

# Water Resource Management Design Review

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Dec 9, 2016

Armstrong Hall, 1098C

# Team Comments/Design Review

## Headings

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- Introduction of Reviewers- Name, Organization/Department

- Handouts- red page numbers

Plants Used Spring 2016 (Page 2-3)

# Finances

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- Budget:
  - Started Semester with \$9,997.
- Thank you to the following organizations:
  - CIE: Service Learning: Service Learning Sustainability Grant- \$3000 (Happy Hollow)
  - Office of Engagement: Service Learning Grants- \$3000 (1500 Happy Hollow, 1500 Hydroponics)

# Happy Hollow Park



Taken at Happy Hollow Park, January 2015

# Agenda

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- Overview of team
- Community partner introduction
- Project background
- Semester progress
- Open discussion

# Introduction

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- Monica Moran, Design Lead
  - *Sophomore, Environmental and Ecological Engineering*
- Matt Springer, Financial Officer
  - *Freshman, First Year Engineering*
- Nolan Miller, Project Partner Liaison
  - *Freshman, First Year Engineering*
- Blaire Coleman, Archivist
  - *Sophomore, Industrial Engineering*
- Stephanie Verhoff
  - *Senior, Natural Resources and Environmental Science*
- Jacob Mickey
  - *Freshman, First Year Engineering*

# West Lafayette Parks and Recreation

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- Serves to:
  - Enhance quality of life
  - Designate trails
  - Maintain the grounds of West Lafayette parks



Taken from: [www.westlafayette.in.gov](http://www.westlafayette.in.gov)

# Purpose of Happy Hollow Park Team

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- Aids the West Lafayette Parks and Recreation Department in remediating potential problems in Happy Hollow Park.
  - Mitigate hill slope soil erosion
- Work with Dan Duntun
  - Director of the Lilly Nature Center



# Happy Hollow Park

- Approximately 81 acres
  - Playground
  - Hiking/exercising trail
  - Shelters and other areas for entertaining
  - History of erosion
    - Progressively worsening for 30+ years



Taken at Happy Hollow Park, September 4, 2015  
Information from: [www.westlafayette.in.gov](http://www.westlafayette.in.gov)

# Stakeholders

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- West Lafayette Parks and Recreation Department
  - Utilizes solution
- Park Goers
  - Residents
  - Hikers
  - Bikers
  - Students
- Wildlife
  - Animals affected by possible solution

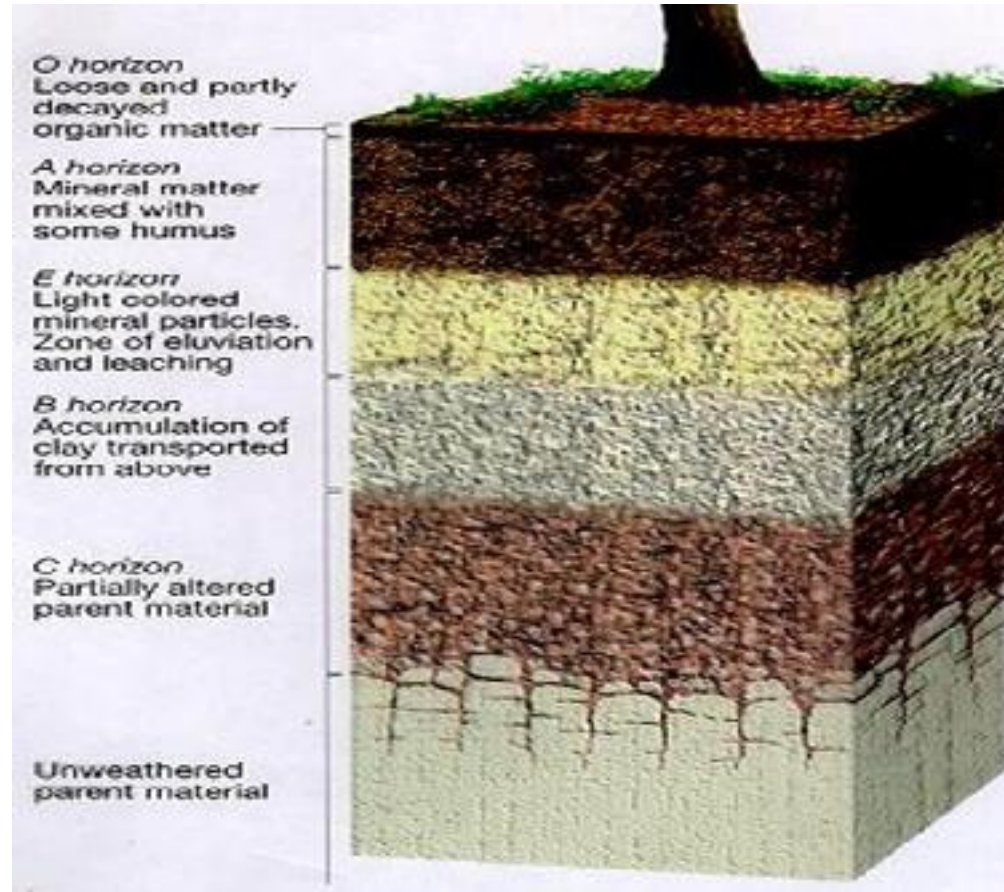
# Main Problem: Erosion

- Erosion is:
  - “The process whereby materials of the earth's crust are loosened, dissolved, or worn away and simultaneously moved from one place to another” –United States Geological Survey



Taken at Happy Hollow Park, January 2014

# Severity Level of Erosion



Taken from: [http://www.ctahr.hawaii.edu/mauisoil/images/a\\_profile\\_clip\\_image002\\_0000.jpg](http://www.ctahr.hawaii.edu/mauisoil/images/a_profile_clip_image002_0000.jpg)

# Project Background

- Reason for project:
- Severe erosion throughout Happy Hollow Park
  - Types of erosion
    - Gullies
    - Stream bank erosion
    - **Hill-slope erosion**
  - Contributing sediment to the Wabash River
  - Largely natural, exacerbated due to manmade development
  - Affecting use of park (aesthetics and purpose)



Taken at Happy Hollow Park, September 2013

# Vision for Project

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- To create a long-term mitigation method for hill slope erosion in Happy Hollow Park
  - Mitigate erosion on hill slopes
  - Allow reestablishment of topsoil and vegetation on the park's hill sides to trap sediment

# Criteria

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- “Natural” and camouflaged
- Long lifespan (plant re-establishment)
- Must not let soil detach due to runoff
- Safe around pets/wildlife
- Withstand water flow (runoff)
- Easy to install
- Does not leave harmful residue/pollutants

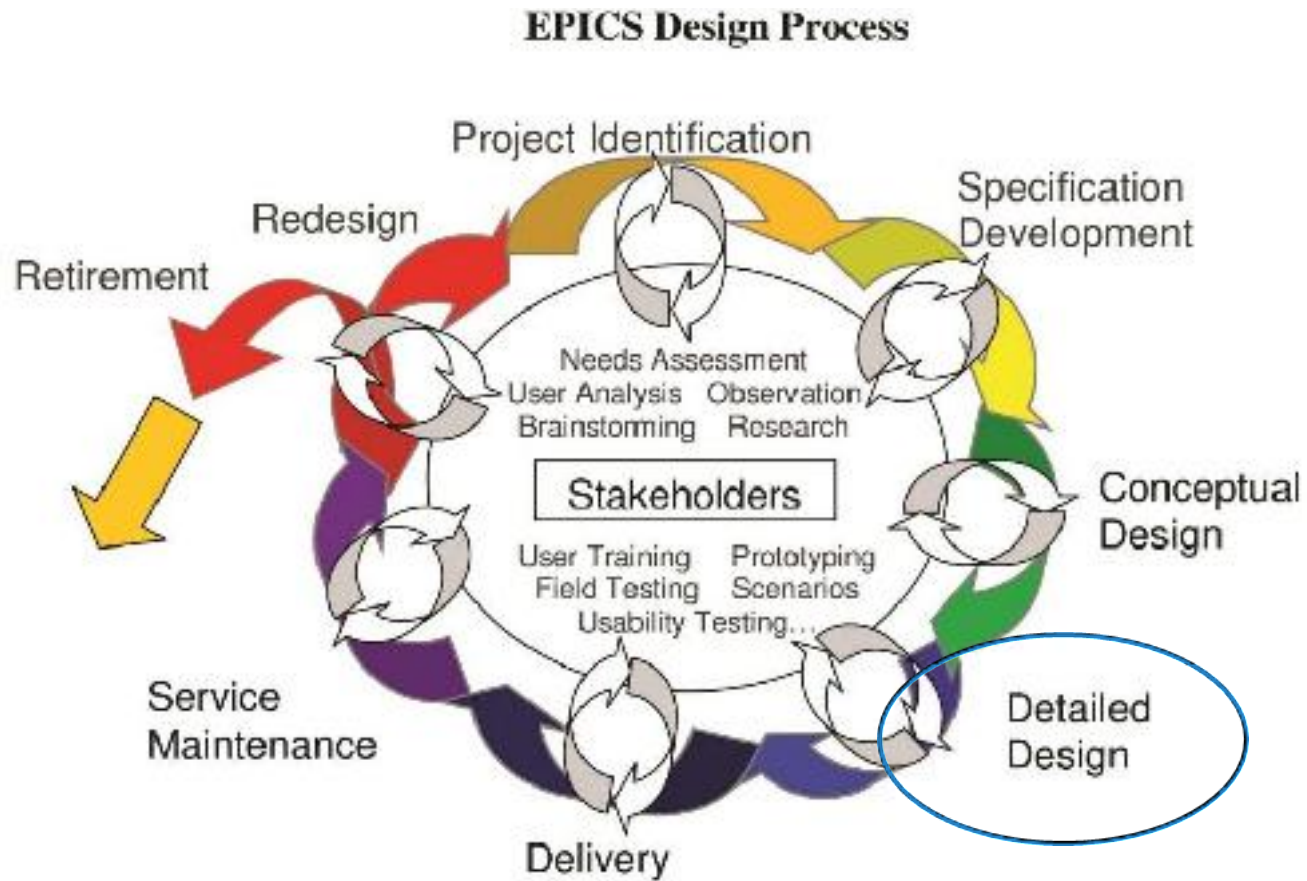
# Constraints

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- Must trap (average) 2 inches of soil behind every berm (allows for plant re-establishment)
- Must allow for plant re-establishment on the test plot



# EPICS Design Process



# Semester Progress

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- GIS analysis
- Onsite water flow analysis
- Trees and shrubs planted
- Took and analyzed soil samples from several locations
- Installed additional signage
- Finalized pamphlet and door hanger
- Selected two new hills and gathered data

# Primary Testing Site (North Hill)



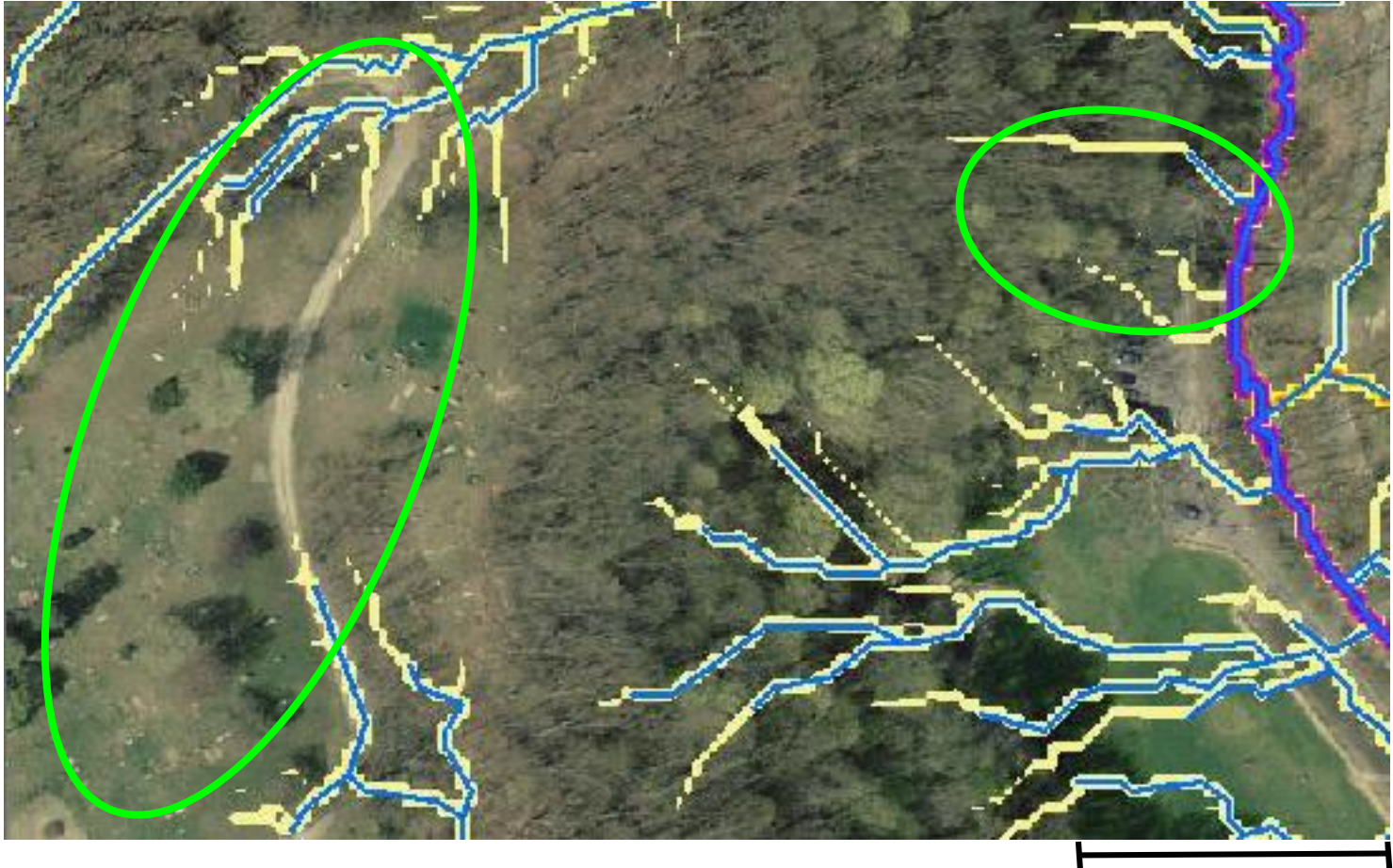
Taken at Happy Hollow Park, April 2016

# GIS Analysis



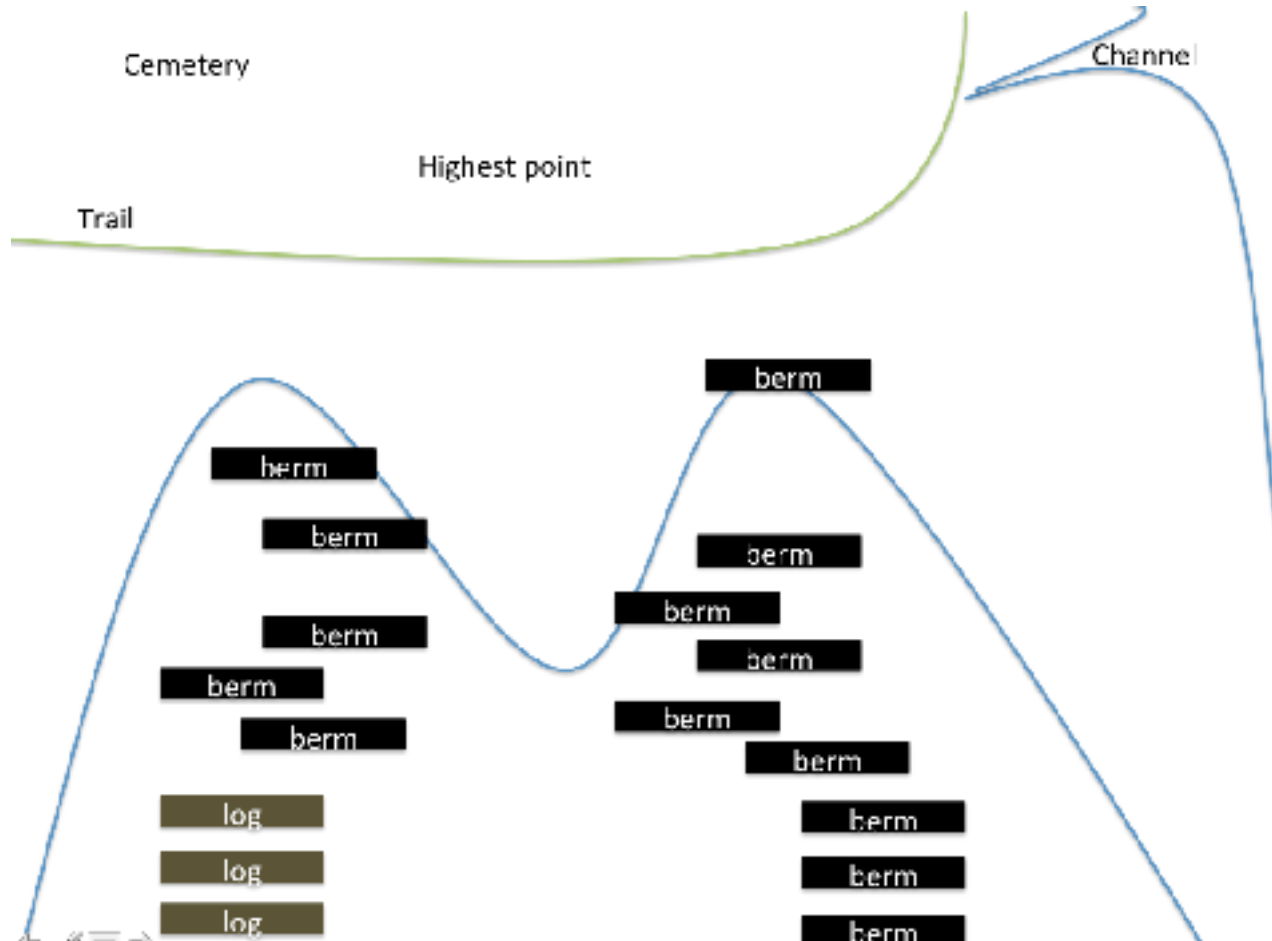
200 ft

# GIS Analysis



200 ft

# Water Flow Analysis



# Prototype 1 – Spring 2015



Taken June 2015



Taken August 2015

# Test site from Spring 2016



April

IEPICS *2016* PURDUE



September  
2016





# Plants Used Spring 2016 (Page 2-3)

- Creeping Red Fescue
- Annual Ryegrass
- Columbine
- Jacob's ladder
- Blue wood aster



Taken from:

<http://m5.i.pbase.com/g6/26/411626/2/78880705.9YK57Ybu.jpg>

# Shrubs and Saplings

**Flowering dogwood**  
(*Cornus florida*)



Taken from:  
[http://www.mtcubacenter.org/images/plant-finder/Cornus\\_florida\\_2.jpg](http://www.mtcubacenter.org/images/plant-finder/Cornus_florida_2.jpg)

**Allegheny Serviceberry**  
(*Amelanchier laevis*)



Taken from:  
[http://67.227.221.91/~ncwildflowerorv/images/plants/amelanchier\\_laevisMaxPatch2004.jpg](http://67.227.221.91/~ncwildflowerorv/images/plants/amelanchier_laevisMaxPatch2004.jpg)

**Spicebush**  
(*Lindera benzoin*)



Taken from: <http://awaytogarden.com/wp-content/uploads/2008/04/lindera-detail.jpg>

# Old Signage (Page 4)



**Please do not disturb the  
experimental plot on the hillside!**

- Walking off-trail on hillsides is a major cause of erosion in Happy Hollow Park.
- Purdue EPICS is constructing an experimental plot on this hillside to test different solutions to the park's erosion problem.

EPICS



Taken April 2016

# New Signs (Page 4)



# Pamphlet Design (Page 5)

## Your Efforts



### What you can do:

Switch from using sprinklers in your gardens to using a soaker



Use rain barrels to catch and hold rain for later use.  
(Go to [www.tippecoonow.com/opt\\_rain\\_barrel.php](http://www.tippecoonow.com/opt_rain_barrel.php))

Use erosion control blankets as matting to prevent soil from being washed away.  
Benefit: less soil loss



Plant rain gardens to catch rain water and allow it to naturally soak into the ground

## EPICS Efforts



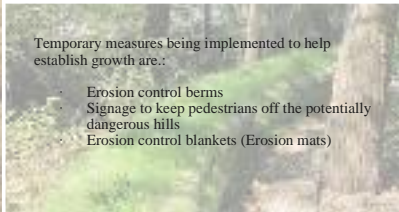
### What is being done already?

Purdue's EPICS Water Resources Management team is working to establish native plant species on hill-slopes in the park to slow water flow and retain soil thus reducing erosion. The plant species are a mix of small trees and shrubs, and perennials.

Some plants we are using include:

- Dogwood
- Jacob's ladder
- Service Berry
- Spicebush

For more plant recommendations please see [inpaws.org](http://inpaws.org)



Temporary measures being implemented to help establish growth are:

- Erosion control berms
- Signage to keep pedestrians off the potentially dangerous hills
- Erosion control blankets (Erosion mats)



**EPICS / PURDUE**  
 Purdue Water Resource Management Team

EPICS is an acronym for Engineering Projects in Community Service and is a program that allows Purdue Students to serve the community in within the fields of their interests. The students are divided into teams that work on different community projects.

## Erosion Problems and the Consequences...

### and How You Can Help

## Happy Hollow Park

# Pamphlet Design (Page 6)



## What is soil erosion?

Soil erosion is a natural process where the topsoil is lost by water and wind through rain. When the volume, speed or concentration of water flow, which creates an erosive environment for native plants.

When rain falls on bare soil.

When it is combined with:

- The volume of water is high and concentrated
- Can negatively impact the natural tree, shrubs and other plants in a happy Hollow Park.



Source: <http://www.usda.gov/forestland/forest/soil/erosion.html>

## What Could Happen In Three Years

... if we don't reduce soil erosion.

### Polluted Waterways

Higher sediment levels in the Mill Creek will cause algae growth and lead to a decline in fish diversity. This will cause fatalities, and decrease recreational beauty.

### Ecosystems Compromised

When erosion continues, then soil fertility decreases. Over time plant life will be negatively impacted and there would be an unmanageable amount of sediment washing the river. This could possibly impact stream life causing additional concern in the park. The shallow soil can lead to increased tree root and high bushings.

### Danger Ahead!

Soil erosion because of years of rain are in a bad place where unpredictable weather, flooding, flash floods, creek drop-offs, and road water dams are all possible due to a lack of vegetation.

Would you like this to happen to you?



Source: <http://www.usda.gov/forestland/forest/soil/erosion.html>



Source: <http://www.usda.gov/forestland/forest/soil/erosion.html>



Source: <http://www.usda.gov/forestland/forest/soil/erosion.html>

## What Could Happen In Five Years

... if we do reduce soil

### Clean Waterways

Lower sediment levels in the Mill Creek will cause higher water quality and healthy aquatic communities.

### Thriving, Scenic Ecosystems

With stable soil, soil is more available to native plant life, which can flourish, making waterways a more pleasant place to visit. There can be a healthy forest of trees and shrubs with better soil.

### Stable

Stable soil is more available to native plant life, which can flourish, making waterways a more pleasant place to visit. There can be a healthy forest of trees and shrubs with better soil.



Source: <http://www.usda.gov/forestland/forest/soil/erosion.html>



Source: <http://www.usda.gov/forestland/forest/soil/erosion.html>

# Doorhanger Design (Page 7)

□ To be distributed next semester

**Erosion at Happy Hollow Park**

**What is soil erosion?**  
Soil erosion is a process where the topsoil gets removed by water and wind over time. This creates an unstable environment for plants to grow.

**How does erosion affect you?**

When it is accelerated it...  
- Can not absorb properly and cause runoff.  
- Can negatively impact the Watershed Plan.  
- Destroy beds, shrubs and other plants in Happy Hollow Park.

*To find out how YOU can help see back!*

**What can you do to help?**

1. Switch from using sprinklers in your gardens to using drip irrigation.
2. Use mulch covers to retain heat, which can be used to water gardens. (see how to prepare covering trees/sprinklers)
3. Use erosion-control blankets on slopes by planting to prevent soil from being washed away.
4. Plant rain gardens to capture runoff from your lawn and lawn. This can create natural beauty in your yard!

**What is being done already?**  
Purdue's Water Resource Management EPICS (Engineering Projects In Community Service) team is working on establishing native plant species on a hillside at the park's new water flow and catch soil. These plants are being used because of their extensive root system, which will help hold the soil in place and reduce erosion.

**Some plants we are using include:**

- Wild columbine
- Jacob's ladder
- Bluewood aster
- Spotted touch-me-not

**For more plant recommendations go to: [www.epics.org](http://www.epics.org)**

**EPICS / PURDUE**  
WEST LAFAYETTE  
Parks and Recreation

# Budget

<b>Description &amp; Justification</b>	<b>Fall 2016 Predicted Expenses</b>	<b>Fall 2016 Actual Expenses</b>	<b>Spring 2017 Predicted Expenses</b>
Plants for the hillside	\$250.00	\$250.00	\$1,250.00
Erosion Mat			\$250.00
Berms (10ft) x 15			\$800.00
Compost	\$30.00	\$30.00	
Signs	\$120.00	\$119.50	
Posts for the signs	\$30.00	\$125.70	
Printing Costs for the Pamphlets	\$80.00		
Printing Costs for the Door Hangers	not accounted for		
<b>TOTAL</b>	<b>\$510.00</b>	<b>\$525.20</b>	<b>\$2,300.00</b>



# Preparing for Delivery



# Middle Hill

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# South Hill

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# Soil Test Report (Page 8)

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- Samples from several locations on all three hills

## Results:

- pH- more basic than desired

- North: 8.5
- Middle: 8.6
- South: 8.5

- Organic matter

- 1.1-1.5% parent material
- 3.1- 4.0% compost and berm material

- Calcium levels- high

- Shows calcareous parent material
- 88.2-92.8%

# Final Report Started

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## □ Includes:

- Background
- Past Semesters
- Educational Component
- Progress on test site and new test sites
- Plan for future
- Financial Statements

# Plans for Delivery

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- January 2017 – Finalize budget, order plants
- February 2017 – Draft of final report, site layout
- March 2017 – Community outreach for volunteers, order compost and berms
- April 2017 – Site delivery, media coverage of community involvement or final product

# Questions and Feedback?

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Taken at Happy Hollow Park, October 2013

# Hydroponics



Photo taken: January 2015 at Purdue Greenhouse



# Introduction

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- Steven Bjankini, Design Lead
  - *Junior, Electrical Engineering*
- Nicholas Bitner, Financial Officer
  - *Freshman, First Year Engineering*
- Andrew Duke, Project Partner  
Liason
  - *Freshman, First Year Engineering*
- Anwasha Sanyal, Project Archivist
  - *Freshman, First Year Engineering*
- Yihan Xie, Webmaster
  - *Junior, Agricultural and Biological Engineering*
- Eric Brill
  - *Freshman, First Year Engineering*
- Tyler Son
  - *Senior, Mechanical Engineering*

# Agenda

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- Overview of project background
- Goals and objectives
- Semester progress
- Remaining tasks
- Questions and feedback

# Habitat for Humanity

- Mission:
  - To make a world where “everyone has a decent place to live” ([lafayettehabitat.org](http://lafayettehabitat.org))
- Contact is Doug Taylor, Executive Director for Lafayette branch, but project will be delivered to Oakland High School or The Crossing.
- Working to build a small-scale hydroponic system for educating pre-professionals.



# Oakland High School

- Limited enrollment high school and member of the Lafayette School Corporation
- Contact is James Koval, a social studies teacher who runs their two current hydroponics systems
- Pros:
  - Hydroponics already integrated into curriculum
  - Sufficient sunlight and space
- Cons:
  - Would need to run power to field for pump
  - Already have 2 systems and a relatively small number of students.



<http://ohs.lsc.k12.in.us/>

# The Crossing

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- The Crossing provides a state accredited academic education as well as providing students with job training.
- Contact is Zachary Martin, director of Hydroponics at the Crossing.
- Would be installed at Hamilton, IN site.
- Pro
  - Established program for preprofessionals in hydroponics
- Cons
  - Distance has been prohibitive. Many unknowns remain.

# Project Specifications

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- Must be nutrient film technique system
- 16'x5' maximum area for system
- Low operating cost
  - Fertilizer, disinfecting, desalting, and electricity
- All parts must be easily replaceable and food safe
- Produce crops of comparable quality to supermarket

# Project Deliverables

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- Hydroponics system used for
  - Education of benefactors
  - Provides produce for the local community
  - Microbusiness opportunity
- User manual for maintaining and operating the system
  - Simple enough to be maintained by students
- Educational materials

# Semester Goals

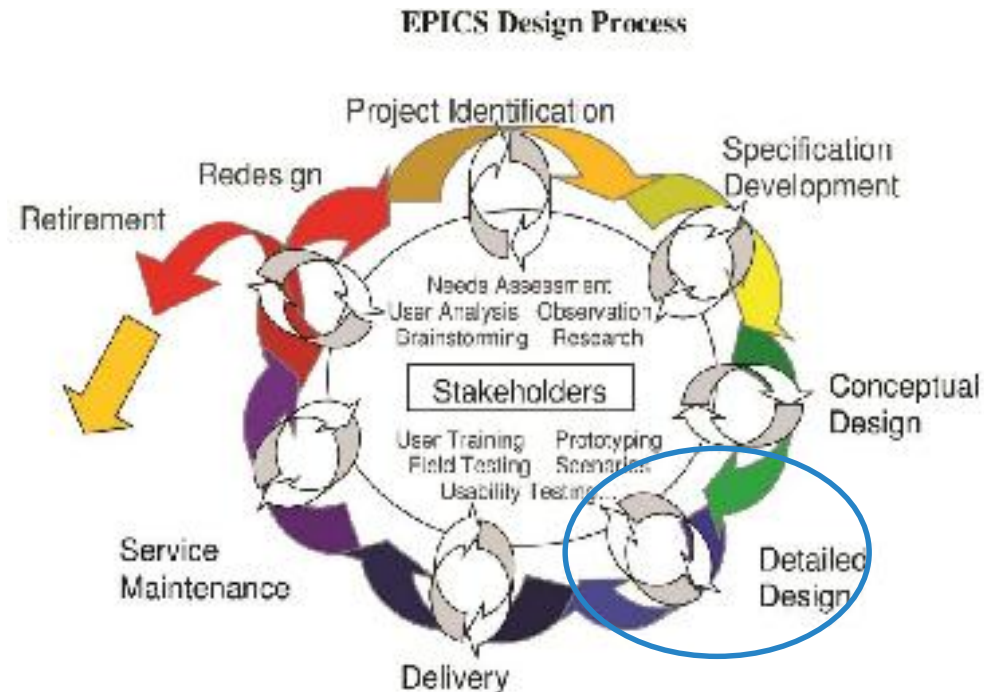
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- Improve the irrigation/reduce the pressure
- Purchase new appropriate pump for the test bench
- Collect testing data
  - Distribution uniformity
  - Sunlight at proposed project site
  - Fertilizer comparison
- Select best fertilizer for the price



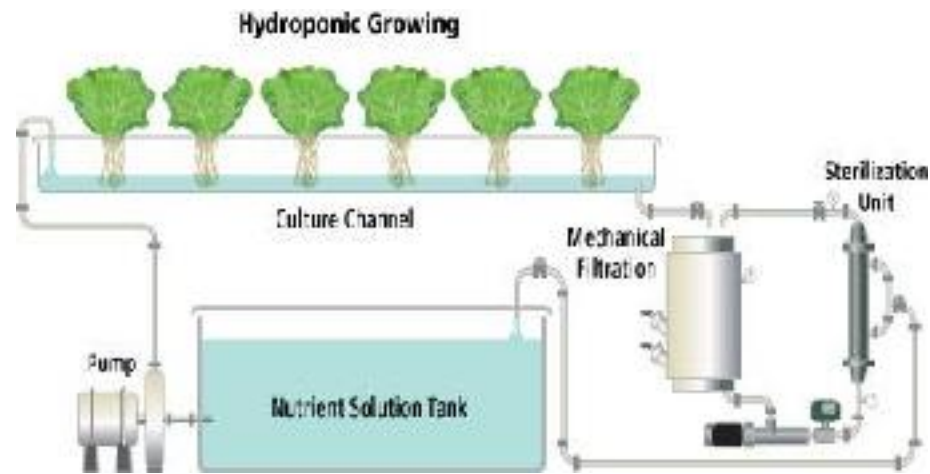
# Current Phase in Design Process

- Currently in Detailed Design
- Progress since mid-semester
  - Sunlight testing:  
Bean Bag ruled impractical
  - Investigated two potential sites
  - Updated DFMEA
  - Trial of fertilizer testing completed
  - Expanded materials safety
  - Pump and fittings purchased
  - Test bench updated



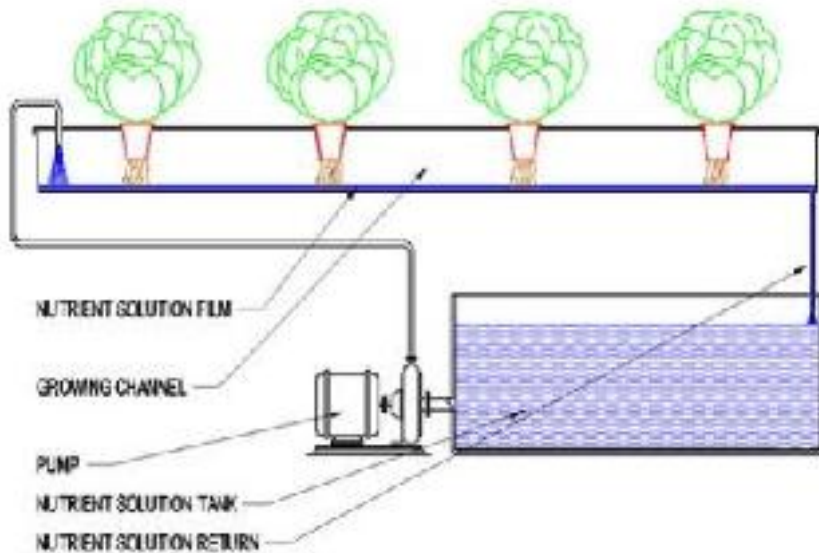
# What is Hydroponics?

- Cultivation of plants by placing the roots in liquid nutrient solution rather than in soil
- Growing plants without a soil medium



Taken from: [www.andnowuknow.com](http://www.andnowuknow.com)

# What is an NFT Hydroponic System?



Taken from: [www.hydor.eng.br](http://www.hydor.eng.br)

- Solution trickles down channel over plant roots
- Drains into tank
- Pumped back to top of channel thereby recycling solution
- Our system uses a capillary matting
  - Safety net if something in the system fails

# Why NFT Over Other Systems?

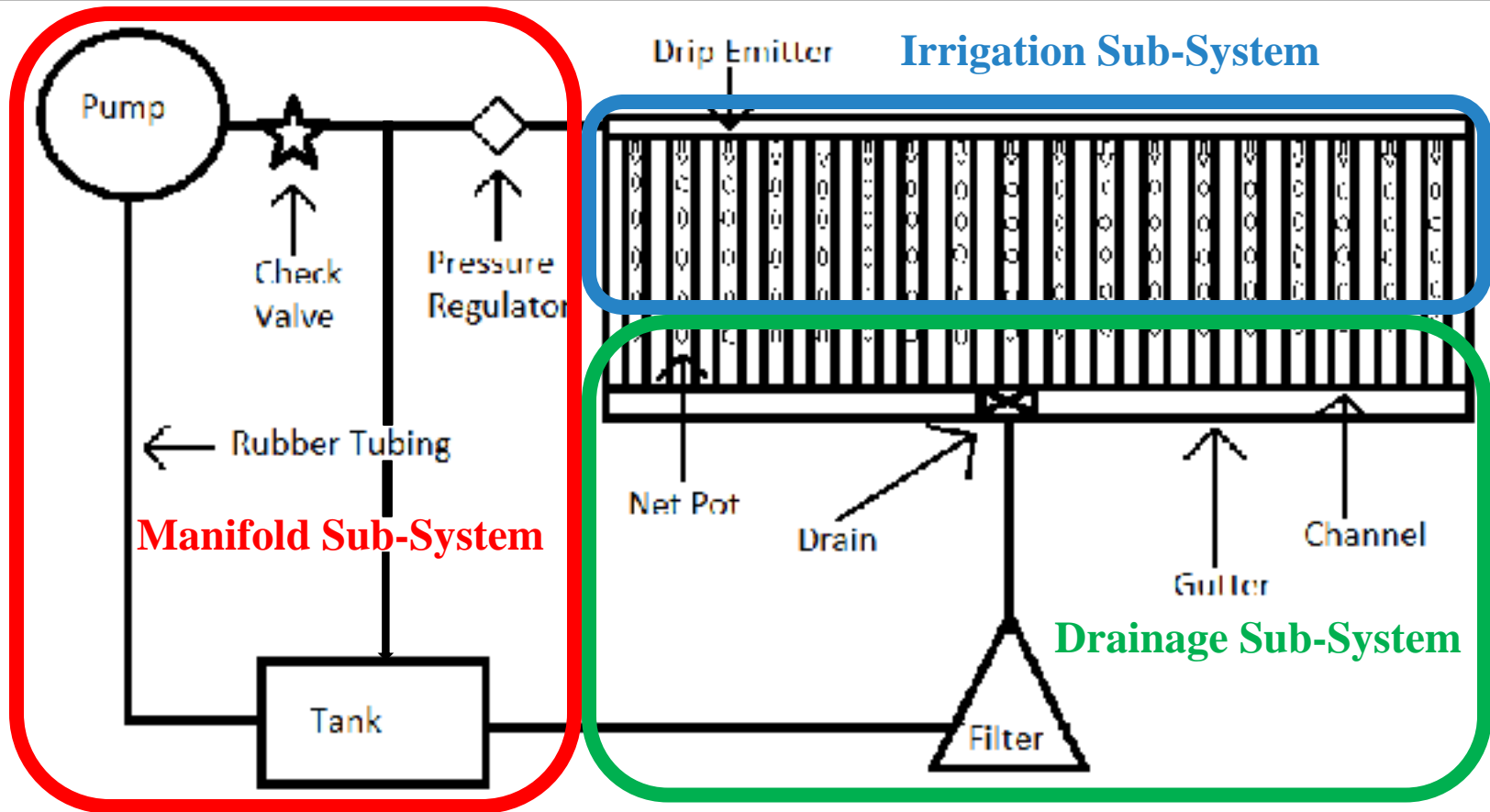
## Consistent Flow

- Simultaneous access to water, oxygen, and nutrients
- Consistent access to water for crops is time efficient which leads to greater leafy green production.
- More uniform pH
- Reduces salt build up on plants

## Less Obstructive Medium

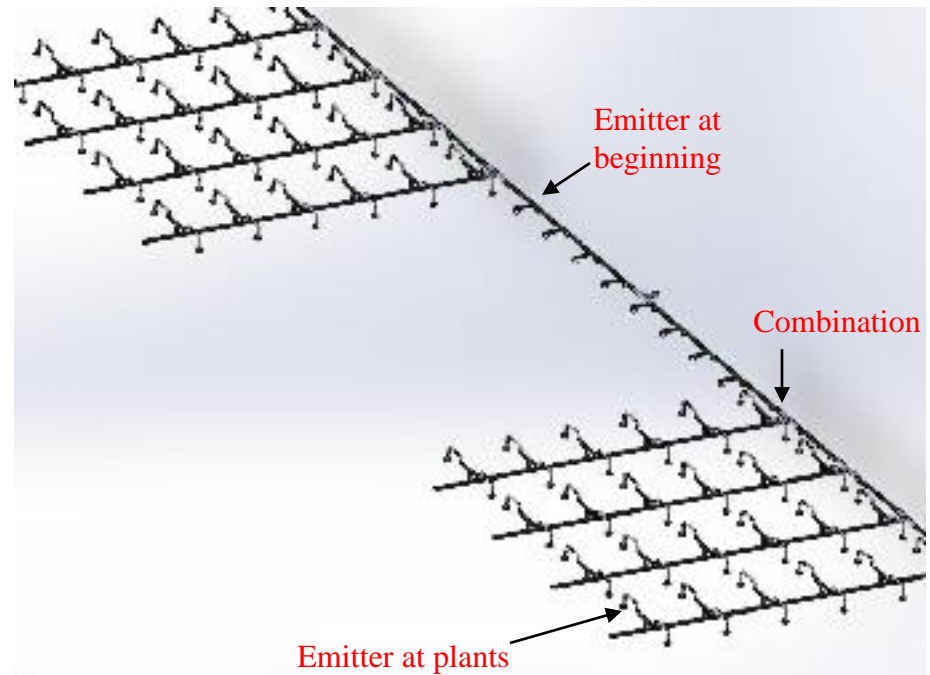
- Easy to disinfect
- Easy to inspect for disease or inadequacy
- Easier to observe for educational purposes

# Overall System Explanation

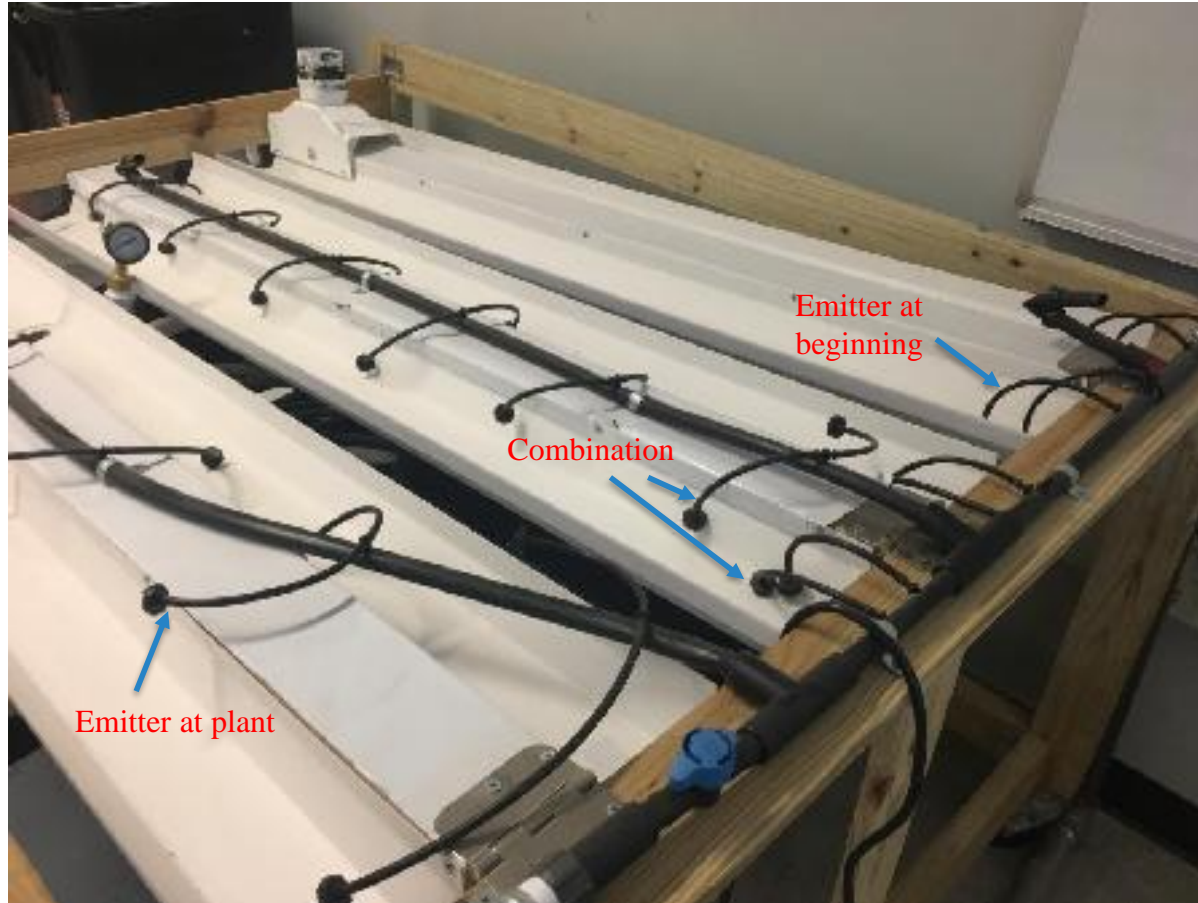


# Irrigation Sub-System

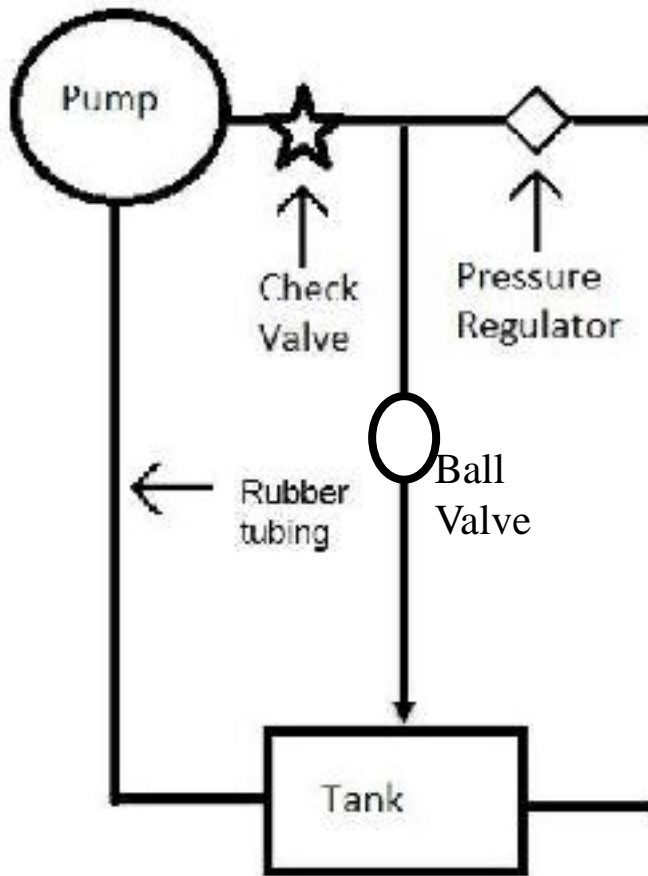
- Supplies water and nutrients
- All supplied by ½” mains (one per channel)
- Three application methods
  - Drip emitter at beginning of channel only
  - Drip emitters applied to individual plants
  - Combination of the above



# Application Methods



# Manifold Sub-System



- Pump
- Check valve
  - Prevents backflow
- Pressure regulator
  - Prevents spike above set pressure
- Tank
  - pH/nutrient control
- Ball Valve
  - Controls flow back to tank



# Semester Progress

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- ❑ Sunlight testing: Bean Bag ruled impractical
- ❑ Investigated two potential sites
- ❑ Updated DFMEA
- ❑ Trial of fertilizer testing completed
- ❑ Expanded materials safety
- ❑ Pump and fittings purchased
- ❑ Test bench updated

# Sunlight Testing

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- ❑ Habitat's Bean Bag community center bordered by a berm raised 25 feet
- ❑ Lettuce requires 6 hours of direct sunlight
- ❑ Based solely on the berm this could only be achieved from March 20<sup>th</sup> to September 20<sup>th</sup>
- ❑ Growth not recommended for hottest month
- ❑ 5 month maximum growing season was decided by both Doug Taylor and the team to be unacceptable

## Design Failure Mode & Effect Analysis (Pages 9-12)

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- Provided context for evaluating assigned values
- Recognized algae buildup as a potential risk after viewing similar systems in Purdue greenhouses
- Prepared design solutions to reduce algae buildup
- System issue with highest values:
  - Tubing clogging
    - Frequency and severity will be researched with test bench
    - Algae prevention plan ready if needed

# Algae Prevention

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- Algae growth dependent upon phosphorus, nitrogen, light levels, pH, and temperature
- Goal: reduce light and heat reaching water
- Solutions:
  - Cover channels with polyethylene weed barrier
    - Inexpensive, durable, food safe, relatively unobstructive
  - Nonsubmergible pump: less heat

# Fertilizer Testing

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## □ Semester Goals:

- Ensure both fertilizer blends, Jack's 16-4-17 and Miracle Grow plus MOST, meet nutritional needs
- Ensure triweekly pH testing is sufficient

## □ Conclusions:

- Both fertilizers meet needs
- Triweekly pH testing sufficient



# Fertilizer Testing

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- Growth slow:
  - Purchased electrical conductivity meter to verify concentration is correct
  - Purchased mesclun mix lettuce microgreens seeds for faster growth and quicker testing
- Miracle Grow plus MOST will be tested first in hydraulic bench
  - 55% price of Jack's 16-4-17
  - Less soluble, better to investigate clogging

# Materials Quality (Page 13)

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- Food Safety
  - FDA approval of all components in contact with nutrient solution except one pressure gauge to be used in the test bench
- Durability
  - Researching warranties and pressure limits
- Light permittivity
  - Light breeds algae
  - PVC presents potential issues, but can be covered in foil

# Hydraulic Test Bench

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- The hydraulic test bench is a small scale prototype of the final system
  - New pump, bulkhead fitting, pressure gauges, misc. fittings
  - Replaced PVC with hose for easier assembly/disassembly
- We are going to use this prototype to test for:
  - Irrigation uniformity and performance
  - Pump curves and testing
  - Fertilizer/crop care trials post seedling phase



# Pump Comparison

- Former pump:
  - Diaphragm pump: Pressure fluctuations damaged pressure and flow gauges
  - Purchased for test bench, too small for full scale system
- New pump:
  - Centrifugal pump: constant pressure
  - Slightly oversized for system
    - Aquarium pumps too small, pool pumps too large

	Pump Requirements	Pump Specifications*
Pressure (PSI)	17.3	16
Total Flow (gph)	192	1080

\*Pump specifications are for maximum efficiency

# Semester Spending

Part Name	Number of units	Price per unit	Total cost
Cast Iron 1/3 HP Centrifugal Pump 115/230V	1	\$331.17 /ea	\$331.17
100 PSI Pressure Gauge	2	\$9.98 / ea	\$19.96
Pro Flo Zinc Female Hose Mender	2	\$4.98 / ea	\$9.96
Pro Flo Zinc Male Hose Mender	2	\$4.98 / ea	\$9.96
6' Pump Power Cord With Standard 3-Prong Plug SPX1250WA	1	\$19.99 / ea	\$19.99
Mesclun Mix Lettuce Microgreens Seeds	1	\$2.95 / ea	\$2.95
HM Digital COM-80 Electrical Conductivity (EC) and Total Dissolved Solids Hydro Tester	1	\$31.52 / ea	\$31.52
Reducing Hex Nipple	1	\$4.37 / ea	\$4.37
		<b>Total spent:</b>	<b>\$429.88</b>
		<b>Projected:</b>	<b>\$597.00</b>

# Plans for Next Semester

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- Visit the Crossing and choose site
- Recover parts from Bean Bag
- Crop trials in test bench
  - Update maintenance manual with new data
- Greenhouse funding and installation
- Educational standards and materials
- System installation

# Questions and Feedback?

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Photo taken: April 2015