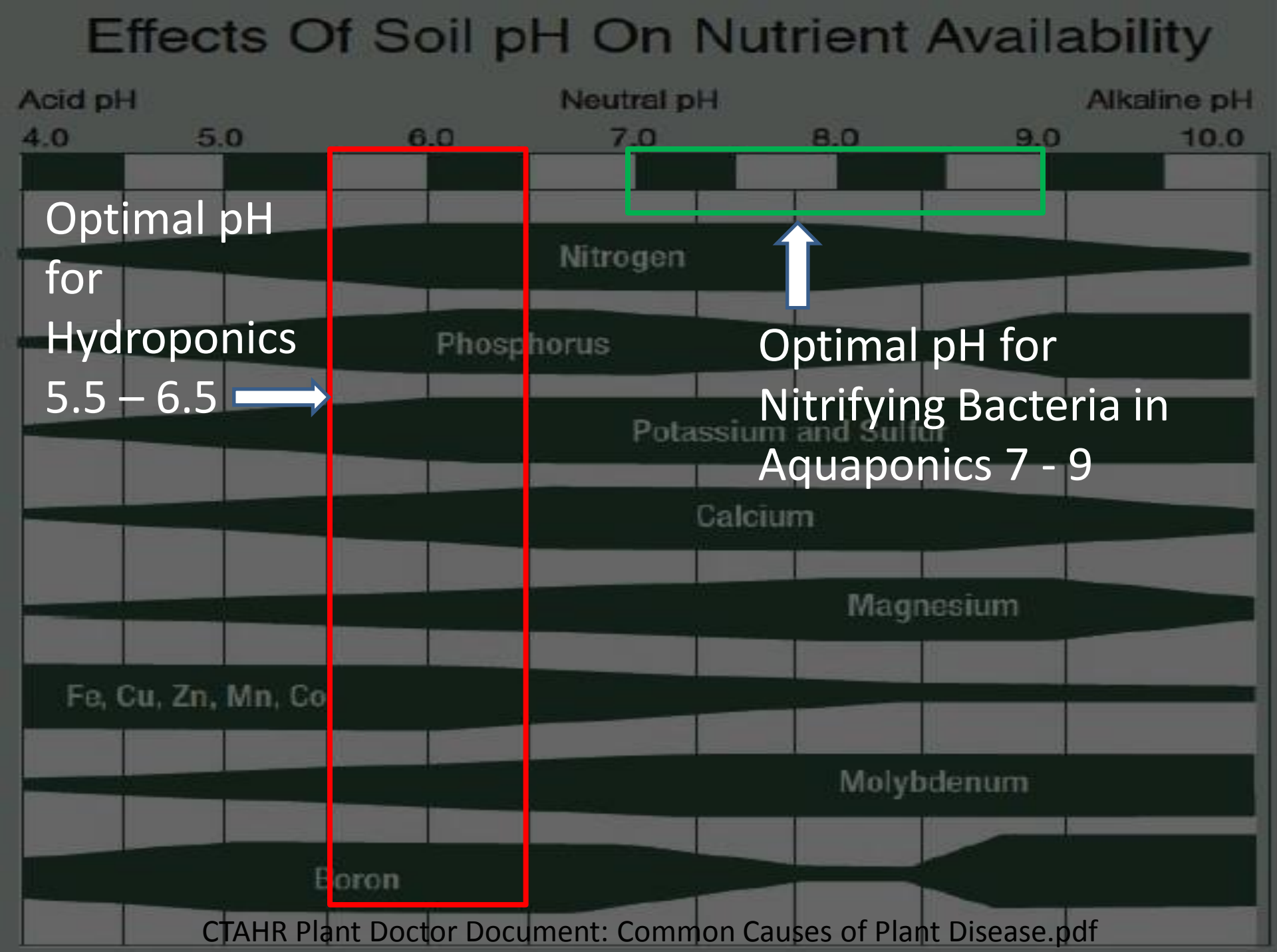
Effects Of Soil pH On Nutrient Availability



CTAHR Plant Doctor Document: Common Causes of Plant Problems.pdf



CTAHR Plant Doctor Document: Common Causes of Plant Disease.pdf



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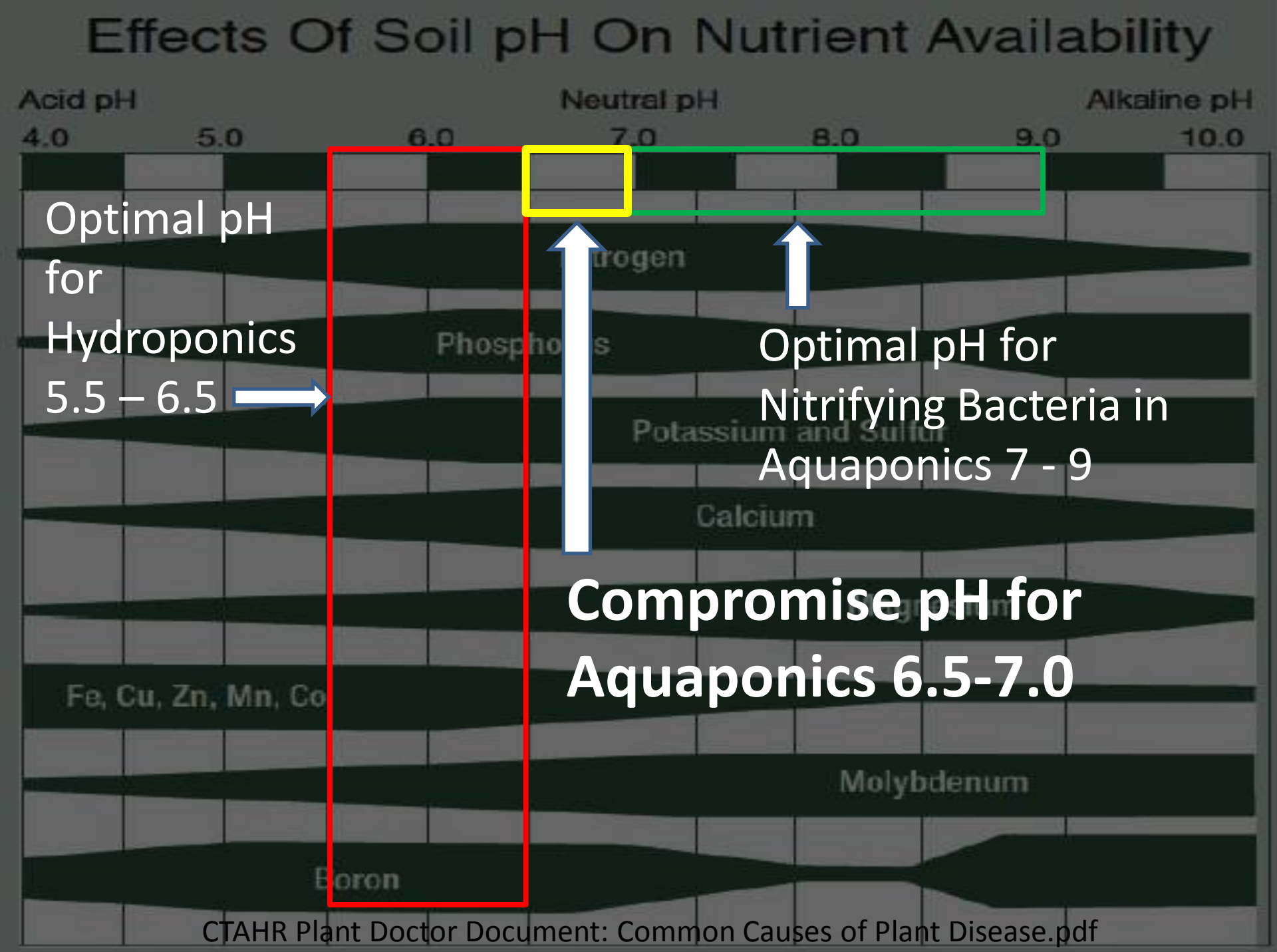


CTAHR Plant Doctor Document: Common Causes of Plant Disease.pdf

Supplementation (Typical)

Note: Keep pH between 6.5 – 7.0 when supplementing

These are known to be Fish Safe

- **Iron:** Chelated Iron
- **Potassium:** Sulfate of Potash
- **Calcium:** Calcium Carbonate, Oyster Shells, Crushed Coral, Coral Sand. **(pH Buffer)**

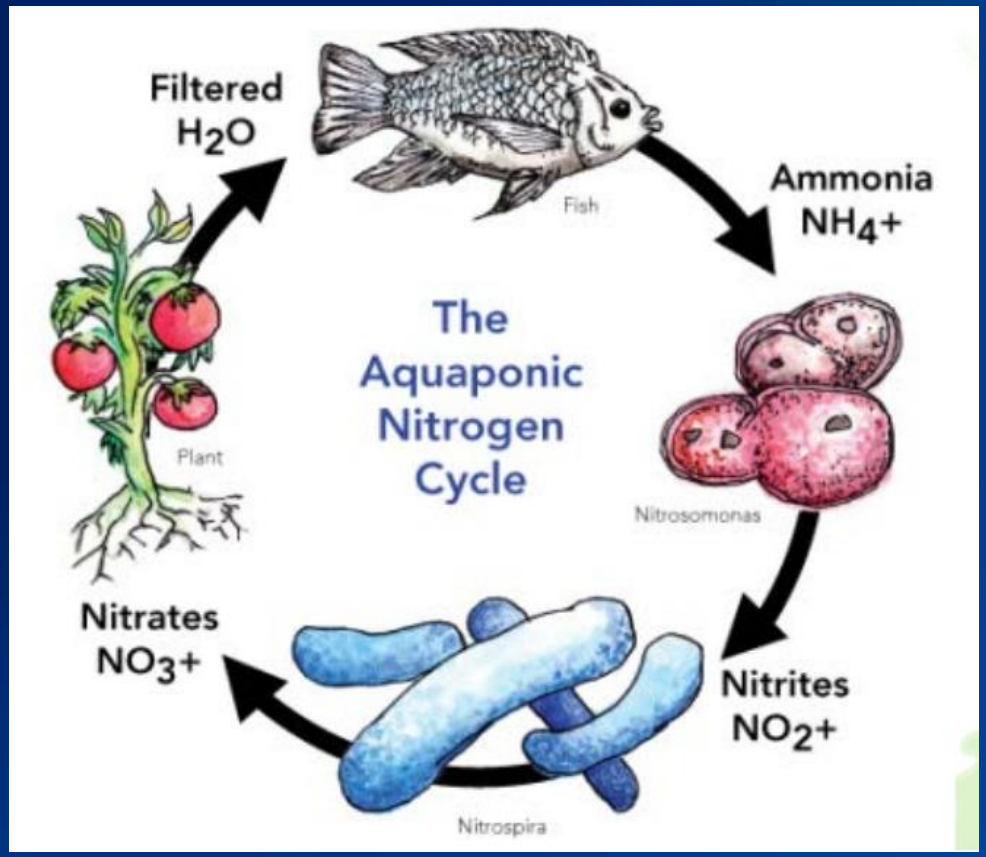
End of Discussion on Nutrient Deficiencies & pH

Next: System Startup
&
Water Quality

The Nitrogen Cycle

Fish

Plant Roots



Fish

Ammonia

Nitrosomonas

Nitrites

Nitrobacter /
Nitrospira

*Nitrates

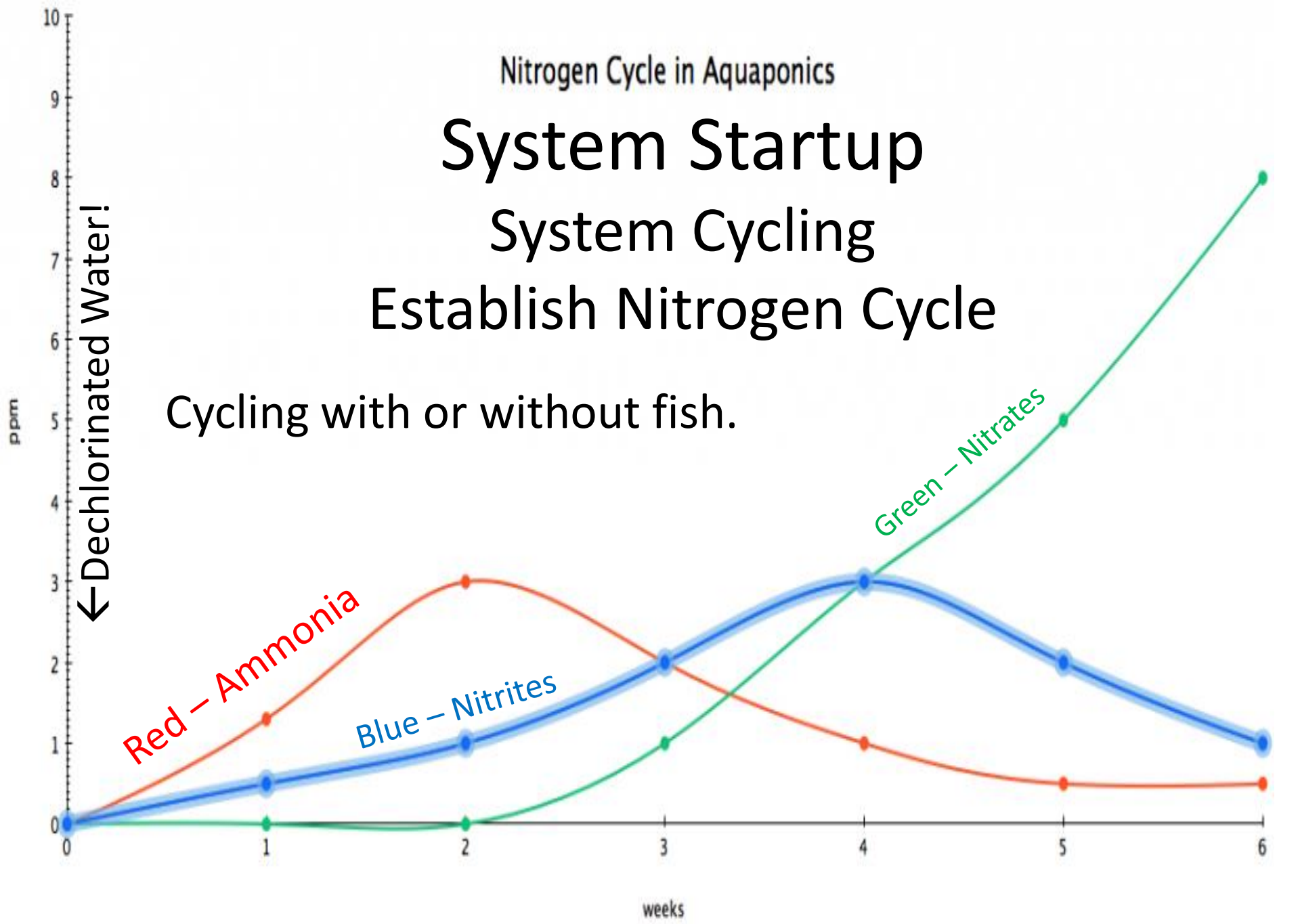
http://www.extension.iastate.edu/forestry/tri_state/tristate_2014/talks/PDFs/Aquaponic_System_Design_and_Management.pdf

System Startup

System Cycling

Establish Nitrogen Cycle

Cycling with or without fish.



http://aquaponics.ie/wordpress/index.php/what-is-aquaponics/starting-your-system/

Water Quality

- What to Measure:
  - TAN (Total Ammonia Nitrogen): NH_3 & NH_4^+
  - Nitrites: NO_2^- (Toxic)
  - Nitrates: NO_3^- (Safe, Plant Food)
  - pH
  - kH (Alkalinity, Buffering Capacity)
  - Dissolved Oxygen (DO)
  - Temperature

How to Test for Water Quality

Figure 2. Various methods for measuring water quality parameters

a) Test strips

b) Aquarium Kits

c) Commercial aquaculture kit (individual)

d) Commercial aquaculture kit (multiparameter)

e) Individual parameter meter

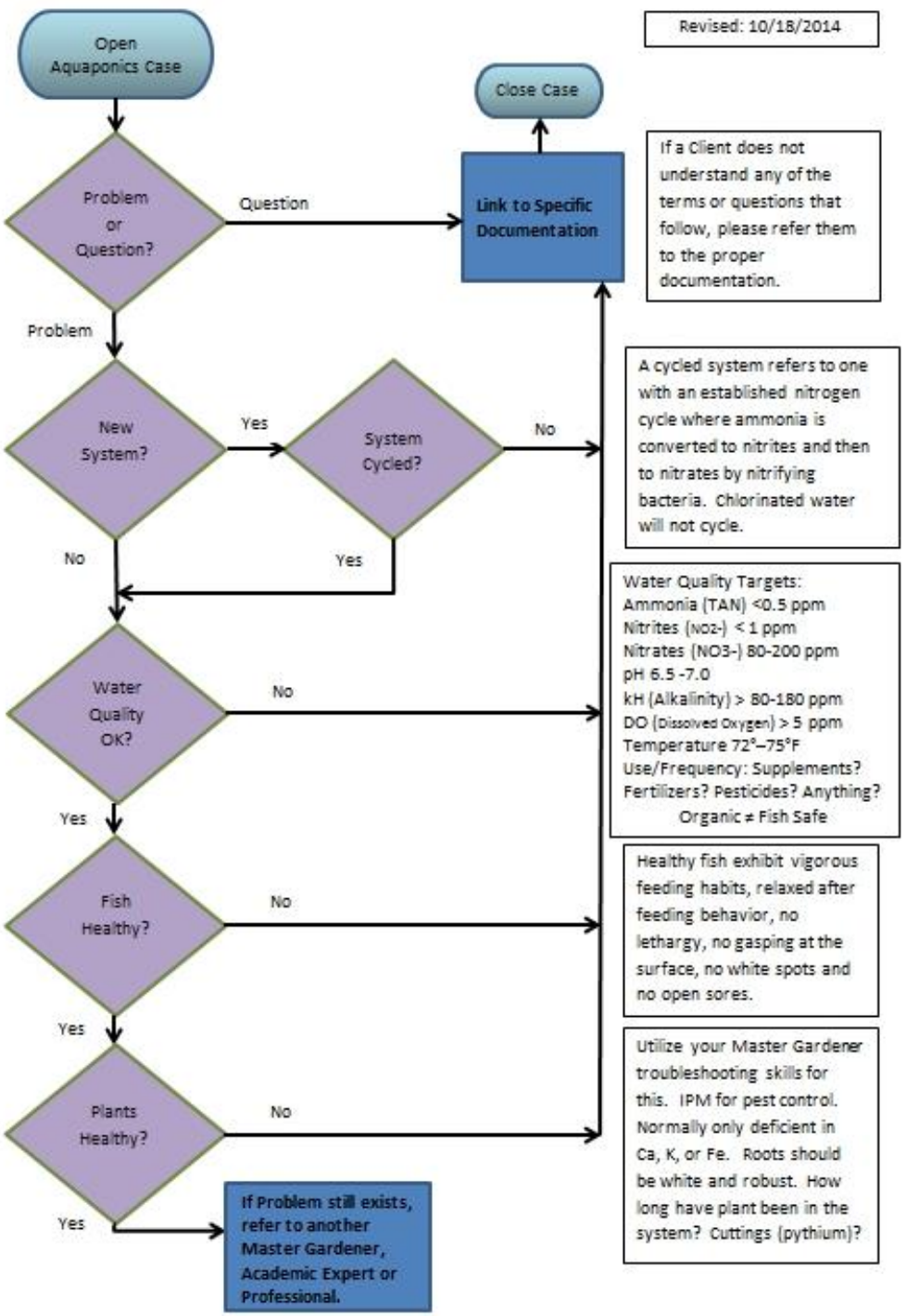
f) Multiparameter meter

RuthEllen Klinger-Bowen, Clyde S. Tamaru, Bradley K. Fox, Kathleen McGovern-Hopkins, Robert Howerton

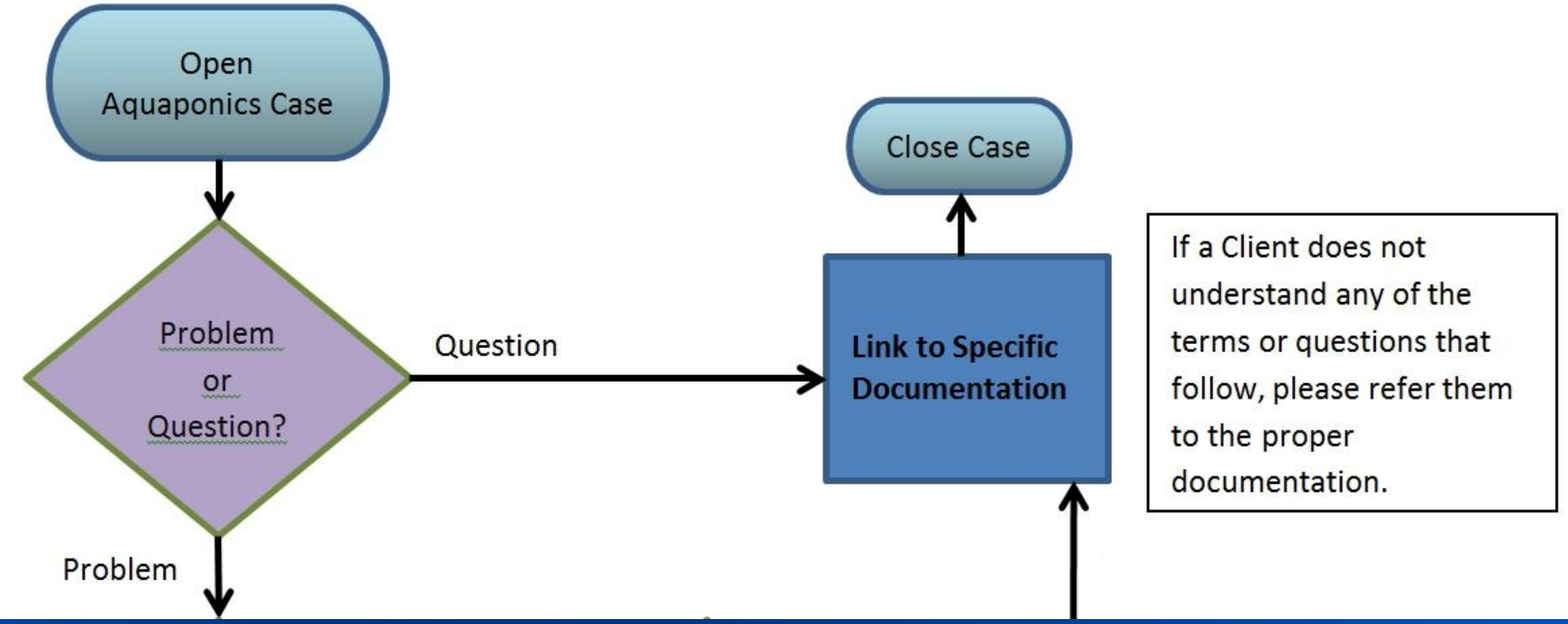
http://www.ctsa.org/files/publications/TestingAquaponicWater.pdf

End of Discussion on System Startup & Water Quality

Next: The Troubleshooting Flowchart


Revised: 10/18/2014
Open Aquaponics Case
Close Case
Problem or Question?
Question
Link to Specific Documentation
If a Client does not understand any of the terms or questions that follow, please refer them to the proper documentation.
Problem
New System?
Yes
System Cycled?
No
A cycled system refers to one with an established nitrogen cycle where ammonia is converted to nitrites and then to nitrates by nitrifying bacteria. Chlorinated water will not cycle.
No
Yes
Water Quality OK?
No
Water Quality Targets:
Ammonia (TAN) <0.5 ppm
Nitrites (NO2-) < 1 ppm
Nitrates (NO3-) 80-200 ppm
pH 6.5 -7.0
kH (Alkalinity) > 80-180 ppm
DO (Dissolved Oxygen) > 5 ppm
Temperature 72°–75°F
Use/Frequency: Supplements? Fertilizers? Pesticides? Anything?
Organic ≠ Fish Safe
Yes
Fish Healthy?
No
Healthy fish exhibit vigorous feeding habits, relaxed after feeding behavior, no lethargy, no gasping at the surface, no white spots and no open sores.
Yes
Plants Healthy?
No
Utilize your Master Gardener troubleshooting skills for this. IPM for pest control. Normally only deficient in Ca, K, or Fe. Roots should be white and robust. How long have plant been in the system? Cuttings (pythium)?
Yes
If Problem still exists, refer to another Master Gardener, Academic Expert or Professional.

Start



Is this a question about a problem that you're having, or Is this a general question about aquaponics?

Aquaponics Troubleshooting Flowchart – Links to Specific Documentation

General Questions on Aquaponics

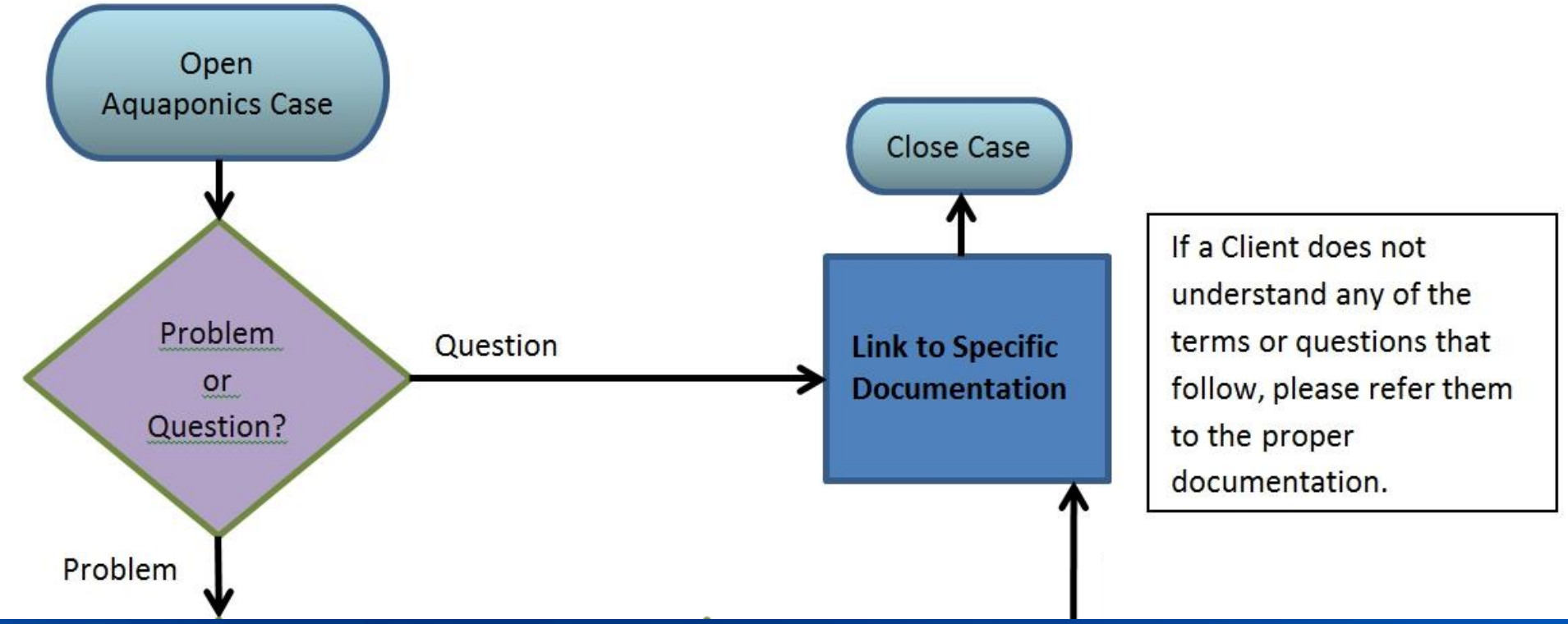
University of Hawaii Master Gardener Program-Tropical Topics-Aquaponics/Aquaculture
http://www.ctahr.hawaii.edu/uhmg/tropical-topics.asp#aqua
Tags: barrel-ponics challenges opportunities bell siphon hydroponic lettuce production ipm integrated pest management food safety suspended net pot non-circulating

CTAHR Cooperative Extension Service Aquaculture and Aquaponics
http://www.ctahr.hawaii.edu/site/ExtAQU.aspx
Tags: Soilless Farming Research Outreach Program AquacultureHub Training Online Learning ATOLL

Dr. Clyde S. Tamaru: Extension Specialist Department of Molecular Biosciences and Bioengineering
http://www.ctahr.hawaii.edu/sustainag/leaders/tamaru.html
Tags: aquaculture aquaponics hydroponics fishponds sustainable agriculture videos downloads publications

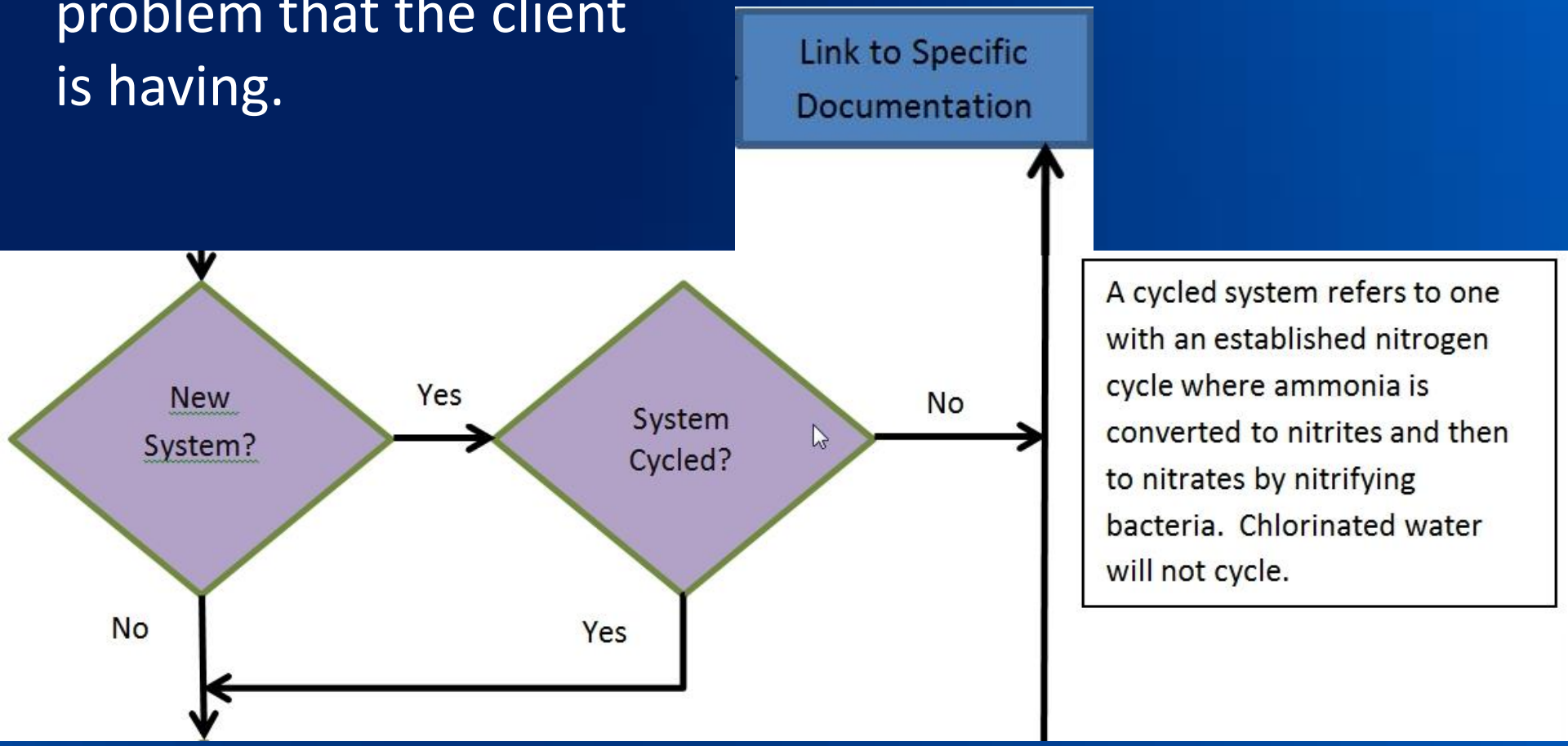
Dr. Robert Howerton: Resources from the Introduction to Aquaponics and Aquaculture Course
http://sustainablemaui.org/aquaponics-and-aquaculture-resources/
Tags: water quality publications nitrite ammonia pH carbon dioxide alkalinity hardness dissolved oxygen

Start



Is this a question about a problem that you're having, or Is this a general question about aquaponics?

Question about a problem that the client is having.



Is this a new system?

If yes, is the system cycled?

New System, System Cycling, the Nitrogen Cycle

Aquaponics at the College of Tropical Agriculture and Human Resources (CTAHR)
http://www.ctahr.hawaii.edu/uhmg/conference/downloads/MG_aquaponic.pdf
Tags: master gardener conference 2010 ahupua'a land grant hatch act smith-lever urban agriculture tilapia feed bell siphon Waimanalo media commercial nft raft nitrogen cycle vermicast tea types water quality plant weight state hospital

The Chemistry and Microbiology of Aquaponics
http://www2.hawaii.edu/~cwatters/Lesson%208%20Chemistry%20and%20Microbiology%20of%20Aquaponics.pdf
Tags: ammonia nitrites nitrates oxygenation DO dissolved oxygen pH carbon dioxide temperature pathogens chlorine chloramines feeding nitrogen cycle cycling test kits stock capacity mg/L

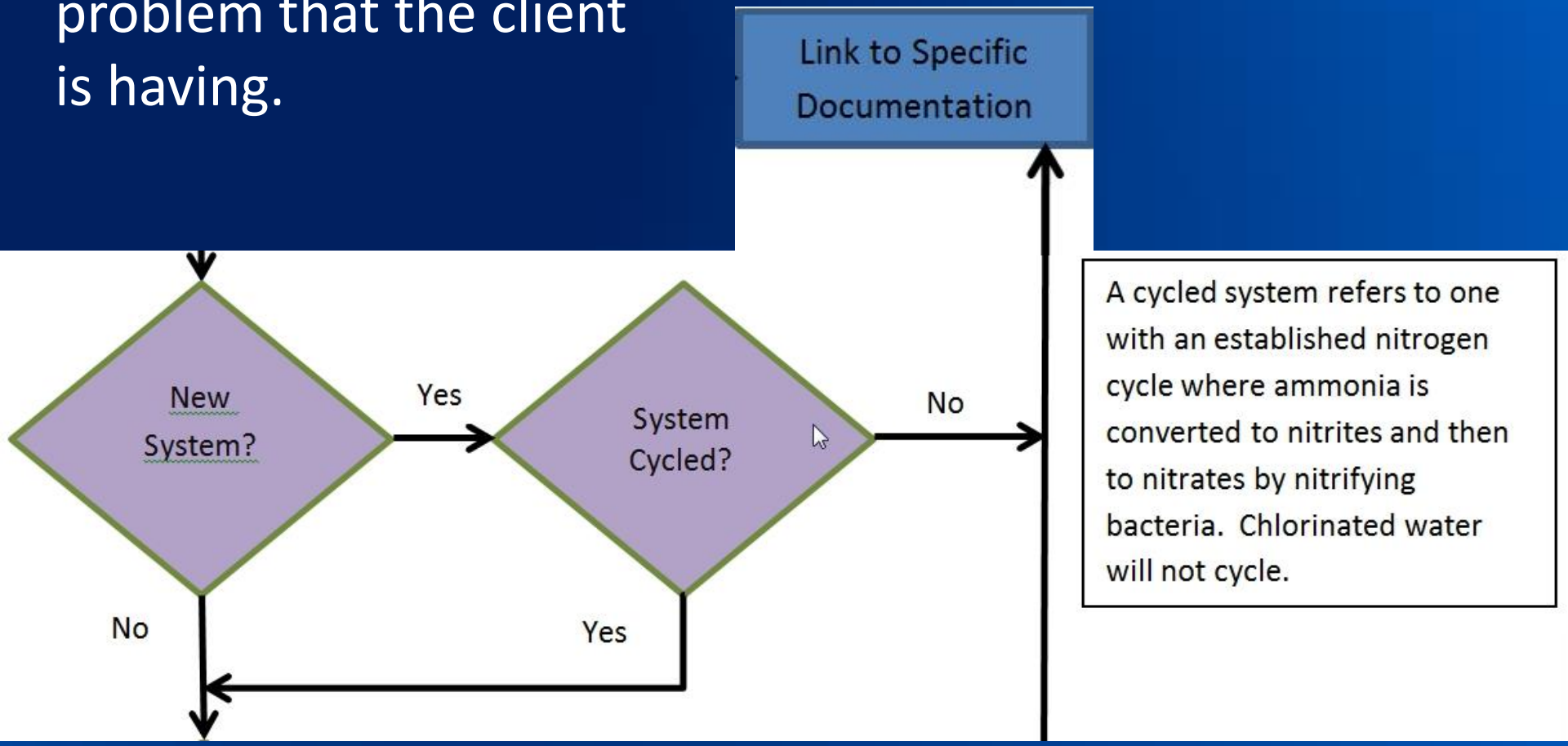
Barrel-ponics
http://www.ctahr.hawaii.edu/uhmg/downloads/barrel-ponics.pdf
Tags: aquaponics construction parts list grow bed stand flood valve floating raft plumbing maintenance starting nitrogen cycle plants fish

The Chemistry of Aquaponics PDF from the Texas Aquaponic Guide including Terms
http://cleanfoodsolutions.org/uploads/The_Chemistry_of_Aquaonics.pdf
Tags: stages cycling water fish bacteria plant testing pH ammonia tan nitrites nitrates alkalinity hardness general carbonate chlorine chloramine dissolved oxygen DO chemical terms

Nitrogen Cycle Poster
http://www.csus.edu/envs/Documents/Posters/Nitrogen%20Cycle.pdf
Tags: ammonia ammonium ammonification nitrification nitrites nitrates denitrification toxicity

Top of the Document

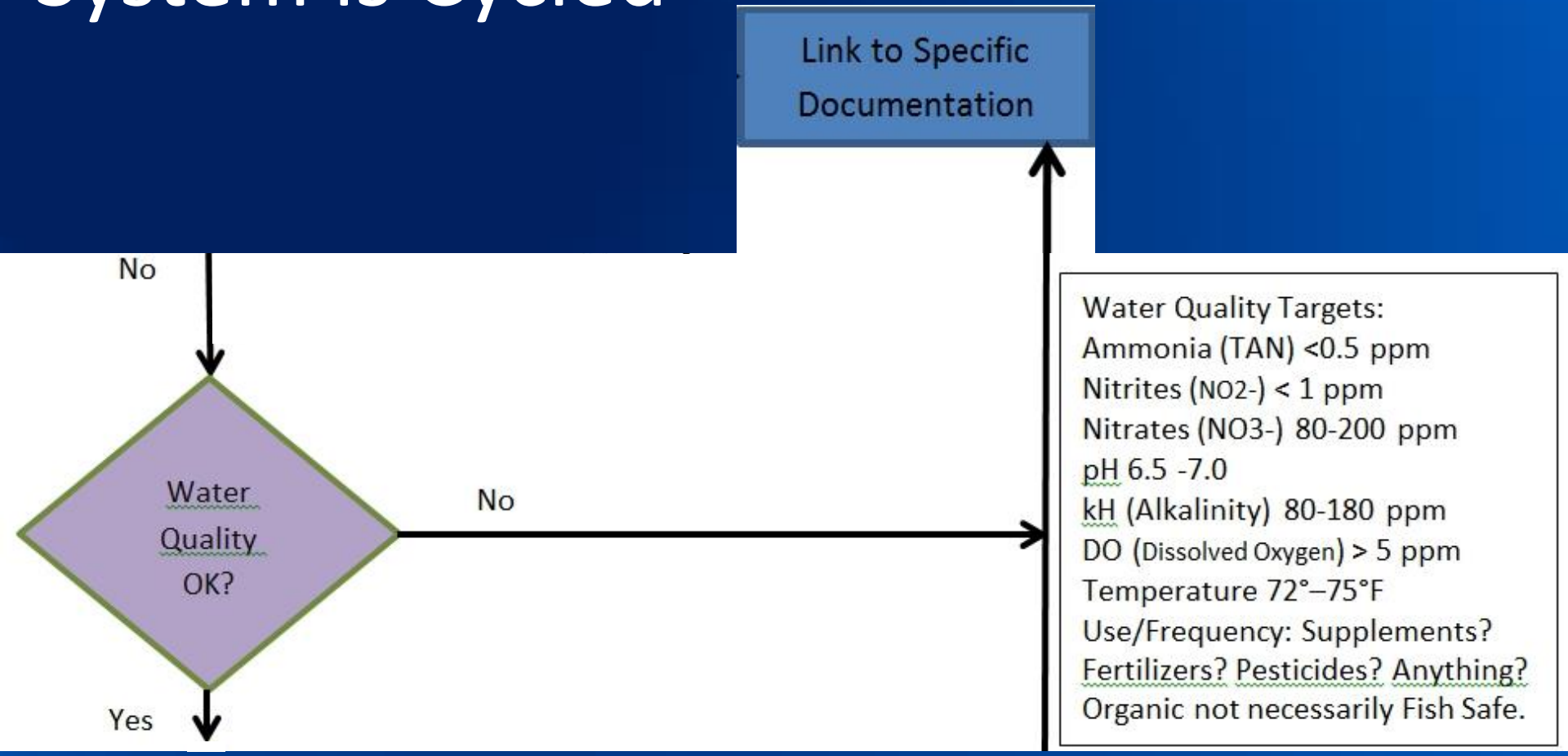
Question about a problem that the client is having.



Is this a new system?

If yes, is the system cycled?

Not a New System
System is Cycled



Is the Water Quality and Chemistry OK?

Water Quality / Chemistry

The Chemistry and Microbiology of Aquaponics
http://www2.hawaii.edu/~cwatters/Lesson%208%20Chemistry%20and%20Microbiology%20of%20Aquaponics.pdf
Tags: ammonia nitrites nitrates oxygenation DO dissolved oxygen pH carbon dioxide temperature pathogens chlorine chloramines feeding nitrogen cycle cycling test kits stock capacity mg/L

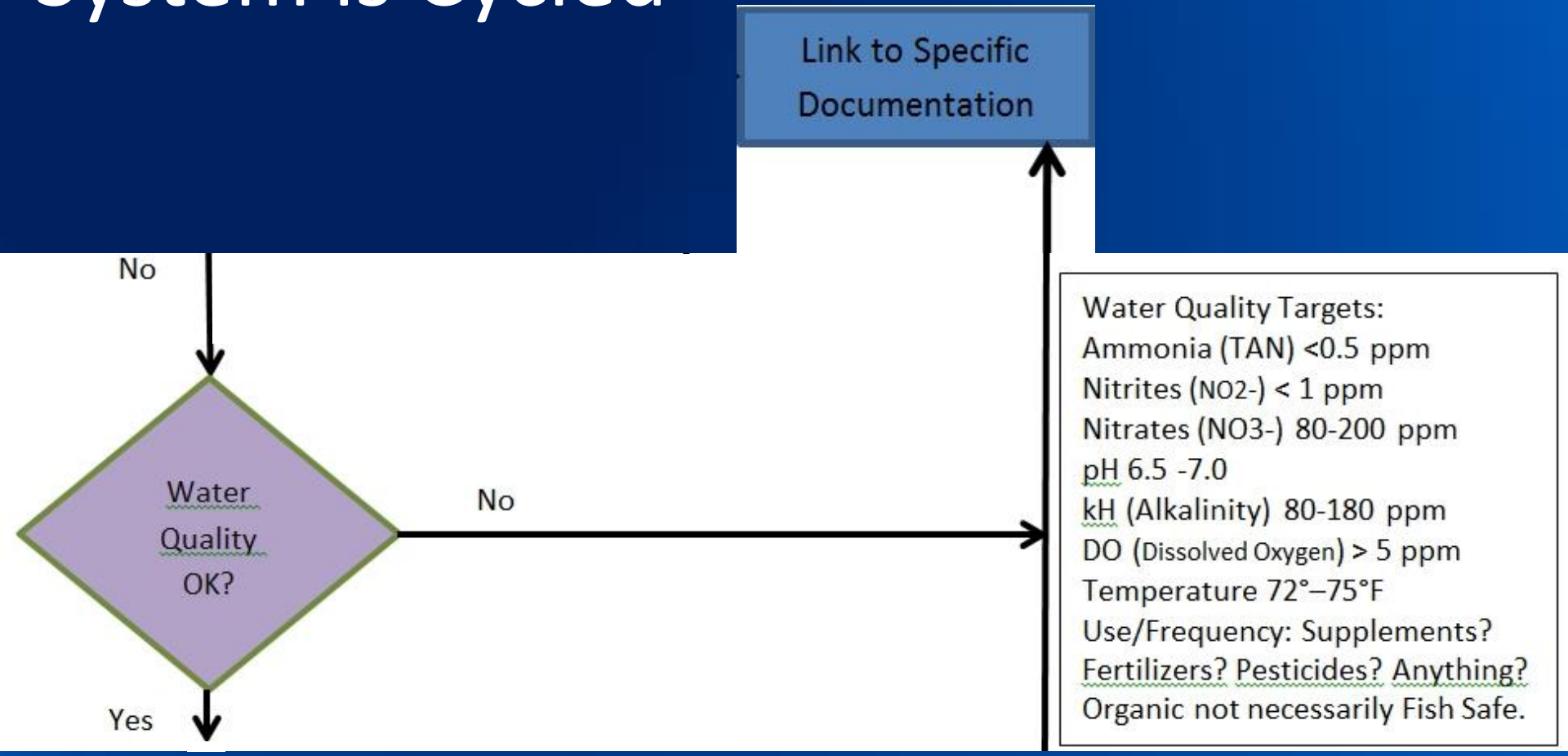
Testing your Aquaponic System Water: A Comparison of Commercial Water Chemistry Methods
http://www.ctsa.org/files/publications/TestingAquaponicWater.pdf
Tags: temperature DO dissolved oxygen pH alkalinity kH ammonia unionized ionized uia ia nh3 nh4+ macronutrients micronutrients frequency accuracy precision

Water Quality in Aquaponic Systems
http://ag.arizona.edu/ceac/sites/ag.arizona.edu.ceac/files/Water%20Quality%20in%20Aquaponic%20Systems%20-%20Shultz.pdf
Tags: DO dissolved oxygen nitrogen ammonia nitrite nitrate pH alkalinity carbon dioxide temperature cycle biofiltration biofilter denitrification hardness npk feeding rate supplementation

The Chemistry of Aquaponics PDF from the Texas Aquaponic Guide including Terms
http://cleanfoodsolutions.org/uploads/The_Chemistry_of_Aquaponics.pdf
Tags: stages cycling water fish bacteria plant testing pH ammonia tan nitrites nitrates alkalinity hardness general carbonate chlorine chloramine dissolved oxygen DO chemical terms

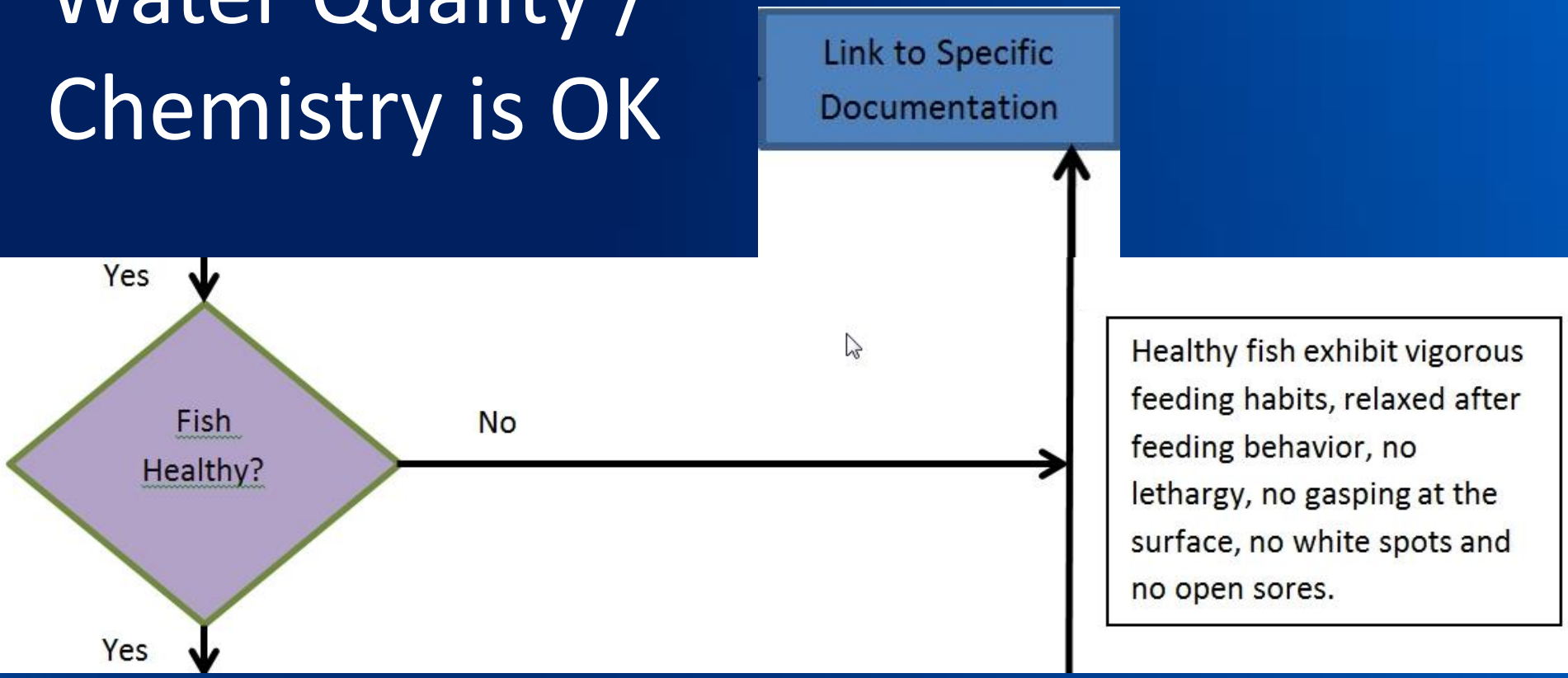
Ammonia in Aquatic Systems
http://edis.ifas.ufl.edu/fa031
Tags: ammonium total nitrogen tan nh4+ nh3 nitrite cycle nitrospira nitrosomonas nitrobacter oxygen alkalinity salt testing uia ia pH temperature

Not a New System
System is Cycled



Is the Water Quality and Chemistry OK?

Water Quality / Chemistry is OK



Fish feeding vigorously, relaxed between feedings?

Not Healthy if: fish lethargic or agitated, white spots, open sores, gasping for air at surface.

Fish Health

Tilapia Life History and Biology

https://srac.tamu.edu/index.cfm/event/getFactSheet/whichfactsheet/53/

Tags: nile niloticus characteristics taxonomy cichlids oreochromis nest builders mouth brooders aureus mossambicus physical characteristics banding patterns coloration reproduction sexual maturity feeding behavior nutritional requirements environmental salinity dissolved oxygen temperature pH ammonia nitrite diseases growth yields regulations

Aquaponics—Integration of Hydroponics with Aquaculture

http://www.aces.edu/dept/fisheries/education/documents/aquaponics_Integrationofhydroponicswaquaculture.pdf

Tags: nutrients effluent plants fish water quality biofiltration bibliography speraneo s&s Aqua Farms rakocy organic books magazines journals

Recirculating Aquaculture Tank Production Systems: Aquaponics—Integrating Fish and Plant Culture

http://fisheries.tamu.edu/files/2013/09/SRAC-Publication-No.-454-Recirculating-Aquaculture-Tank-Production-Systems-Aquaponics-Integrating-Fish-and-Plant-Culture.pdf

Tags: rakocy design uvi types nft

The Role of Stress in Fish Disease

http://fisheries.tamu.edu/files/2013/09/SRAC-Publication-No.-0474-The-Role-of-Stress-in-Fish-Disease.pdf

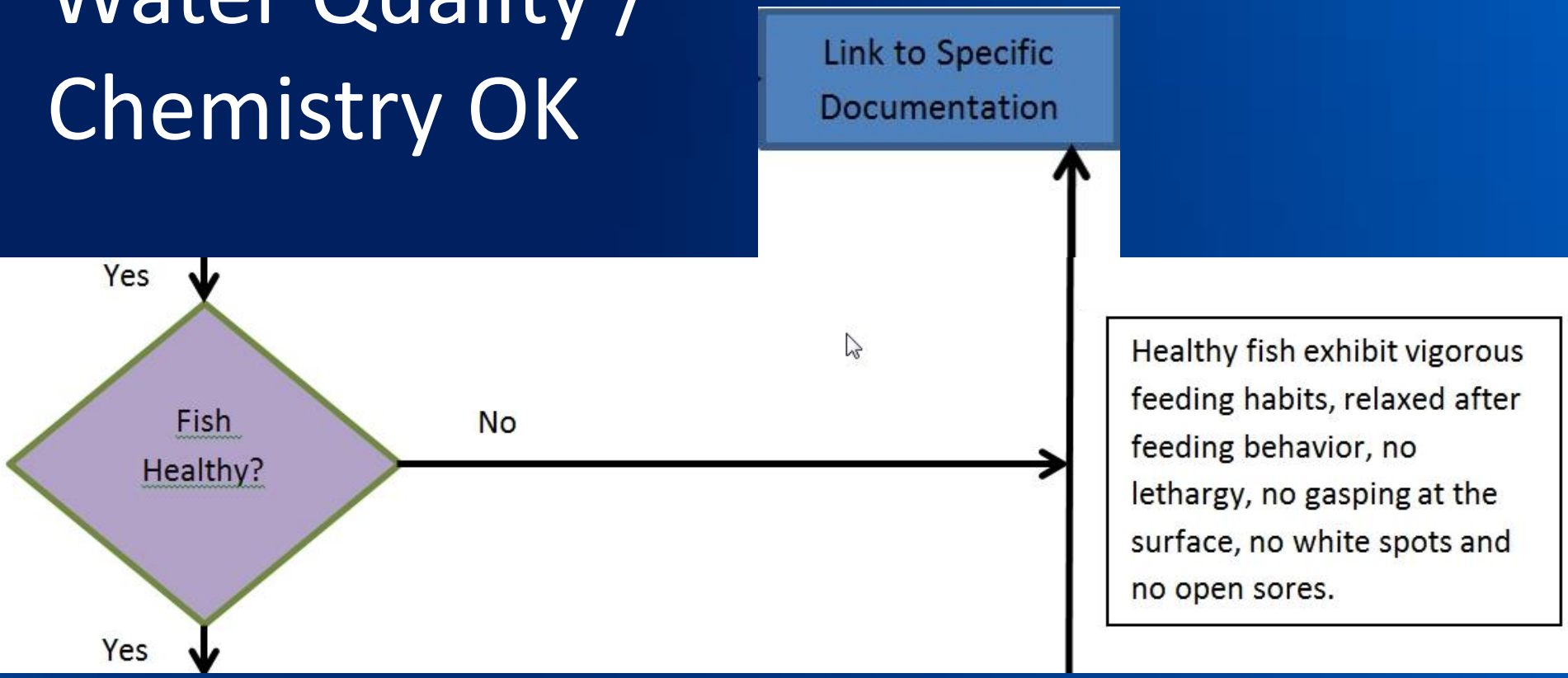
Tags: physiological physical injury density handling nutrition sanitation defense infection mucus slime layer scales skin inflammation antibodies prevention water quality transporting

Francisellosis in Tilapia

http://www.ctsa.org/files/publications/Biosecurity_Pub158.pdf

Tags: Francisella fno disease noatunensis orientalis asiatica white nodules spleen kidney

Water Quality / Chemistry OK



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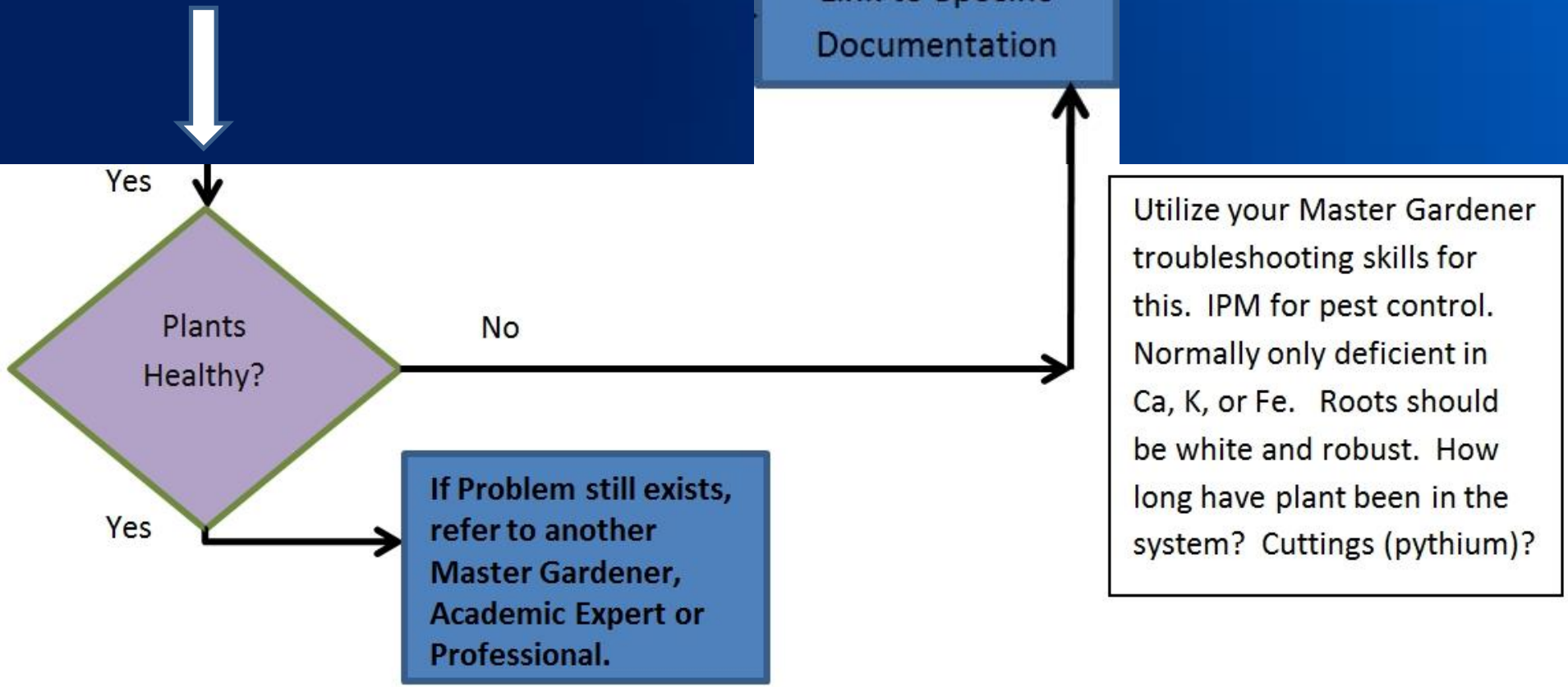
Fish are Healthy



Are the plants healthy?
If the client is not satisfied, refer this case out. Document final solution.

Plant Health

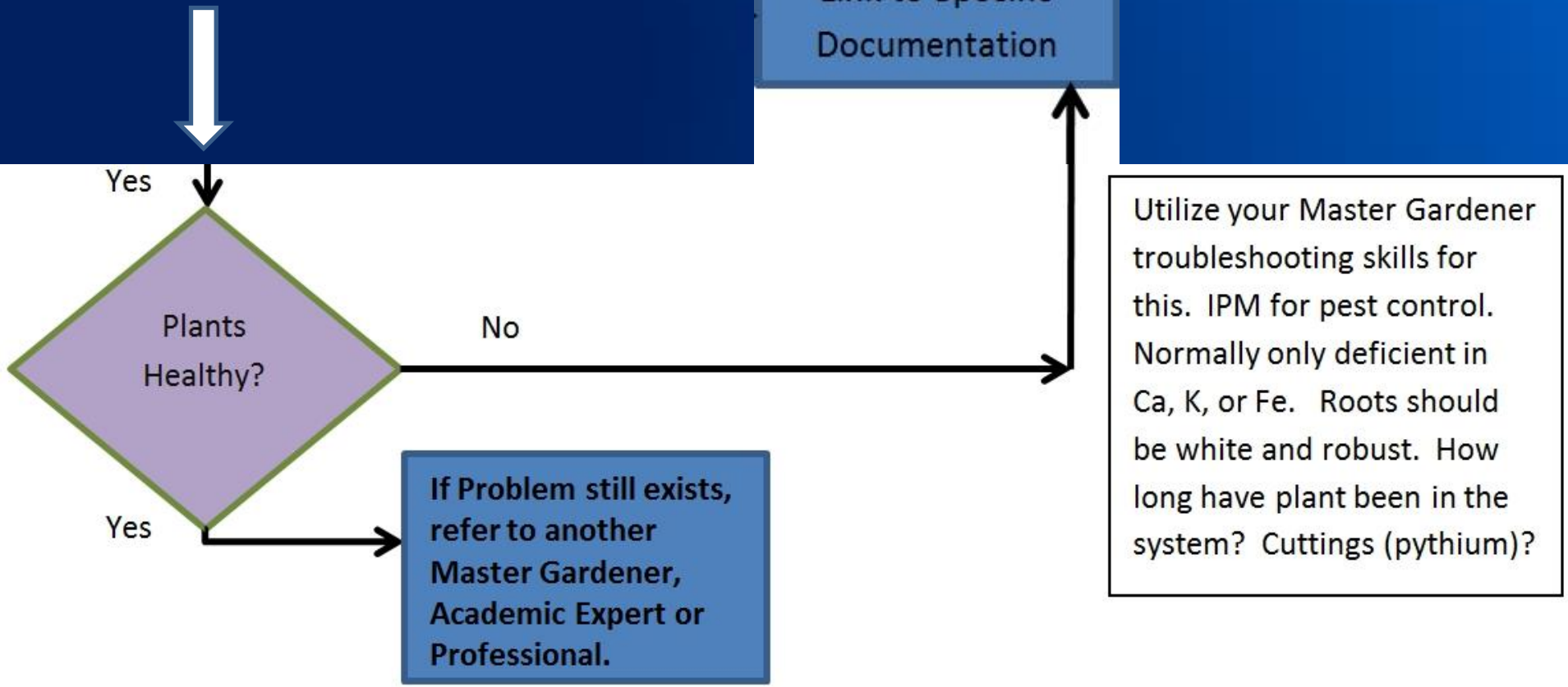
Integrated Pest Management for Commercial Aquaponic Systems
http://www.ctahr.hawaii.edu/sustainag/workshop/downloads/Aquaponics-Classroom/Sugano_IPM_aquaponics.pdf
Tags: ipm id pest monitor habitat modification cultural physical control biotechnology biological control chemical control chewing beetles caterpillars leaf miners sucking vascular tissue discolor distortion honey dew sooty mold aphids whiteflies grasshoppers mealy bugs scales leaf hoppers rasping sucking mites brown discoloration ants fruit flies snails slugs nematodes root rotting galling fungus bacteria virus phyto-plasma pathogens nutrition monitoring traps population infestation location natural enemies season environmental conditions strategies habitat modification breeding sites physical barriers screens rotation fallow spacing companion planting crop selection aeration worms sanitation biotechnology pesticides label law allowed crop listed environmental hazard benefits

Are we ready for insecticide-free aquaponics system?
http://www.ctahr.hawaii.edu/sustainag/workshop/downloads/Aquaponics-May2013/KHWang.pdf
Tags: ipm environmental hazard biodiversity national organic program nop sunset list insectary plants wasp nesting blocks reflective raft Vermicompost thrip natural enemies lady beetle green lacewing hover fly buckwheat cilantro sunn hemp aphid-collecting wasp

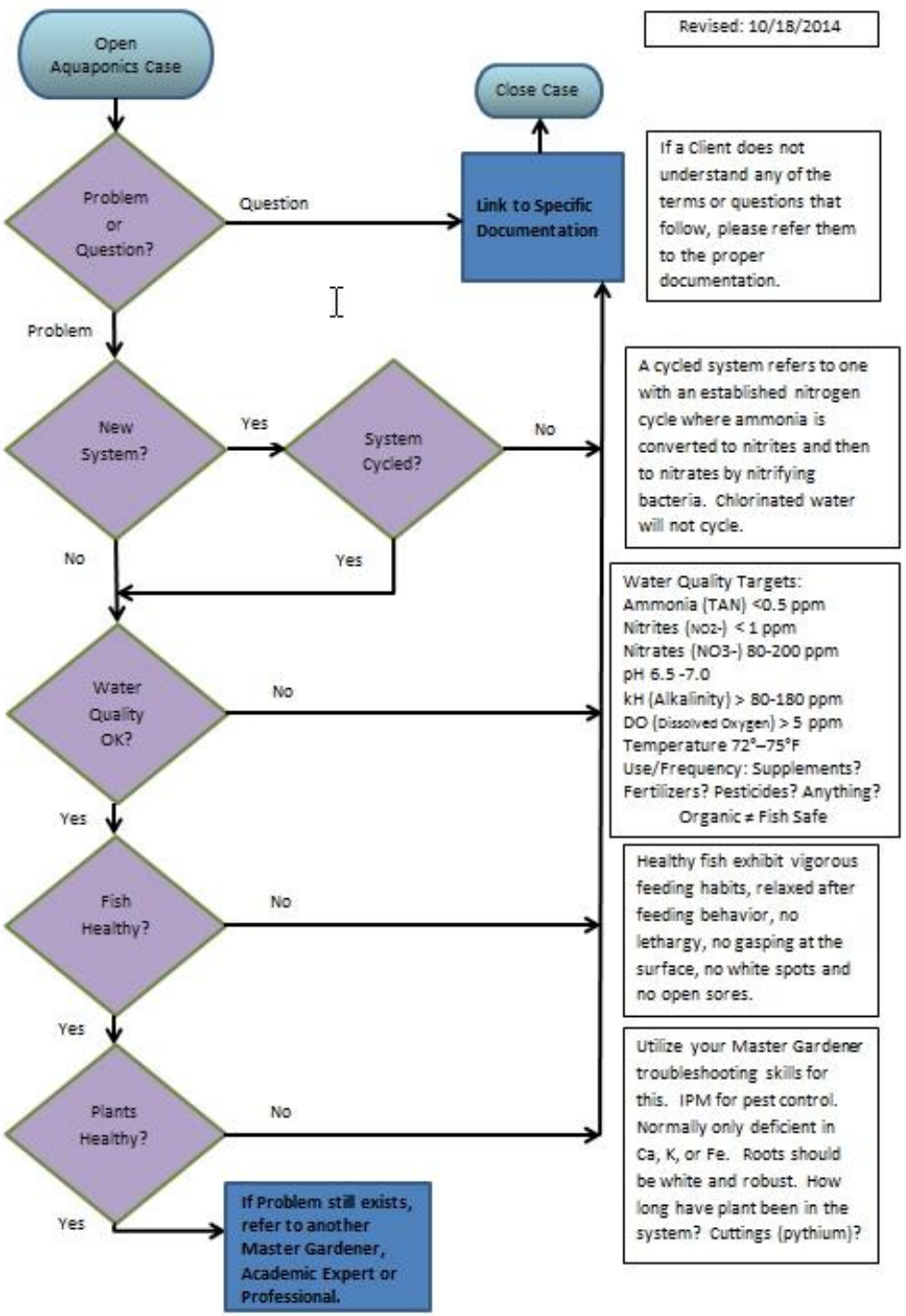
Beneficial Use of Vermicompost in Aquaponic Vegetable Production
http://www.ctahr.hawaii.edu/sustainag/news/articles/V10-Fox-Verm-Aquaponics.pdf
Tags: advantages limitations pH buffering potassium hydroxide calcium optimal nitrifying bacteria iron chelated sustainable renewable agricultural practices nutrient deficiencies compost worms enhance plant growth crop yield root structure worm tea microbial metabolites

Yield and Quality of Aquaponic Pakchoi
http://www.ctahr.hawaii.edu/sustainag/workshop/downloads/Aquaponics-Classroom/Radovich_PakChoi.pdf
Tags: Vermicompost media variety head size weight phytonutrient

Fish are Healthy



Are the plants healthy?
If the client is not satisfied, refer this case out. Document final solution.


Revised: 10/18/2014
Open Aquaponics Case
Close Case
Problem or Question?
Question
Link to Specific Documentation
If a Client does not understand any of the terms or questions that follow, please refer them to the proper documentation.
Problem
New System?
Yes
System Cycled?
No
A cycled system refers to one with an established nitrogen cycle where ammonia is converted to nitrites and then to nitrates by nitrifying bacteria. Chlorinated water will not cycle.
No
Yes
Water Quality OK?
No
Water Quality Targets:
Ammonia (TAN) <0.5 ppm
Nitrites (NO2-) < 1 ppm
Nitrates (NO3-) 80-200 ppm
pH 6.5 -7.0
kH (Alkalinity) > 80-180 ppm
DO (Dissolved Oxygen) > 5 ppm
Temperature 72°–75°F
Use/Frequency: Supplements? Fertilizers? Pesticides? Anything?
Organic ≠ Fish Safe
Yes
Fish Healthy?
No
Healthy fish exhibit vigorous feeding habits, relaxed after feeding behavior, no lethargy, no gasping at the surface, no white spots and no open sores.
Yes
Plants Healthy?
No
Utilize your Master Gardener troubleshooting skills for this. IPM for pest control. Normally only deficient in Ca, K, or Fe. Roots should be white and robust. How long have plant been in the system? Cuttings (pythium)?
Yes
If Problem still exists, refer to another Master Gardener, Academic Expert or Professional.

What Did We Cover?

- Basic Concepts
- Types of Systems
- Nutrient Deficiencies & pH
- System Startup & Water Quality
- Troubleshooting Flowchart

Aquaponics for Master Gardeners

- End of Presentation -

Link to Reference Documentation List

Link to Troubleshooting Flowchart