AURI Initiative on Building an Industrial Hemp Industry in Minnesota and *Erosion Control R&D Project Update*

Riley Gordon, AURI Engineer

auri
Agricultural Utilization Research Institute

About AURI

- To foster long-term economic benefit through development of new value-added uses for agricultural products

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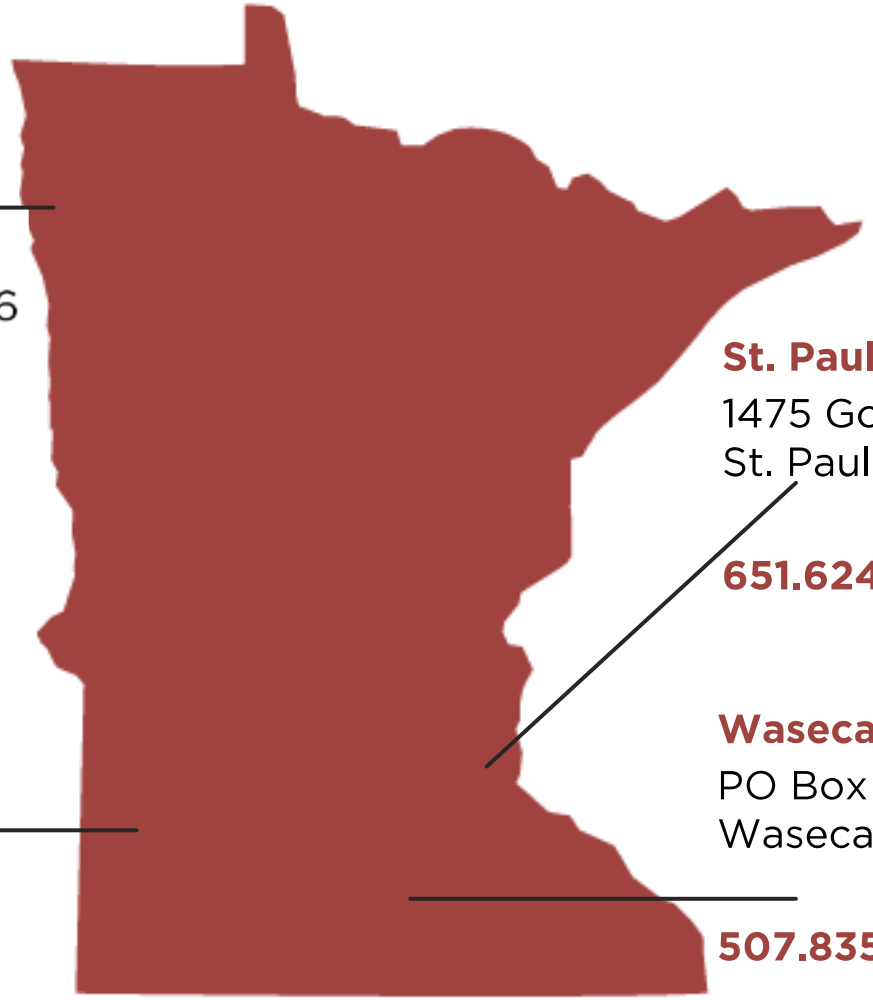
AURI Locations



Crookston
510 County Road 71
Crookston, MN 56716

800.279.5010

St. Paul
1475 Gortner Ave.
St. Paul, MN 55108

651.624.6055

Marshall
1501 State St.
Marshall, MN 56258

507.537.7440

Waseca
PO Box 251
Waseca, MN 56093

507.835.8990

Offices

Clients

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Agricultural Utilization Research Institute

AURI Focus Areas

Food

Grain: oils, powders, hemp hearts

Bio-based Products

Stalks: various fiber

and hurd applications

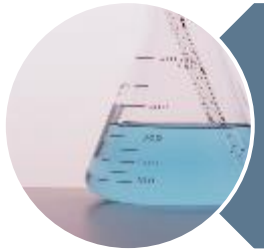
Coproducts

Several byproducts resulting from processing hemp

Renewable Energy

Hemp Biofuels

AURI's Services



Applied Research and Development

Hands-on Scientific Assistance

Innovation Networking

Hemp Initiative

- **Objectives:**
- Focus on developing a hemp value-chain for Minnesota and the Midwest.

1. Work closely with producers and processors identifying industry needs.
2. Analysis of CBD oil, hemp seed meal, hemp flower and hemp fiber for quality control and identification of new uses (fuel, feed, fiber).
3. Identification of hemp-based markets.
4. Identify state-of-the industry for processing and coproduct approval for feed.
5. Release public report with findings of opportunities and hurdles for the hemp industry in MN.

https://www.auri.org/research-reports/hemp/

Milestones of Minnesota Journey in Hemp –

2014 – Farm Bill (section 7606) allows research pilot industrial hemp by state approval

2015 MN Industrial Development Act became law

2016 grows first industrial hemp crop

2018 Farm Bill passes allowing industrial hemp production nationwide

2020 – MN hemp infrastructure continues to emerge at rapid rate, crop ins. available

- **CBD oil extraction processing/Value Chain**
- **Food grade industrial hemp oil and protein plant**
- **Fiber Shed development research and studies**
- **Feed characterization (future animal feed approval pending)**
- **Seed production and processing interest**

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Current Grain Economics

Yields around 1200lb/acre

2.5 ton/acre of stalks

Can grow large acreage and retrofit existing farming equipment for planting/harvesting

Conventional - $0.40/lb

Organic - $1.00/lb

Drying and Cleaning are two biggest pieces

Dry to 9%; clean to 99.95% purity

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Hemp Fiber – Domestic End-Markets Need Development!

Investor Interest

Feasibility Studies
- Distance of field to processing site to remain profitable
- Level of processing and equipment needed for desired end markets
- Identifying best end-use markets for all plant components: seeds, fibers, hurds, dust, etc.

Form Relationships with Existing Fiber Processing Partners

Grower Participation and Processing Facility Investment

Retting, Collection and Handling

Hemp Seeds

Cleaning

Hulling

Hulls
- Feed
- Fuel

Hearts
- Food

Pressing

Oil
- Food
- Fuel
- Cosmetics
- Paints

Meal
- Food
- Feed

Hemp Stalks

Decortication/Cleaning

Hurds (55%)
- Paper
- HempCrete
- Absorbent
- Bedding
- Fuel
- Mulch
- Erosion Blankets

Fiber (25%)

Primary (long fibers)
- Textiles
- Biocomposites

Secondary (Shorter fibers)
- Insulation
- Paper
- Supercapacitors
- Rope/twines

Dust (20%)
- Fuel

Three Year LCCMR Research Project June 2021 – June 2024

Research Partners And Supporters:

auri Agricultural Utilization Research Institute

DEPARTMENT OF NATURAL RESOURCES

DEPARTMENT OF AGRICULTURE

DEPARTMENT OF TRANSPORTATION

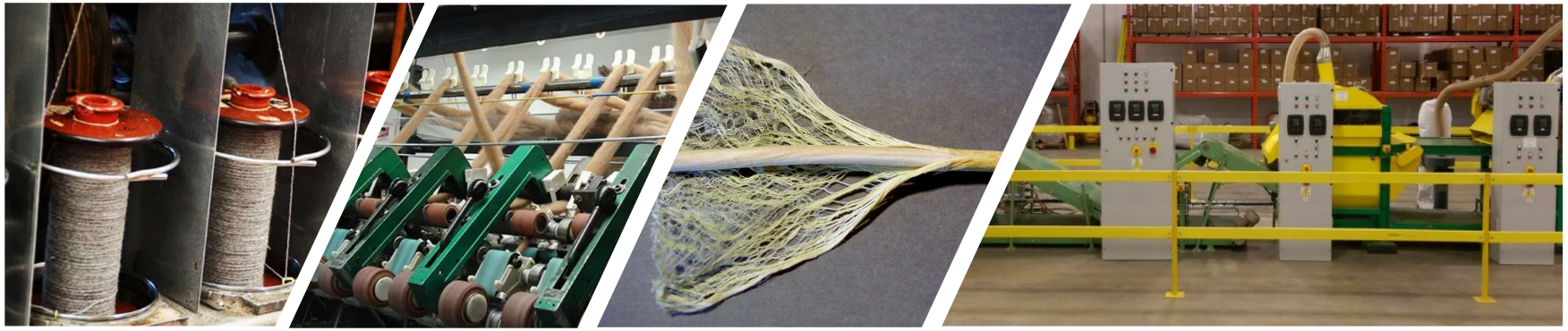
MnROAD Safer, Smarter, Sustainable Pavements Through Innovative Research

ENVIRONMENT AND NATURAL RESOURCES TRUST FUND

Reducing Plastic Pollution with Biodegradable Erosion Control Products

Soil and Erosion Control Product Opportunity Space in MN

- **Erosion control blanket (all types): 1,558,000 square yards/year**
- **Hydraulic Erosion control applications (all types): 1,180,000 pounds/year**
- **Silt fence (all types): 287,000 linear feet/year**
- **Sediment control logs (all types): 441,000 linear feet/year**
- **$30.1 million spent each year on erosion control products on local and state roads**



Outcomes:

- Technical Development of Erosion Control Product prototypes utilizing Industrial Hemp as a replacement for plastic components
- Complete lab and field testing required to evaluate that various prototype products meet or exceed current specifications, allowing MnDOT and other agencies the option to source these biodegradable products for wide scale adoption in MN

AG PROCESSING SOLUTIONS AND FORSBERGS TEAM UP TO SEPARATE FIBER & HURD

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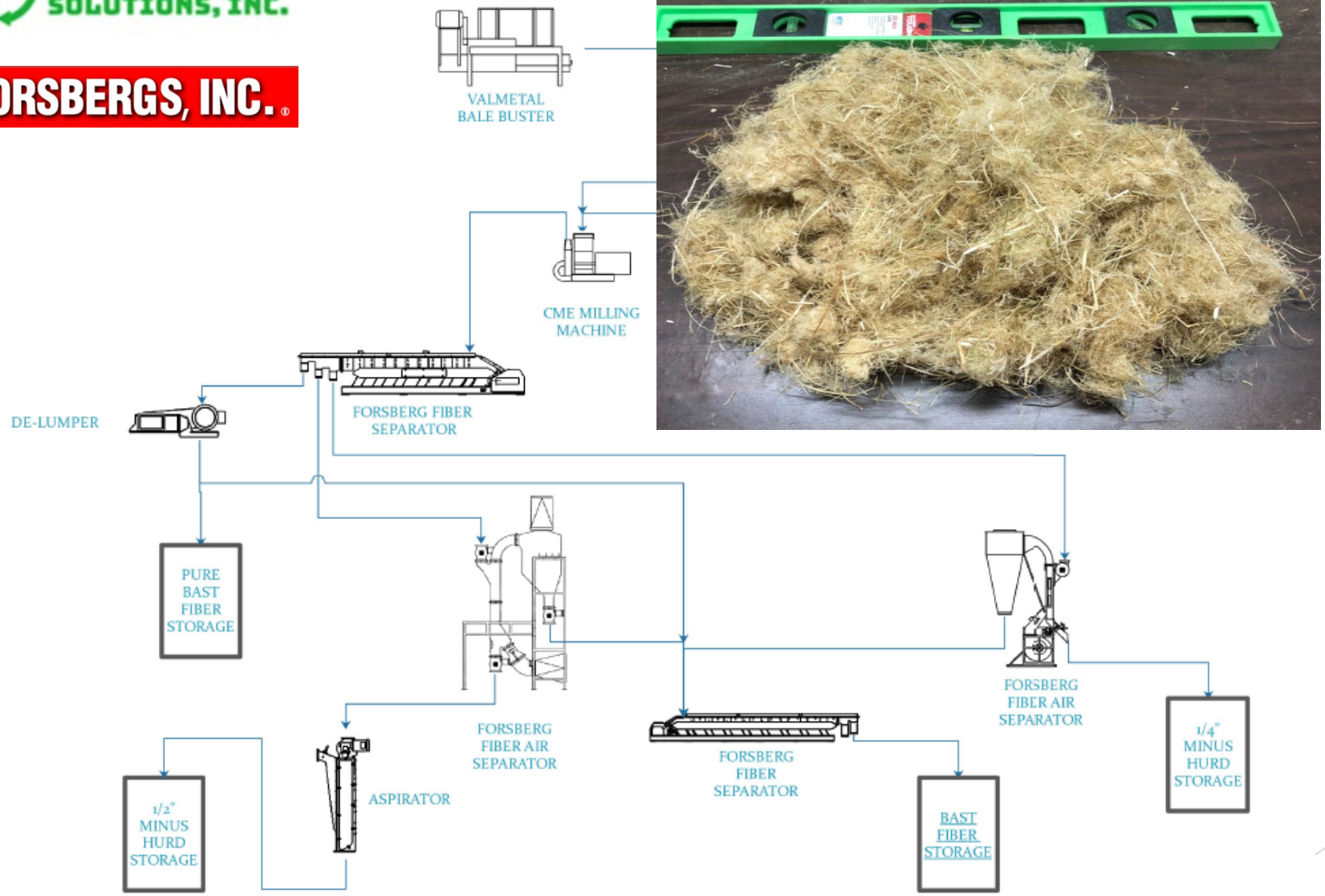
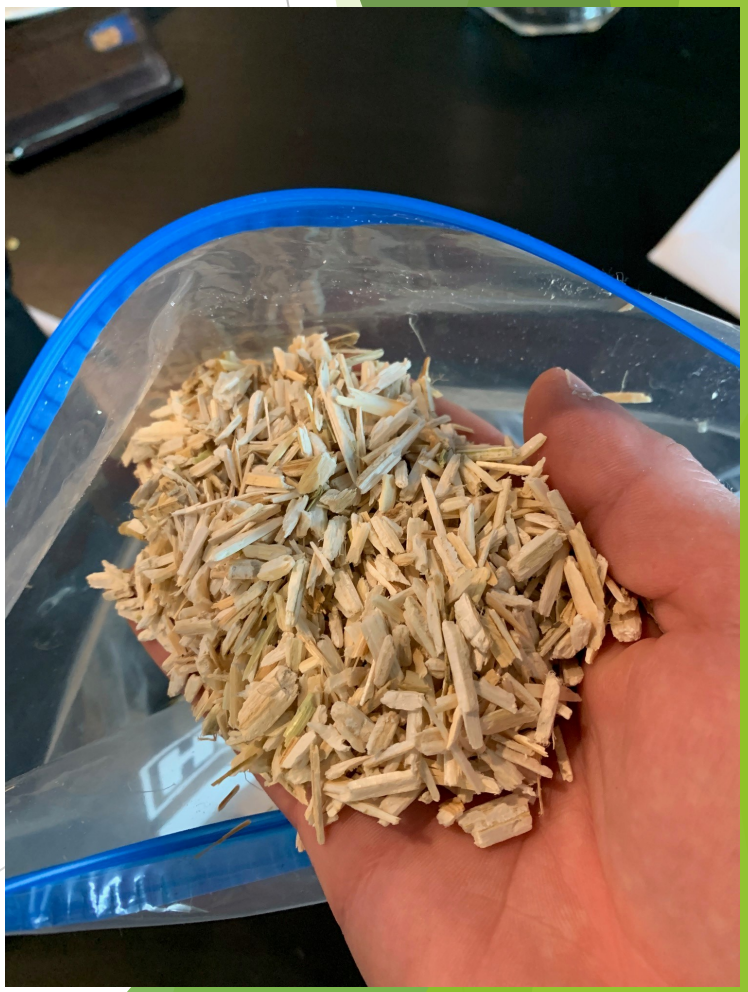
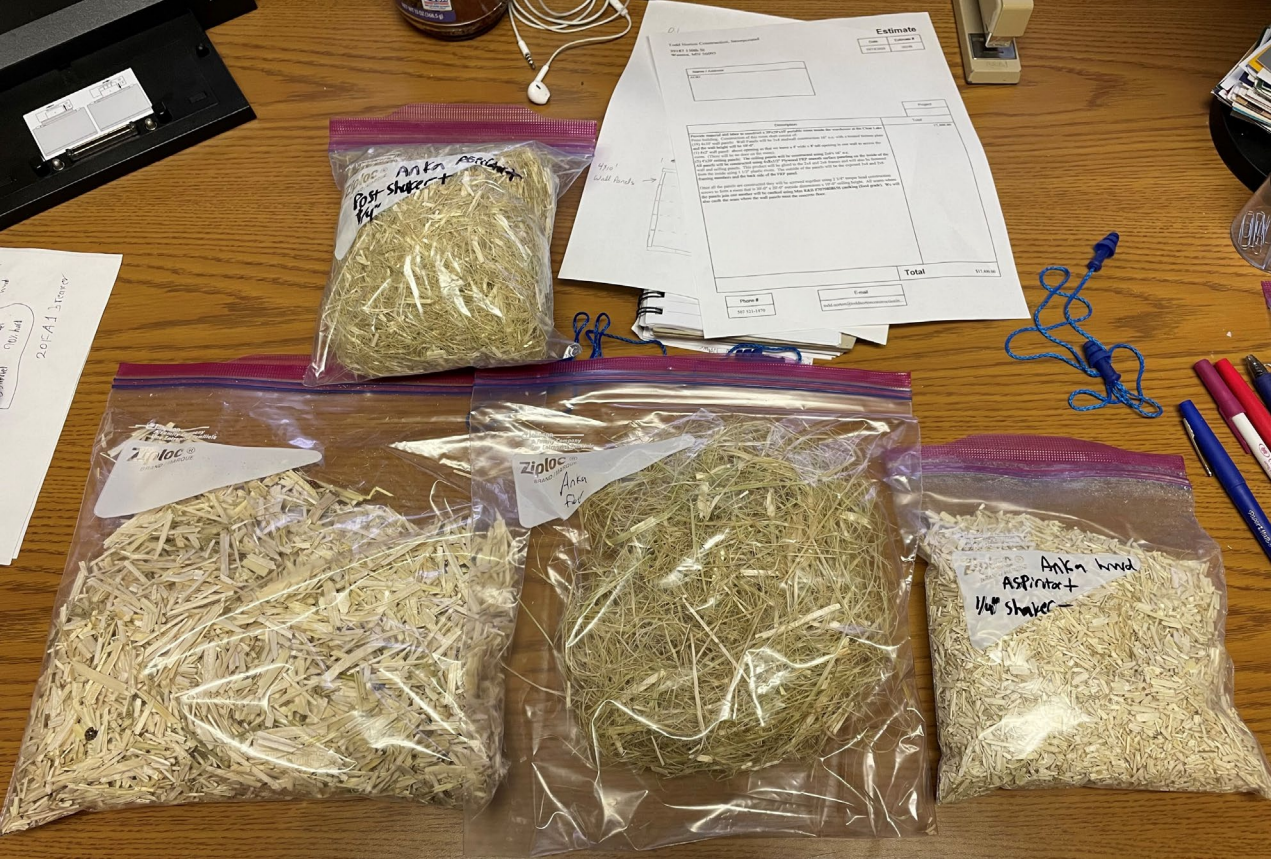
FORSBERGS, INC.®







AURI Decorticator Operational at Waseca Lab

Fiber Carding and Cleaning Equipment

Belfast MINI MILLS LTD.

RAMELLA 1947

TATHAM

filtrexx®
SUSTAINABLE TECHNOLOGIES

American Excelsior Company®

Questions, concerns or ideas regarding Hemp in Minnesota, or upcoming Erosion Control R&D project are welcome.

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Crown Iron Works

Specialty Extraction of Hemp

Richard Ozer, PE
Crown Iron Works
Blaine, MN 55449

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Crown Iron Works

- **WE ARE**: The world leader in oilseed extraction technology, refining plants and equipment & transferring our knowledge into specialty segments.
- **WE DELIVER**: Superior-quality, superior-value processing systems and technologies to the agricultural industry and beyond.

Engineered Systems + **Proprietary Process Equipment**

2

Factors that Effect Extraction

- **Solvent flow past the material**
  - Uniform washing of the bed of material
- **Solvent: Temperature**
  - How will this effect extract
- **Solvent: Feed Ratio**
  - Effects extraction efficiency and overall cost of operation
- **Feed Material:**
  - Flakes or crumbled pellets or either

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Types of Extractors

Percolation Type

- Horizontal Deep Bed
- Shallow Bed
- Material should be + 1.2 mm
- Gravity solvent flow over a bed of material.
- Material depth 0.5 meter for shallow bed design.

Immersion Type

- Material is drawn through a bath of solvent as is totally immersed in the solvent throughout the extraction process.
- Material depth less than 300 mm.
- Material remains fully immersed in solvent until discharge
- Able to work with fines < 1 mm

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Selection Considerations

- **Capacity**
  - Dependent on product value or availability.
- **Product Type**
  - Granulated Pellet of Lightly crumbled flake
  - Heavier or lighter than solvent.
- **Solvent**
  - Affinity of solvent for solute.
- **Residence Time**

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Benefits of These Extractors

All Crown Extractors are Continuous, Counter Current & Shallow Bed which generally:

- Require less solvent
- Has less bed compaction - Shallow bed has less weight per unit area of screen
- More flexibility in handling variable input rates and materials, particularly fines
- More able to attain percolation with materials that expand in the solvent

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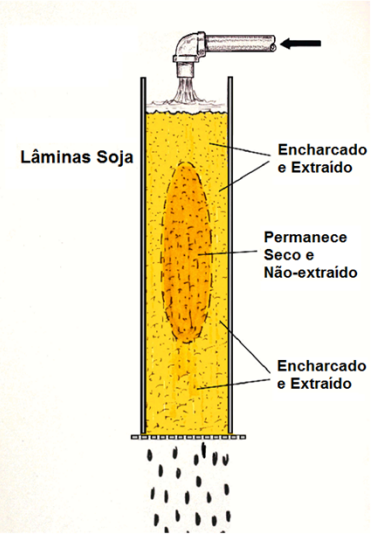
Solvent Distribution



- **Less tendency for solvent channeling.**
  - o This can be a particular problem with deep bed extractors
- **Liquid will tend to migrate to the walls or any line of least resistance.**
- **Any inconsistency with bed compaction will lead to channeling. That's why deep bed extractors should be wet loaded.**

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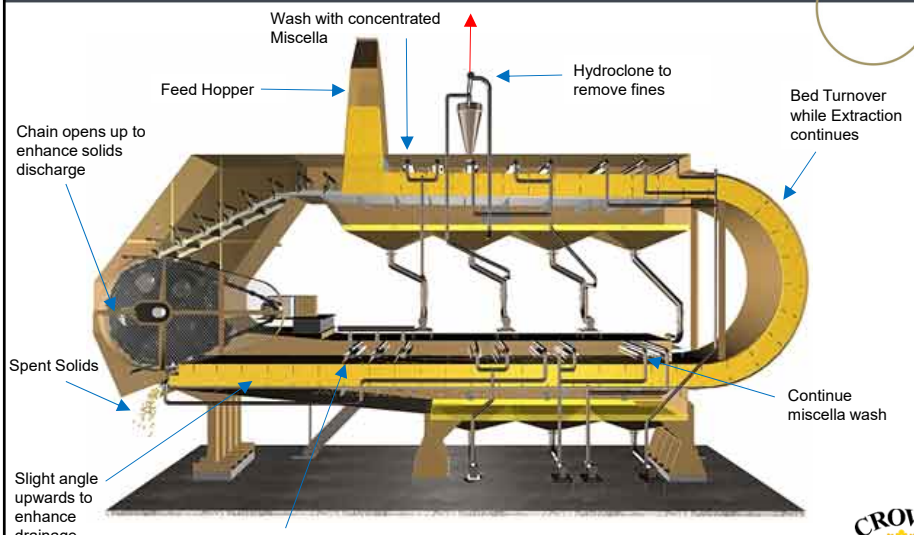
Model III Percolation Extractor



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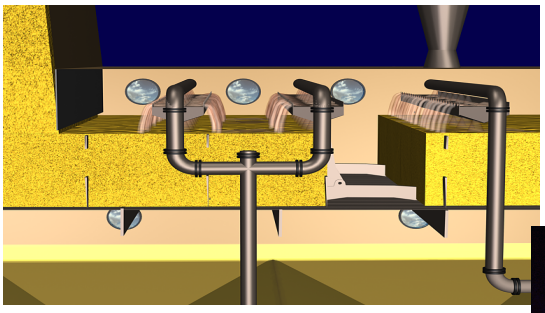
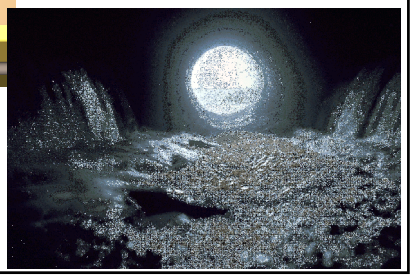
Liquid Distribution

- **Uniform liquid distribution across full bed width**
  - o V- notch weirs give even distribution whatever the flowrate





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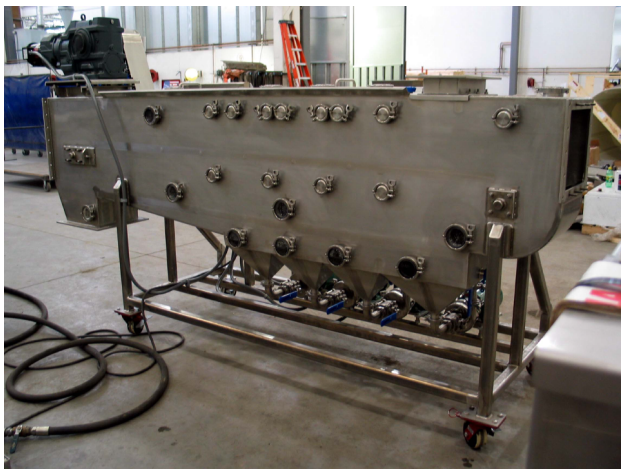
Model V Percolation Extractor



- Non granulated hemp
- Coffee Grounds
- Oilseeds, Soy, Sunflower
- Canola
- Soy Protein Concentrates
- Marigold
- Citrus Peel
- Tree Bark
- Echinacea
- Beverages

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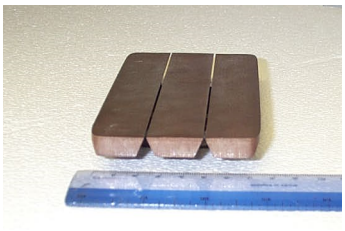
Screen Design

- V-bar screen allows material to work through relieved side for Self Cleaning Action
- Fixed screen – no complicated screen-to-wall seals
- Underscreen wash available for products that swell
- Undercoating of screens for sticky products is available.



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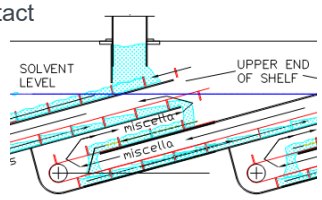
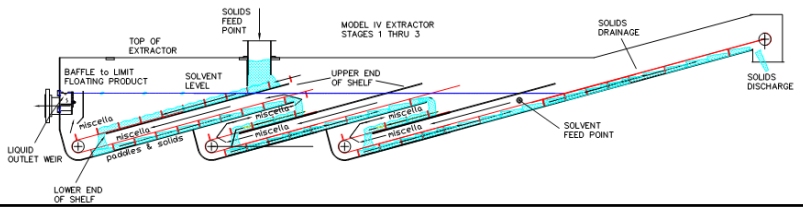
Immersion Extraction

- Counter-current wash for materials that are heavier than solvent. Test work has proven that Immersion Extraction is suitable for granulated pellets or lightly ground flakes
- Complete bed turnover required for good solvent contact
- Gentle bed turnover minimizes product breakage
- Low velocities minimize loss of fines





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Equipment Specialty Extraction

- **Model IV Extractor**
  - Pelleted & granulated hemp
  - Spices
  - Saw Palmetto
  - Evening Primrose
  - Barbasco Root
  - Black Currant
  - Salicornia
  - Vanilla
  - Silica Gels
  - Washing to Remove Products of Reaction

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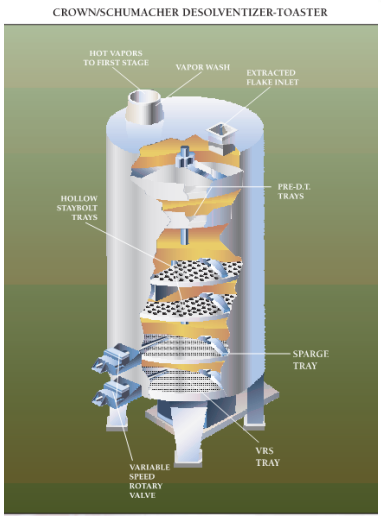
Desolventization

- **Recovery of the solvent from the spent solids**
- **With Hemp, understanding that the spent material has little or no value**
- **That lost solvent represents**
  - Long term financial load
  - Hazard to the environment



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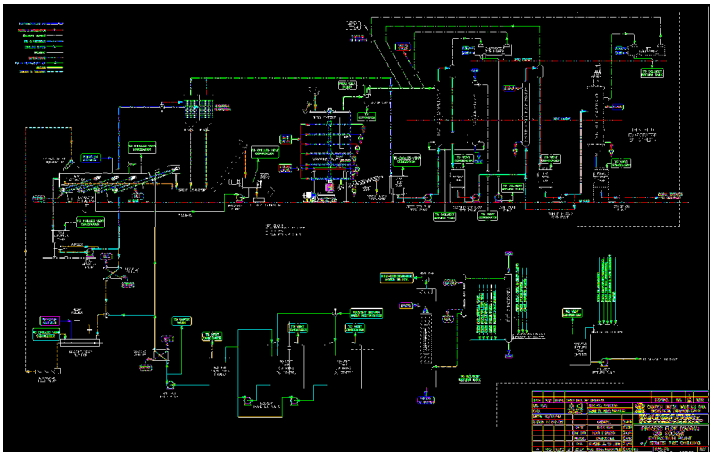
PFD for Hemp – An Integrated Design



Unit Operations Included:

- Chilling
- Desoventization of solids
- Recovery of solvent from non-condensables
- Extraction
- Desoventization of Extract
- Winterization

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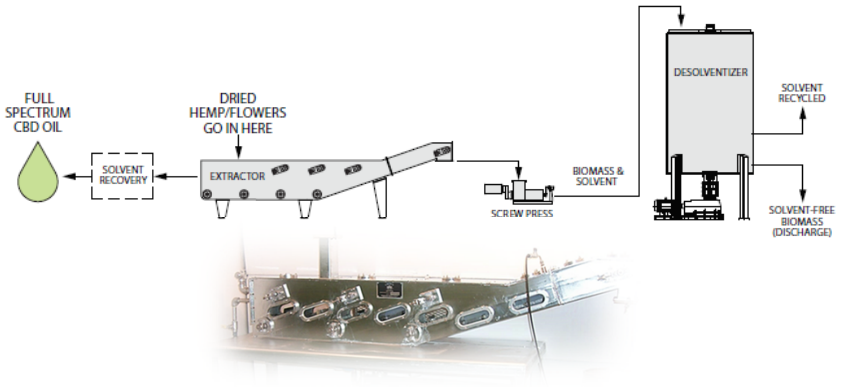
Crown Process Solution



Details:

- Multiple Solvents possible (Ethanol, Hexane)
- Crude Hemp Oil & Spent Biomass at far less than <1% Residual Solvent
- 5 mtpd plan footprint ~ 50' x 100'

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Benefits of Crown CBD Extraction

5-50
tons per day

99%
solvent recovery

- **Continuous** extraction method
- **Scalable** input capacity to allow for growth
- Fast **Speed** to Market
- Environmentally responsible, **>99%** Solvent Recovery
- Optimized for **max oil extraction**
- **Low Labor** Requirements ~ 2 plant operators
- Multiple Solvent **Options**
- **Piloting** capabilities available
- Technical **training** and **aftermarket** program

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TCO Calculator - Ethanol

Consumables	Ethanol in the spent solids ONLY			12/20/2019
Plant Feed Rate kg/day	5000	5000	5000	5000
% H2O in feed	8%	8%	8%	8%
% H20 in solids post extraction	4%	4%	4%	4%
% extractables	10%	10%	10%	10%
Extraction efficiency	90%	90%	90%	90%
solids after extraction kg/day	4350	4350	4350	4350
% ethanol in solids Pinnacle	10.00%	9.00%	8.00%	7.00%
etoh w solids Pinnacle kg/day	483.33	430.22	378.26	327.42
% ethanol in solids CIW	0.20%	0.20%	0.20%	0.20%
Etoh w solids CIW DT kg/day	8.72	8.72	8.72	8.72
Potential savings Etoh kg/day	474.62	421.50	369.54	318.70
Potential savings Etoh $/day	$ 4,771	$ 4,237	$ 3,715	$ 3,204
Days per year	300	300	300	300
Potential $ savings per year	$ 1,431,269	$ 1,271,098	$ 1,114,409	$ 961,089

Food Grade Ethanol $ / gallon	$ 30.00		Price EtOH	Brenntag
specific Gravity Etoh	0.79		+6000 gal/qt	$ 3.00
lb/gallon Etoh	6.5807		tax	$ 27.00
cost per kg	$ 10.05		total $/gallon	$ 30.00

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Assumptions:

- Considers ethanol with spent solids only
- Does not consider ethanol lost when opening vessels
- Recover extract possible
- Cost of ethanol $30/gallon for truckload quantities

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TCO Calculator - Steam

Plant Feed Rate kg/day		5	5	5	5	5
Solvent Feed Ratio		3	4	5	6	7
Miscella Oil Concentration	%	6.24%	3.84%	2.78%	2.17%	1.78%
Miscella to evaporator	lb/hr	809	1314	1819	2324	2830
Concentrated Oil	% oil	96.0%	96.0%	96.0%	96.0%	96.0%
Concentrated Oil	lb/hr	1211	1211	1211	1211	1211
Steam to Evaporator	lb/hr	424	692	960	1228	1496
Additional steam per incr in S:F	lb/hr		268	268	268	268
Steam per 24 hour day	lb/day	10176	16608	23040	29472	35904
Days per year		300	300	300	300	300
Cost of steam/yr	$/year	$ 61,056	$ 99,648	$ 138,240	$ 176,832	$ 215,424
Benchmark Solv/Feed Ratio	3					
Difference/year	+ save$/-extra$	$ -	$ (38,592)	$ (77,184)	$ (115,776)	$ (154,368)

Cost of steam/1000 lb/hr	$ 20.00

Assumptions:

- Evaporation can be the largest steam user
- Very sensitive to Solvent Feed Ratio
- Considers Rising Film Single Stage Evaporator
- Cost of ethanol $20/1000 lbs of steam

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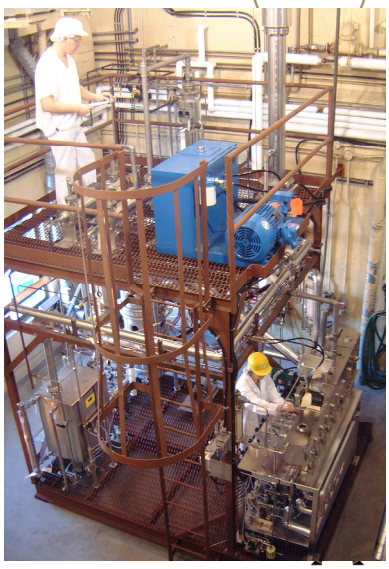
Extraction Plants – Pilot Scale

Small Pilot Plants:

- Small Pilot Plants for experimentation teaching
- Pilot Scale to 1-2 TPD
- Alternate Solvents
- Sanitary Construction



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PILOT PLANT CAPABILITIES

Down Draft Desolventizer (DDD)

SOLVENT LAB

PERCOLATION & IMMERSION EXTRACTORS

MOST LIQUID SOLVENTS

STEAM AVAILABLE FOR HEATING

DIRECT CONNECTION TO PREP AREA

6 TPD MAX

HAPLEX® System

PREP & DRYING LAB

NON XP

INCLUDES PREP AREA

VSC, COOKER, CRACKER & FLAKER

WATER & NON HAZARDOUS SOLVENTS

STEAM AND NATURAL GAS

UP TO 6 TPD

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What other products can I extract???

- Algae
- Artemisia
- Borage
- Coffee
- Echinacea
- Egg Powder
- Fruit fibers
- Krill
- Marigold
- Neem
- Fruit pulps
- Vegetable pulps
- Wood fiber
- Hemp
- Palm Kernel
- Paprika
- Soy Protein Concentrate
- Pyrethrum
- Rice Bran
- Saw Palmetto
- Gingko Biloba
- Shea Nut
- Yucca & Barbasco
- Sugar Cane Filter Cake
- Sunflower seeds
- Wheat Germ
- Spent Coffee Grounds

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Thank You!
Crown Iron Works
Richard W. Ozer, P.E.
rozer@crowniron.com
9879 Naples St NE, Blaine, MN 55449
CPM
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Lower Sioux Indian Community: Industrial Hemp

Presented by:

Earl Pendleton

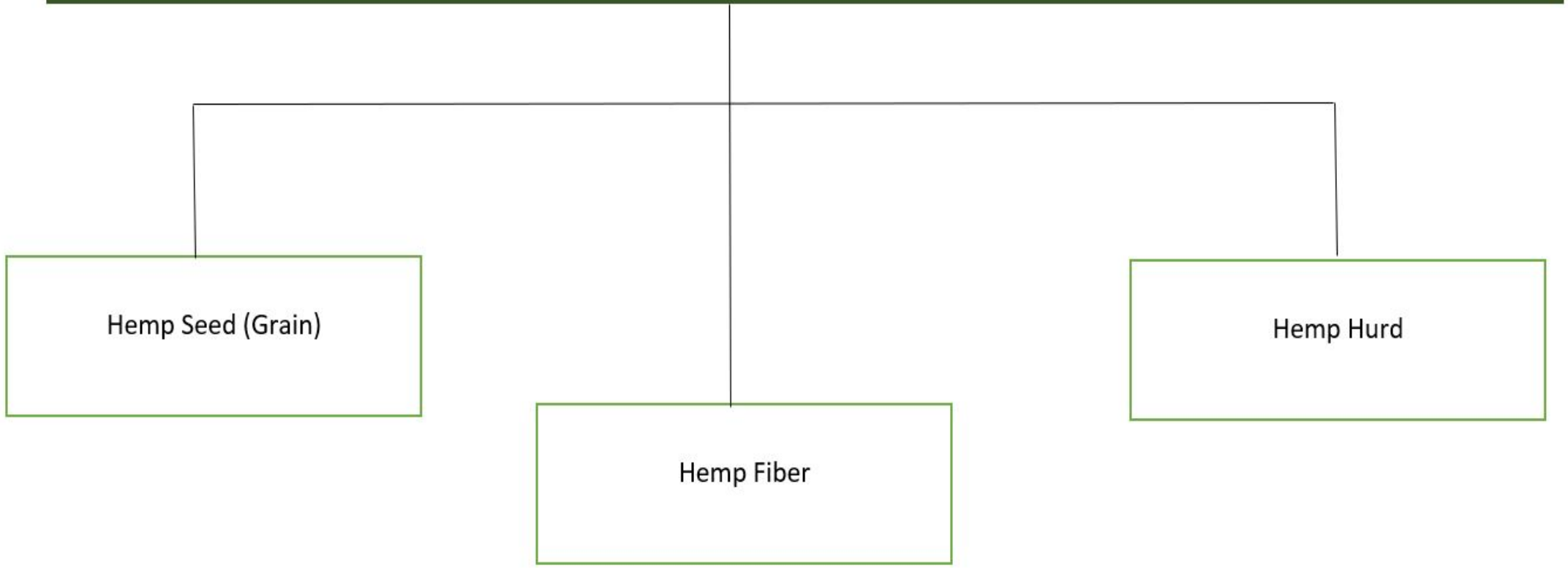
Hemp-lime Project Update

- Within 6 months we will have built the first hempcrete insulated home in MN, installed by Community Members using material grown and processed from the Community.

What is Industrial Hemp?

Industrial Hemp is a plant species that is grown specifically for industrial use. It can be used to make a wide range of products. Along with bamboo, hemp is one of the fastest growing plants on Earth.

3 Main Parts



THE VERY USEFUL INDUSTRIAL HEMP

Hemp cultivation requires no chemicals, pesticides or herbicides.

with over 50,000 different uses...

HEMP SEEDS

Harvest

HULLING | PRESSING / CRUSHING

Intermediate processing

Further processing

HEMP MEAT

Food

Dairy products

HEMP SHELL

Flour

FLOUR

Bakery Products

HEMP OIL

Personal Care Products

Cooking Oil

Fuel / Paint

HEMP CAKE

Food

Beer

Feed

FEED

Hemp seeds contains nutritious,
Polyunsaturated Fatty Acids (PUFAs) 80%
the highest amount found within the plant kingdom.
Highly nutritious of humans and animals.

HEMP is a RESOURCE

20 years for trees to mature **vs** **4** months for hemp

Hemp can yeild 3-8 dry tons of fiber per acre, FOUR times what an average forest can yeild.

Paper, fertilizers, soil nutrients and animal bedding can be made from leftover waste when processing hemp.

This means all parts of the plant are being used, or put back into the earth.

HEMP STALKS

DECORTICATING

HEMP FIBER

Hackling — PRIMARY (Line) Fiber: Fabric, Insulation, Carpeting, Paneling

Hackling — SECONDARY: Cordage, Pulp, Recycling Additive

Scutching — TOW: Cordage, Bagging, Fiber Board

Anything made out of cotton, timber or petroleum can be made out of hemp

Hemp fiber is the **strongest natural fiber** in the world

HEMP HURDS

Scutching

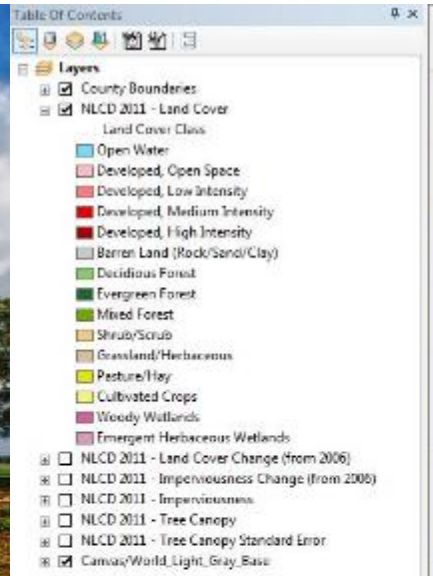
Fiber board
Compost
Mortar
Paper filler
Absorbent bedding
Chemical feedstocks
- Plastics / Paint / Sealant

Hemp hurds can be cleanly **Converted** into **Gasoline!**

Through a Heat Process called **PYROLYSIS**
Hemp Biomass can also make Ethanol, Methanol & Methane Gas

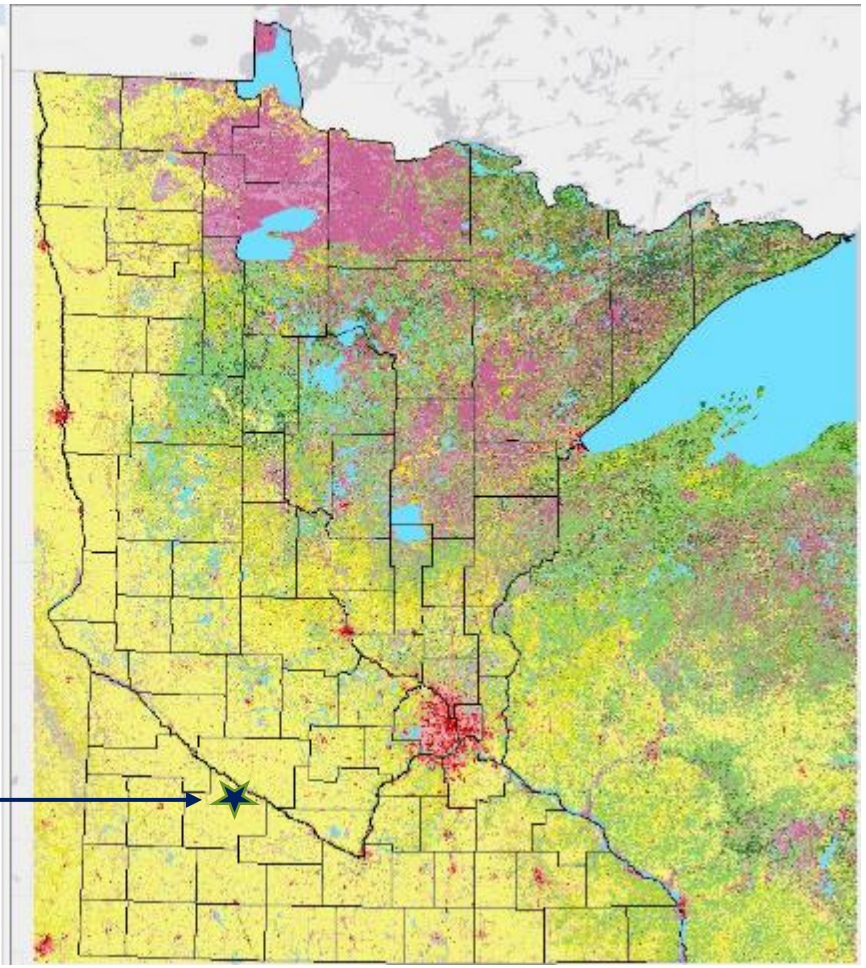
Why Grow Hemp?

The Land: LSIC in the heart of Minnesota's row crop land



Minnesota Land Use: DNR

Lower Sioux Indian Community

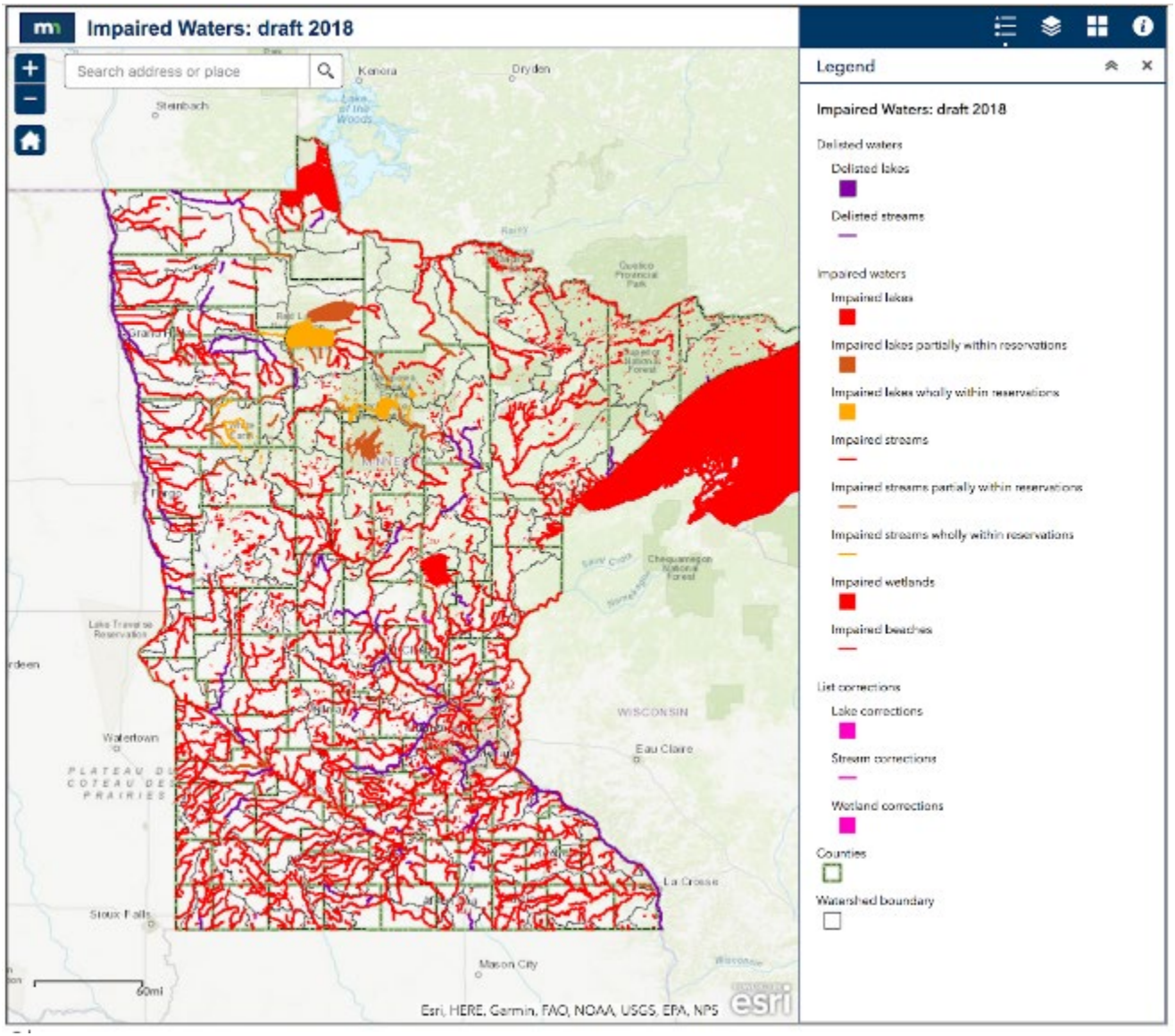


Water Quality

We can see this where the Minnesota River meets the Mississippi River just south of the twin cities. Also called Mendota, or *Bdote*, in Dakota meaning the confluence of two rivers. This is where the Minnesota River ends but you can see that it carries with it much of the nutrients it has collected through Minnesota's agricultural landscape.

Photo taken: Spring 2015

MPCA Map: Streams and Rivers that fully support aquatic life



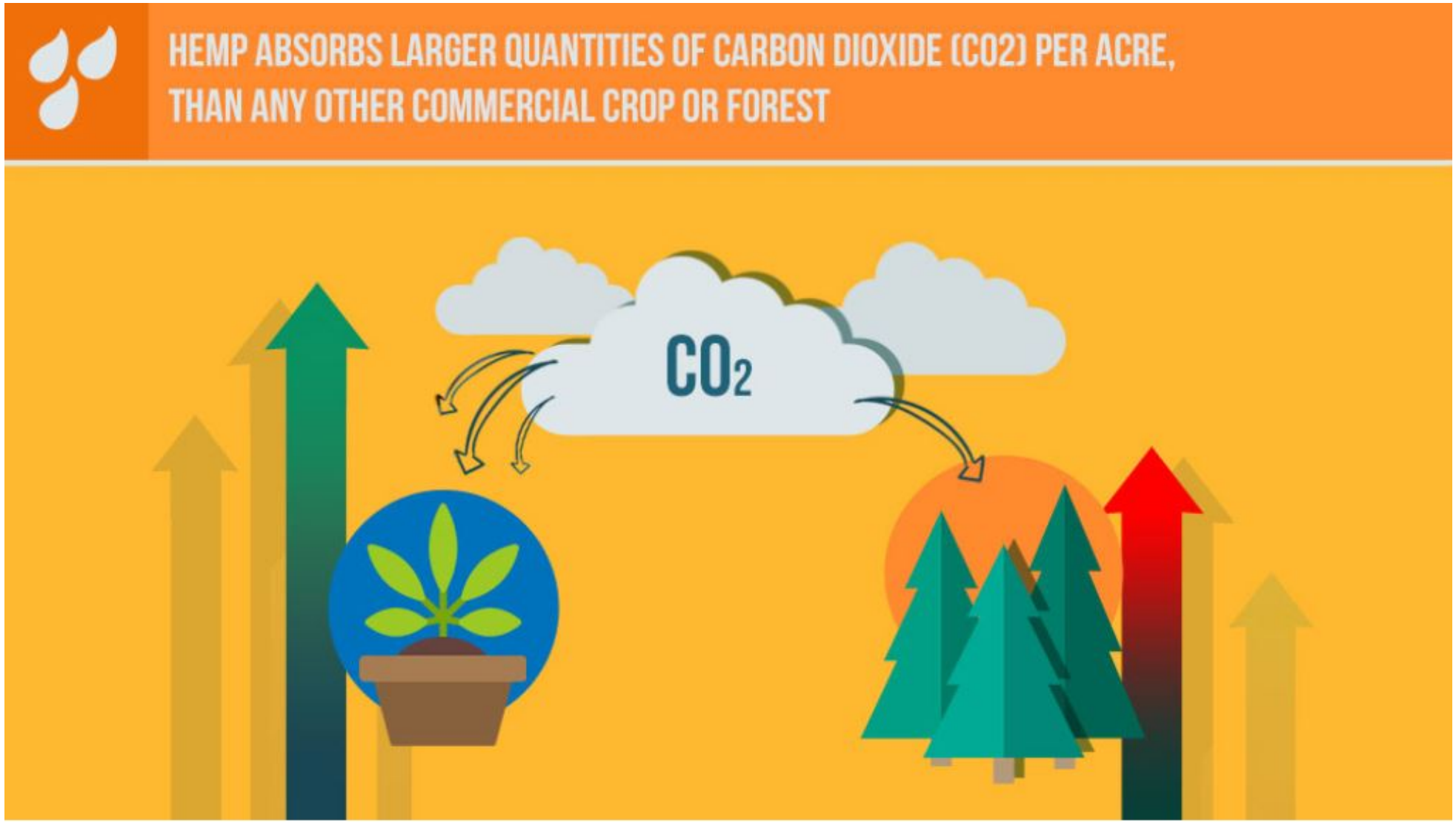
Conventional Farming Challenges: Water Quality

- Minnesota is home to more than 10,000 lakes and more than 90,000 miles of rivers and streams. But many of those waterways are threatened by pollution and agricultural practices.
- **40 percent of Minnesota's lakes and streams are polluted.**

  Why?

  1. Soil
  2. Fertilizers

Hemp’s Carbon Absorption



We are the first generation to spend 90% of our time indoors.

*US Enviornment Protection Agency

HISTORY OF CONSTRUCTION MATERIALS

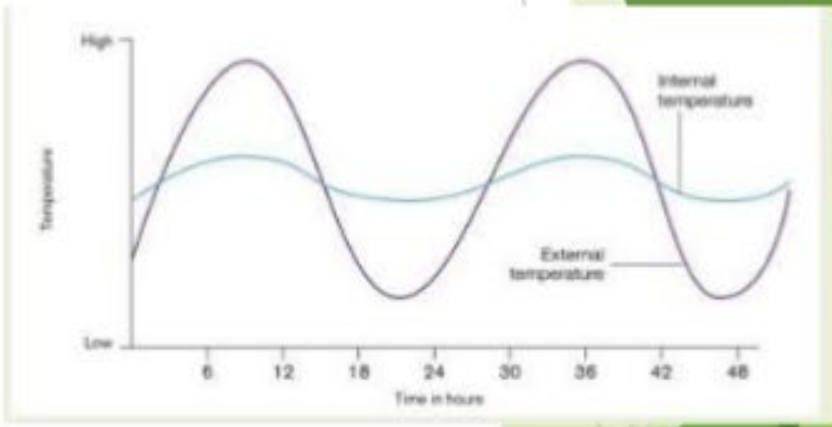
What is Hempcrete?

- In a traditional sense, Hempcrete or Hemp concrete is a term used to describe a hemo-lime bio-composite construction material
- It is created by mixing water through a blend of
  - Shiv (woody stem of the hemp plant)
  - Lime based binder
- The subsequent reaction creates a mouldable material that is traditionally used to form
  - Walls
  - Floor slabs
  - Ceilings
  - Roof insuation

Mechanical Properties – Thermal performance

- Excellent insulator, U-value of approximately 0.15 W/m^2K for a 300 mm wall

- Contains a high amount of thermal mass, allowing buildings internal temperature to fluctuate less and allow occupants to be more comfortable
- Hygroscopic material that absorbs moisture during high humidty periods and releases it when the humidity falls

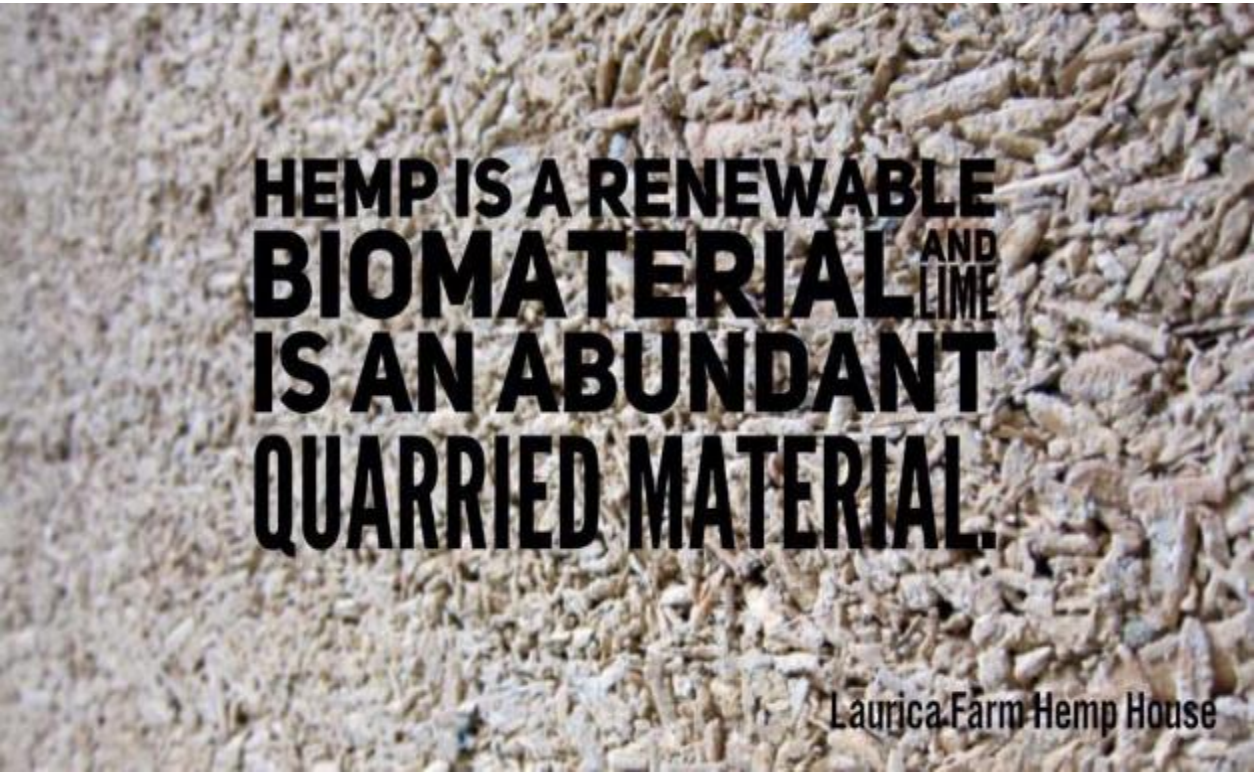


Hemp Homes

Image of a historic hemp home. Built in 1698 in the Miasa village in Nagano, Japan.

Inside a hempcrete home near Asheville, NC

Hemp Homes ARE Different


HEMP IS A RENEWABLE
BIOMATERIAL AND LIME
IS AN ABUNDANT
QUARRIED MATERIAL.
Laurica Farm Hemp House

The Cost

- New contractor built homes cost $121.04/sq ft in the Midwest according to the U.S. Census Bureau's survey in 2017.

-Materials account for a little over half of this cost with the remaining cost being allocated to labor.

- Hempcrete home costs? The first home built by former mayor of Asheville, NC's hemp home cost $133/sq ft in 2009.

LSIC: Hemp Production and Housing

The LSIC Goals

1. Grow 45 acres of Industrial Hemp in 2019.
2. Grow up to 240 acres of Industrial Hemp by 2020.
3. Follow a Three Phase Approach to Building with Industrial Hemp

Thank You!