**Design Overview**

Our team seeks to demonstrate how human activity within a watershed can create a landscape that provides for greater biodiversity through the wise use of water. Our design is an opportunity for direct connection with the Fly Ranch ecology through a built environment that supports the pleasurable role of being an ecological steward. Our design allows users to engage with their impact on the water resources of Fly Ranch through interactive infrastructure that educates them about their place within the water cycle. This framework will encourage users to have a positive ecological impact during their stay at Fly Ranch, leaving a lasting impression on their relationship to conservation, appreciation, and awareness of water use.

The Butterfly Bathhouse will use rainwater harvested from a large roof catchment area and heated using a passive solar hot water system, connecting users to the water and sun elements of the land. The shower’s greywater system output allows participants to water native, edible, and medicinal plants through their use of the shower facility. This places them in direct relationship with the site’s water management: where it is collected and how it is used next. Earthworks, or shaping the landscape for efficient water flow, will direct overflow from the greywater system to a nearby fruit tree orchard. The bathhouse’s water collecting roof is shaped in the image of the Painted Lady, a native Nevada butterfly, which serves as a homage to the non-human world of Fly Ranch, which we vow to support. This prototype is currently scaled to support four toilets and three showers, including an ADA accessible bathroom with combined toilet and shower stall, as well as three sinks. The shower and bathroom stalls will be built using recycled wood framing with clay-straw insulation and earthen plasters. These earthen building techniques will demonstrate both fire-resistant and sustainable building practices.

 The Bathhouse’s flush toilets are connected to a blackwater biofiltration system; a low-maintenance, high benefit system that partners with bacteria and plants to transform human waste into a valuable resource. Human waste will undergo three stages of natural purification, and the wastewater, with its nutrients, will be reused by shrubs and fruit trees. The primary treatment for effluent is in a two-chamber septic tank where anaerobic bacteria digest bio-solids. Then, by gravity-flow, the blackwater flows to a Wastewater Garden system (WWG); a type of horizontal flow constructed wetland where the wastewater is kept below a dry layer of gravel, preventing malodor, mosquitoes, and human contact. Planted with a diversity of botanicals adapted to thriving in a water-saturated gravel media, the planting features native wetland plants of the local region, as well as decorative wetland trees and shrubs, including ones useful for producing firewood, flowers, and food for birds. A properly designed WWG provides secondary wastewater treatment that meets regulatory standards, greatly reducing levels of biochemical oxygen demand, total dissolved solids, and fecal coliforms. The plants and their microbial root ecosystems also put the wastewater and nutrients to productive use, growing rapidly and making a lush, green microhabitat. In the final step, the treated wastewater from the WWG is used for a gravity-flow subsurface irrigation of another green zone, where fruit trees and shrubs use the remaining water and nutrients. This green area, the equivalent of a planted drain field, provides additional water for the nearby food forest orchard, as well as provides shade and a windbreak to protect the Bathhouse from high winds.

The infrastructure of this Bathhouse design supports the very basic human needs of cleanliness and sanitation. However, our emphasis is on the system’s ability to reconnect these needs back into a regenerative cycle that both enhances biodiversity and empowers users as stewards.

**Materials and Maintenance**

To create this catchment system, a steel roof in the shape of butterfly wings will be used to collect the 8 inches of annual rainfall average of Gerlach, Nevada. The left and right wings are each 40’ x 30’. Tail wing dimensions are 44’ x 22’, extending the Bathhouse collection surface area to 2675 total square feet—capable of catching over 13,300 gallons a year of pure, potable water. The roof catchment system could provide about 666 ten-minute showers using a low-flow Raindance shower head. Other additional sources of water could be diverted from nearby rooftops or pumped from the reservoir or well source. A hallway for maintenance access between the bathrooms and showers provides easy access to the system’s plumbing from the raintank to the solar water collectors, and back to the showerheads. A simple sediment filtration system known as a ‘first flush’ will ensure rainwater is potable for showering. Any additional filtration system needed is dependent on the specific water source used to supplement the rainwater supply.

Steel roof panels provide durability and can catch nearly 100% of rainfall, with a runoff coefficient of .98. Steel is also able to condense and collect ambient water vapor (dew). Our steel roof will be colored with pigments to express the Painted Ladies’ beautiful colors. Skylights, patterned with the butterfly’s white spots, will provide natural lighting throughout the structure. Little to no maintenance will be necessary on this steel roof for decades.

 Facing the North, a 3,200 gallon storage cistern represents the butterfly’s head. A solar powered pump sends the rainwater to the solar hot water panels located on the structure’s South end, where it will be heated and stored in two 80 gallon tanks available for hot shower use. Users can monitor their water use through a display inside the shower stall that indicates their total gallons used. The bathhouse greywater will support 3 semi-dwarf fruit trees and medicinal plants in a nearby food forest by running simple, gravity-fed plumbing from the shower using a branched drainage system to nearby mulch basins.

Overall, the system is designed to be low maintenance through key design principles of gravity-fed plumbing and passive solar. Symbiotic relationships within biological systems will improve the functionality of the system over time.

Septic tanks require minimal maintenance. Annually, they should be opened to see if solids are building up and the reusable filter checked and washed with water if necessary. Design of the septic tank to allow a 2.5 day residence time at full occupancy is good for ensuring the septic tank bacteria have enough time to do good primary treatment. By upsizing our septic system to 2,000 gallons, we ensure adequate processing during peak use of the Bathhouse facilities.

The Wastewater Garden also has low maintenance requirements. If there is no occupancy for a period of time, especially in the warmer months when plants are growing, the garden requires supplemental watering. To regulate supplemental watering, a float valve can be installed to detect when this is required in order to ensure plants in the constructed wetland don’t dry up. Typical gardening maintenance is needed for the plants.The final green area, the planted drain field with subsurface irrigation, contains the treated water from the Wastewater Garden. It needs normal gardening maintenance as well: pruning of trees and shrubs. An effluent filter is used on the outlet baffle of the septic tank that assists in the removal of solids from wastewater before it enters into the WWG and drain field, thus extending the life of the WWG gravel media and preventing clogging of the drain field soils.

The WWG is made water-tight with an EPDM geomembrane liner. The system uses PVC pipe to distribute and collect the treated wastewater. PVC plumbing is used to transport wastewater from the bathhouse to the septic tank, from the septic tank to the WWG and from the WWG into the distribution subsurface irrigation of the final green area, which also supplements the orchard. A control box made of concrete is located at the end of the WWG, controlling the water leading to the drain field. The media of the WWG is washed gravel which is sourced from the nearest quarry. Both the WWG and the final drain field use plants sourced from local nurseries.

The Greywater shower system uses ABS plumbing, and for maintenance the addition of mulch to the basins once a year, or depending on the rate of decomposition. This creates an accumulation of organic material that helps absorb the greywater and release it’s nutrients to the plant root systems.

**System Outputs**

The Wastewater Garden system and its final drain field area will handle all the blackwater that is sent to it. The beauty of the system is that plants and their microbial assistants accomplish both the treatment and productive reuse of the sewage water so that there is no “export” from the system. Much of the wastewater is evapotranspired by the plants, remaining nutrients enrich the soils of the drain field, which in this design will be utilized by the nearby food forest. Whole system outputs could be considered products from the plants chosen, including pollinator habitat, fruit, a wind break, carbon sequestration, and shade.

**Cost Estimate:**

Major components of the design are as following:

**Rainwater Catchment Roof & System:**

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| --- | --- |
| **Item**  | **Estimated Material Costs** |
| Galvanized Steel Tank (8’x8’6) 3200 gallon | $4900 |
| Metal Roofing (2600sf) & Fasteners  | $3500 |
| Wood Framing & Hardware | $2000 |
| Cement Footings | $500 |
| Solar Panel & Batteries (to run lights & pump) | $1250 |

**Plumbing:**

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| --- | --- |
| Water Pump | $200 |
| Solar Hot Water Collectors (x2) | $3000 |
| Plumbing Pipes & Supplies  | $900 |
| Shower Hardware (x3)  | $500 |
| Low-flush Toilets (x3) | $450 |
| Sinks  | $100 |

**Wastewater & Greywater Garden System:**

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| --- | --- |
| Septic Tank (2,000 gallon) | $2000 |
| Wastewater Garden geomembrane (50 sf) | $150 |
| Gravel (75 cubic feet) | $200 |
| Nevada Wetland Plants and Orchard Trees  | $400 |
| Mulch | $100 |

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| --- | --- |
| **Total Estimated Materials:** | **~$20,150** |

**Labor:**

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| --- | --- |
| **Task** | **Estimated Labor Cost** |
| Wood Framing, Roof Installation, Toilet / Bathroom Stall Construction | $3000 |
| Plumbing & Installing Rainwater Tank, Solar Hot Water Panels, Showers, & Greywater System | $2500 |
| Plumbing & Installing Toilets, Septic Tank, & Wastewater Garden | $3000 |
| Installing Solar Electric System, Pump, & Lights | $1000 |
| Building & Installing Butterfly Head, Painting Butterfly Wings | $1500 |
| **Total Estimated Labor:** | **~$11,000** |

**Additional Cost Considerations:**

We anticipate the costs of importing these materials to site will be expensive compared to other previous project locations, and intend to use local materials wherever appropriate.

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| **Grand Estimated Total:** | **~$30,000 - $35,000** |

**Environmental Impact**

The guiding principle of the Butterfly Bathhouse is to make a regenerative ecological impact through water conservation and recycling. Our design creates a living classroom to showcase the value of rainwater harvesting; passive solar water heating; natural building techniques; water recycling; and native wetland plants. Water recycling is low-cost; creates greenery that provides habitat; sequesters carbon; low maintenance; chemical-free; and safe, since there is no exposure of sewage.

Some precautions and considerations for environmental impact include choosing a site where there is no existing key habitat or high water table with flooded or saturated soils. Locating the Bathhouse building site near a road may be ideal so as not to disturb the local ecology during the construction process. We plan to repurpose materials wherever possible to prevent the impact of using new materials--wooden posts could be harvested from pine beetle ravaged forests or upcycled from nearby reuse stores; the butterfly head will be fabricated from all repurposed metal and “trash” materials; and wooden pallets stuffed with straw and covered with earthen mortar will provide natural insulation for the structures walls.

The advantages of constructed wetlands are that because they rely on more natural methods, they are often less expensive to build and far less expensive to operate than conventional sewage treatment plants. Subsurface wetlands use little or no electricity and technology and require little technical supervision once installed, have more intense treatment action, reducing required area significantly *(Green and Upton, 1992; Steiner et al, 1992; Cooper, 1992)*

Through our design, we intend to set a precedent for the integration of the built environment with natural biological systems of water recycling and reuse. Our hope is that by using our Butterfly Bathhouse, visitors will be inspired to reconsider their relationship with our precious water, learning how simple ecological design and appropriate technologies can turn our “waste” water into a resource for a thriving planet.