Minimizing horticultural impacts on surface water quality to encourage reuse through enhanced pond management

March 26, 2019 COHA C3 Webinar 1

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COHA C3 Project 7

Main Project Objectives

1. Define, collect and analyze information about the current levels of nutrients entering and held in ponds in selected agricultural landscapes and production systems.

2. Test and investigate the efficacy of enhanced pond management practices at the farm level

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Work Plan Years 1&2

FY 2018-2019 – Year 1

- Literature review
- Participating farm sites identified
- Establish Technical Advisory Committee (TAC)
- Year-end TAC meeting to review project plan and prepare for next season

Deliverables: TAC-approved project plan, participating farms identified, completed literature review

FY 2019-2020 – Year 2

- Benchmark monitoring at selected sites completed and summarized
- Installation of Pre-Pond technologies completed
- Annual data analysis and review completed
- TAC meeting

Deliverables: Pre-pond technologies installed, benchmarking data summary

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Technical Advisory Committee

- Members include:
  - Soil Resource Group
  - Terrapin Water
  - Ontario Ministry of Agriculture Food & Rural Affairs
  - Landscape Ontario
  - University of Waterloo
  - Clemson University
  - Agriculture and AgriFood Canada
  - IQDHO
- Meeting March 20th to review literature, work plan

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Literature Review

- Completed review
- Prepared spreadsheet summary of relevant papers
- Shared and discussed relevant findings with Technical Advisory Committee
- Focus on available technologies, experimental setup, and sampling techniques

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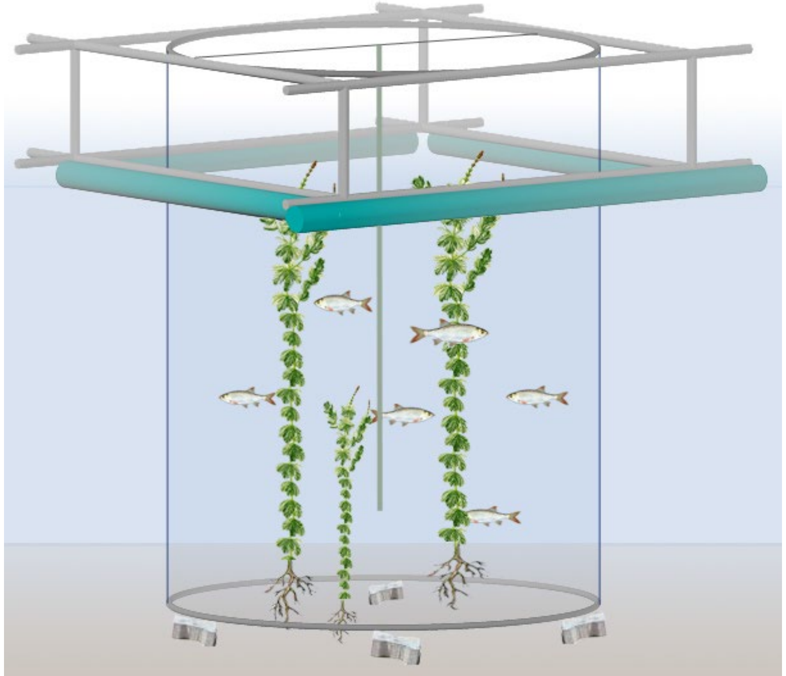
MESOCOSM DESIGNS



Ozkan2008

Hitchcock et al. 2015

SAMPLING/CRITICAL PARAMETERS

Water

- Optical DO*
- Temperature*
- Conductivity*
- Turbidity*
- Chlorophyll a*
- Phycocyanin*
- pH*
- Typical ICP suite:
  - TP, other?
  - NH3, NO3, other?

Sediment

- TP, other?
- TN, other?
- Fe?

Vegetation

- % coverage
- Spp. diagnostics:
  - Algae
  - Cyanobacteria
  - Macrophytes
  - Periphyton?
- Biomass?
- Shoot/Root lengths?
- Tissue analysis?

Climate

- Precipitation
- Irrigation records
- Coverage area
- Irrigation type
- Outdoor temp
- PAR

Pond

- Depth
- Area
- Slope
- Flow rates
- Turnover
- Secchi depth
- Inputs

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PRE-POND OPTIONS

OPTIONS	Details
Planted drainage ditch (i.e. vegetated filter strips)	Plantings- plant selection critical (emergent & submerged plants) – consider uptake kinetics and biofilm contribution Requires annual harvesting ? Get sediment/soil buildup Can be effective for N, P, agrochemicals Lost production space
Under-bed media or terracing (i.e. dry grass swales with media filters)	Wood shavings or chips, LECA (clay aggregate w silicate matrix – consider pore sizes and flow restrictions), shale, gravel or a combo? Anaerobic conditions – denitrification (0.8m LECA, more for woodchips?) Also significant P removal under certain conditions Can have production on top

Key considerations:

- Precipitation
- Catchment area
- Flow rate
- Hydraulic Retention Time
- COMBINE the 2 concepts

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White et al. 2011

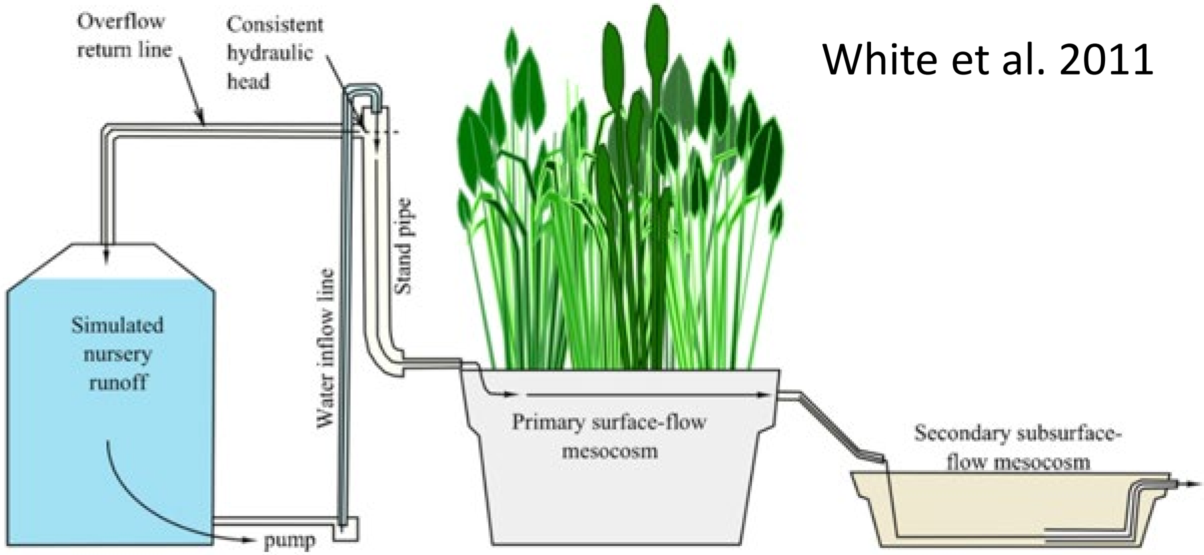
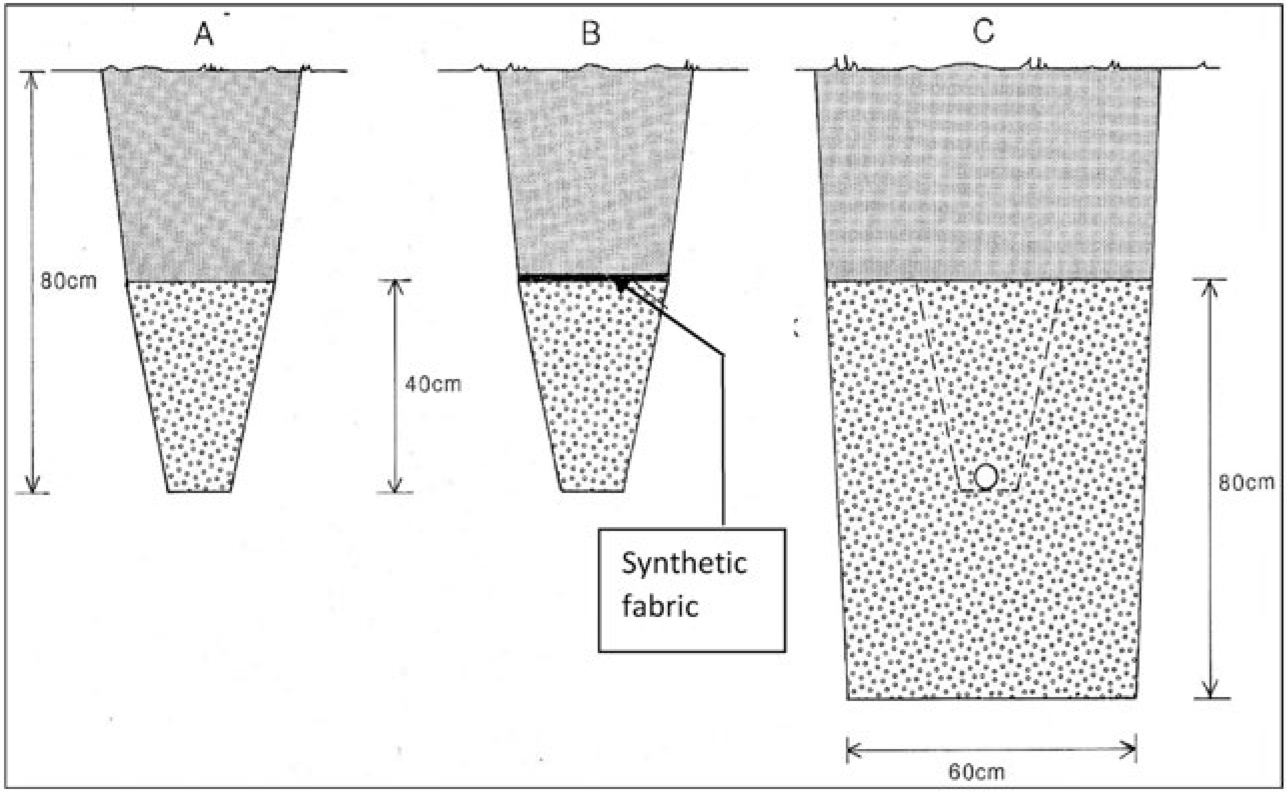


Fig. 1. Water-flow schematic from inflow tank through secondary treatment outflow.

Bjerkholt et al. 2019



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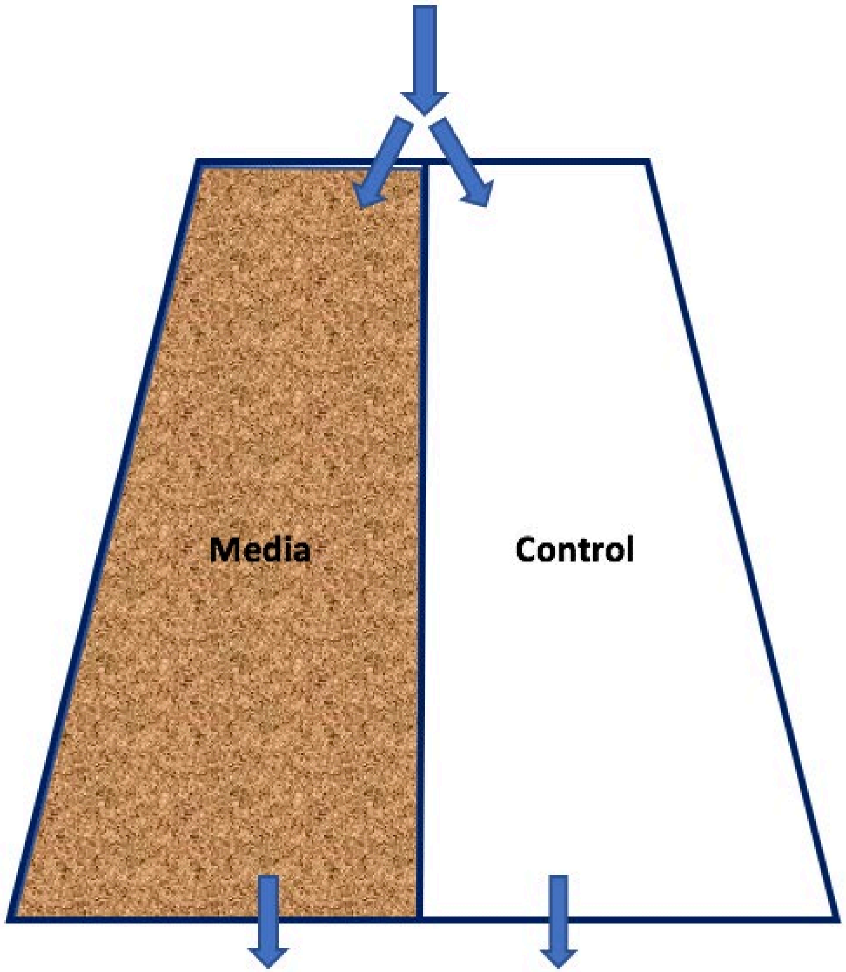
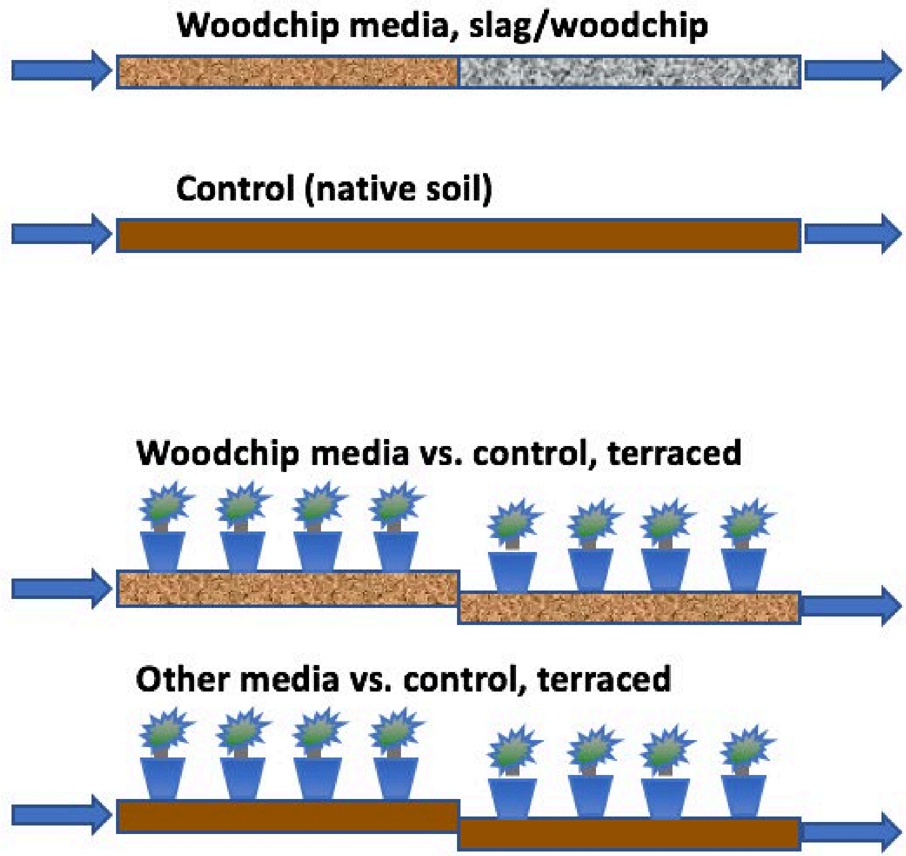
PRE-POND OPTIONS

Top Profile:



Side Profiles – without/with plants:



COVERINGS

E.g. Shade cloth, weed barrier, swimming pool cover, etc.:

ADVANTAGES	DISADVANTAGES
Relatively simple maintenance	DO impacts? (impt for irrig water) – so aerate
Less microbial/algal growth?, less Chl*a*, TSS, DO, less clogging	Increase pH, high respiration with solid covers
Reduction in evaporative losses	Potential for release of P from sediment
Suspended shade cloth covers worked best?	Potential for cyanobacteria to thrive

Key considerations:

- Setup for cover removal, initial costs?
- SAV (lower in water column) maybe more effective?
- Can potentially consider USA site for data?
- **Combine with aeration** to avoid low DO and most of the disadvantages

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AQUATIC VEGETATION

Macrophytes:
- Charophytes
- Filamentous algae
- Vascular plants

ADVANTAGES	DISADVANTAGES
Water clarifying, less TSS, may be effective for nutrient removal	P not removed significantly?
Improved sedimentation	% due to periphyton/biofilm
Vascular plants better in dug ponds	Harvesting required

Duckweed:

ADVANTAGES	DISADVANTAGES
Can use the harvested product	High harvesting frequency?
High growth rate, shading factor	Requires high nutrient levels
Double nutrient removal rates over macrophytes?	% due to periphyton/biofilm and sedimentation

Key considerations:
- Root & photosynthetic features
- Pond depth
- Organic loading
- Evapotranspiration rates
- Retention times

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CONSTRUCTED FLOATING WETLAND (PHYTOLINKS, or CFW)

Key considerations:

- Benchmark 1st
- Pond hydraulics etc
- Positioning of CFW
- Plant selection
- Short-circuiting
- Control
- **Combine with additional subsurface substrate**

ADVANTAGES	DISADVANTAGES
Improve filtration & sedimentation	Better with higher nutrient & TSS levels?
Nutrient removal (+periphyton)	P removal varies
Lots of literature is positive	Design/pond hydraulics key
Adjust to water level	Moderate-high setup costs
Root & shoot harvesting possible	Annual harvesting
Decrease pH?	Contribution of CFW vs periphyton or pond dynamics challenging

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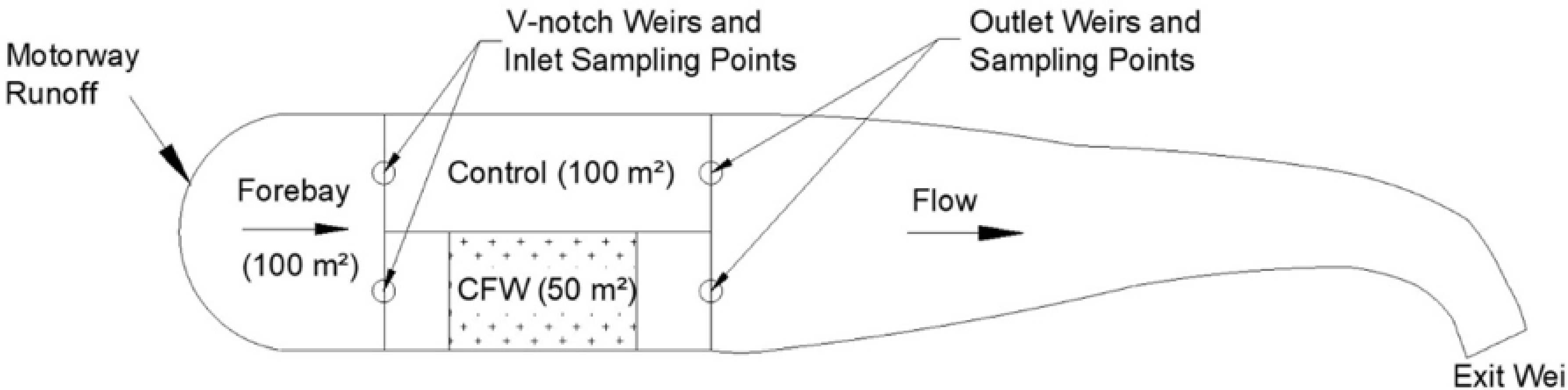
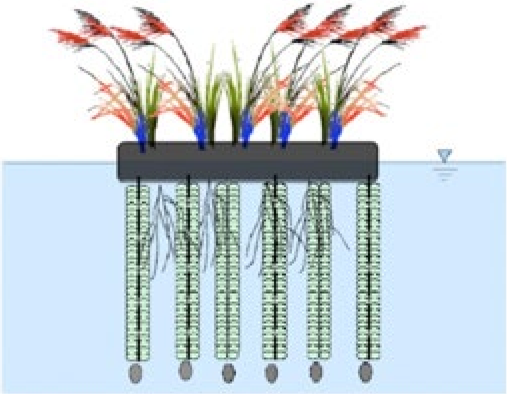


Fig. 8. Configuration of CFW and control system. After Borne et al. (2013).

Sorption substrates

ADVANTAGES	DISADVANTAGES
Can be used in combo with CFW	Cost of some options is high
Promotes biofilm/periphyton growth by increasing surface area	Lifespan?
Can increase effective N/P removal	P removal limited unless combined with CFW
Suppression of algae/duckweed	HRT critical, see CRW considerations

Alternative periphyton substrates?
BioCord
Coarse calcined clay
Zeolite
Wood chips/fibres
Bentonite
Wollastonite



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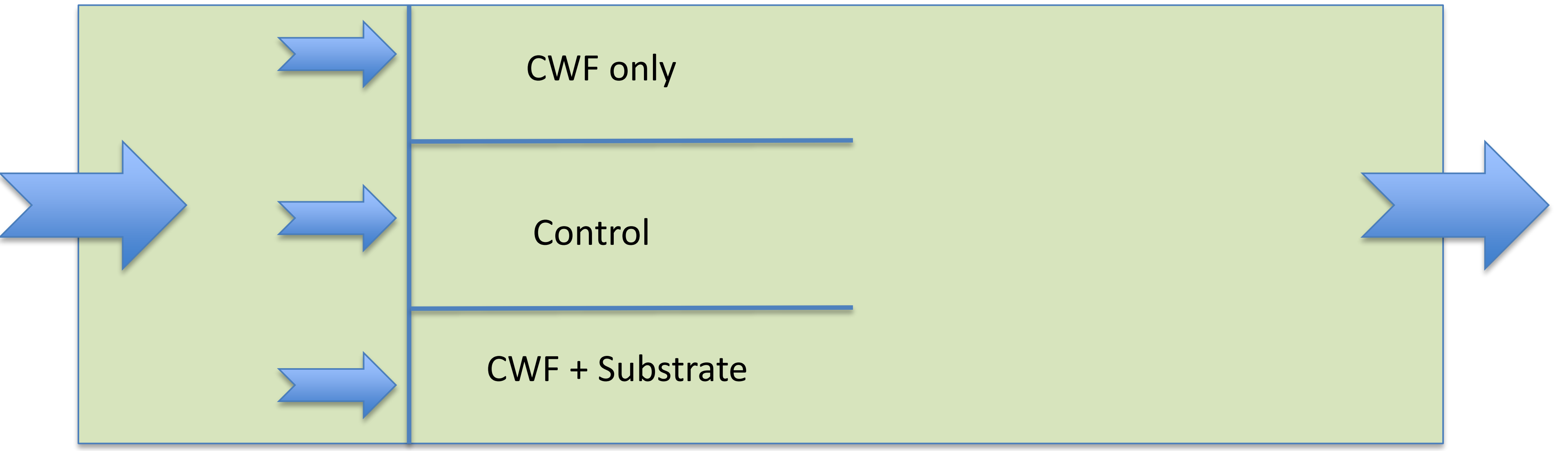
CFW & Substrate Enhancement



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AERATION OPTIONS

SYSTEM	CONSIDERATIONS
Aeration	Current the common practice Best for deeper ponds (>3m) Large bubbles, rise quickly Limited water:air interaction time
Nanobubbles	Improved dispersion of oxygen for reduction of organic matter? Still better for deeper water Smaller bubbles rise more slowly, and have greater surface area exposure Cost??

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Farm Site Selection

- Potential farms visited in 2018-2019
- Re-visiting prior to 2019 sampling season to confirm which ponds/watercourses to benchmark and use for chosen treatment technologies
- Participating farms have multiple pond sites to choose from!

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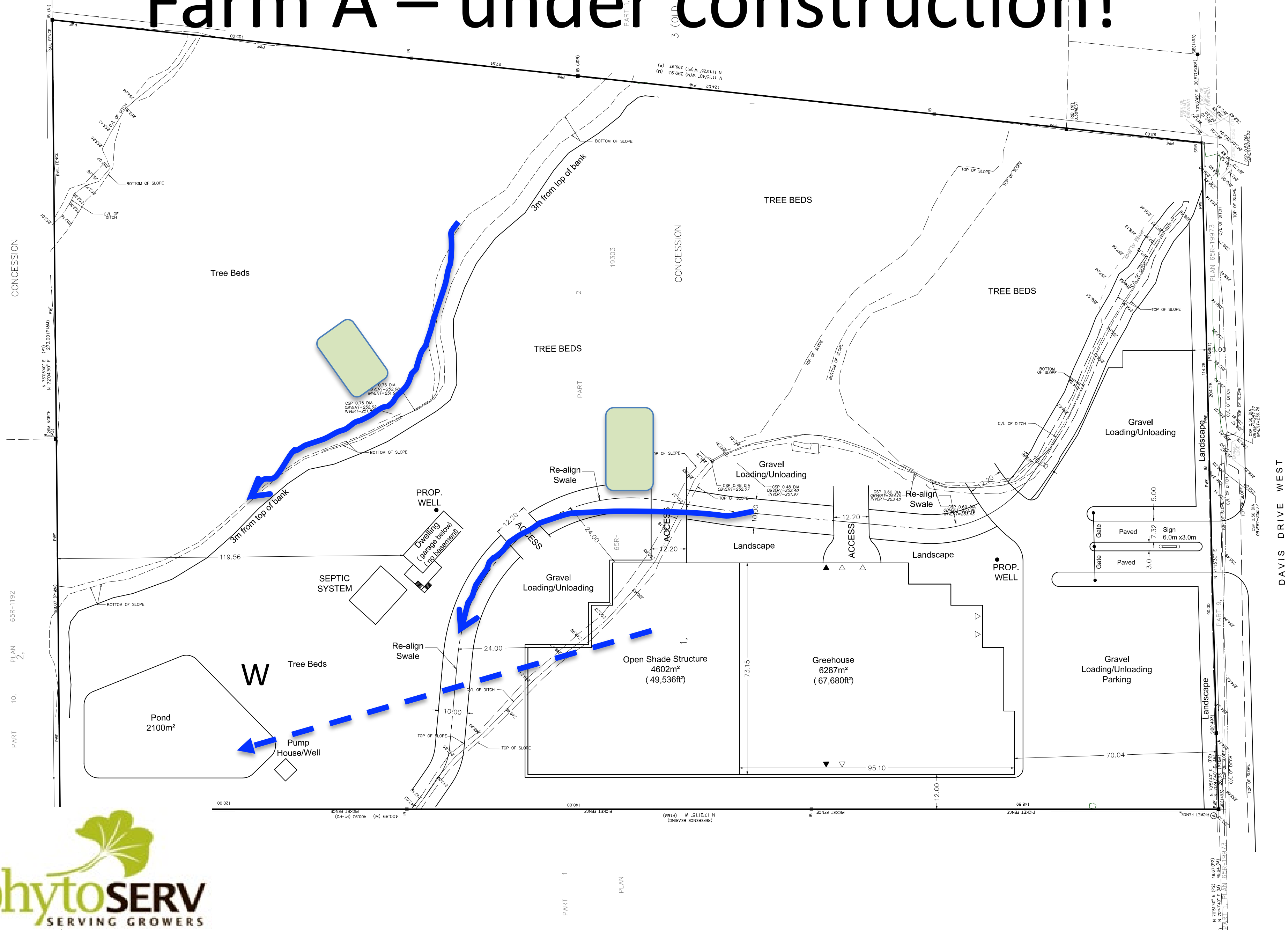
Farm A – under construction!



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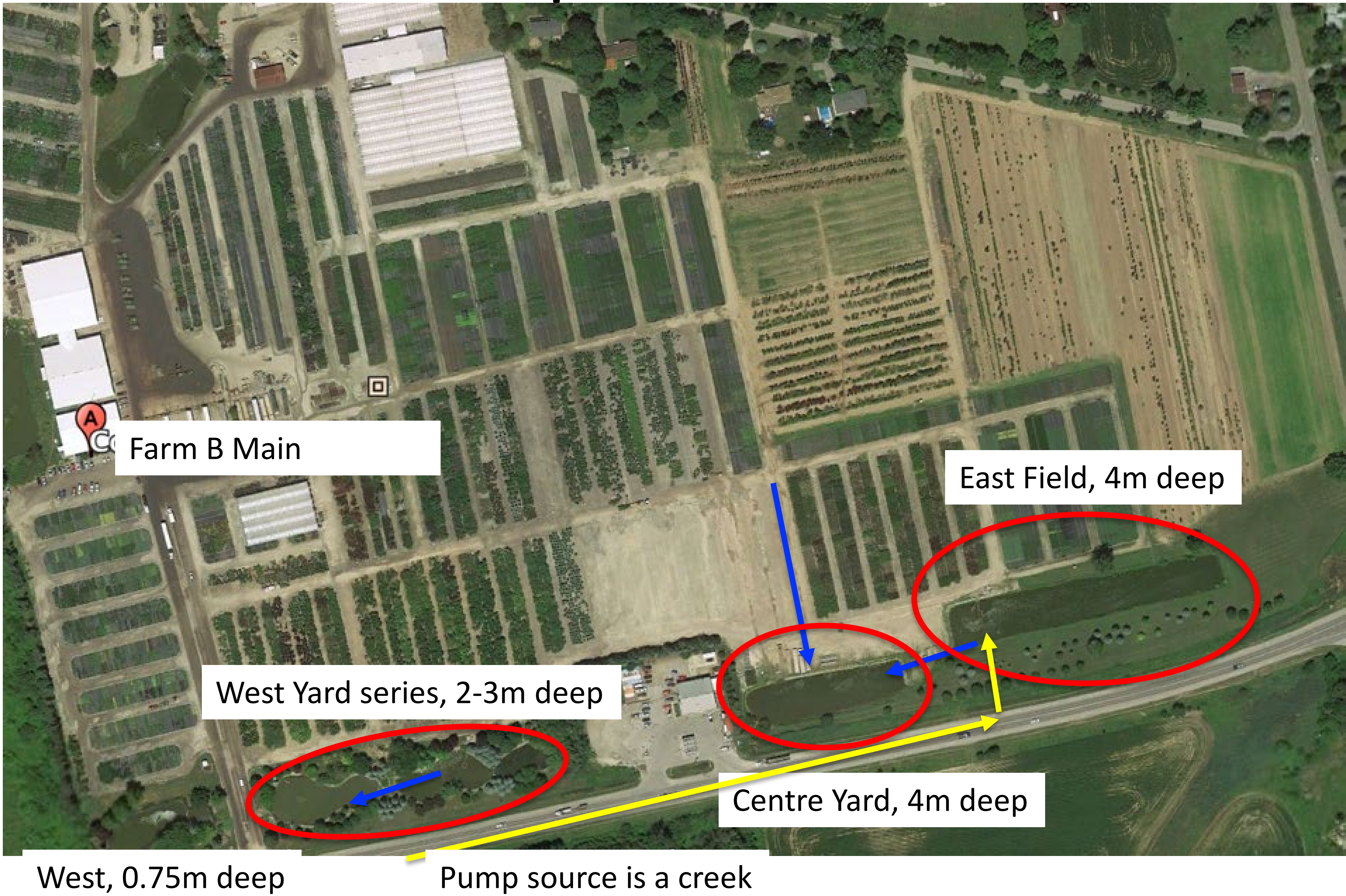
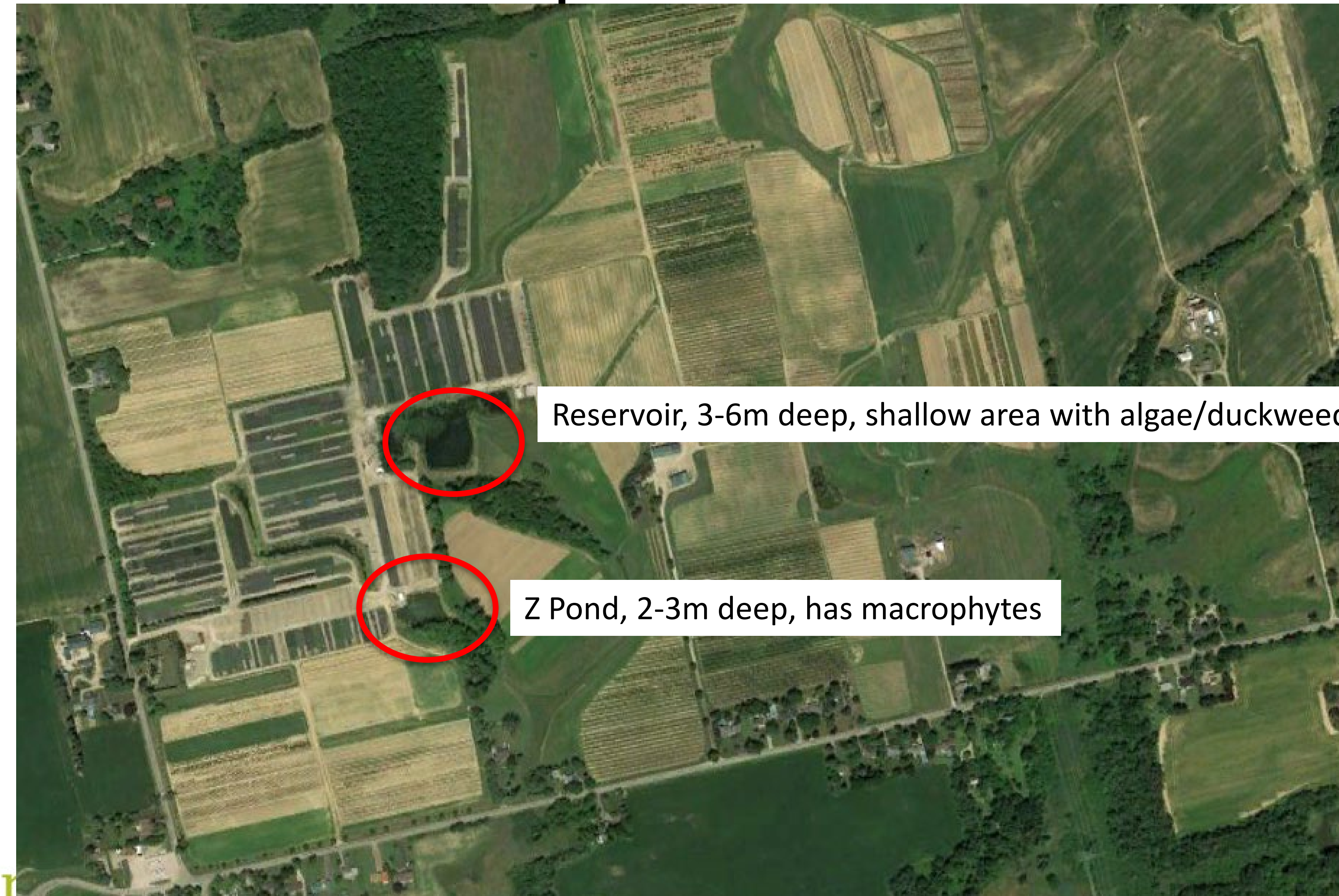
Farm B – Option 1 Main Farm



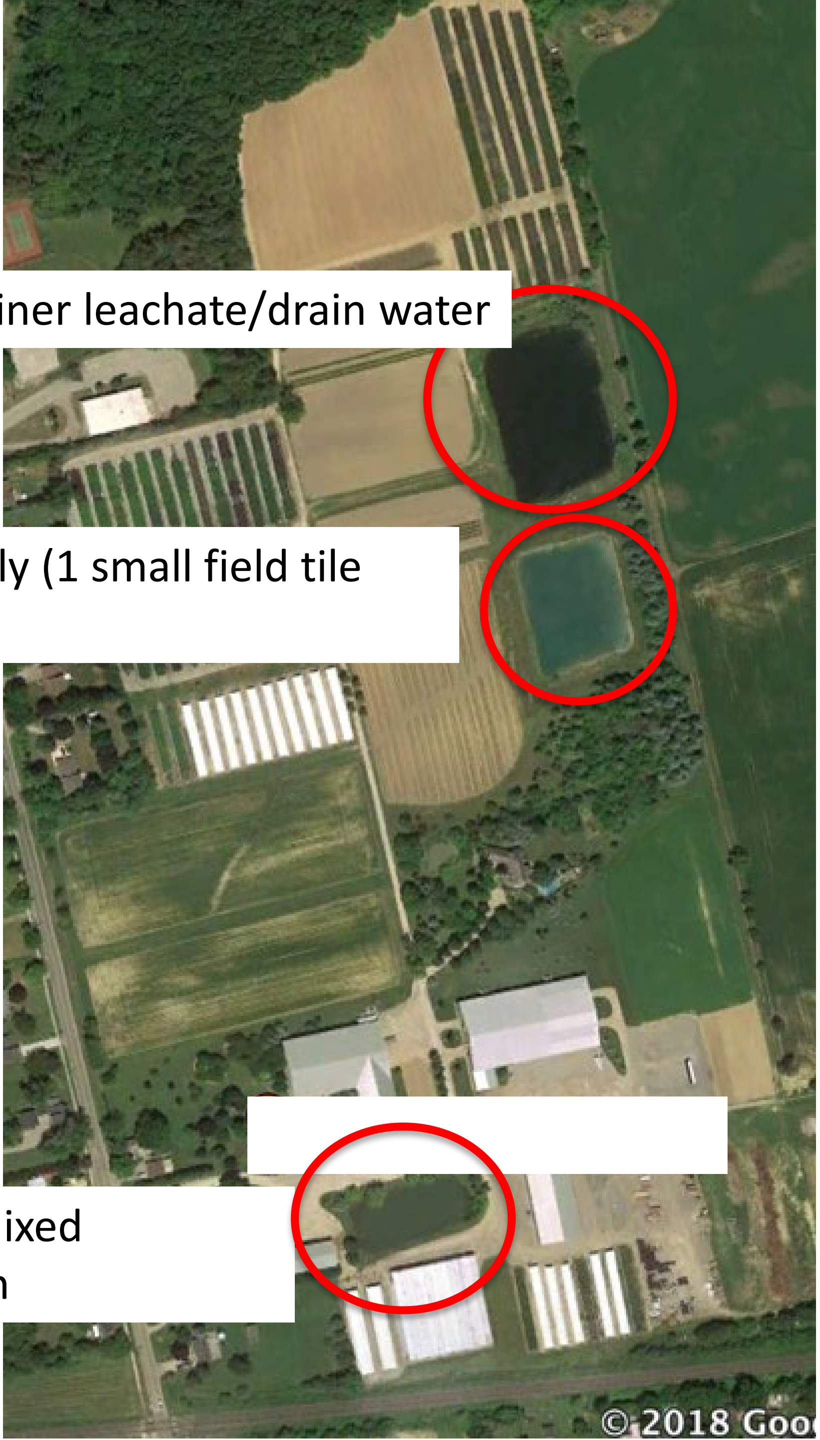
Farm B – Option 2 other farm



Farm C – Option 1
Home Farm

A Pond, 7.5-9m deep (2/3), 3-4m corner, container leachate/drain water

B Pond, 3-4.5m deep, inputs from Pond A only (1 small field tile negligible), more isolated, backup



C Pond, 3m deep, fluctuating levels, mixed roof/yard water, not used for irrigation

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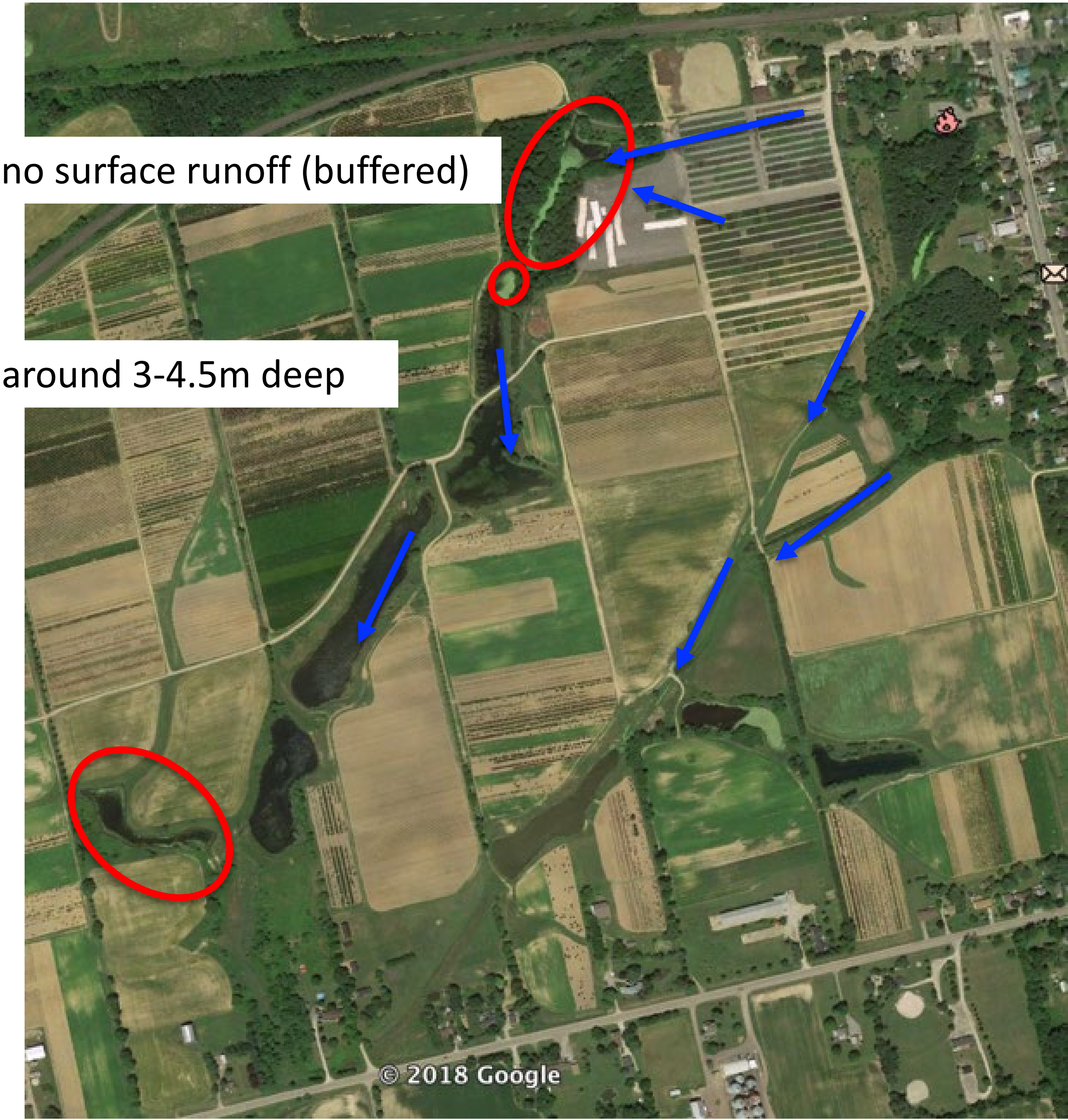
Farm C – Option 2 other farm

Pond 1, 3-4.5m deep, duckweed, no surface runoff (buffered)

Ponds 2-5 in series, around 3-4.5m deep



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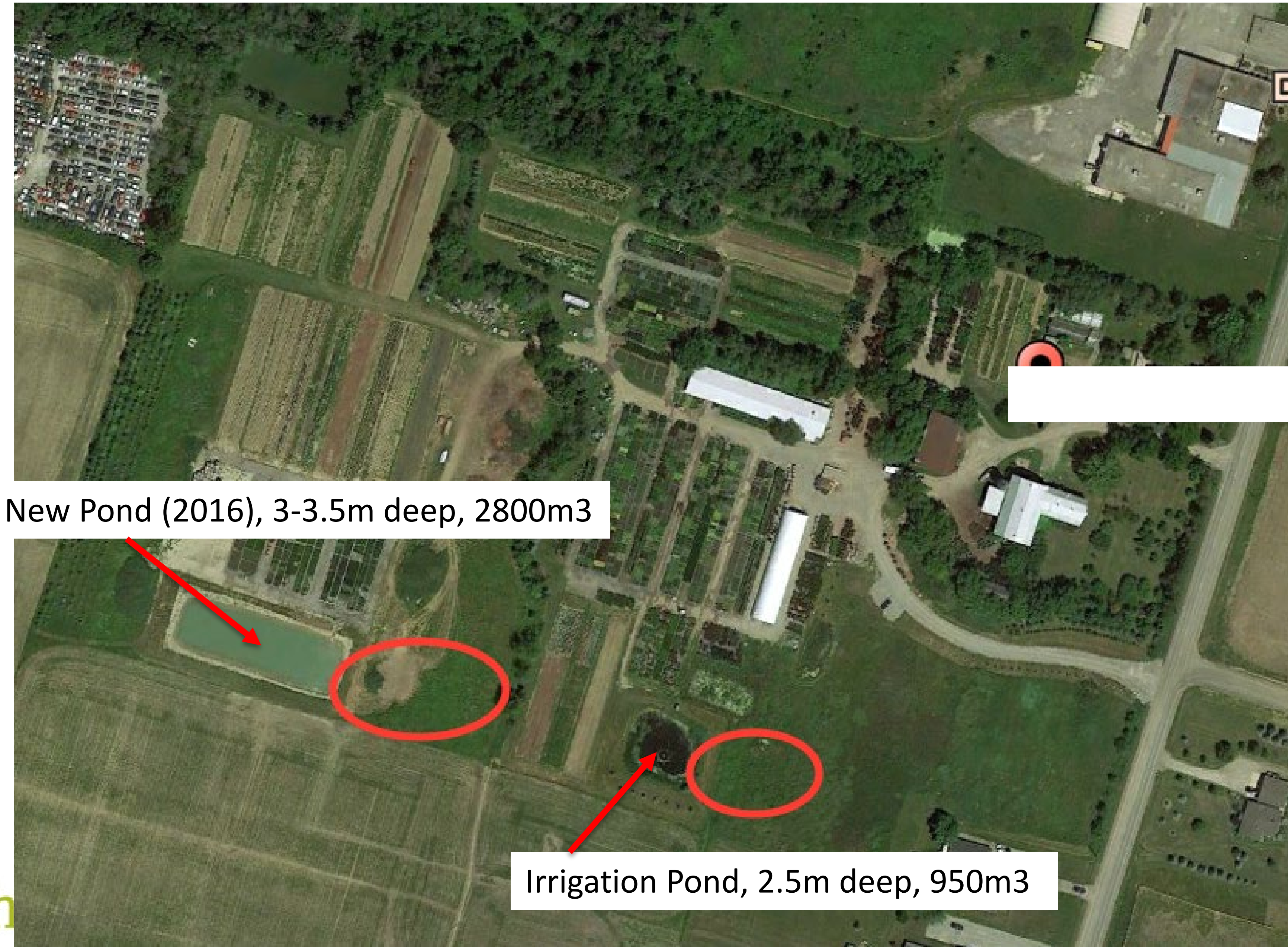
Farm D


New Pond (2016), 3-3.5m deep, 2800m3
Irrigation Pond, 2.5m deep, 950m3