

River Refugium Project (RRP)

CERNUNNOS FOUNDATION

BRIGHT MEADOW GROUP

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| ****RIVER REFUGIUM PROJECT**** Cernunnos Foundation Bright Meadow Group | ****RRP4 – Greenhouse ****&**** Biomass Module**** Document No: RRP0002.5 | Version: 2.0 | 01 April 2026 Status: Published – Version 2.0 | Supersedes: Version 1.0 (2025) *Contact: robert@brightmeadowgroup.com | www.cernunnosfoundation.com* |
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****Abstract**** The greenhouse complex is the River Refugium Project's core biological engine – the zone where nutrient-rich process water becomes high-value biomass, fibers, algae, and structural material. Unlike traditional agriculture, the RRP greenhouse complex is designed to extract value from pollution itself, turning excess nitrogen and phosphorus into industrial commodities. This document explains the greenhouse architecture, crop segmentation, growing systems, nutrient routing logic, and biomass-handling module. All yield figures are provisional academic proxies flagged ▶ pending replacement by pilot data.

****1. What the Greenhouse Complex Does****

The 13-house production complex is engineered for four overarching functions: capture nutrients with year-round biological uptake; convert nutrients into biomass with predictable yields; segment crops for ease of maintenance, tailored conditions, and controlled harvest cycles; and generate feedstock for thermochemical conversion.¹ Each greenhouse functions as a controlled-environment wetland with adjustable nutrient chemistry, specific hydraulic regimes, climate-controlled air systems, predictable turnover, and a clean-in/clean-out maintenance cycle.

****2. Nutrient Routing Grid****

The PLC-controlled nutrient routing grid is the central logic of the complex – a manifold system directing different pools of nutrient-rich water to crops that can best utilize them.² Routing factors include nitrate concentration, phosphorus ratio, micronutrient levels, dissolved organics, trace-metal loads, temperature, and seasonal crop curves. The grid allows the system to behave as an adaptive nutrient engine, shifting loads dynamically based on crop demand, greenhouse downtime, feedstock needs for HTC, and stormwater-driven nutrient surges.

****3. Greenhouse Types ****&**** Engineering****

The 13 production greenhouses cover five primary crop categories, each with distinct architecture and system integration role:

- High-lipid algae (1-2 houses): shallow-rack or raceway-style channels, LED-assisted lighting, CO₂ injection from off-gas capture. High turnover, reliable HTC/HTL feedstock, rapid nutrient uptake.▶³
- Fast-fiber crops – hemp, jute, flax (3-4 houses): deep-water culture or ebb-and-flow, heavy biochar substrate, high airflow. High biomass per square foot, strong hydrochar synergy.▶⁴
- Structural biomass – willow coppice, bamboo (2-3 houses): substrate beds for uniform rod formation, rotational cutting cycles, CO₂-enriched atmosphere. Biochar-ready, year-round cutting.▶⁵
- Energy grasses – miscanthus, nettles (2-3 houses): deep hydroponic beds, large airflow fans, seasonal lighting. Enormous tonnage, ideal for HTC.▶⁶
- Polishing algae beds (1-2 houses): shallow beds for final nitrogen and phosphorus polishing, micro-contaminant uptake, light suspended-solids capture. Output stable enough for clean-water return.▶⁷

All yield and uptake figures for the above crop categories are provisional

academic proxies. ▀ These will be replaced by measured monthly values from pilot operations. See RRP8 for the data collection protocol and RRP6 for the modular slot framework governing financial projections.

4. Greenhouse-Wide Engineering

Across all greenhouse types: cross-tube airflow, roof ridge venting, CO₂ injection loops, and waste-heat integration from the HTC/HTL thermal loop govern climate architecture. Dedicated pumps per house, return lines to the routing grid, and overflow safeties govern hydraulics. Biochar from HTC becomes root medium, microbial habitat, and filtration layer – closing the loop between growing and thermochemical conversion.⁸

The clean-in/clean-out cycle is the operational key to year-round uptime. Each house can be fully isolated for deep cleaning, pathogen reset, equipment service, or substrate replacement without interrupting the others. Uptime target: 85–97% depending on scenario. ▀ Measured uptime will be confirmed by pilot operations.

5. Biomass Module

Once biomass leaves the greenhouse houses, it enters the biomass processing module – the bridge to HTC/HTL. Functions include chopping, shredding, grinding, slurry preparation, dewatering where needed, char-blending, and load-balancing for the thermochemical plant.⁹ Design priorities are low contamination risk, smooth feedstock flow, no off-site hauling, and year-round throughput. This module ensures the HTC system is never starved of feedstock and never overloaded by peak harvest cycles.

Notes

Citations follow Chicago Notes-Bibliography style. Internal Bright Meadow Group / Cernunnos Foundation documents are cited by document title and year. Figures marked ▀ are provisional academic proxies pending replacement by RRP pilot data per RRP8.

- **1. ***Bright Meadow Group, *****Controlled Environment Agriculture (CEA) Standards.***** BMG Greenhouse Ops Draft, 2025.*

- **2. ***Bright Meadow Group, *****Nutrient Routing Grid.***** CF/BMG SCADA Engineering Notes, 2025.*

- **3. ***Mata, T.M., Martins, A.A., and Caetano, N.S., *****Microalgae for Biodiesel Production and Other Applications,***** Renewable and Sustainable Energy Reviews 14 (2010): 217-232.*** ▀ Provisional – pending pilot data.**

- **4. ***van der Werf, H.M.G., *****Assessing the Impact of Pesticides on the Environment,***** Agriculture, Ecosystems & Environment 60 (1996): 81-96. Hemp yield proxies.*** ▀ Provisional – pending pilot data.**

- **5. ***Haughton, A.J. et al., *****A Novel, Integrated System Approach to Assess the Case for Bioenergy Crops,***** GCB Bioenergy 1 (2009): 408-411. Willow/biomass proxies.*** ▀ Provisional – pending pilot data.**

- **6. ***Heaton, E.A., Dohleman, F.G., and Long, S.P., *****Meeting US Biofuel Goals with Less Land,***** Global Change Biology 14 (2008): 2000-2014. Miscanthus yield proxies.*** ▀ Provisional – pending pilot data.**

- **7. ***Körner, S. and Vermaat, J.E., *****The Relative Importance of Lemna gibba L., Bacteria and Algae for the Nitrogen and Phosphorus Removal in Duckweed-covered Domestic Wastewater,***** Water Research 32 (1998): 3651-3661.*** ▀ Provisional – pending pilot data.**

- **8. ***Bright Meadow Group, *****HTC Feed Preparation Guidelines.***** CF/BMG

Process Engineering, 2025.*

- **9. ***Ibid.**