Metropolitan Council Algae Research Project Update

Presented to the Metropolitan Council Management Committee

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Energy Collaboration

- **Met Council and the U of M**
  - **Algae research**
  - **Super bus**
  - **Biofuel demonstration project**

MCES Interest in Algae

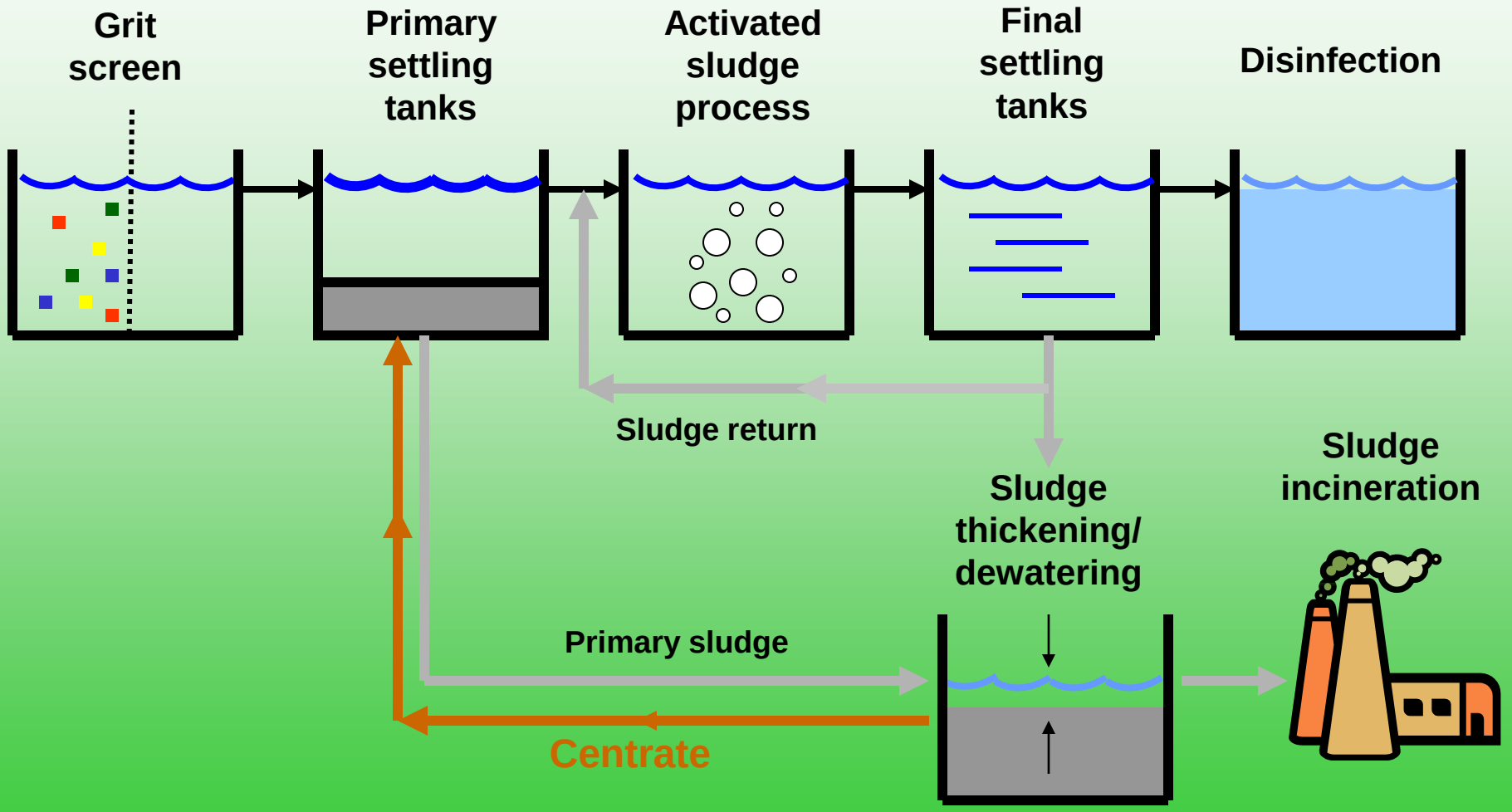
- **Phosphorus limits**
  - Current 1 mg/l based on 12 month average
  - Sept 2008 MPCA suggested 0.3 mg/l
  - New limit = ?
- **Nitrogen limits**
  - Seasonal ammonia removal (nitrification)
  - Hypoxia in Gulf of Mexico
- **Greenhouse gases**
  - Some limits for WWTP possible
  - Cap & trade => value for reduction
- **Renewable fuel**

Project Timeline

Phase	Period	Tasks
1	2006-08	Lab scale investigations at UM
2	2008-09	Construction & operation of small pilot plant at Metro plus additional laboratory investigations at UM
3	2009-10	Continuation of Phase 2 with focus on performance of bioreactor A
4	2010-13	Construction & operation of demonstration scale facility (LCCMR $)

Bob Polta, Ph.D., PE

Metro Plant Schematic



Centrate P Recycle

- **Metro inf soluble P load ~ 4,100 lb/day**
- **Centrate soluble P ~ 2,000 lb/day**
- **Centrate = 49% of influent SP load**
- **Metro inf soluble COD load ~ 125 ton/day**
- **Centrate soluble COD ~ 10 ton/day**
- **Centrate = 8% of influent COD load**

Concept

Activated Sludge Process

Algal Growth

Accomplishments

- **Phases 1 and 2**
  - **Identified and quantified key factors and processing parameters for microalgae growth and wastewater treatment**
  - **Constructed pilot-scale reactor at Metro Plant**
  - **Determined removal efficiencies for soluble phosphorus, nitrogen, and COD over 30 day batch feed experiment**

Accomplishments, cont.

- **Phase 3**
  - **Verified:**
    - **Biomass growth rates**
    - **P, N and COD removals**
  - **Determined:**
    - **Biomass energy content**
    - **Biomass total extractable material (oil is subset)**
    - **P removal mechanism**

Pilot Plant Location

Pilot Plant Schematic

Centrate Treatment

Growth Reactors

Algal Settling

Centrifuge Dewatering

Reactor Details*

Volume - liters	**840**
Harvest – liters/day	**220**
Area – ft^2 (m^2)	**128 (11.9)**
Fluorescent light - watts	**1,920**
Light intensity - umole/m^2/sec	**25****
Daylight – umole/m^2/sec	**170-1800****

**BRA most recent experiment*

***photosynthetically active radiation (400–700 nm)*

Performance Summary

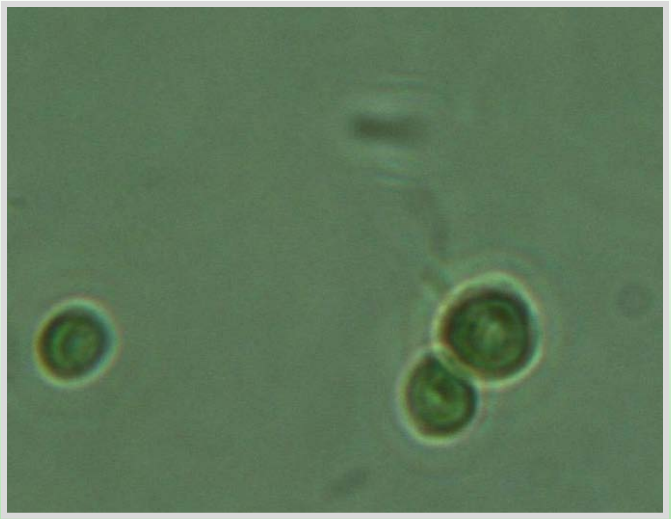
Total solids production – gm/m^2/day	**23**
Volatile content of solids - %	**50**
Ave energy content – BTU/lb	**3,980**
Ave extractable content - %	**20**
Ave soluble P removal - %	**69**
Ave soluble N removal - %	**62**
Ave soluble COD removal - %	**93**

Current Council Efforts

- **Modified bioreactor operating in small greenhouse at Metro**
  - **Seeded with new UM algal strain reported to yield higher oil content**
  - **To be operated using natural light only**
- **Second experiment in SMB pilot plant to determine the impact of light (photosynthetically active radiation) on biomass growth, biomass characteristics, and nutrient removal performance**

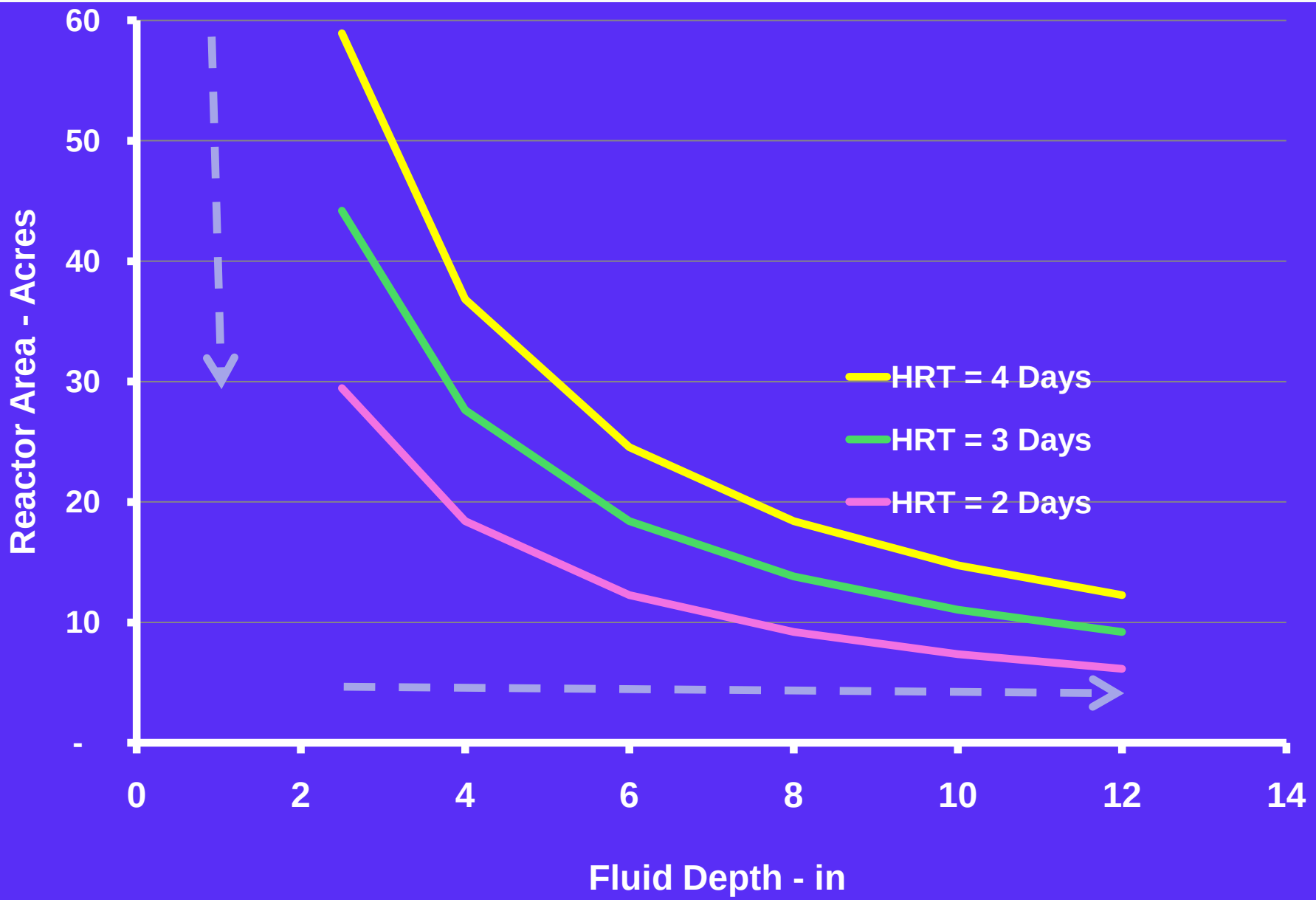
Biomass

- **(Top) Biomass at 1000x illustrating individual cells**



- **(Bottom) Reactor contents collected from greenhouse reactor on Monday (July 12) at 11 a.m.**

Next Steps: Reactor Area



Unanswered Questions

- **Temperature limitations (winter)**
- **Natural light limitations**
- **Light/dark cycle**
- **Reactor configuration--continuous operation**
- **Harvest technologies**
- **Biomass to biodiesel technologies**
- **Value of remaining solids**
- **Value of using flue gas**

Next Phase Pilot Effort

Continuous Feed Alternative	A	B
Centrate feed – gal/min	0.3	0.6
Solids production – lb/day	5	10
Number of reactors	2	4
Reactor area – sq ft	1,200	2,400
Greenhouse – sq ft	1,500	3,000
Construction cost – thousand $	200	325

LCCMR Funding Objectives

- **$900,000 includes:**
  - **Development and demonstration of technologies for converting algal biomass to bio-fuels**
  - **Evaluation of systems against designed technical specifications**
  - **Evaluation and quantification of green impacts and benefits including**
    - **Pollutant removal**
    - **Water usage and quality**
    - **Carbon sequestration**
    - **Energy balance**
    - **Fuel quantity and quality**
  - **Conducting of economic and environmental life-cycle analysis**

Value Proposition

- **Algae grown in wastewater processes:**
  - **Strong co-benefit of pollution reduction**
  - **CO_2, phosphorus, and nitrogen available**
  - **Water available and free**
  - **Thermal energy available**
  - **Space available around plants**
  - **Expertise in dewatering (engineering and operations)**
  - **Laboratory/analytical availability**
  - **Possible market for biodiesel**
  - **Value recovered from cell mass reduces treatment costs**