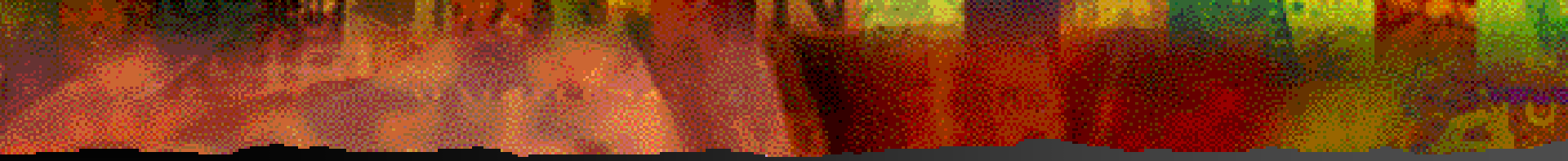

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Research and Community Outreach Development at Lethbridge College, Alberta

Nick Savidov
Lethbridge College

For Aquaponics Association Putting Out Fruits Conference
Sep 20 – Sep 22, 2019

Lethbridge College

Aquaponics Research in Alberta has been conducted by Aquaculture Centre of Excellence at Lethbridge College since early 2000s

https://lethbridgecollege.ca/departments/aquaculture-centre-of-excellence/aquaponics-research

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30


36 Ave S
Aquaculture Centre
of Excellence
Lethbridge
College

Recirculated Aquaculture System and aquaponic research at Aquaculture Centre of Excellence, Lethbridge College

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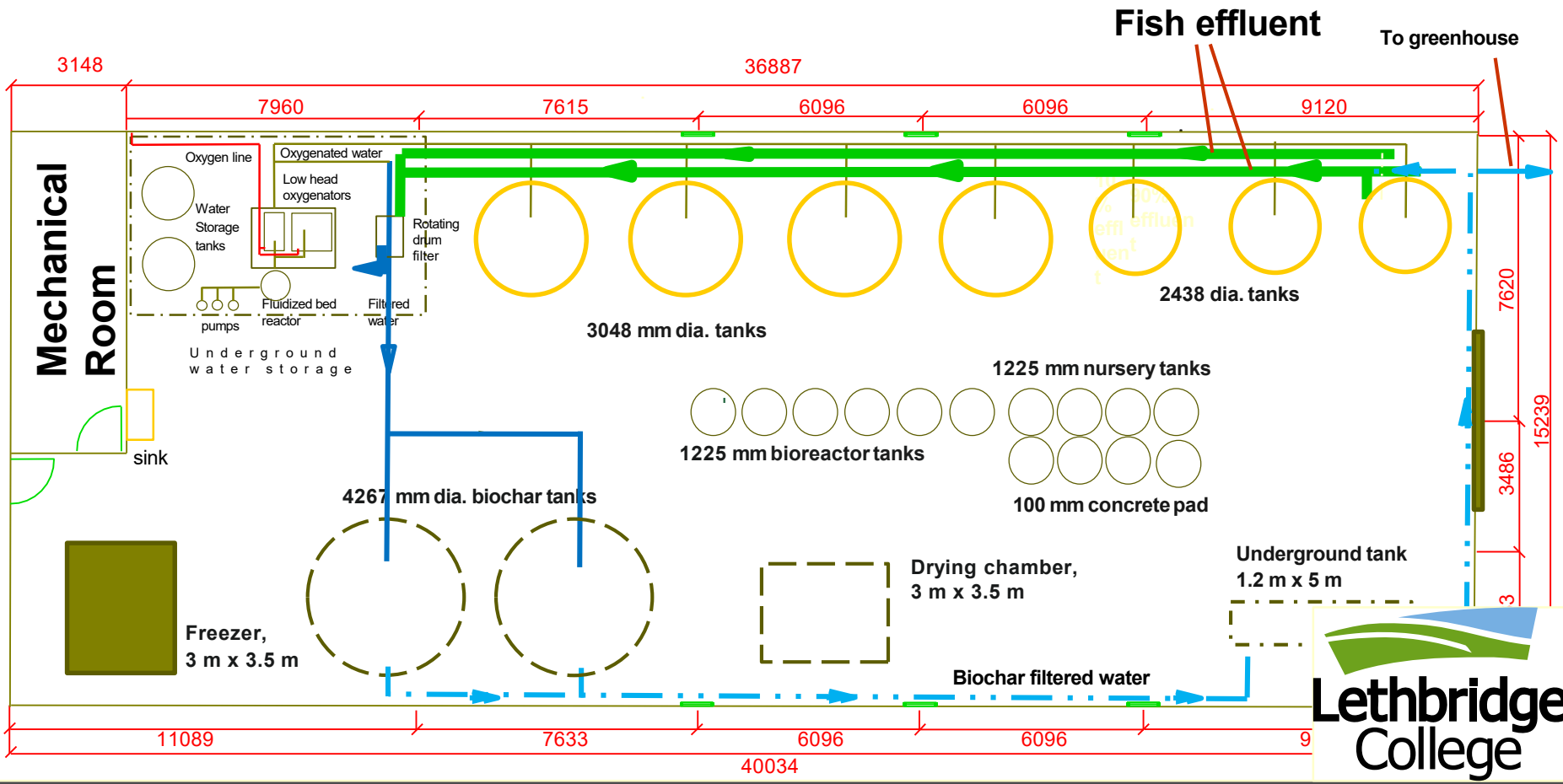
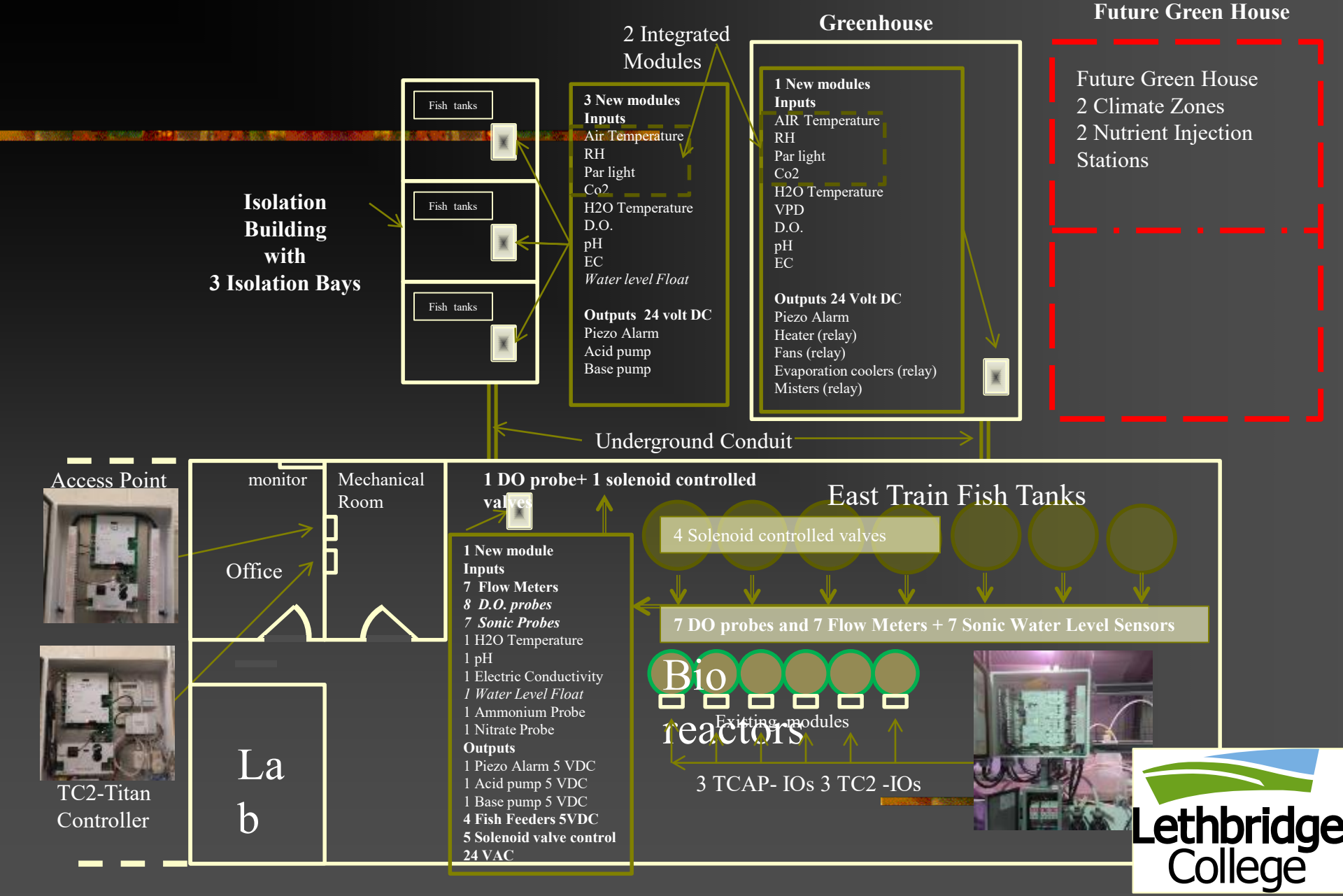
RAS Production Facility at the Aquaculture Centre of Excellence (6567 sq. feet) is connected to research greenhouse (3000 sq. feet)



Computer control system at ACE



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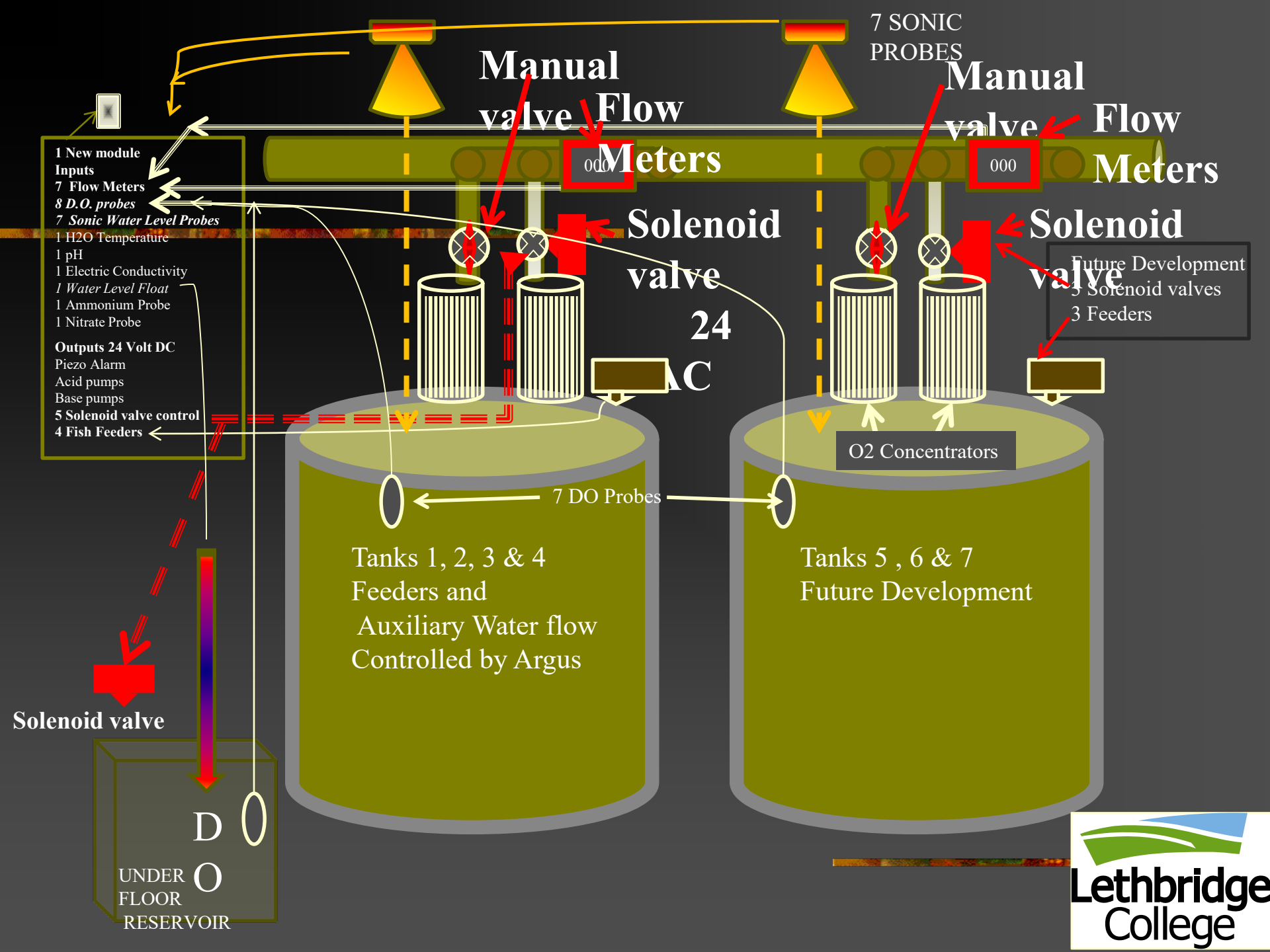
7 SONIC PROBES
Manual valve
Flow Meters
Manual valve
Flow Meters
000
000
Solenoid valve
Solenoid valve
24 AC
1 New module Inputs
7 Flow Meters
8 D.O. probes
7 Sonic Water Level Probes
1 H2O Temperature
1 pH
1 Electric Conductivity
1 Water Level Float
1 Ammonium Probe
1 Nitrate Probe
Outputs 24 Volt DC
Piezo Alarm
Acid pumps
Base pumps
5 Solenoid valve control
4 Fish Feeders
Future Development
3 Solenoid valves
3 Feeders
O2 Concentrators
7 DO Probes
Tanks 1, 2, 3 & 4
Feeders and
Auxiliary Water flow
Controlled by Argus
Tanks 5 , 6 & 7
Future Development
Solenoid valve
D O
UNDER FLOOR RESERVOIR
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Lethbridge College was awarded by CCI NSERC program for 5 years to further develop and commercialize aquaponics in Canada in 2014. Charlie Shultz was the lead aquaponics scientist at that time.

To date, it is the largest aquaponics project in Canada and one of the largest in the world with total budget $3.2M including $2.2M from the federal government of Canada

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Budget

	YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5	TOTAL
NSERC	476,642	471,086	474,007	379,046	372,933	**2,173,714**
INDUSTRY (Cash and In-Kind)	96,100	109,600	151,100	151,600	161,600	**670,000**
POST SEC / OTHER (Cash and In-Kind)	80,250	80,250	80,250	80,250	80,250	**401,250**
TOTAL	652,992	660,936	705,857	610,896	614,783	**3,245,464**

Based on 4 Pillars

1. Agri-H_2O
2. Agri-Food
3. Agri-Business
4. Community Engagement

Pillars/Major objectives of NSERC CCI Aquaponics Project at Lethbridge College

Pillar 1: Agri-H_2O
Development of commercial aquaponics production platform

Pillar 2: Agri-Food
Consumer-oriented study on acceptance of aquaponics produce and evaluating its quality industry through engagement and partnerships

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Pillars/Major objectives of NSERC CCI Aquaponics Project at Lethbridge College

Pillar 3: Agri-Business
Economics of aquaponics production – designing economic simulator model

Pillar 4: Community Engagement
Providing support in commercialization of aquaponics technology to communities and industry through engagement and partnerships

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Pillar 1 - Agri-H2O - platformDevelopment of commercial aquaponics production

Main Objectives:

- Creating a Stable Nutrient Rich Plant Solution from Various Fishes Effluents and Solid Wastes
- Continuous Evaluation of the Nutrient Solution Using Specially Designed Aquaponics Modules
- Food Safety
- Organic Certification

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Pillar 1. Agri-H2O

Overarching goal: Development of commercially viable and safe aquaponics production platform for the industry

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Objective 1. Creating a Stable Nutrient Rich Plant Solution from Various Fishes Effluents and Solid Wastes

- Two production protocols include warm-water aquaponics and cold-water aquaponics systems depending on fish species
- Warm-water aquaponics includes tilapia and barramundi
- Cold-water aquaponics includes rainbow trout

The selection of crops was determined by the crops environmental requirements and market demand

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Some of the plant species and varieties used in the NSERC trials

1. Basil, cv. Lemon (Ocimum africanum),
2. Basil, cv. Lime (Ocimum americanum),
3. Basil, cv. Genovese (Ocimum basilicum),
4. Basil, cv. Nufar (Ocimum basilicum),
5. Basil, cv. Thai (Ocimum. basilicum var.thyrsiflora),
6. Bok Choy (Brassica rapa, var. chinensis)
7. Watercress (Nasturtium officinale)
8. Swiss Chard, cv. Bright Lights (Beta vulgaris ssp. Vulgaris)
9. Romaine Lettuce (Lactuca sativaL. var. longifolia)
10. Tatsoi (Brassica rapa var. narinosa)
11. Parsley, cv. Giant of Italy (Petroselinum crispum)
12. Cilantro, cv. Calypso (coriandrum sativum)
13. Lettuce, cv. Dragoon (Lactuca sativa)
14. Lettuce, cv. Coastal (Lactuca sativa)
15. Pac Choi, cv. Win-Win Choi F1 (Brassica rapa var. chinesis)
16. Hybrid Pickling Cucumbers, cv. Harmonie F1 (Cucumis sativus)
17. Tomato, cv. Paisano (Solanum lycopersicum)
18. Tomato, cv. Roma 72-170 (Solanum lycopersicum)
19. Long English cucumbers, cv. Carmen (Cucumis sativus)
20. Pac Choi, cv. Flash (Brassica oleracea)
21. Chives, cv. Dolores (Allium schoenoprasum)

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Objective 1. Creating a Stable Nutrient Rich Plant Solution from Various Fishes Effluents and Solid Wastes

The bioreactors were used to carry out aerobic bio-fermentation process to achieve complete mineralization of all organic fish waste

Several parameters were studied to optimize the fermentation process including:

- Temperature
- pH
- Dry matter content

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Objective 1. Creating a Stable Nutrient Rich Plant Solution from Various Fishes Effluents and Solid Wastes

6 aerobic bioreactors were used to create nutrient solutions from fish waste

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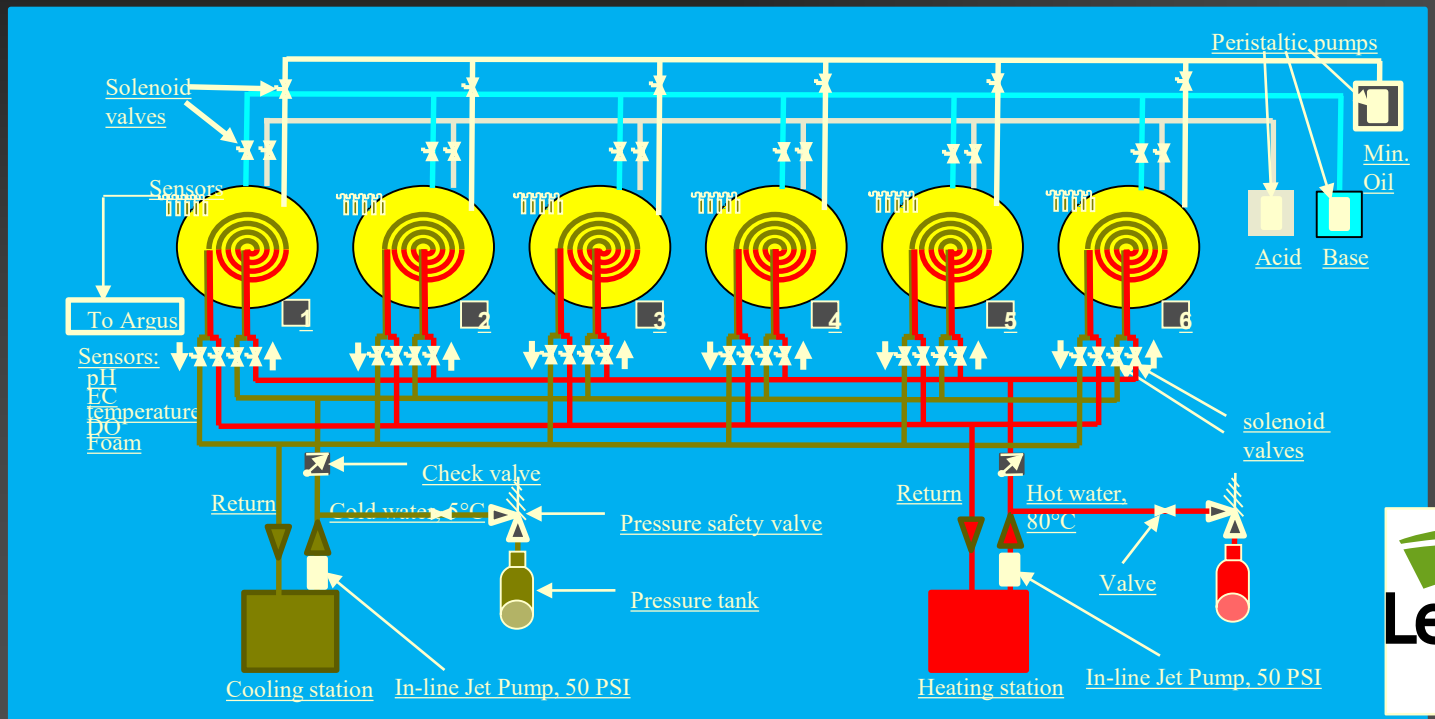
Objective 1. Creating a Stable Nutrient Rich Plant Solution from Various Fishes Effluents and Solid Wastes

Specially designed computer control system is able to automatically maintain chosen parameters and collect data every second



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Inputs:

- Temperature
- pH sensor
- DO sensor
- EC Sensor
- Foam level sensor

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Outputs:

- pH control: peristaltic pumps for acid and base, solenoid valves, two per bioreactor
- Temperature control, four solenoid valves per bioreactor:
  - cold water inlet valve
  - cold water outlet valve
  - hot water inlet valve
  - hot water outlet valve
- Foam control: peristaltic pump for oil, solenoid valves, one per bioreactor

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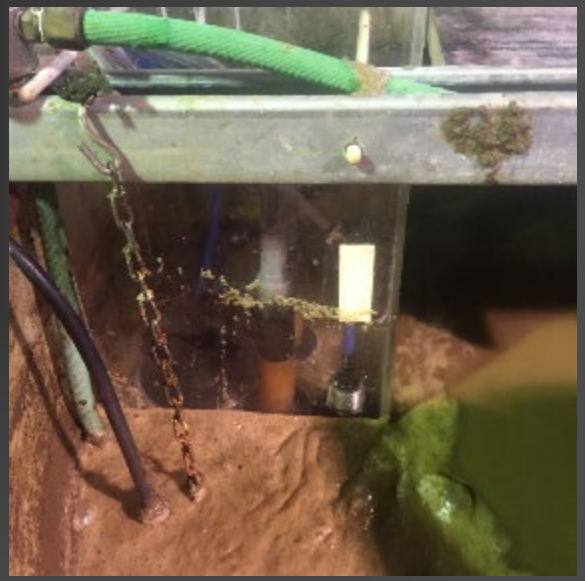

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ARQUS


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Data collected on effects of:

- Temperature
- pH
- DO levels
- EC
- Dry matter content
- Nitrification

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Nitrification process in aerobic bioreactors

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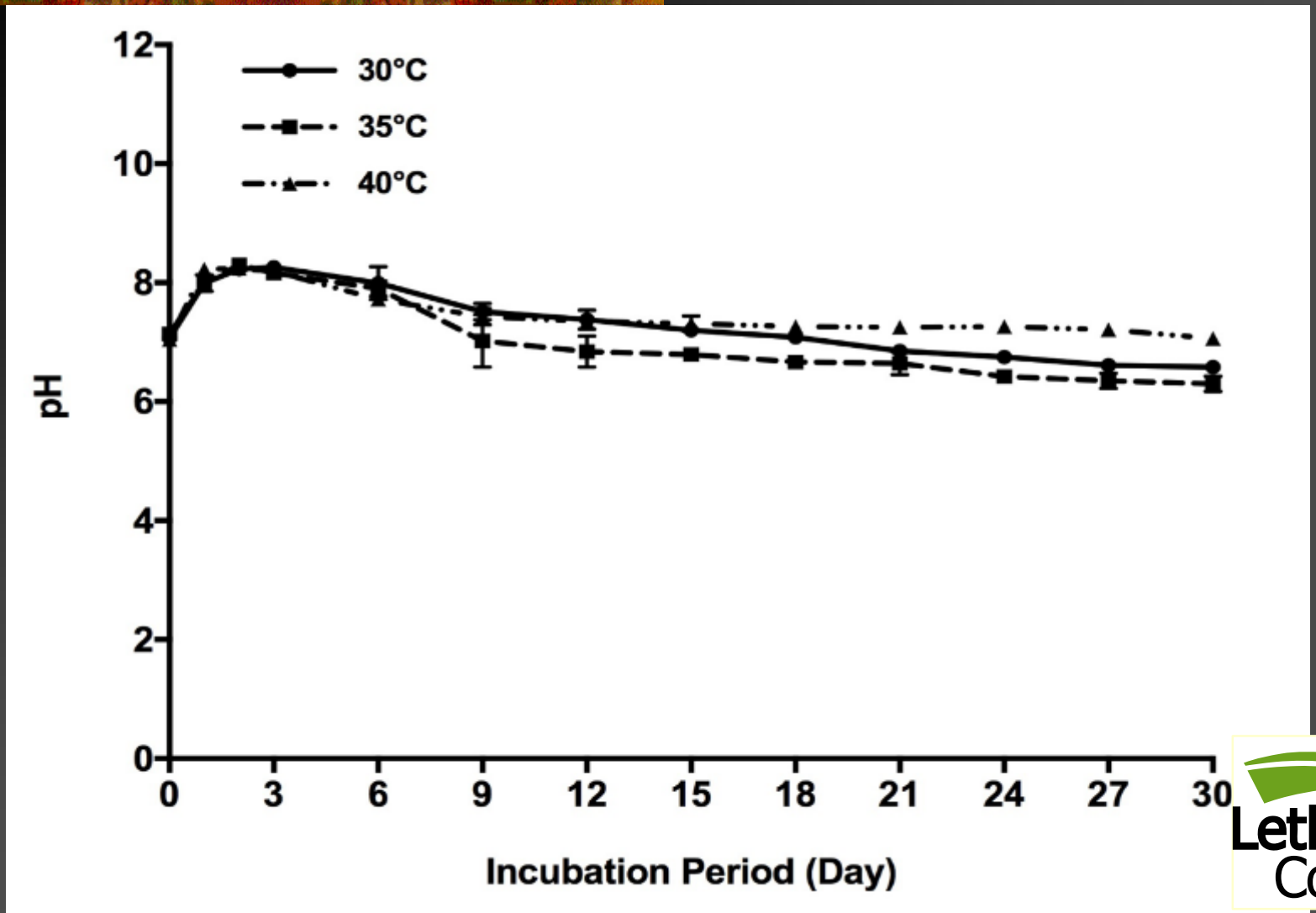
pH change during aerobic digestion of aquaculture solid waste for the control bioreactor (carried out without pH adjustment).



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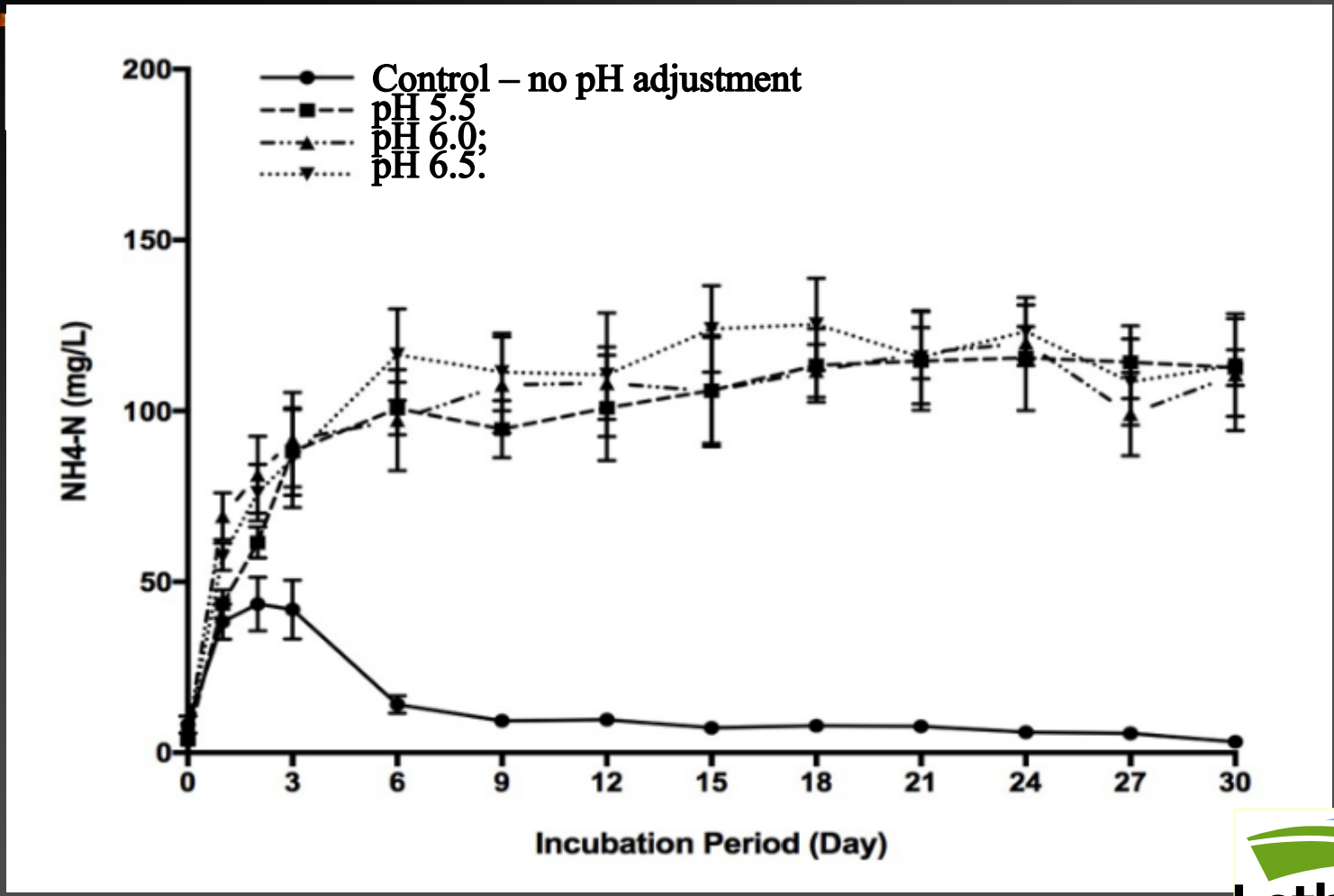
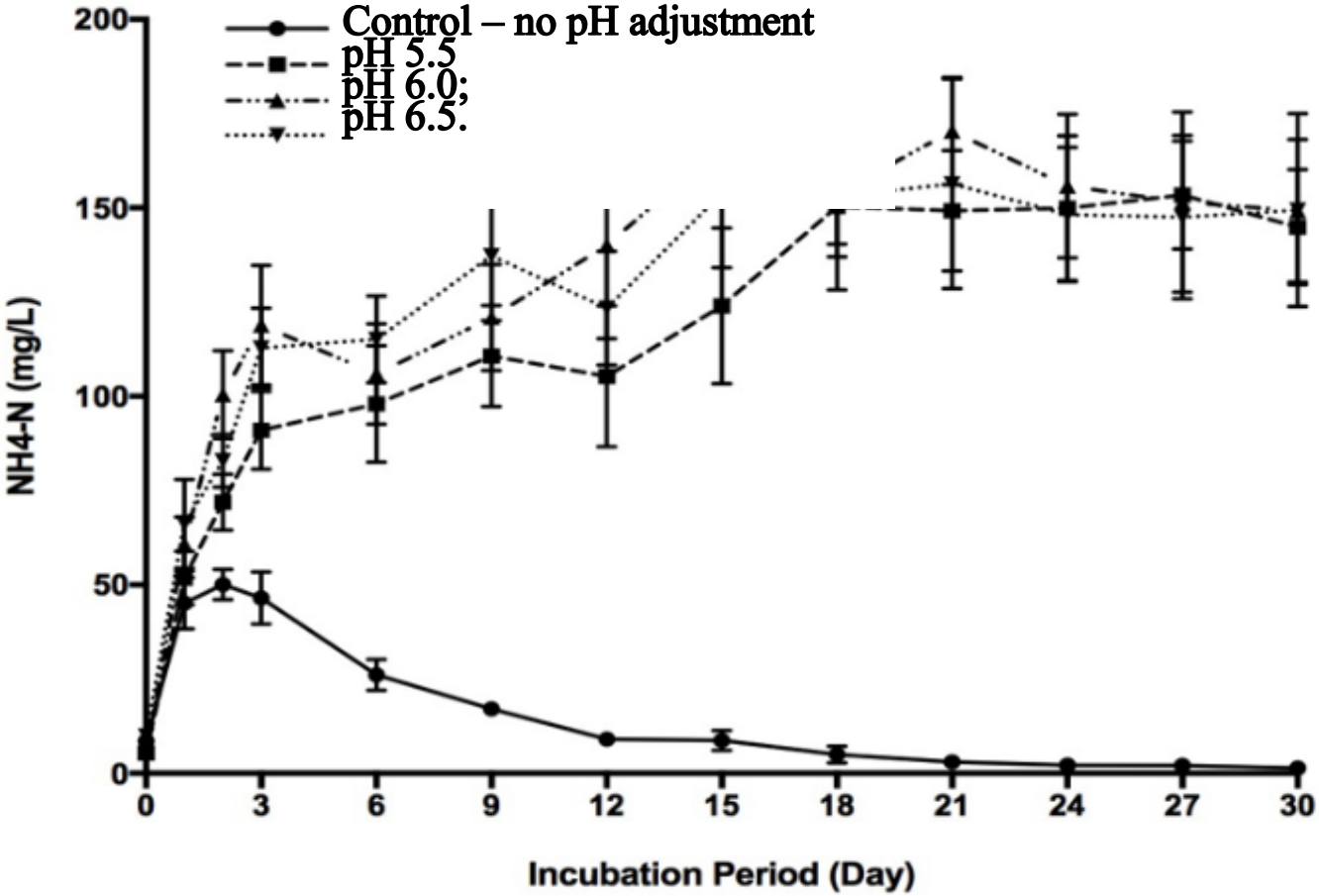
- Kinetics of ammonification during aerobic digestion of aquaculture solids at 30°C



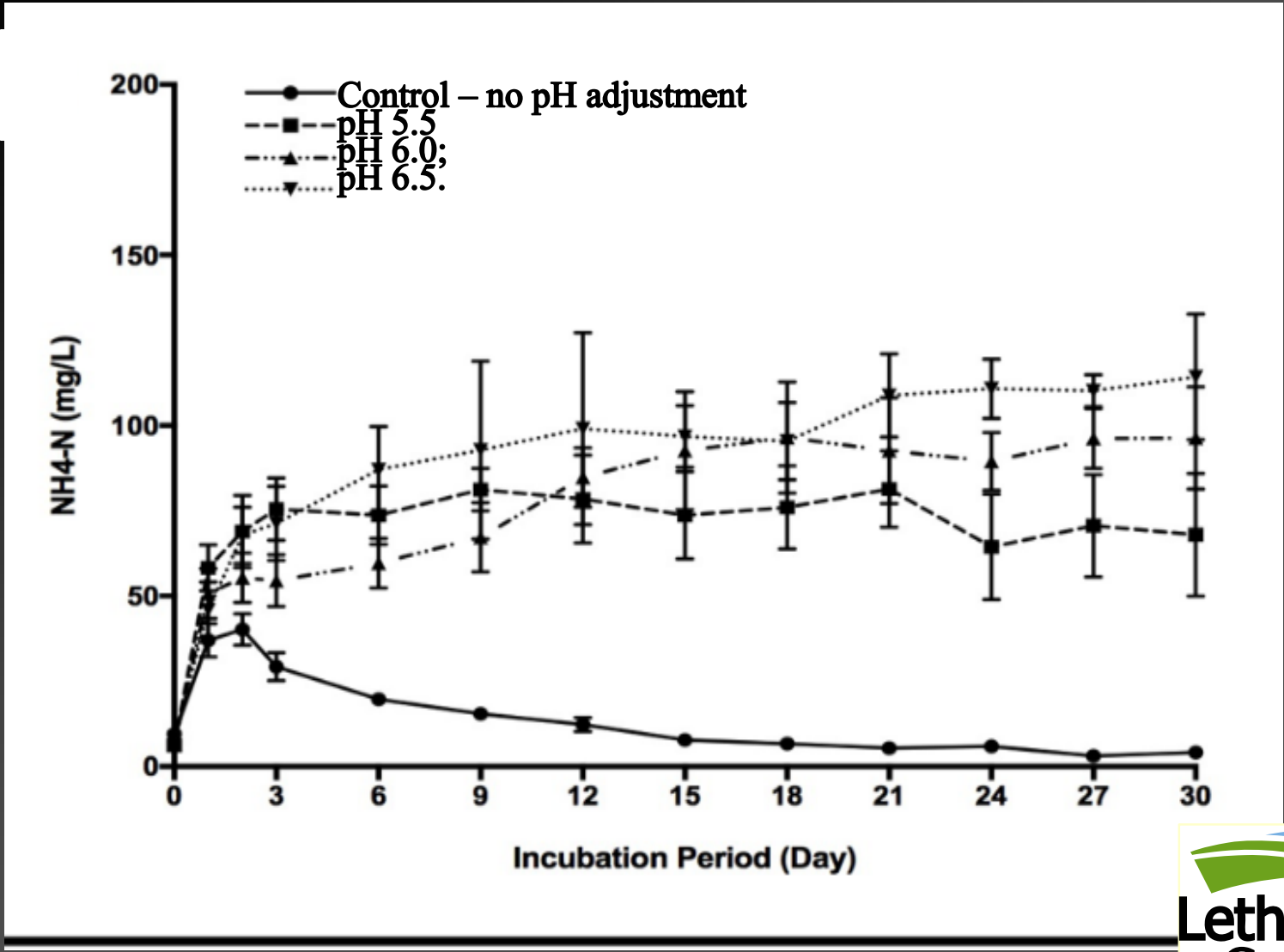
Lethbridge College

- Kinetics of ammonification during aerobic digestion of aquaculture solids at 35°C



Lethbridge College

- Kinetics of ammonification during aerobic digestion of aquaculture solids at 40°C



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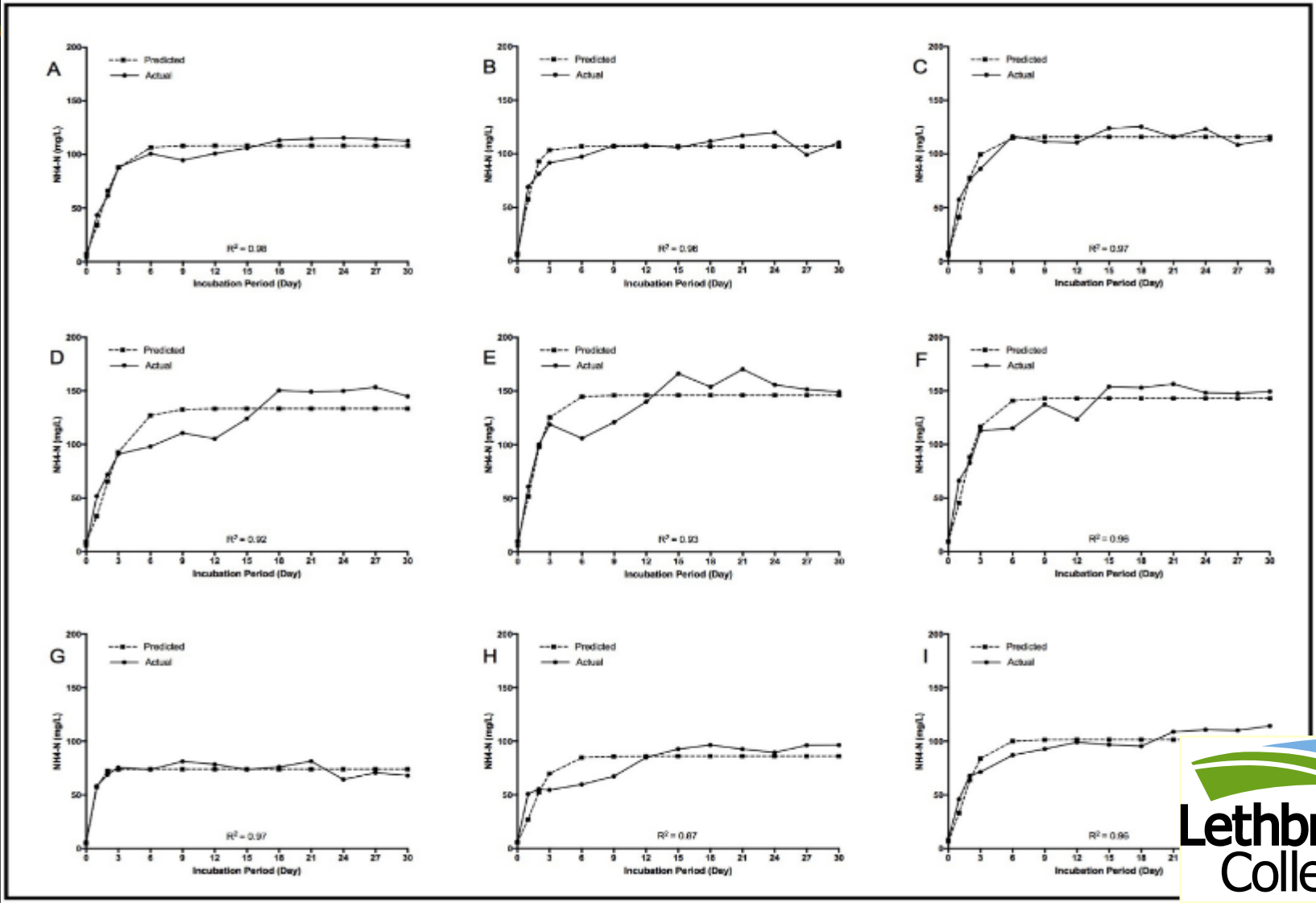
- Actual and predicted kinetics of ammonium production during aerobic digestion of aquaculture solid waste

pH 5.5 pH 6.0 pH 6.5

30°C

35°C

40°C



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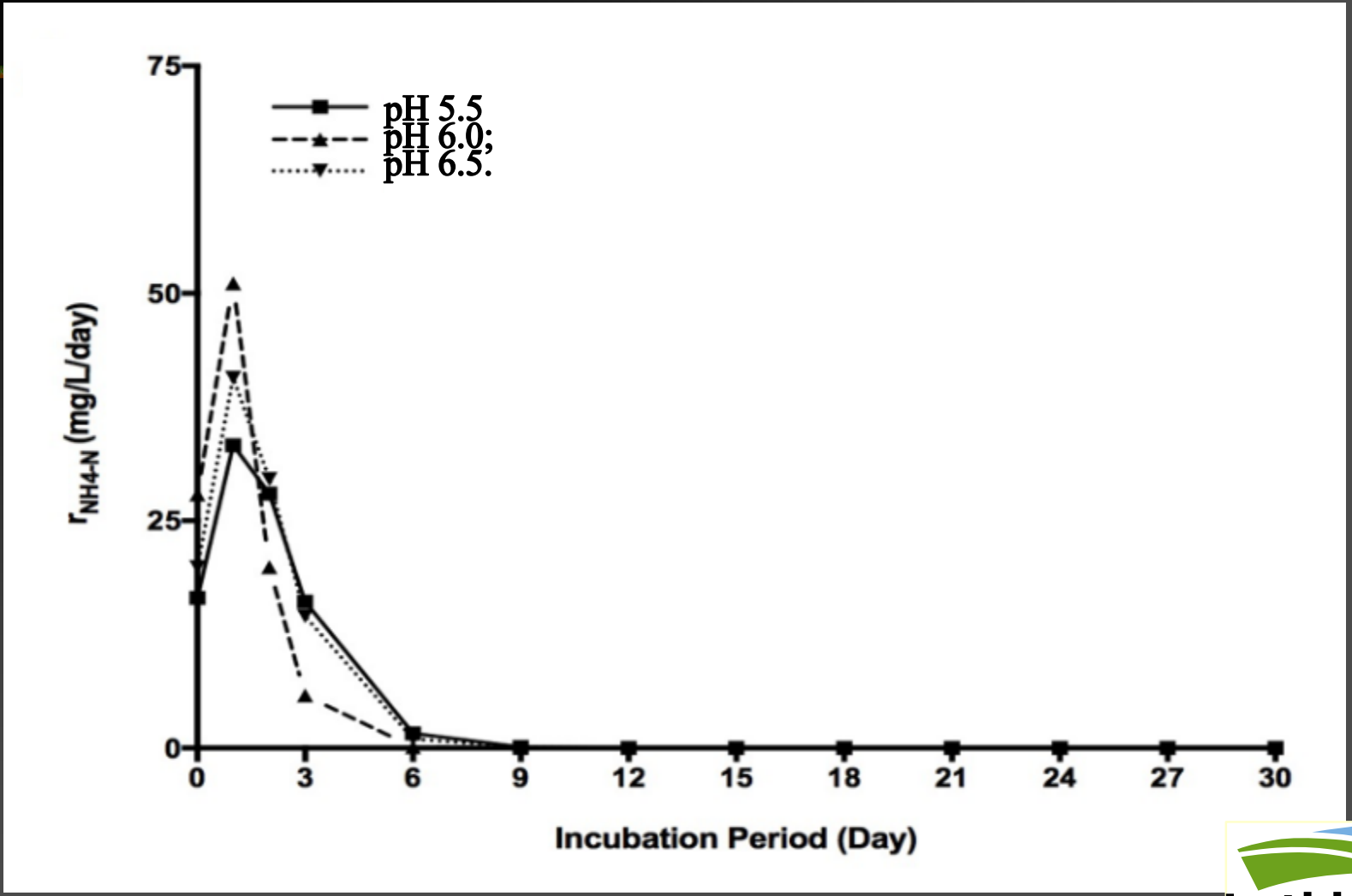
- Production of ammonium during aerobic digestion of aquaculture solids at 30°C



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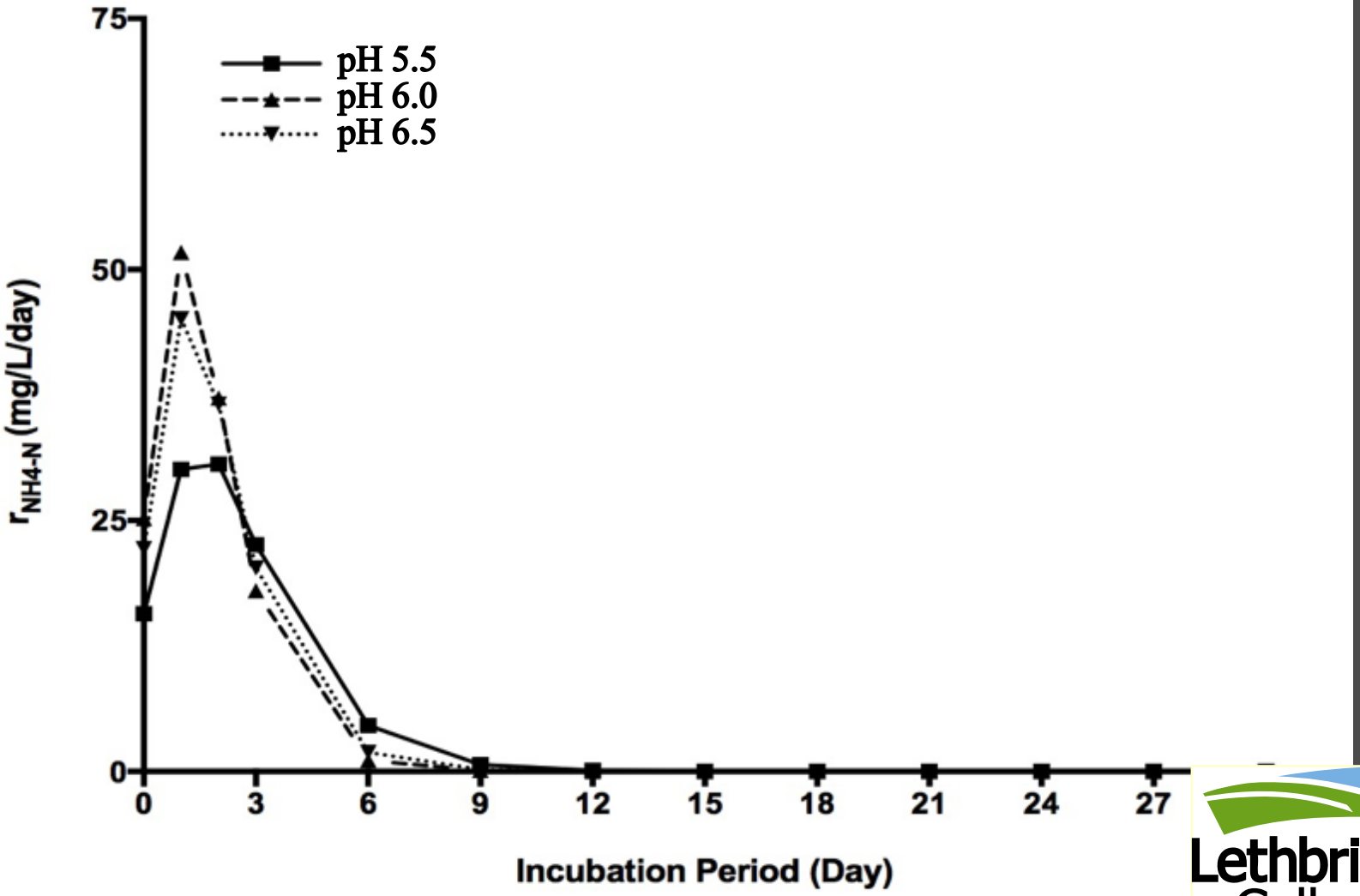
- Production of ammonium during aerobic digestion of aquaculture solids at 35°C



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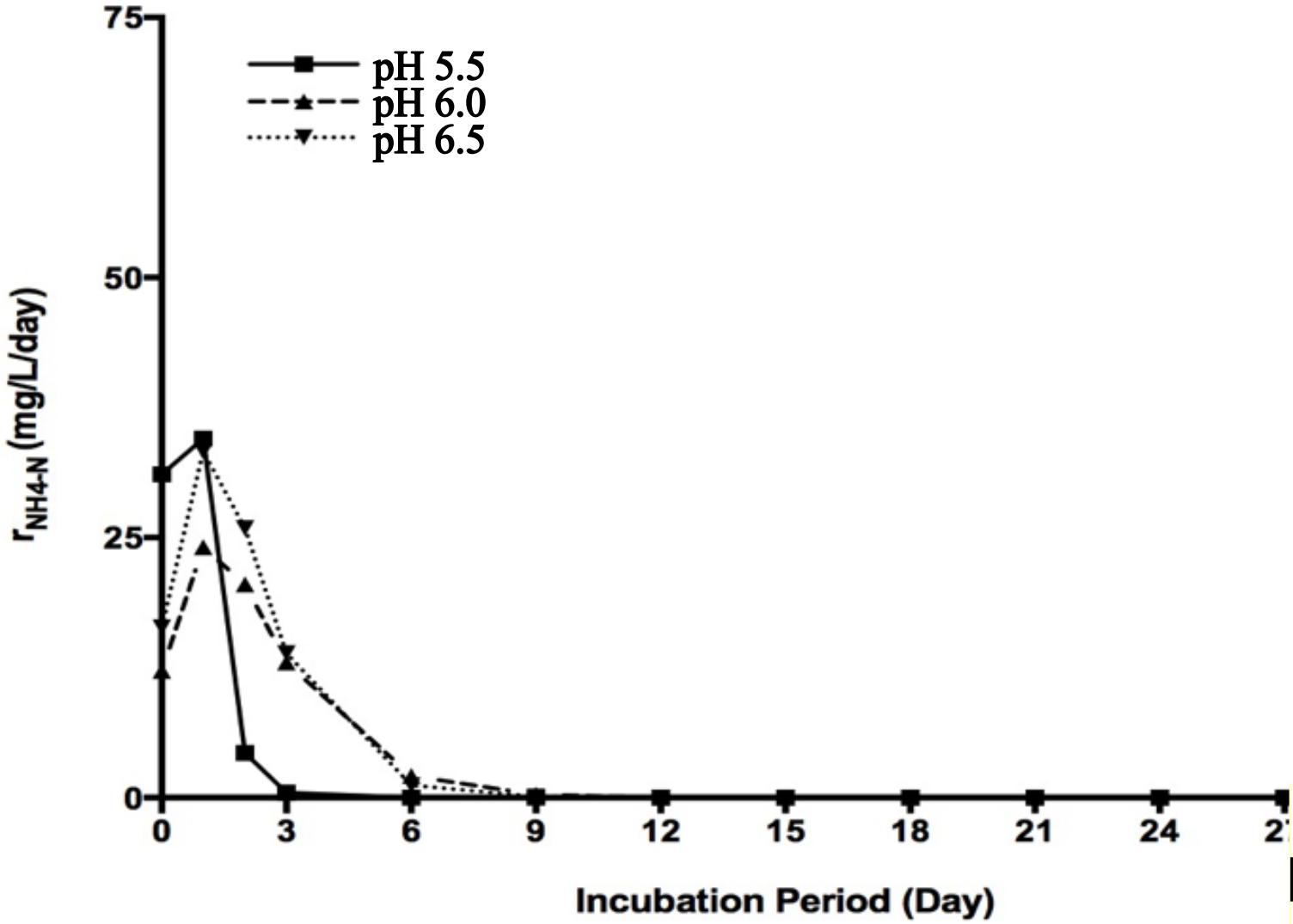
- Production of ammonium during aerobic digestion of aquaculture solids at 40°C



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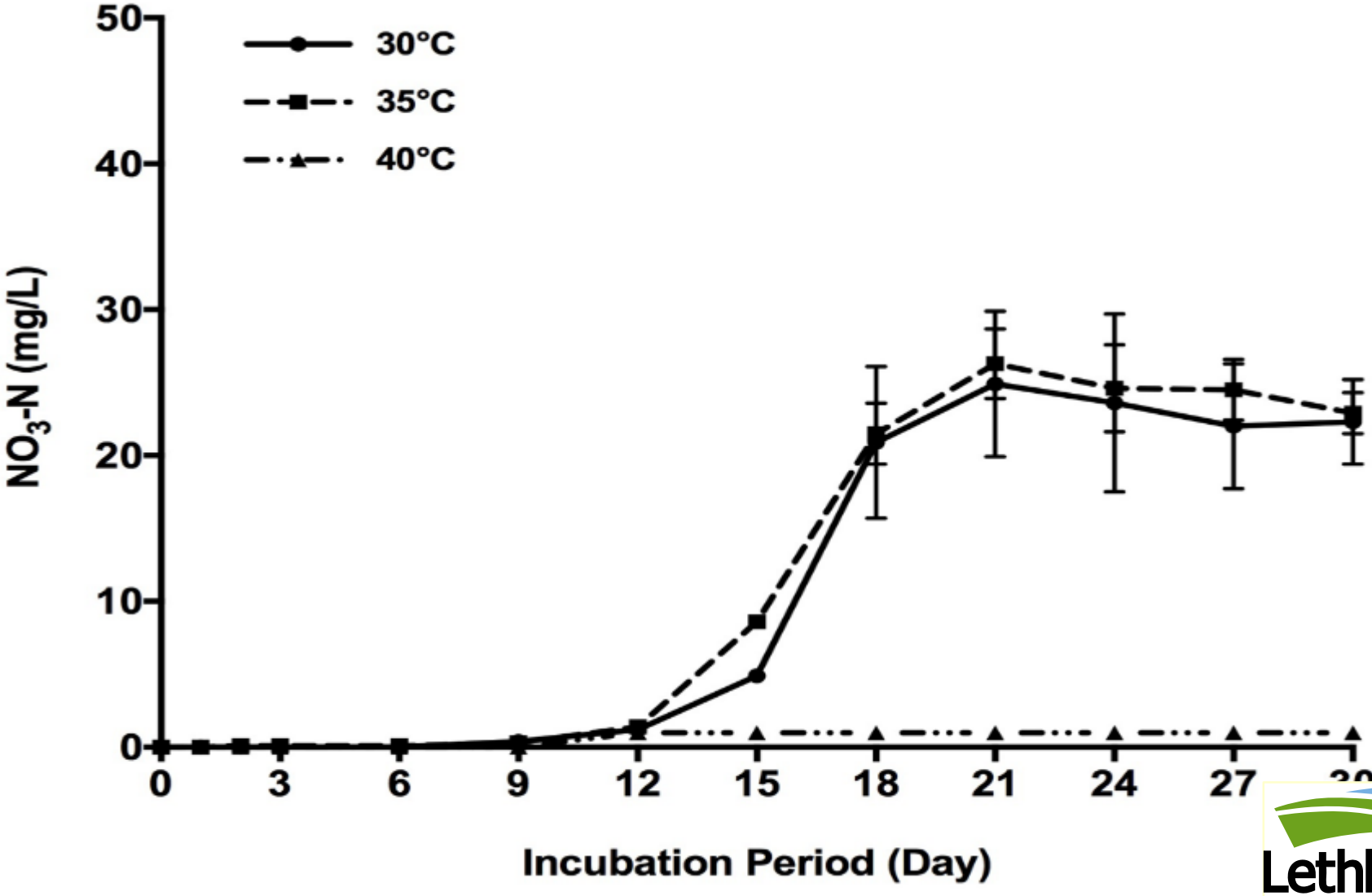
- Kinetics of nitrification during aerobic digestion of aquaculture solid waste



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- Optimal pH – 6.0-6.5
- Optimal temperature – 35^{o}C
- DO – above 5 ppm
- Dry solids content – 1-4%

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The trials were conducted using:

- 12 Deep Flow Culture, DFC, systems, 2,000 L
- 9 Deep Flow Technique, DFC, systems 700 L
- 41 Nutrient Film Technique, NFT, systems, 80 L
- Hydroponic setup in seasonal greenhous

UVI DFT and NFT systems were equipped with LED lights

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The trials were conducted in 4 locations:

- Aquaculture Centre of Excellence
- Quarantine facility
- Cousins Building
- Greenhouse

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Experimental aquaponics modules used in the project

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12 Deep Flow Culture systems, 2,000 L

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41 Nutrient Film Technique, systems, 80 L

9 Deep Flow Technique, DFC, systems 700 L

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The main result of aquaponic crop studies in NSERC project was a demonstration that the sustainable plant production required significantly less fish feed input per sq. m. than previously thought, as little as 3-5 g of fish feed per square meter per day

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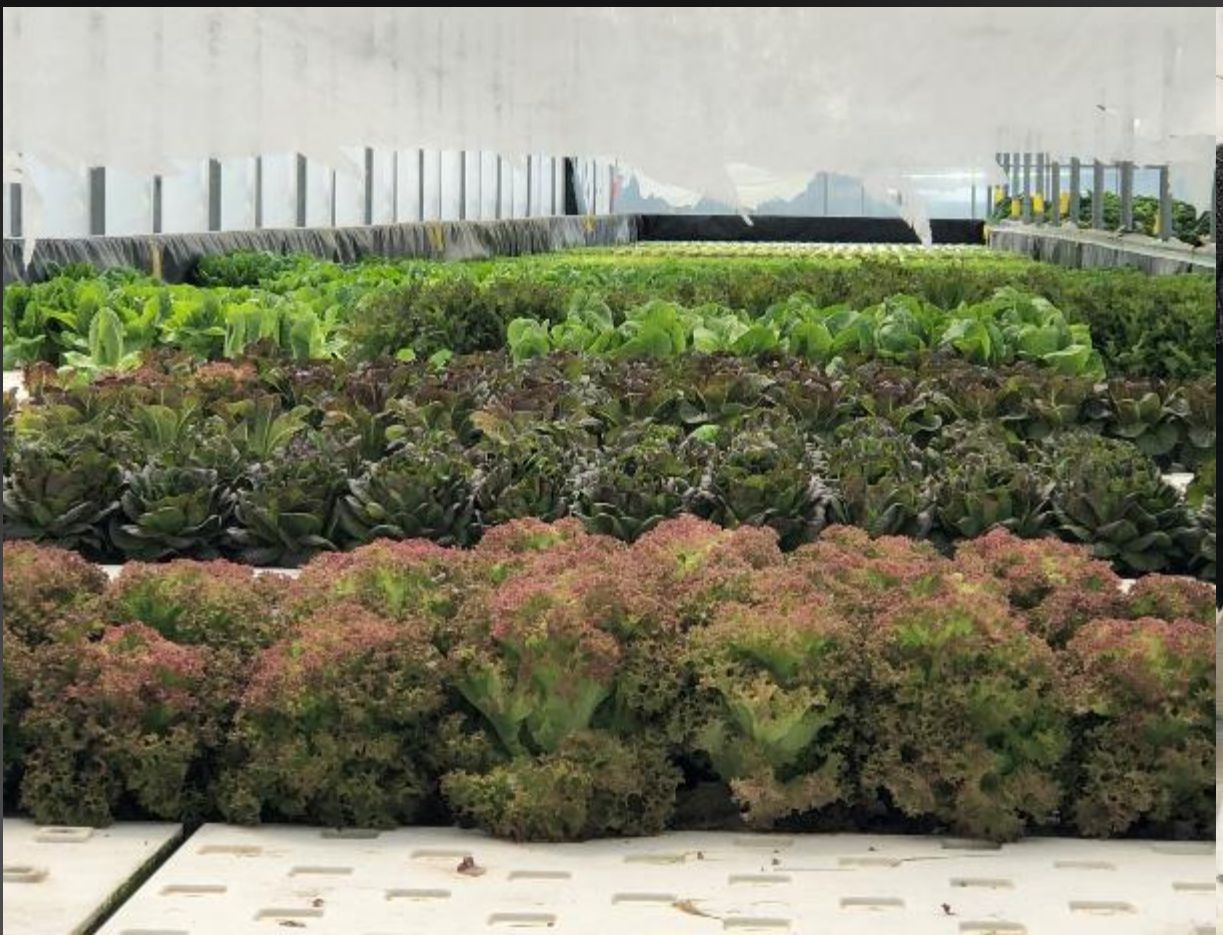
This findings were confirmed by Fresh Flavor Inc., a commercial aquaponics company in Alberta



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Pillar 1 - Agri-H_2O

Food Safety

Project 3

- Develop government standards and protocols to support commercialization of IFPS
- Create recommended standards for the **organic certification** of soilless agriculture
- Create recommended standards for **food safety** assurance in IFPS in AB and CA

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Food safety is a growing public concern, especially, when waste management is incorporated into a food productions cycle, like in aquaponics

Escherichia coli

Salmonella

Campylobacter jejuni

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Develop Standards and On-Farm-Food-Safe, OFFS, protocols will be developed to support commercialization in collaboration with GAP Canada


GFTC

Guelph Food Technology Centre

On-Farm Food Safety Certification

Guelph Food Technology Centre has certified

CDC South - Aquaponics

301 Horticulture Station Road East, Brooks, Alberta T1R 1E6 Canada

as meeting the Canadian Horticultural Council On-Farm Food Safety Program requirements in a third party audit conducted by GFTC, assuring compliance to the CHC OFFS standard for

Production & Packing of Basil

Certification Option: C
Audit Date: April 28, 2011
Certificate Expiry Date: June 5, 2012
Certificate Number: 2010-279
Authorized By:

Issue Date: May 26, 2011

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Potential risks, which may be associated with aquaponics, will be studied and compared with conventional systems.

	Aquaponics	Hydroponics	Conventional (Field & Aquaculture)	Organic (Field)
Inputs – Intentional	Fingerlings Seedlings Water Fish Feed Soilless Medium pH Adjustment Reagents Flocculants Microbial Cultures Biocontrol Agents	Seedlings Water Soilless Medium Synthetic Fertilizers pH Adjustment Reagents Pesticides Biocontrol Agents	Seeds/Transplants Fingerlings Water Fish Feed Synthetic Fertilizers pH Adjustment Reagents Pesticides & Other Chemicals Manure Compost Biosolids	Seeds/Transplants Water Organic Fertilizers: Manure Compost Organic Crop Protection Agents

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Objective 4. Organic Certification

Objective: to develop government protocols to support industry through the creation of recommended standards for the organic certification of aquaponics in Canada.

The Canadian General Standards Board (CGSB) has outlined the rules for organic crop production (CAN/CGSB-32.310.2006).

Currently, no regulations exist to allow for the organic certification of crops grown in soilless culture systems and this gap has slowed the growth of industry

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A taskforce comprised of key partners from academia, industry, and government, to develop a set of recommended guidelines allowing for organic certification in Canada for crops while protecting organic integrity will be established.

Collaboration with Organic Agriculture Council of Canada in the development of the standards will be considered.

The adoption of standards would allow for new market potential and increased revenue for industry. Several of LC's partners have agreed to participate on the Organic Certification task force.

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Pillar 2 - Agri-Food

Consumer Acceptance

Project 1

Aquaponic Product Quality Sensory Testing

- Organoleptic assessment of fish and plant quality derived from Aquaponic production

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Pillar 2: Agri-Food. Consumer-oriented study on acceptance of aquaponics produce and evaluating its quality

Aquaponics Product Quality Sensory Testing
Objective: Organoleptic assessment of fish and plant quality

Once basic product analytical and sensory characteristics (specifications) were established, the greenhouse produce and fish were assessed for overall organoleptic qualities (taste, touch, smell etc.).

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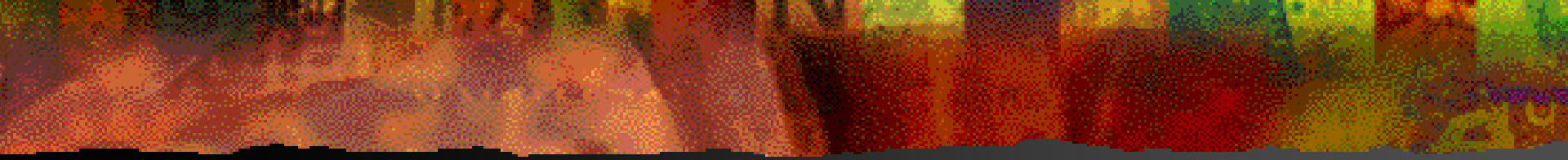

Y1-3 LC Chefs participated in a professional development workshop to learn applied research methodologies to conduct organoleptic quality assessments of fish and crop produce derived from IFPS.

Y2–4: Sampling and evaluation of fish and plant organoleptic properties took place 4X per year. Between six and twelve samples were tested per session. For each session a report was produced with results

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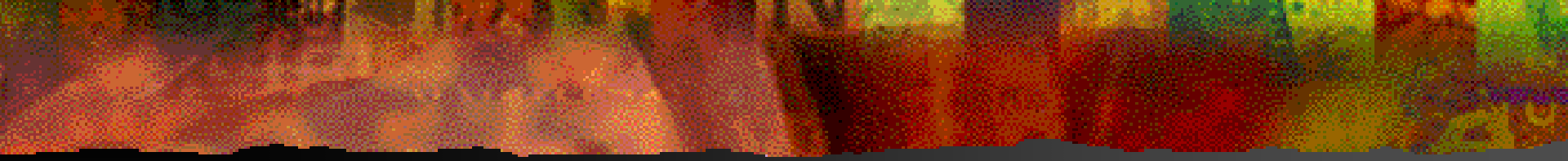

Pillar 3: Agri-Business - Economics of aquaponics production – designing economic simulator model

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Pillar 3 - Agri-Business

Economic ROI

Project 1

Designing Economic Simulators for IFPS Systems

- develop applications for industry to test "what if" scenarios for determining the maximum ROI using various combinations of fish species integrated with complementary crops

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The economic simulating model was developed by Bruce Viney, Alberta Agriculture, with the input from Dr. D. LeRoy, University of Lethbridge

General Spreatsheet Information

Staircase Layout

Primary Input

Fish Tanks

Fish Growing Assets

Fish Power Consumption

Greenhouse Investments

Fish Costs and Returns

Greenhouse Costs and Returns

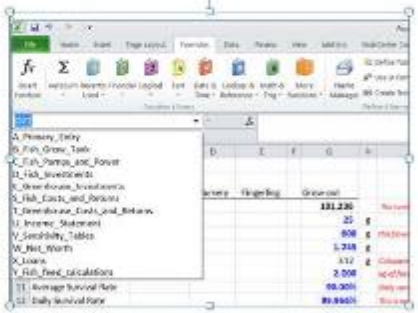
Income Statement

Sensitivity Tables

Net Worth

Loan Tables and Fish Feed Tables below

To navigate from table to table: Select the appropriate table name from the dropdown menu to the left of the formula bar as shown in the picture below.



To replicate a worksheet:

- Select and right click on the name tab at the bottom of the workbook
- Select Move or Copy
- Select the workbook from the list and click Create a copy
- Hit OK the rename the copy as needed

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Project 2 Optimizing the Economics of Balanced IFPS Systems

- Maximizing the ROI of commercial balanced systems by using various combinations of fish species integrated with complementary crops

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Pillar 4 - Community Engagement

Project 1

Encouraging Mainstream Support for IFPS by Industry and Community

- IFPS Showcase at LC to present outcomes, network and generate new partnerships
- Partner exchanges with industry,

academia, government and community

- IFPS training for community and industry
- Knowledge dissemination

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Partnerships

Centre for Applied Research, Innovation and Entrepreneurship (CARIE) is the main College research administrating body.

CARIE connects with partners after scientific collaboration with a partner to formalize arrangements with industry and academic partners

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Granary Road Aquaponics Project

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Educational Aquaponic Green House

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Granary Road Farmers Market and Educational Park is a company located in Calgary, Alberta

https://granaryroad.com

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The company partnered with Lethbridge College to construct the first public demonstration aquaponics facility to promote the technology

Granary Road and Lethbridge College Aquaculture Centre of Excellence (ACE) are pleased to announce a technology and training collaboration in Aquaponics! Opening in our Greenhouse in 2019, visitors at Granary Road will be able to experience firsthand the benefits of research and science at one of Canada's finest academic institutions. ACE is meeting the demand for quality applied research into aquaculture practices specifically adapted to northern geographical locations. Our greenhouse operations, bio-secure isolation facilities, water recirculation technologies, and water quality testing and molecular lab capabilities provide a solid foundation for a variety of aquatic-based research, particularly in:

- Aquaponics
- Aquatic ecosystem health
- Water quality
- Water conservation
- Waste management

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ACE Goals

The applied research conducted through ACE accomplishes four major goals that benefit our internal and external stakeholders. The Aquaculture Centre of Excellence:

- Develops the present and future workforce
- Promotes direct application of research results
- Creates partnerships with industry to sustain economic development
- Increases institutional capacity for contract applied research and other service activities to the community, business and industry

The efforts and research occurring at Lethbridge College Aquaculture Centre of Excellence and the partnership with Granary Road, is an example of one of the ACE goals. Technology and research will be applied to business, training for Lethbridge College students at a private facility, post-graduate employment, and scholarship opportunities supported by Granary Road make this an important and exciting collaboration for Alberta **...and the freshest-grown-on-site produce will be available at Granary Road!**

We welcome Granary Road visitors and interested students to inquire further about our exciting collaboration by emailing us at info@granaryroad.com and learning more about our Aquaponic Green House in the future on our website at www.granaryroad.com

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Fish

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Biochar filtration unit

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Youth Changing the Course

Project Sponsored by
Fort Macleod Community
Aquaponic Greenhouse Society

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- Intention of our project is to engage youth to take an active role in learning new, sustainable methods of increasing local food production through aquaponic growing methods
- Our Outreach began with presentations on aquaponic growing to each of the elementary schools within Livingstone Range School Division

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- To date we have spoken to more than 1400 elementary age students
- Student leaders from our first school installation, joined us as Presenters as we spoke to other students in the School Division (youth leadership, mentoring)

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- With each presentation, we were able to offer a stand alone aquaponic system utilizing a 55-gallon tank and approximately 1/2 m. sq. growing bed
- We were successful in applying for funding from Environment and Climate Change Canada which enabled us to hire a Community Facilitator and provide more systems

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- Our Facilitator meets with teachers, students and community members, working along side them to ensure they have a successful growing experience
- Our Funding enables us to provide free of charge a stand-alone system

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- At this point we have systems at five elementary schools and will have five systems installed at the high schools by September 30, 2019
- That will give us most of the 2019/20 academic year to monitor evaporation rates, engage students who we hope will in turn engage other students and hopefully have some bountiful harvests

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Bamboo Biochar studies

The studies at Lethbridge College included the development of biochar as a highly efficient filtration medium and a highly stable greenhouse growing substrate

- This work was initiated in 2004 at Crop Diversification Centre South, Brooks, Alberta, in collaboration with Alberta Research Council (Alberta Innovates)

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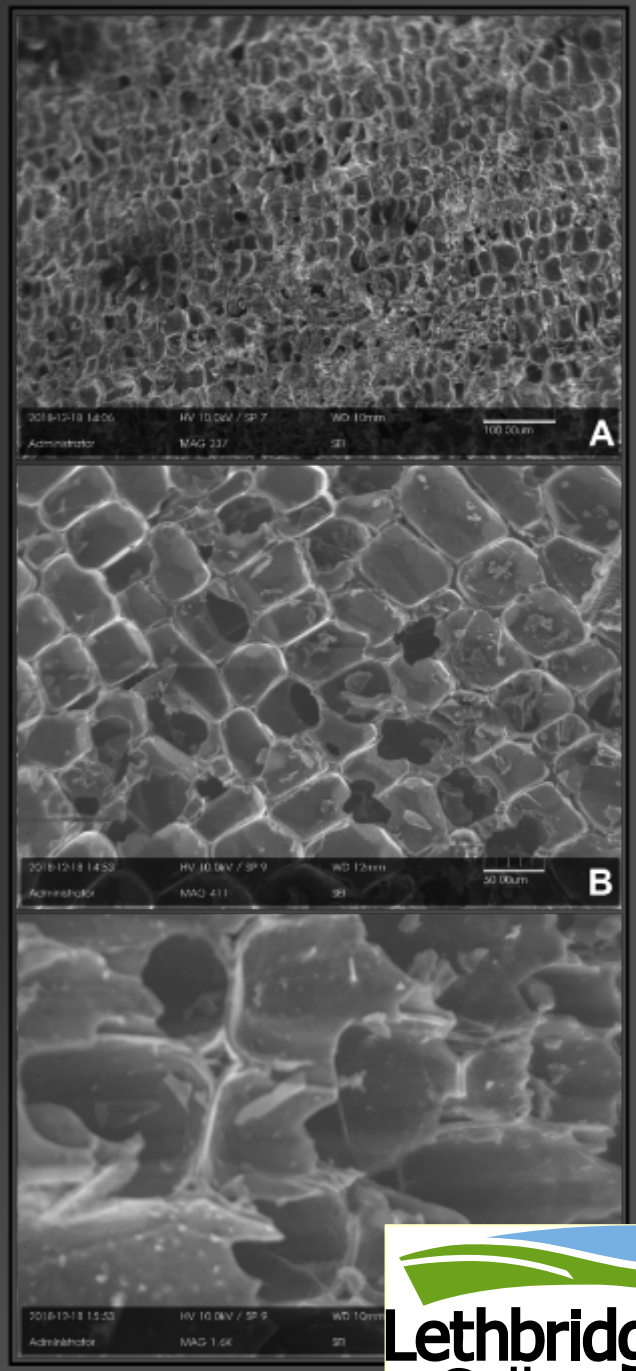
Pilot-scale Biochar tricking filter at Aquaculture Centre of Excellence, Lethbridge College

Biochar pores at different magnification



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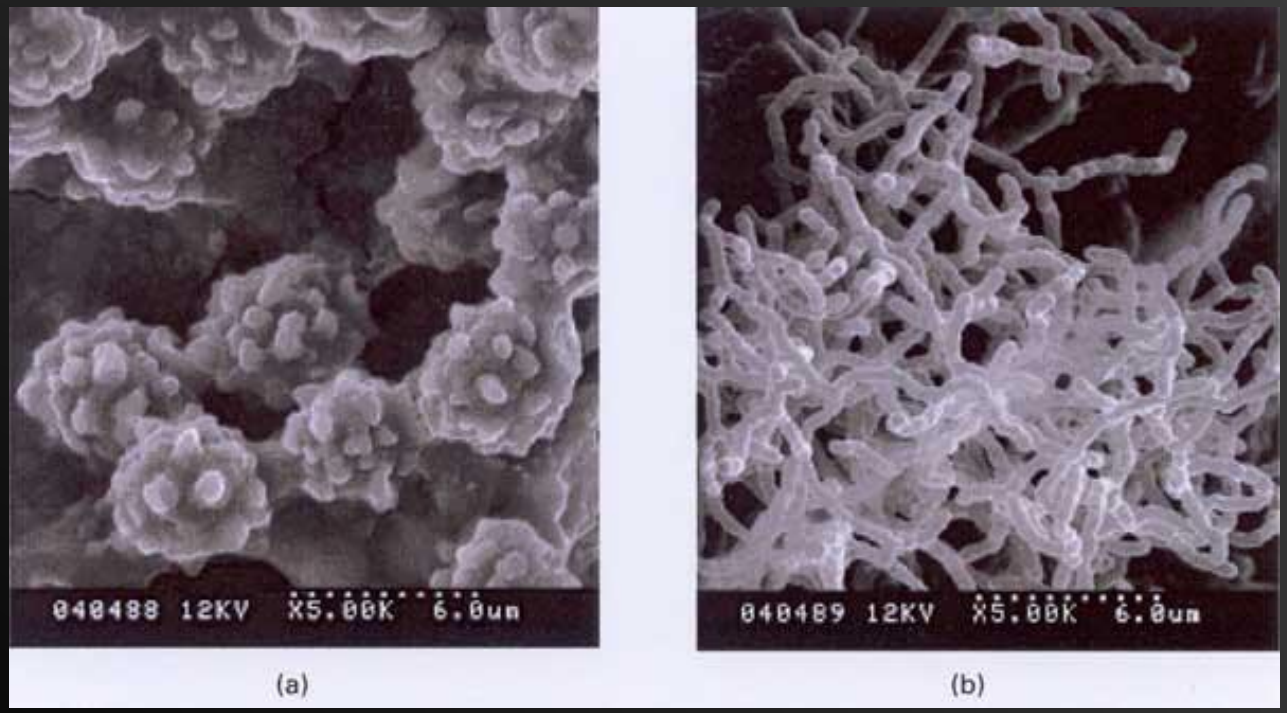
The bamboo biochar extremely developed pore area allows to use it as highly efficient biofiltration media



SEM photographs of the different type of microorganisms the mixture surface of bamboo charcoal and rice bran.

Yoshizawa Shuji and Satoko Tanaka, Food and Fertilizer Technology Center (http://www.fftc.agnet.org/library.php?func=view&id=20150107145511)

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The effect of the flow rate, the depth of biochar filter and the particle size on the suspended solid particles were investigated

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Physical Characteristics	Fine Biochar	Coarse Biochar
Bulk density (g/cm^3)	0.366	0.176
True density (g/cm^3)	1.541	1.613
Total porosity (%)	76.25	89.09

The Conclusions

Bamboo biochar represents a highly efficient relatively low-cost filtration solution to remove finer particles (1-100 micron) for aquaponics and aquaculture.

The biochar filter use will be most appropriately as a water polishing step after removal of larger particles (30-1000 micron) using sedimentation tanks or drum filters

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Results also indicated that the performance of biochar-based filtration depends on the operational conditions (biochar media size, biochar filter bed height and loading rate).

Biochar also has a potential as a highly efficient biofilter housing beneficial bacteria and considerably exceeding the potential of know biofiltration media

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Pure Life Carbon is the industry partner of Lethbridge College in the development of biochar technology. It is the Albertan company, which commercialized biochar technology

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PURE LIFE
CARBON

The Company & Absolute Carbon

July 2019 Summary

PURE LIFE CARBON

Absolute Carbon - Competitive Advantage

- Our feedstock is **consistent, premium, and horticultural** grade
- First to market as a soilless carbon based growing media globally
- 10+ years of private and academic research and studies
- Independently tested, backed and verified by top-of-class scientists, researchers, and academia
- 100% made from renewable, environmentally friendly plant based feedstock
- >100 year lifespan and diverse product uses
- Tested, validated, and used by commercial growers

PURE LIFE CARBON

Cannabis Production

- Worlds 1st pharmaceutical grade, carbon based soilless growing media
- Organic, **sterile**, and sustainable
- Creates superior plant health and vigorous root development
- Superior air, probiotic, water & nutrient holding and delivery capacity (High CEC)
- Reduces Risk
  - Difficult to overwater
  - Containment free
  - Absorbs heavy metals, pesticides, herbicides and other contaminants from the nutrient solution or water
  - Consistent crops, forecast plant to plant production more accurately
  - Gnat's and other insects cannot live in Absolute Carbon
  - Acts as a natural algicide, preventing algae from forming
  - Battery storage effect, minimizes impact of equipment failure, like a plugged emitter or mistakes with nutrient delivery.

PURE LIFE CARBON

Continued

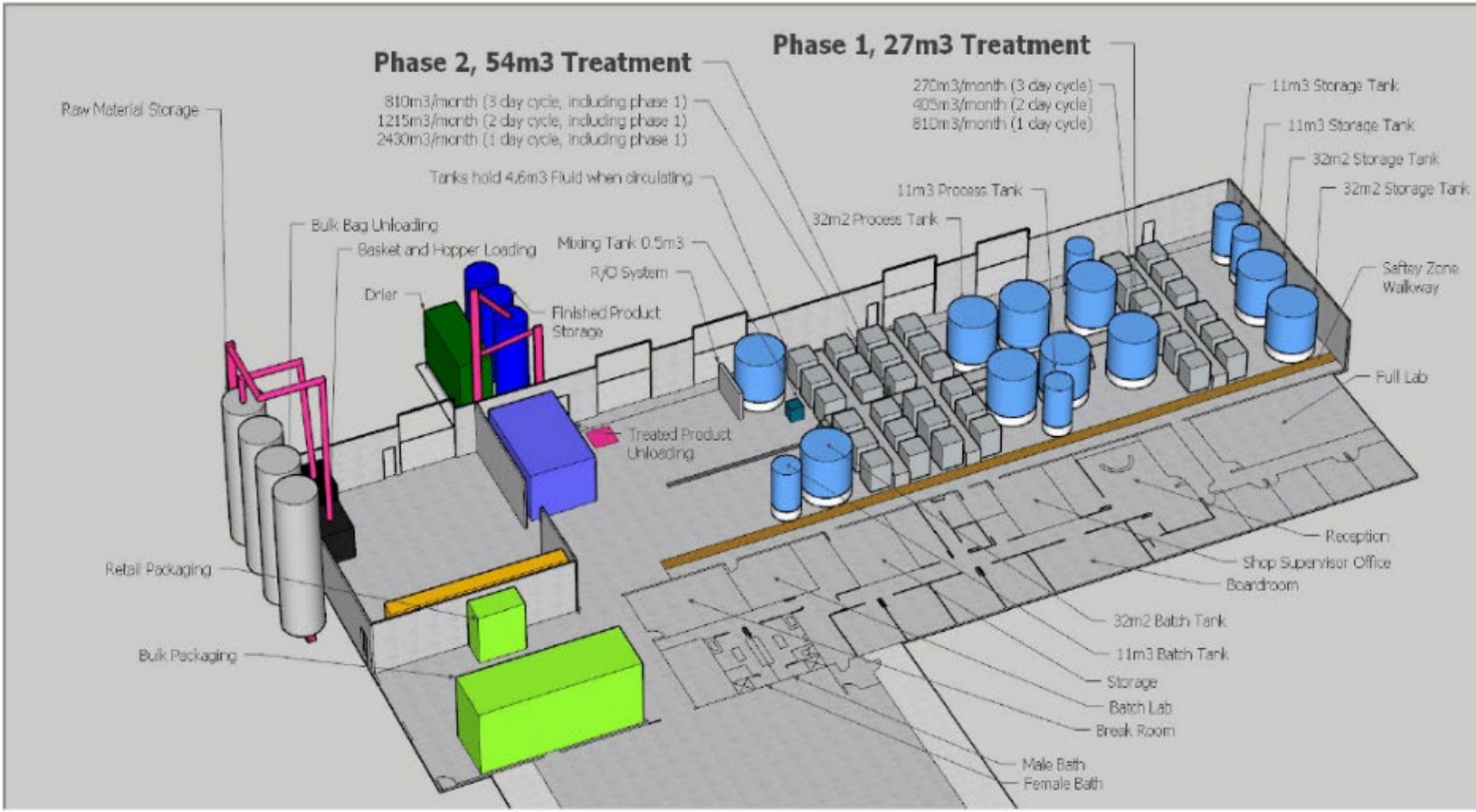
- Minimizes required media volume to grow in. Typically 7.5 liters is enough per plant
- Customizable to your facilities requirements, optimizing specie specific plant performance
- Reduces daily handling labour, and minimizes transplanting
- Does not require alteration of current seed starting or clone process
- Sequesters greenhouse gasses through its full lifecycle
- **100% Reusable or Recyclable**
- **INCREASED GROWTH RATES AND YIELD BY 10-15%**
  - ***when compared to Rockwool**

PURE LIFE CARBON

Processing Facility

- At present, Pure Life Carbon operates from a 1,500 sq. ft facility in Blackfalds, AB
- Facility is used to process and package raw product into the Absolute Carbon product line
- Current monthly processing capacity: 20 m^3
- Expansion into a new facility in 2019 with a processing capacity > 1200m3 per month

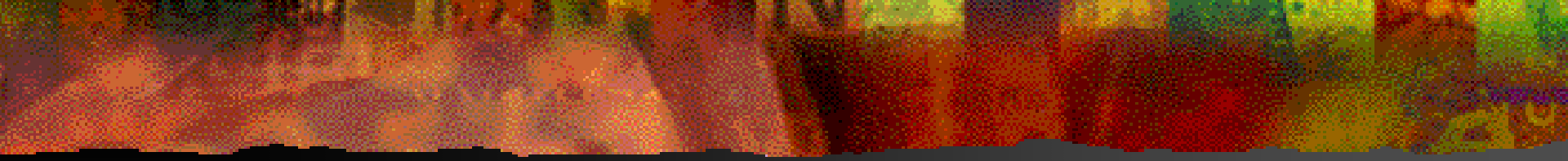
Facility Design



PURE LIFE CARBON

Products & Services

- **Absolute Carbon**
  - Premium Plant Based Biochar
  - Horticulture Grade
  - Contaminant free
- **Charged Carbon**
  - Absolute Carbon features
  - Phosphorus charged
  - pH Balanced to 5.5 – 6.5
- **SuperCharged Carbon**
  - Charged Carbon features
  - Inoculated with Organic Nutrient
- **Carbon Live**
  - SuperCharged Carbon features
  - Beneficial probiotics and microbes added
- **Carbon X**
  - Customized to your specific facility requirements
- **AquaChar**
  - Used for filtration of nutrient solutions
  - Breaks down nutrient particles
- **Growing Bags & Pouches**
  - Made from recycled products
  - Sterile and 100% synthetic
  - Optimized for cannabis production
- **Recycling & Repurposing**
  - Used Pure Life Carbon products
  - Other organic wastes streams such as plant mass



Future Developments – Integrated Agriculture Technology and Technology Access Centres

Total Budget - $4.2M

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The main objective is to enhance the ability of local businesses to solve problems and become more innovative and competitive through access to technology, expertise, and equipment.

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The industry will have access to the College expertise in the areas:

- Integrated Food Production Systems
- Aquaculture and Aquaponics
- Greenhouse Operations
- Crop Productivity Enhancement
- Technology and Automation
- Bioprocess design and development
- Bioprocessed nutrient application technologies
- Sustainable production

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The following services will be provided by the TAC:

- Applied Research & Development;
- Technical Services & Consulting;
- Training and Education.

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Principal schematics of the water circulating system between RAS and Greenhouse Facility in IATS

Components of Aquaponics Fish Facility:

Moving Bed Biofilm Reactor, MBBR, with HDPE carrier 40m^3

Low Head Oxygenator, LHO, on the top of MBBR

Drumfilter Effluent Collector 10 m^3

Drumfilter

10' Grow-out Tanks 4.5m^3

8' Grow-out Tanks 2.4 m^3

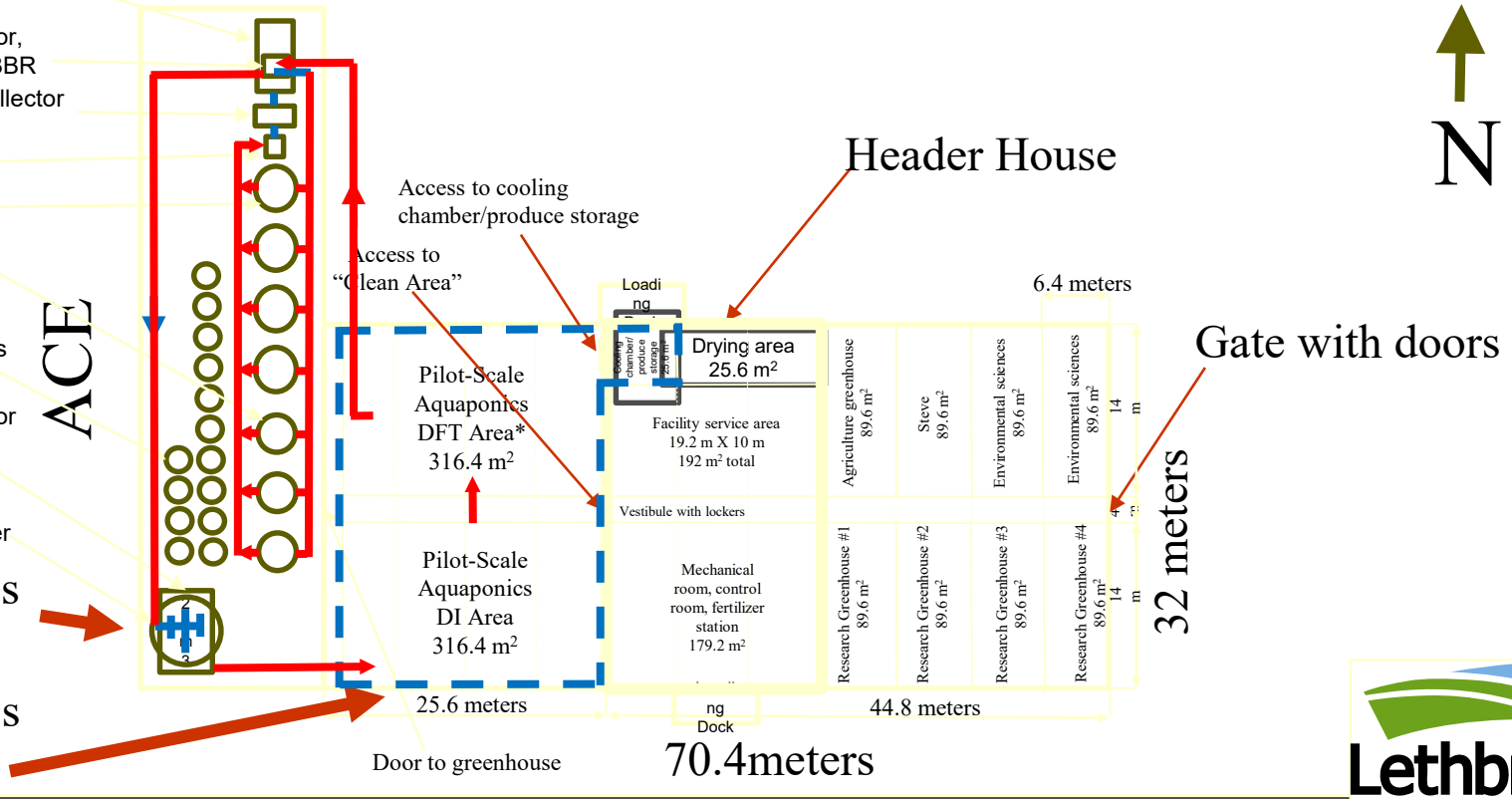
4' Aerobic Bioreactors 1 m^3

BTF Effluent Collector beneath BTF 20 m^3

14' Biochar Trickling Filter, BTF, with sprayer 10 m^3

Aquaponics Fish

Aquaponics Plants



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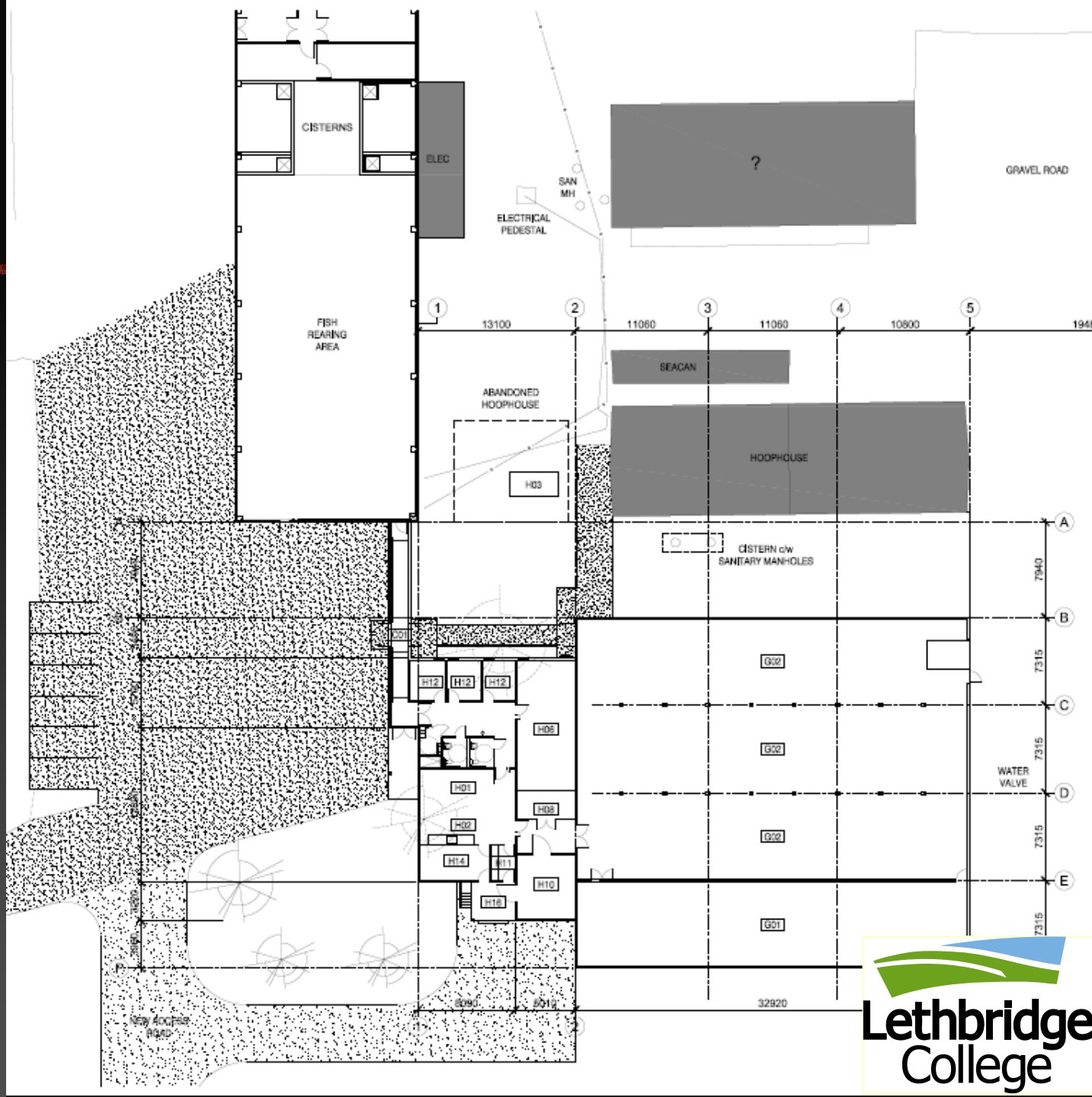
IATC Research Facility



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