

Wastewater Reuse for Biofuel Production



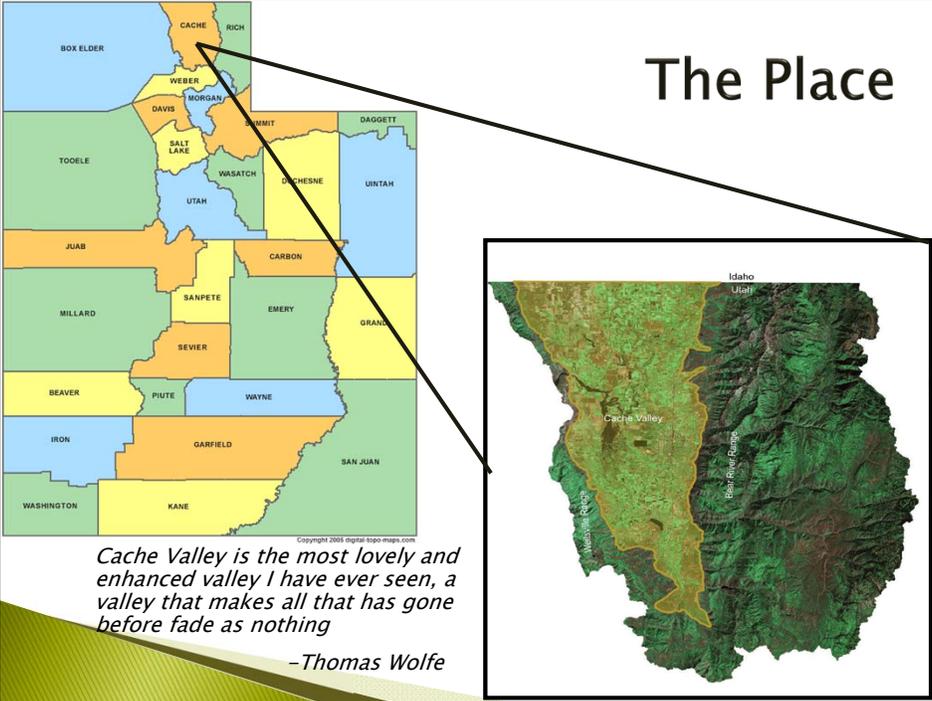
Issa A. Hamud P.E.
Erick Griffiths



Outline

- ▶ The Place
- ▶ The City of Logan Environmental Department
- ▶ The Regional Wastewater Treatment Facility
- ▶ Wastewater Reuse
- ▶ TMDL
- ▶ Algae Growth
- ▶ Algae Harvesting
- ▶ Biofuels

The Place



Cache Valley is the most lovely and enhanced valley I have ever seen, a valley that makes all that has gone before fade as nothing

—Thomas Wolfe

The City of Logan Environmental Department

- ▶ Regional wastewater treatment
- ▶ County-wide solid waste and disposal



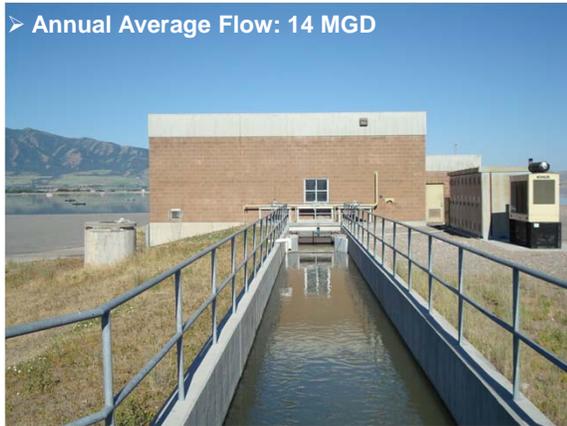
► **Communities Served:**

- Logan
- Smithfield
- Hyde Park
- North Logan
- River Heights
- Providence
- Nibley
- Utah State University



Headworks

► Annual Average Flow: 14 MGD



► Bar Screens



Influent Wastewater Characteristics

2010 Logan Lagoons Wastewater Influent

Constituent (mg/l)	Spring	Summer	Fall	Winter	Typical Weak Wastewater
TSS	120	87	104	140	100
BOD	108	89	98	118	110
Ammonia	17	14	18	18	12
Total Phosphorus	5	3	4	5	6

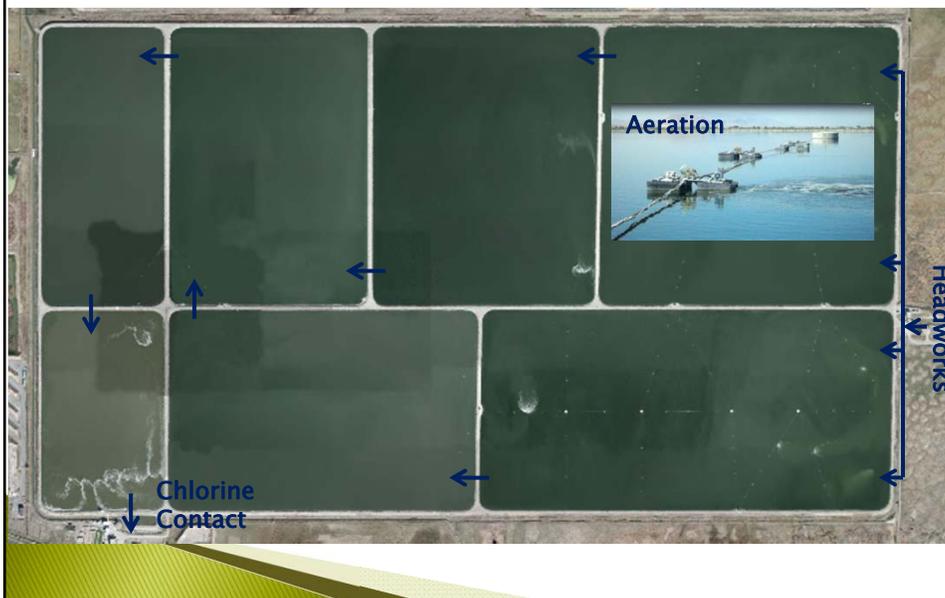
City of Logan Wastewater Lagoons



City of Logan Constructed Wetlands for Ammonia Reduction



Process Flow



Effluent Water Quality

2010 Logan Lagoons Wastewater Effluent

Constituent (mg/l)	Spring	Summer	Fall	Winter
TSS	22	21	23	40
BOD	25	9	7	25
Ammonia	14	7	4	11
Total Phosphorus	4	4	2	3

Effluent Limitations

Constituent (mg/l)	30-day Average		7-day Average	
TSS	25		35	
BOD	25		35	
Ammonia	Spring	Summer	Fall	Winter
	11.9	9.1	11.2	14.4

Current Water Reuse

- ▶ Irrigation
 - During the summer months, near 100% of the effluent is used for irrigation by downstream farmers
 - Approximately 800 acres of pastureland and cropland between the WWTP and Cutler Reservoir that are flood irrigated
 - Approximately 580 acres are irrigated fallow/pasture area and 220 acres are used for crop production

Receiving Water Body

Cutler Reservoir

Beneficial uses:

- ▶ Secondary contact recreation
- ▶ Warm water game fish
- ▶ Waterfowl, shorebirds, and other aquatic organisms
- ▶ Agricultural water supply



**Utah Department of Environmental Quality
Division of Water Quality TMDL Section**

Middle Bear River and Cutler Reservoir TMDLs

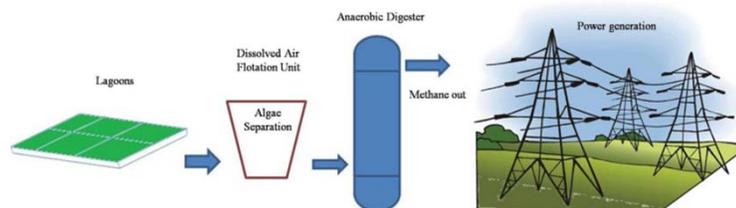
- ▶ TMDL was completed in 2010
- ▶ Allowable load of phosphorus:
 - 4,405 kg (May to October)
 - 11, 831 kg (November to April)
- ▶ The City will need to reduce the total phosphorus of effluent by as much as 65%

Initial Recommendation for Improvement to Meet New Limits

- ▶ Sequential Batch Reactor (SBR)
 - Peak Month Average Daily Flow 48 mgd
 - Annual Average Daily Flow 28 mgd
 - Capital Cost \$188 million
 - Annual O&M Cost \$ 3 million
- Increasing Logan's base rates \$60/month

Alternative Solution– Wastewater Reuse for Biofuel Production

- ▶ Enhance algae growth to consume nutrients in the wastewater
- ▶ Harvest the algae
- ▶ Convert algae to biogas



Algae Growth in the Lagoons

➤ Natural occurring algae growth



Enhance Algae Growth

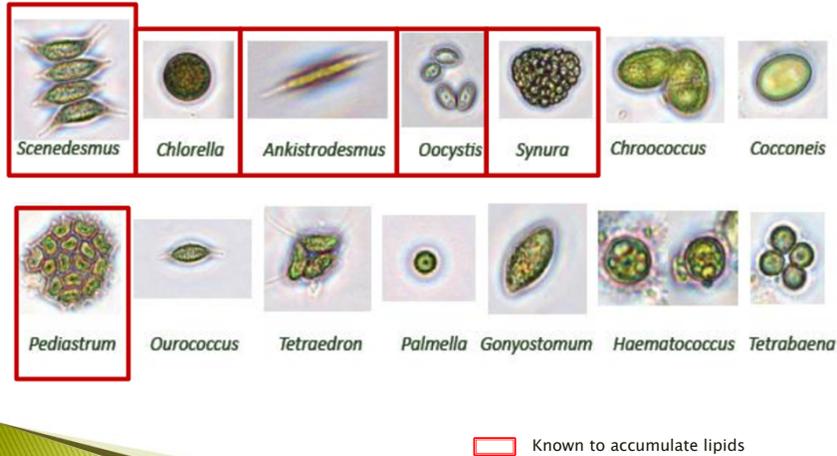


Left: Small Scale Raceways

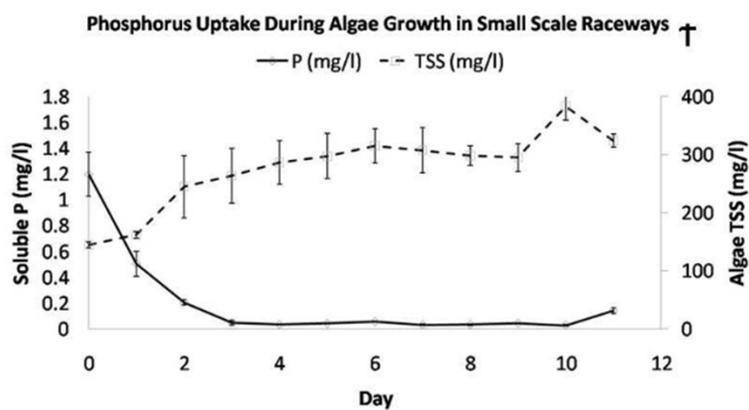
Right: Pilot Scale Raceways



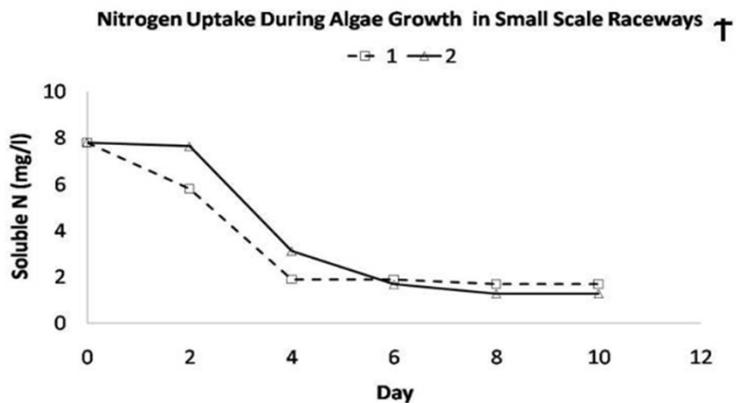
Algae Strains in Wastewater Lagoons



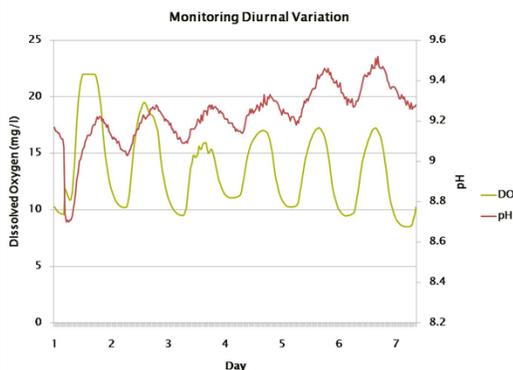
Phosphorus Uptake by Algae



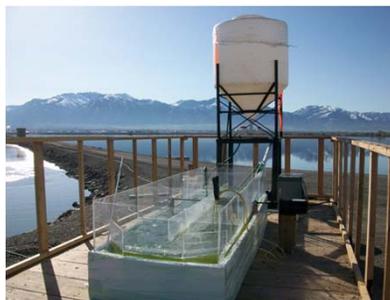
Nitrogen Removal



Enhance Algae Growth

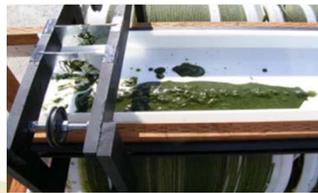


▶ Mobile Testing Unit



Enhance Algae Growth

- ▶ Rope Biofilm Reactor (RBR)

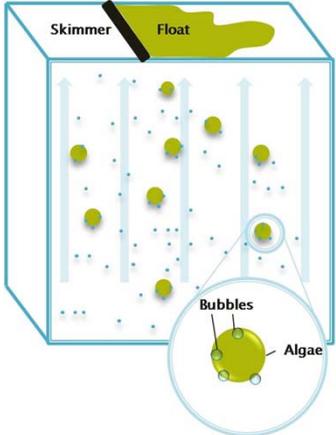


Harvesting Algae

- ▶ Dissolved Air Flotation (DAF)
- ▶ Cross Flow Filtration



DAF

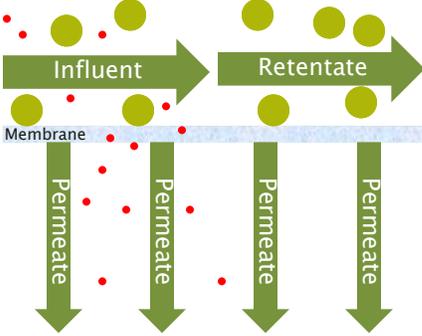




- ▶ Water is supersaturated under pressure
- ▶ Pressure is released, micro-bubbles form and raise algae to the surface
- ▶ The algae is skimmed off the surface
- ▶ Chemicals are added to aid flocculation when necessary

Cross Flow Filtration

- ▶ Algal suspension flows parallel to surface of membrane
- ▶ Algae contained in the retentate while water is released in permeate





Algae Production Estimates

- ▶ Treated Water: 14 MGD
- ▶ Average Algae Formula:
 $C_{106}H_{263}O_{110}N_{16}P$
- ▶ Phosphorus Loads: 3-6 mg/l

Estimated Algae Production \approx 12-24 tons per day (d.w.)

Convert Harvested Algae into Energy

- ▶ Biogas
 - Methane combustion to produce electricity
- ▶ Biodiesel
 - Run diesel garbage trucks
 - Logan City operates approximately 40 trucks

Pilot Testing to Convert Algae to Biogas



Anaerobic Digesters on-site

- 1000 gal
- Co-digestion of other materials (green waste, food waste, etc.)

Anaerobic Chamber at USU

- Identify biogas yields from algae



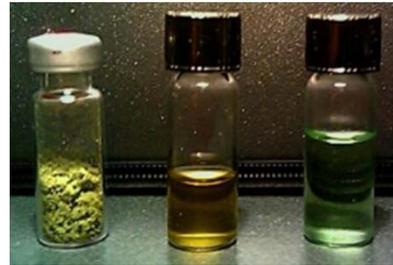
Estimated Gas Production

- ▶ 180,000–500,000 cubic feet per day
- ▶ Produce electricity to power 170 – 500 homes



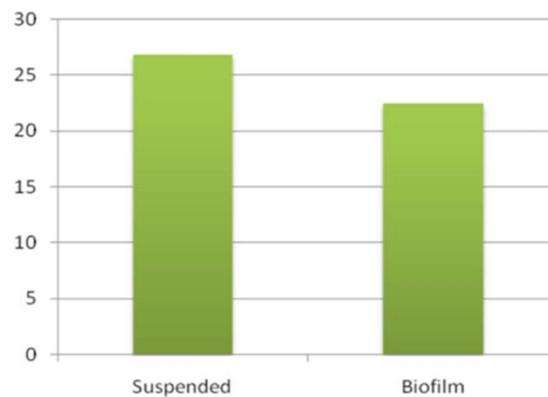
Biodiesel

- ▶ Conversion of algae lipids to biodiesel
- ▶ USU is working on process to produce biodiesel on a large scale



Preliminary Biodiesel Results

% FAME (w/w)



Fatty Acid Methyl Esters (FAME)

Questions

