# EVAPOTRANSPIRATION COVER EVALUATION REPORT

## TRIMMER ROAD LANDFILL SITE
## TOWN OF PARMA, MONROE COUNTY, NEW YORK

**(SITE REGISTRY No. 8-28-012)**

*Prepared for*

**DVIRKA AND BARTILUCCI CONSULTING ENGINEERS**

*By*

**ECOLOTREE, INC.**

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# 1. Ecolotree® Cap (ECap) Overview

## 1.1 Introduction

Since 1984, environmental solid waste management regulations have prohibited or discouraged trees on landfill covers because decaying roots were believed to provide preferential water flow channels. As the field of phytoremediation (the use of plants for removing contaminants or preventing contaminant migration) has developed over the last 10 years, however, there has been a growing interest in the use of densely planted trees on top of landfills in place of current prescriptive covers. The intended result of vegetative caps is a functional alternative or compliment to the low-permeability 'raincoat' cover layer specified for landfill closure under current regulatory guidelines. In contrast to compacted clay and geomembrane cap barrier performance, which is expected to decrease with time due to differential settling, freeze-thaw cracking, desiccation cracking, and plasticizer leaching, vegetative covers are expected to improve over time due to deeper root growth and increased water holding capacity created by leaf drop, root sloughing, and root exudation. The Ecolotree® Cap (ECap) is a patented phytoremediation system (US #5,947,041) that uses fast growing, deep rooting Salicacea trees (e.g. poplar, cottonwood, willow) to cover landfills and contaminated soils.

Hybrid poplar trees are often utilized for phytoremediation applications because they exhibit high water uptake and growth rates, develop deep root systems, are easily propagated, and can be planted economically. *Populus spp.* are dioecious, meaning that they possess either male or female reproductive organs, but not both. To prevent unwanted migration at sites, ECaps are planted with only male clones. Although literature values for hybrid poplar water uptake rates vary greatly amongst studies and geographic locations, Hinckley et al. (1994) report that mature poplar plantations in eastern Washington have the potential to take up 32-42 inches of water per year (870,000 – 1.14 million gallons per acre). Hybrid poplars grow quickly, typically between 3-10 feet per year. Poplar roots have been observed at 7 ft below ground at a leachate irrigation site in Oregon (**Figure 1**), and at 9.5 ft below ground at a RCRA site in Wisconsin (C. Johnson, pers. comm). Appropriately selected hybrid poplar trees can grow vigorously for 20+ years (Dickmann and Isebrands, 1999) and can have lifespans of 50+ years (Isebrands, 2000).

## 1.2 ECap Objectives and Benefits

The two primary ECap objectives are to minimize water percolation into landfill waste and to prevent surface soil erosion. Infiltration is minimized by a 'sponge and pump' mechanism. The sponge consists of a water-holding layer of soil and amendments that acts as a reservoir to store sufficient water through the seasons. The well-aerated soil pores hold precipitation like a sponge until plant roots can access the water. The vegetation pumps water from the cover soils, using the water for growth or releasing it into the atmosphere by transpiration. Thus, plants dehydrate the soil sponge during the growing season and create water storage capacity for the dormant winter months. Soil stabilization results from precipitation interception by the tree canopy and the dense rooting of the trees and understory grasses. These factors help to minimize scour erosion, wind-blown dust, and exposure of subsurface contaminants.

In addition to these primary objectives, vegetative caps can also provide numerous auxiliary benefits:

1. Future post-closure operating flexibility. As technology advances, it may become desirable to operate a vegetative cap as a biocell. Landfill biocells accelerate microbial waste mineralization and stabiliation by adding water; carbonacious waste mineralization reactions consume water in conversion of hydrocarbons to methane and carbon dioxide. When soil moisture exceeds the field capacity of the vegetated cap soils, water will percolate below the root zone and into waste. This water addition can be engineered by surface or subsurface irrigation.

2. Land application of urban solids. Vegetative caps have the capacity to convert land-applied waste products into soil. Biosolids, lawn wastes, organic biomass, and street sweepings may be surface applied between tree rows or used in building the cover soils.

3. Organic contaminant remediation. Trees can remove organic contaminants from surficial soils and near-surface waste by plant uptake and biodegradation by root-associated microorganisms.

4. Greenhouse gas reduction. Since plant root exudates can increase microbial concentrations in soil by 10-100 times (Katznelson, 1965), it is speculated that vegetative landfill covers reduce methane emissions at landfills by enhancing methanotrophic bacteria concentrations. In addition, atmospheric $CO_2$ is removed by plants and stored in wood, leaves, soil humus, roots, and root exudates.

5. Habitat enhancement. By inter-planting shrubs and trees with hybrid poplars, or letting these plants move in naturally, future mixed-species forest ecosystems can be created as habitat for a diverse wildlife community.

6. Raw wood production. Poplar wood has market as wood fiber, biomass fuel, livestock feed, paper pulp, dimensional lumber, furniture lumber, and extruded particle wood products. Thus, the trees can be harvested on a 6-14 year rotation, and can be managed to vigorously re-grow (coppice) from the cut stump.

7. Aesthetic benefits. An ECap grows a forest, whereas a traditional landfill cap grows a grass-covered mound. The forest ambiance created by this system benefits the people who live adjacent to or drive past the landfill. The trees intercept dust, provide a windbreak, create a natural noise barrier, screen the landfill from view, and provide a potential recreation area.

## 1.3 ECap Application and Efficacy

### 1.3.1 Application and Case Histories

The first ECap was installed in 1990 at a construction debris landfill cap in Oregon. Since that time, this system has been installed at 12 additional landfills across the United States, including pre-Subtitle D landfill caps (Pennsylvania, Washington, Iowa), Subtitle D demonstrations (Iowa, Virginia, Michigan), a permitted RCRA cap (Tennessee), and an interim Subtitle D closure with leachate irrigation (Iowa). Examples of these installations are as follows:

Lakeside Reclamation Landfill – Beaverton, Oregon

The Lakeside Reclamation Landfill is an operating construction debris landfill. In 1990-91, 11,000 5 ft tall hybrid poplar whips were planted into 4 ft of silt-loam soil covering a 3-acre waste cell (**Figure 2**). Excavations performed one year after planting showed dense poplar root growth at 4 ft below the surface. Since 1990-91, the trees have grown approximately 7 ft per year, and presently stand 60-80 ft tall (**Figure 3**). The owner has achieved regulatory approval to proceed with an ECap cover over the remainder of the landfill for final closure.

Horseshoe Bend Landfill – Lawrenceburg, Tennessee

Due to groundwater contamination from the historic (1956-1963) disposal of paint sludge, this 5-acre municipal landfill was placed on the Superfund National Priorities list in 1990. In 1997, the Tennessee Division of Superfund approved a plan that included an ECap cover. In 1998, 1,400 hybrid poplars were planted on 1.8 acres of the site to minimize percolation into waste, reduce groundwater recharge, and stabilize surface soils. Groundwater monitoring and site evaluation will take place every five years until no longer deemed necessary by the state regulators.

Duvall Custodial Landfill – Duvall, Washington

In March 2000, a 13-acre ECap was installed in lieu of a geomembrane cover at this pre-Subtitle D landfill. The Washington Department of Health approved the design, which consists of hybrid poplars planted into the existing 6 ft of loam covering waste. Approximately 10,000 5 ft tall hybrid poplar whips (four varieties) were planted. Tree survival for the first growing season was 98%. Instrumentation currently measures climatic data, soil moisture content, and runoff flow rates, and collected leachate will be irrigated onto the ECap in future years. The total project cost, including irrigation system installation and leachate collection system modification, is budgeted at $600,000, compared to the initial selection of a $3 million geomembrane cover.

### 1.3.2 Evaluation by ACAP

The Alternative Cover Assessment Program (ACAP) was created by the US Environmental Protection Agency to evaluate landfill covers that are conceptually different but functionally equivalent to geomembrane or clay covers now permitted under existing solid waste regulations. ACAP works in partnership with EPA offices, other federal and state agencies, private industry, and universities. ACAP conducts the performance evaluation at a site for a period of five years. One or more prescriptive cover test cells are built adjacent to an 'alternative' cover; the cells are lined such that all percolating water can be accurately quantified. The yearly drainage through the side-by-side covers is measured and evaluated with respect to the performance objective. The data obtained from the 11 ACAP studies constructed across the nation are intended for use by site owners and state/federal decision-makers to evaluate landfill cover options and the products promoted by technology vendors. The ECap cover is presently being evaluated at two of these sites (constructed in 2000, data not available to date):

Marine Corps Logistics Base – Albany, Georgia

The Marine Corps Logistics Base (MCLB) has a chlorinated solvent groundwater plume resulting from a historic landfill area. The base needs to cap this area within several years, and would like to use a vegetative cap in place of the prescribed compacted clay cap. To document ECap equivalence to the prescribed cover, the base is evaluating the two covers via ACAP. The HELP and Ecolotree hydrologic models were run to design an ECap cover equivalent to the prescribed cover for percolation under average year and extreme year conditions. The test pads were constructed and trees were planted in March 2000, with meaningful results expected beginning in 2001. Feasibility study estimates for capping 17 acres and performing 30 years of O&M are $10.5 million for the prescriptive RCRA cap and $5.4 million for the ECap (Lunardini and Daniel, 2000).

Bluestem Landfill #2 – Marion, IA

Bluestem Landfill #2 is an operational MSW landfill with a future capped area of over 90 acres (beginning in 2002). For ecological, economic, and aesthetic reasons, Bluestem staff hope to install a vegetative cover in place of current prescriptive cover designs for future closure activities. In order to permit an alternative cover for final closure, the Iowa Department of Natural Resources (IDNR) has requested that further demonstration data be obtained. To obtain this definitive data, Bluestem has agreed to participate in ACAP. Based on water modeling results, an ECap cover was chosen that consists of 2 ft of interim cover and 3 ft of borrow soil blended with compost at a 5:1 ratio (by volume). RCRA Subtitle D (geomembrane) cap, IDNR-approved compacted clay cap, and ECap test cells were constructed and instrumented in September 2000. A full-scale ECap installation at the site is expected to cost 25% less than a clay cap and 60% less than a geomembrane cap.

## 2. ECap Design and Layout

## 2.1 Hydrologic Water Modeling

### 2.1.1 Overview

In collaboration with various academic faculty and consulting engineers since 1995, Ecolotree staff have created a hydrologic performance model to determine appropriate site-specific ECap designs. The model is designed to predict water percolation below the root zone for porous vegetative caps, in contrast to the Hydrologic Evaluation of Landfill Performance (HELP) model, which was designed to predict percolation through low permeability covers. The vegetative water model takes into account the water inputs (precipitation and irrigation) and outputs (runoff, evapotranspiration, and percolation below the root zone) to predict soil moisture fluctuations on a weekly basis (**Figure 4**). Review of climate records, soil hydrologic properties, landfill slope, cover soil thickness, and projected water uptake rates is required to set up the model parameters. The model assumes that a mature tree stand has been established and that significant percolation occurs only when the soil moisture content exceeds its field capacity. Monthly percolation is calculated from the following equation:

$$\text{Percolation} = \text{initial soil moisture} + \text{precipitation} + \text{irrigation} - \text{runoff} - \text{effective ET} - \text{final soil moisture}$$

#### 2.1.2.1 Climatic Conditions

The Trimmer Road Landfill is located in a freeze-thaw climate with moderate summers, frozen conditions in the winter, and mild spring and fall weather. This climate is very hospitable to hardwood deciduous trees, and poplar species such as eastern cottonwood can be found growing on and surrounding the landfill.

Historic precipitation values (1961-1990) for were obtained from the Midwestern Regional Climate Center. The average annual precipitation for Rochester, New York between during this time period was 31.97 inches. Rochester typically receives fairly uniform precipitation, with monthly averages ranging from 2.08 – 3.40 inches. Snow constitutes the majority of the precipitation between December and February. Average monthly potential evapotranspiration (PET) estimates (1990-1999) for grass were provided for Rochester by the Northeast Regional Climate Center. Average annual grass PET for this time period was 21.31 inches.

#### 2.1.2.2 Hydrologic Modeling Results

Leakage through vegetative caps is determined to a great extent by the soil available water holding capacity (AWHC). Sand has a very low AWHC of 0.4-1.0 inch/ft, while silt loam has a high AWHC of 2.0-2.3 inch/ft (Carrow et al., 1990). Thus, the Ecolotree hydrologic model was evaluated for the following conditions:

- ECap, 4 inches of AWHC (**Table 1, Figure 5**)
- ECap, 6 inches of AWHC (**Table 2, Figure 6**)
- ECap, 8 inches of AWHC (**Table 3, Figure 7**)
- Grass-only cap, 1 foot of silt-loam soil, AWHC = 2.16 inches (**Table 4, Figure 8**)

The predicted annual percolation rates and cover efficiency values ((precipitation – percolation)/precipitation) were obtained for the ECap covers and grass-only cover. The results are as follows:

- ECap, 4 inches of AWHC: percolation = 4.0 inches, efficiency = 87%
- ECap, 6 inches of AWHC: percolation = 2.6 inches, efficiency = 92%
- ECap, 8 inches of AWHC: percolation = 1.7 inches, efficiency = 95%
- Grass-only cap, 1 foot of silt-loam soil: percolation = 6.2 inches, efficiency = 81%

The model assumes that a mature ECap has been established at the site, characterized by full canopy and maximum water uptake rates. Typically maturity is achieved by the end of the third growing season. Although the understory grasses will help to reduce percolation during the two or three establishment years following planting, more percolation is expected to take place than for a mature ECap. By inference from the existing hydrologic models, predicted percolation for a 6 inch AWHC ECap is expected to be approximately 4 inches for year 1 and year 2, and 3 inches for year 3.

### 2.2 Cover Recommendations

The model predicts that a 1 ft thick soil cover planted with grass will leak substantially under average climatic conditions. This leakage is due to an insufficient amount of AWHC in 1 ft of soil, lower evapotranspiration rates than with a tree-grass cover, and the shallow rooting nature of grasses (typically 12-18 inches deep, not expected to root into waste). Abnormal climatic conditions, such as higher precipitation rates, cooler summers, and warmer winters than average, would result in even higher leakage rates. The ECap cover is expected to leak significantly less water than the grass-only cover because it has greater AWHC, increased evapotranspiration rates, and deeper rooting potential.

Based on these results, an ECap cover is recommended to minimize the long-term percolation of water into waste, and thus minimize the long-term liability of the state and the landfill owner. The ECap also has numerous auxiliary benefits, as outlined in section 1.2, *Objectives and Benefits*. To ensure a successful ECap, two criteria must be met:

1. Provide a minimum of 4 inches of AWHC in the cover soils and amendments (necessary for water storage and tree health).

2. Provide a minimum of 3 feet of rootable material to reduce the potential of 'windthrow' (blowing over of trees caused by severe winds). If site investigations indicate that the near-surface waste is rootable, then the waste can be used for a portion of the 3 foot requirement.

Although the ECap cover materials would ideally be constructed to contain 8+ inches of AWHC, this solution is probably not economically feasible. Approximately 4 ft of silt-loam soil would be required to provide an AWHC of 8 inches. Thus, an ECap cover containing 4 inches of AWHC is more realistic. Since the site currently has an average of approximately 6 inches of silt topsoil (1.1 inches of AWHC), an additional 2.9 inches of AWHC is needed. This additional AWHC can be obtained with a variety of materials, contingent on availability and cost. Although laboratory testing for AWHC is necessary to confirm a final cover design, three examples of potential covers are as follows:

1. 6 inches of existing soil and 1.5 ft of borrow topsoil (assuming a silt material)
2. 6 inches of existing soil and 2.5 ft of sandy loam fill dirt
3. 6 inches of existing soil and a 1.5 – 2.0 ft blend (estimated) of sandy loam fill dirt and organic amendments (e.g. compost, wastewater treatment biosolids)

If the near-surface waste is deemed rootable, it can also contribute to the AWHC of the ECap cover. A 1 ft layer of rootable municipal waste has an AWHC of approximately 2.6 inches (Oweis and Khera, 1998). Thus, the total AWHC of an ECap with a 4 inch AWHC soil cover would actually be on the order of 7.6 inches.

Surface application of organic amendments, such as composted yard waste or wastewater treatment biosolids, is also strongly recommended. These amendments could be applied in a 3 inch thick, 1 ft wide swath along the tree rows to provide nutrients, increase AWHC, reduce weed competition, and discourage burrowing animals from damaging the trees. The amendments could be applied on a one-time basis at the time of planting, or could be applied on a 3-6 year rotation, contingent on amendment availability, cost, and soil fertility.

## 2.3 Tree Selection and Layout

The ECap will be planted on the flat upland portion of the landfill, estimated to be 27 acres in size. It is assumed at this time that the existing trees and shrubs on this upland portion will be removed. This vegetation can be ground or chipped and incorporated into the cover soils on-site. Portions of the successional northern hardwoods areas may be left in place and planted around. This decision will be made after evaluating tree density, depth of existing soil, and the logistics of placing and grading borrow soil in these areas. Trees will only be planted on the sloping edges of the landfill to fill gaps in the existing hardwood trees. The planting will consist of approximately 85% hybrid poplar trees, 10% willow, and 5% 'other' (e.g. ash, maple). The hybrid poplar and willow will be planted with a between-tree spacing of 5 feet, and a between-row spacing of 10 feet. The 5% ash, maple, and other chosen species will be intermixed with these trees and spaced 10 feet from the other trees. Approximately 850 trees will be planted per acre (50 $ft^2$/tree), for a total of 23,000 trees. This spacing will provide maximum water uptake capacity and stabilization of surface soils, while allowing for vehicle and equipment access across the site (for mechanized mowing, organic amendment application, and recreational activities). The tree rows will curve gradually in a south to east orientation across the landfill, and will start and stop to accommodate the existing recreational trails (Figure 8). The site will be seeded with native grasses and forbes to provide a lush understory.

## 2.4 Instrumentation Options

If soil moisture monitoring is desired for the landfill cover, the site can be instrumented with datalogged or modemed nests of soil moisture sensors. The soil moisture results, in conjunction with rain gauge results, can provide valuable information for estimating water leakage into waste. The type and quantity of sensors are dependent upon the desired degree of automation, cost, and the availability of local labor for instrument monitoring.

# 3. ECap Construction Activities

## 3.1 Site Characterization

The following site characterization tasks are necessary before site preparation can begin:

1. Mow the upland portion of the landfill.
2. Survey the upland portion of the landfill into a 20-40 block grid pattern. Dig a test pit in the center of each block to determine existing cover thickness.
3. Evaluate the rootability of the near-surface waste by removing approximately 10 trees from across the site and evaluating their root development.
4. Document the location of on-site trees marked for salvage.
5. Analyze the existing cover soils, borrow soils, and amendment sources for nutrient and water-holding properties.
6. Finalize the cover design by selecting borrow soil and amendment sources and determining cover thickness.
7. Layout the tree planting plan.

8. Evaluate the proposed planting technique (vibrating ripper tooth) by testing the equipment at several locations on the landfill.

### 3.2 Site Preparation

The expected site preparation tasks are as follows:

1. Clearing and grubbing: Mow the site to a 3 inch height, remove and chip the existing trees and brush and spread this material across the site.

2. Grading: Place and grade soils and amendments to achieve the specified cover thickness and slope; fill in areas of surface cavitation.

3. Fertilization: Broadcast spread granular fertilizer across the site.

4. Tree row layout: Layout the location of the tree planting rows.

### 3.3 ECap Construction

The expected construction tasks are as follows:

1. Tree planting: Trees will be planted into 3 inch wide, 3 ft deep trenches created by a vibrating ripper tooth (pulled by a Ditchwitch® track trencher or equivalent equipment). Planting should be completed May 15 to maximize survival.

2. Biosolid or compost addition: Apply a 3 inch thick, 1 ft wide layer of biosolids or compost along the tree rows following planting.

3. Understory seeding: Rototill the site to prepare an appropriate seed bed, broadcast spread grass seed across the site, and perform follow-up harrowing.

## 4. EBuffer Installation

Numerous laboratory studies and field applications have demonstrated the effectiveness of hybrid poplar trees in treating a variety of organic pollutants, including trichloroethylene, benzene, toluene, dioxane, and atrazine (Wichman, 1990, Paterson and Schnoor, 1992, Burken, 1993, Nair et al., 1993, Burken, 1996, Newman et al., 1997, Aitchison et al., 2000). Remediation of these compounds is achieved by a combination of plant uptake and enhanced biodegradation by root-associated microorganisms. EBuffers have been installed for interception of landfill leachate, organic contaminant plumes, and fertilizer-impacted groundwater at 16 sites in eight states.

Installation of an EBuffer at the Trimmer Road Landfill is constrained by property boundaries, drainage channels, wetland areas, and existing vegetation. Installation would require purchase of off-site property or a large-scale clearing of existing trees on the side slopes and immediately surrounding the landfill. In addition, it is expected that the existing trees on-site currently provide some phytoremediation treatment of groundwater and leachate seeps. Due to these factors, a full-scale EBuffer installation is not recommended. A small scale strategic planting of trees is recommended, however, in plume or leachate seep areas with insufficient natural vegetation.

## 5. Monitoring and Maintenance Activities

The ECap typically requires little maintenance after the first three growing seasons. However, proper monitoring and maintenance is important during the first three years to ensure a healthy ECap. These activities are as follows:

1. Site inspections: A trained inspector will observe the site every two weeks during the first growing season, and every 3-4 weeks during the second and third growing season. The inspector will look for such conditions as insect damage, surface disturbances or rutting caused by vehicles traversing the site, gullies, soil erosion, and other stresses to the vegetation.

2. Replanting: With proper site preparation, installation, and maintenance, tree survival at the site is expected to be 90+%. However, as with all large-scale vegetative plantings, some mortality is likely. Replanting of observed mortality should be performed in the spring of the second growing season.

3. Mowing and weeding: The site should be mowed to a 3 inch height when the grass or weed height exceeds 8 inches (expected to be 3-5 times annually). Selective removal of noxious weeds, such as morning glory, may be required.

4. Pruning: The trees should be pruned annually to remove double leaders, dead branches, insect damage, and canker.

5. Insect and animal control: Insect and animal damage require quick response times. Cottonwood beetle, gypsy moths, tent caterpillars, and wood borers can damage the trees. Insect reatment is usually achieved by spraying of commercially-available insecticide.

6. Apply fertilizer and other soil amendments: Soil and foliar (leaf) samples will be taken annually and analyzed for macro and micro-nutrients. Based on these results, addition of soil amendments may be required. These amendments could include fertilizer, organic materials, and lime or gypsum (for soil pH adjustment).

Long-term maintenance tasks (after year 3) are expected to consist of quarterly site inspections, mowing 2-3 times annually, and fertilization on an as-needed basis only.

## 7. Pilot Demonstration Study

A 3-5 year pilot study may be desired to demonstrate effectiveness and to observe qualitative differences between different covers (i.e. appearance, soil stabilization, neighbor acceptance). This study could consist of a two acre ECap planted next to a two acre grass-only cap. Instrumentation at the site should include a meteorological station, approximately six nests of soil moisture sensors with 2-3 sensors in each nest, and a modemed system for remote data collection and review. Although this system does not allow for a direct evaluation of percolation below each cap, it does allow soil moisture fluctuations to be tracked in response to precipitation. The soil moisture data can then be linked to the soil moisture and percolation data being collected by the ACAP studies to make strong inferences about cover performance at the Trimmer Road Landfill.

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Table 1: Water Balance for the Ecolotree Cap, Average Climatic Conditions, AWHC = 4 inches

## Water Balance for the Trimmer Road Landfill, Parma, New York

### Year 4 Theoretical Water Balance per Acre: Ecolotree® Cap with 4 inches of Available Water Holding Capacity (AWHC)

| Parameter | | | January | February | March | April | May | June | July | August | September | October | November | December | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Mean Precipitation** | | | | | | | | | | | | | | | |
| Precipitation/month | (inches) | [1] | 2.08 | 2.10 | 2.28 | 2.61 | 2.72 | 3.00 | 2.71 | 3.40 | 2.97 | 2.44 | 2.93 | 2.73 | 31.97 |
| Volume | (gal/acre) | [2] | 56,489 | 57,032 | 61,920 | 70,882 | 73,870 | 81,474 | 73,598 | 92,337 | 80,659 | 66,266 | 79,573 | 74,141 | 868,241 |
| Precipitation/Week | (inches) | | 0.52 | 0.53 | 0.57 | 0.65 | 0.68 | 0.75 | 0.68 | 0.85 | 0.74 | 0.61 | 0.73 | 0.68 | |
| **Irrigation Water Supply** | | | | | | | | | | | | | | | |
| Irrigation | (inches) | | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Volume | (gal/acre) | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Total Inputs** | **(inches)** | | **2.08** | **2.10** | **2.28** | **2.61** | **2.72** | **3.00** | **2.71** | **3.40** | **2.97** | **2.44** | **2.93** | **2.73** | **31.97** |
| **Volume** | **(gal/acre)** | | **56,489** | **57,032** | **61,920** | **70,882** | **73,870** | **81,474** | **73,598** | **92,337** | **80,659** | **66,266** | **79,573** | **74,141** | **868,241** |
| Surface Runoff | (inches) | [3] | 1.04 | 1.05 | 1.14 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 1.37 | 4.60 |
| Volume | (gal/acre) | | 28,244 | 28,516 | 30,960 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 37,071 | 124,791 |
| **Uptake by Trees and Grass (Year 4)** | | | | | | | | | | | | | | | |
| Potential Evapotranspiration (PET) for Grass | (inches) | [4] | 0.42 | 0.68 | 1.28 | 1.66 | 2.80 | 3.55 | 3.75 | 3.23 | 1.98 | 1.13 | 0.48 | 0.34 | 21.30 |
| PET for Grass and Poplar | (inches) | [5] | 0.42 | 0.68 | 1.28 | 1.83 | 3.36 | 4.62 | 4.88 | 4.20 | 2.38 | 1.24 | 0.48 | 0.34 | 25.69 |
| Canopy Storage | (inches) | [6] | 0.00 | 0.00 | 0.00 | 0.13 | 0.41 | 0.45 | 0.41 | 0.51 | 0.45 | 0.37 | 0.15 | 0.00 | |
| Field Capacity of Cover + Canopy Storage | (inches) | [7] | 8.00 | 8.00 | 8.00 | 8.13 | 8.41 | 8.45 | 8.41 | 8.51 | 8.45 | 8.37 | 8.15 | 8.00 | |
| AWHC of Cover + Canopy Storage | (inches) | [8] | 4.00 | 4.00 | 4.00 | 4.13 | 4.41 | 4.45 | 4.41 | 4.51 | 4.45 | 4.37 | 4.15 | 4.00 | |
| Wilt Point of Cover | (inches) | [9] | 4.00 | 4.00 | 4.00 | 4.00 | 4.00 | 4.00 | 4.00 | 4.00 | 4.00 | 4.00 | 4.00 | 4.00 | |
| Soil Water Depletion Fraction, f | | [10] | 1.00 | 1.00 | 1.00 | 0.90 | 0.72 | 0.60 | 0.58 | 0.65 | 0.80 | 1.00 | 1.00 | 1.00 | |
| Breakpoint Moisture Level in Cover, BML | (inches) | [11] | 4.00 | 4.00 | 4.00 | 4.41 | 5.23 | 5.78 | 5.85 | 5.58 | 4.89 | 4.00 | 4.00 | 4.00 | |
| Week 1 Effective ET for Grass and Poplar | (inches) | | 0.11 | 0.17 | 0.32 | 0.46 | 0.84 | 1.15 | 1.22 | 0.69 | 0.59 | 0.31 | 0.12 | 0.09 | |
| Week 2 Effective ET for Grass and Poplar | (inches) | | 0.11 | 0.17 | 0.32 | 0.46 | 0.84 | 1.15 | 0.88 | 0.80 | 0.59 | 0.31 | 0.12 | 0.09 | |
| Week 3 Effective ET for Grass and Poplar | (inches) | | 0.11 | 0.17 | 0.32 | 0.46 | 0.84 | 1.15 | 0.75 | 0.83 | 0.59 | 0.31 | 0.12 | 0.09 | |
| Week 4 Effective ET for Grass and Poplar | (inches) | | 0.11 | 0.17 | 0.32 | 0.46 | 0.84 | 1.15 | 0.70 | 0.84 | 0.59 | 0.31 | 0.12 | 0.09 | |
| Monthly Effective ET for Grass and Poplar | (inches) | [12] | 0.42 | 0.68 | 1.28 | 1.83 | 3.36 | 4.62 | 3.54 | 3.17 | 2.38 | 1.24 | 0.48 | 0.34 | 23.33 |
| Volume | (gal/acre) | | 11,406 | 18,467 | 34,762 | 49,591 | 91,251 | 125,334 | 96,262 | 85,978 | 64,527 | 33,757 | 13,036 | 9,234 | 633,606 |
| **Total Outputs** | **(inches)** | | **1.46** | **1.73** | **2.42** | **1.83** | **3.36** | **4.62** | **3.54** | **3.17** | **2.38** | **1.24** | **0.48** | **1.71** | **27.93** |
| **Volume** | **(gal/acre)** | | **39,651** | **46,983** | **65,722** | **49,591** | **91,251** | **125,334** | **96,262** | **85,978** | **64,527** | **33,757** | **13,036** | **46,304** | **758,397** |
| **Cover and Canopy Moisture Profile** | | | | | | | | | | | | | | | |
| Beginning Cover and Canopy Moisture | (inches) | [13] | 8.00 | 8.00 | 8.00 | 7.86 | 8.13 | 7.49 | 5.88 | 5.04 | 5.28 | 5.87 | 7.07 | 8.15 | |
| End of Week 1 Cover and Canopy Moisture | (inches) | | 8.00 | 8.00 | 7.97 | 8.06 | 7.97 | 7.09 | 5.33 | 5.20 | 5.42 | 6.17 | 7.68 | 8.00 | |
| End of Week 2 Cover and Canopy Moisture | (inches) | | 8.00 | 8.00 | 7.93 | 8.13 | 7.81 | 6.68 | 5.13 | 5.25 | 5.57 | 6.47 | 8.15 | 8.00 | |
| End of Week 3 Cover and Canopy Moisture | (inches) | | 8.00 | 8.00 | 7.90 | 8.13 | 7.65 | 6.28 | 5.06 | 5.27 | 5.72 | 6.77 | 8.15 | 8.00 | |
| Ending Cover and Canopy Moisture | (inches) | [14] | 8.00 | 8.00 | 7.86 | 8.13 | 7.49 | 5.88 | 5.04 | 5.28 | 5.87 | 7.07 | 8.15 | 8.00 | |
| Week 1 Percolation Below Root Zone | (inches) | | 0.15 | 0.09 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.40 | |
| Week 2 Percolation Below Root Zone | (inches) | | 0.15 | 0.09 | 0.00 | 0.12 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.14 | 0.26 | |
| Week 3 Percolation Below Root Zone | (inches) | | 0.15 | 0.09 | 0.00 | 0.20 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.61 | 0.26 | |
| Week 4 Percolation Below Root Zone | (inches) | | 0.15 | 0.09 | 0.00 | 0.20 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.61 | 0.26 | |
| **Monthly Percolation Below Root Zone** | **(inches)** | [15] | **0.62** | **0.37** | **0.00** | **0.51** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **1.37** | **1.17** | **4.04** |
| **Monthly Percolation Below Root Zone** | **(gal/acre)** | | **16,838** | **10,048** | **0** | **13,946** | **0** | **0** | **0** | **0** | **0** | **0** | **37,197** | **31,816** | **109,845** |

11/21/00 Table 2: Water Balance for the Ecolotree Cap, Average Climatic Conditions, AWHC = 6 inches

## Water Balance for the Trimmer Road Landfill, Parma, New York

### Year 4 Theoretical Water Balance per Acre: Ecolotree® Cap with 6 inches of Available Water Holding Capacity (AWHC)

| Parameter | | | January | February | March | April | May | June | July | August | September | October | November | December | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Mean Precipitation** | | | | | | | | | | | | | | | |
| Precipitation/month | (inches) | [1] | 2.08 | 2.10 | 2.28 | 2.61 | 2.72 | 3.00 | 2.71 | 3.40 | 2.97 | 2.44 | 2.93 | 2.73 | 31.97 |
| Volume | (gal/acre) | [2] | 56,489 | 57,032 | 61,920 | 70,882 | 73,870 | 81,474 | 73,598 | 92,337 | 80,659 | 66,266 | 79,573 | 74,141 | 868,241 |
| Precipitation/Week | (inches) | | 0.52 | 0.53 | 0.57 | 0.65 | 0.68 | 0.75 | 0.68 | 0.85 | 0.74 | 0.61 | 0.73 | 0.68 | |
| **Irrigation Water Supply** | | | | | | | | | | | | | | | |
| Irrigation | (inches) | | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Volume | (gal/acre) | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Total Inputs** | **(inches)** | | **2.08** | **2.10** | **2.28** | **2.61** | **2.72** | **3.00** | **2.71** | **3.40** | **2.97** | **2.44** | **2.93** | **2.73** | **31.97** |
| **Volume** | **(gal/acre)** | | **56,489** | **57,032** | **61,920** | **70,882** | **73,870** | **81,474** | **73,598** | **92,337** | **80,659** | **66,266** | **79,573** | **74,141** | **868,241** |
| Surface Runoff | (inches) | [3] | 1.04 | 1.05 | 1.14 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 1.37 | 4.60 |
| Volume | (gal/acre) | | 28,244 | 28,516 | 30,960 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 37,071 | 124,791 |
| **Uptake by Trees and Grass (Year 4)** | | | | | | | | | | | | | | | |
| Potential Evapotranspiration (PET) for Grass | (inches) | [4] | 0.42 | 0.68 | 1.28 | 1.66 | 2.80 | 3.55 | 3.75 | 3.23 | 1.98 | 1.13 | 0.48 | 0.34 | 21.30 |
| PET for Grass and Poplar | (inches) | [5] | 0.42 | 0.68 | 1.28 | 1.83 | 3.36 | 4.62 | 4.88 | 4.20 | 2.38 | 1.24 | 0.48 | 0.34 | 25.69 |
| Canopy Storage | (inches) | [6] | 0.00 | 0.00 | 0.00 | 0.13 | 0.41 | 0.45 | 0.41 | 0.51 | 0.45 | 0.37 | 0.15 | 0.00 | |
| Field Capacity of Cover + Canopy Storage | (inches) | [7] | 12.00 | 12.00 | 12.00 | 12.13 | 12.41 | 12.45 | 12.41 | 12.51 | 12.45 | 12.37 | 12.15 | 12.00 | |
| AWHC of Cover + Canopy Storage | (inches) | [8] | 6.00 | 6.00 | 6.00 | 6.13 | 6.41 | 6.45 | 6.41 | 6.51 | 6.45 | 6.37 | 6.15 | 6.00 | |
| Wilt Point of Cover | (inches) | [9] | 6.00 | 6.00 | 6.00 | 6.00 | 6.00 | 6.00 | 6.00 | 6.00 | 6.00 | 6.00 | 6.00 | 6.00 | |
| Soil Water Depletion Fraction, f | | [10] | 1.00 | 1.00 | 1.00 | 0.90 | 0.72 | 0.60 | 0.58 | 0.65 | 0.80 | 1.00 | 1.00 | 1.00 | |
| Breakpoint Moisture Level in Cover, BML | (inches) | [11] | 6.00 | 6.00 | 6.00 | 6.61 | 7.79 | 8.58 | 8.69 | 8.28 | 7.29 | 6.00 | 6.00 | 6.00 | |
| Week 1 Effective ET for Grass and Poplar | (inches) | | 0.11 | 0.17 | 0.32 | 0.46 | 0.84 | 1.15 | 1.22 | 0.88 | 0.59 | 0.31 | 0.12 | 0.09 | |
| Week 2 Effective ET for Grass and Poplar | (inches) | | 0.11 | 0.17 | 0.32 | 0.46 | 0.84 | 1.15 | 1.22 | 0.87 | 0.59 | 0.31 | 0.12 | 0.09 | |
| Week 3 Effective ET for Grass and Poplar | (inches) | | 0.11 | 0.17 | 0.32 | 0.46 | 0.84 | 1.15 | 1.22 | 0.86 | 0.59 | 0.31 | 0.12 | 0.09 | |
| Week 4 Effective ET for Grass and Poplar | (inches) | | 0.11 | 0.17 | 0.32 | 0.46 | 0.84 | 1.15 | 1.02 | 0.85 | 0.59 | 0.31 | 0.12 | 0.09 | |
| Monthly Effective ET for Grass and Poplar | (inches) | [12] | 0.42 | 0.68 | 1.28 | 1.83 | 3.36 | 4.62 | 4.68 | 3.46 | 2.38 | 1.24 | 0.48 | 0.34 | 24.76 |
| Volume | (gal/acre) | | 11,406 | 18,467 | 34,762 | 49,591 | 91,251 | 125,334 | 126,995 | 93,938 | 64,527 | 33,757 | 13,036 | 9,234 | 672,299 |
| **Total Outputs** | **(inches)** | | **1.46** | **1.73** | **2.42** | **1.83** | **3.36** | **4.62** | **4.68** | **3.46** | **2.38** | **1.24** | **0.48** | **1.71** | **29.35** |
| **Volume** | **(gal/acre)** | | **39,651** | **46,983** | **65,722** | **49,591** | **91,251** | **125,334** | **126,995** | **93,938** | **64,527** | **33,757** | **13,036** | **46,304** | **797,090** |
| **Cover and Canopy Moisture Profile** | | | | | | | | | | | | | | | |
| Beginning Cover and Canopy Moisture | (inches) | [13] | 12.00 | 12.00 | 12.00 | 11.86 | 12.13 | 11.49 | 9.88 | 7.91 | 7.85 | 8.44 | 9.64 | 12.09 | |
| End of Week 1 Cover and Canopy Moisture | (inches) | | 12.00 | 12.00 | 11.97 | 12.06 | 11.97 | 11.09 | 9.33 | 7.88 | 8.00 | 8.74 | 10.25 | 12.00 | |
| End of Week 2 Cover and Canopy Moisture | (inches) | | 12.00 | 12.00 | 11.93 | 12.13 | 11.81 | 10.68 | 8.79 | 7.86 | 8.15 | 9.04 | 10.87 | 12.00 | |
| End of Week 3 Cover and Canopy Moisture | (inches) | | 12.00 | 12.00 | 11.90 | 12.13 | 11.65 | 10.28 | 8.25 | 7.86 | 8.30 | 9.34 | 11.48 | 12.00 | |
| Ending Cover and Canopy Moisture | (inches) | [14] | 12.00 | 12.00 | 11.86 | 12.13 | 11.49 | 9.88 | 7.91 | 7.85 | 8.44 | 9.64 | 12.09 | 12.00 | |
| Week 1 Percolation Below Root Zone | (inches) | | 0.15 | 0.09 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.35 | |
| Week 2 Percolation Below Root Zone | (inches) | | 0.15 | 0.09 | 0.00 | 0.12 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.26 | |
| Week 3 Percolation Below Root Zone | (inches) | | 0.15 | 0.09 | 0.00 | 0.20 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.26 | |
| Week 4 Percolation Below Root Zone | (inches) | | 0.15 | 0.09 | 0.00 | 0.20 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.26 | |
| **Monthly Percolation Below Root Zone** | **(inches)** | [15] | **0.62** | **0.37** | **0.00** | **0.51** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **1.12** | **2.62** |
| **Monthly Percolation Below Root Zone** | **(gal/acre)** | | **16,838** | **10,048** | **0** | **13,946** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **30,319** | **71,151** |

Table 3: Water Balance for the Ecolotree Cap, Average Climatic Conditions, AWHC = 8 inches

## Water Balance for the Trimmer Road Landfill, Parma, New York

### Year 4 Theoretical Water Balance per Acre: Ecolotree® Cap with 8 inches of Available Water Holding Capacity (AWHC)

| Parameter | | | January | February | March | April | May | June | July | August | September | October | November | December | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Mean Precipitation** | | | | | | | | | | | | | | | |
| Precipitation/month | (inches) | [1] | 2.08 | 2.10 | 2.28 | 2.61 | 2.72 | 3.00 | 2.71 | 3.40 | 2.97 | 2.44 | 2.93 | 2.73 | 31.97 |
| Volume | (gal/acre) | [2] | 56,489 | 57,032 | 61,920 | 70,882 | 73,870 | 81,474 | 73,598 | 92,337 | 80,659 | 66,266 | 79,573 | 74,141 | 868,241 |
| Precipitation/Week | (inches) | | 0.52 | 0.53 | 0.57 | 0.65 | 0.68 | 0.75 | 0.68 | 0.85 | 0.74 | 0.61 | 0.73 | 0.68 | |
| **Irrigation Water Supply** | | | | | | | | | | | | | | | |
| Irrigation | (inches) | | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Volume | (gal/acre) | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Total Inputs** | **(inches)** | | **2.08** | **2.10** | **2.28** | **2.61** | **2.72** | **3.00** | **2.71** | **3.40** | **2.97** | **2.44** | **2.93** | **2.73** | **31.97** |
| **Volume** | **(gal/acre)** | | **56,489** | **57,032** | **61,920** | **70,882** | **73,870** | **81,474** | **73,598** | **92,337** | **80,659** | **66,266** | **79,573** | **74,141** | **868,241** |
| Surface Runoff | (inches) | [3] | 1.04 | 1.05 | 1.14 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 1.37 | 4.60 |
| Volume | (gal/acre) | | 28,244 | 28,516 | 30,960 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 37,071 | 124,791 |
| **Uptake by Trees and Grass (Year 4)** | | | | | | | | | | | | | | | |
| Potential Evapotranspiration (PET) for Grass | (inches) | [4] | 0.42 | 0.68 | 1.28 | 1.66 | 2.80 | 3.55 | 3.75 | 3.23 | 1.98 | 1.13 | 0.48 | 0.34 | 21.30 |
| PET for Grass and Poplar | (inches) | [5] | 0.42 | 0.68 | 1.28 | 1.83 | 3.36 | 4.62 | 4.88 | 4.20 | 2.38 | 1.24 | 0.48 | 0.34 | 25.69 |
| Canopy Storage | (inches) | [6] | 0.00 | 0.00 | 0.00 | 0.13 | 0.41 | 0.45 | 0.41 | 0.51 | 0.45 | 0.37 | 0.15 | 0.00 | |
| Field Capacity of Cover + Canopy Storage | (inches) | [7] | 16.00 | 16.00 | 16.00 | 16.13 | 16.41 | 16.45 | 16.41 | 16.51 | 16.45 | 16.37 | 16.15 | 16.00 | |
| AWHC of Cover + Canopy Storage | (inches) | [8] | 8.00 | 8.00 | 8.00 | 8.13 | 8.41 | 8.45 | 8.41 | 8.51 | 8.45 | 8.37 | 8.15 | 8.00 | |
| Wilt Point of Cover | (inches) | [9] | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | |
| Soil Water Depletion Fraction, f | | [10] | 1.00 | 1.00 | 1.00 | 0.90 | 0.72 | 0.60 | 0.58 | 0.65 | 0.80 | 1.00 | 1.00 | 1.00 | |
| Breakpoint Moisture Level in Cover, BML | (inches) | [11] | 8.00 | 8.00 | 8.00 | 8.81 | 10.35 | 11.38 | 11.53 | 10.98 | 9.69 | 8.00 | 8.00 | 8.00 | |
| Week 1 Effective ET for Grass and Poplar | (inches) | | 0.11 | 0.17 | 0.32 | 0.46 | 0.84 | 1.15 | 1.22 | 1.05 | 0.59 | 0.31 | 0.12 | 0.09 | |
| Week 2 Effective ET for Grass and Poplar | (inches) | | 0.11 | 0.17 | 0.32 | 0.46 | 0.84 | 1.15 | 1.22 | 1.05 | 0.59 | 0.31 | 0.12 | 0.09 | |
| Week 3 Effective ET for Grass and Poplar | (inches) | | 0.11 | 0.17 | 0.32 | 0.46 | 0.84 | 1.15 | 1.22 | 1.05 | 0.59 | 0.31 | 0.12 | 0.09 | |
| Week 4 Effective ET for Grass and Poplar | (inches) | | 0.11 | 0.17 | 0.32 | 0.46 | 0.84 | 1.15 | 1.22 | 1.05 | 0.59 | 0.31 | 0.12 | 0.09 | |
| Monthly Effective ET for Grass and Poplar | (inches) | [12] | 0.42 | 0.68 | 1.28 | 1.83 | 3.36 | 4.62 | 4.88 | 4.20 | 2.38 | 1.24 | 0.48 | 0.34 | 25.69 |
| Volume | (gal/acre) | | 11,406 | 18,467 | 34,762 | 49,591 | 91,251 | 125,334 | 132,395 | 114,036 | 64,527 | 33,757 | 13,036 | 9,234 | 697,798 |
| **Total Outputs** | **(inches)** | | **1.46** | **1.73** | **2.42** | **1.83** | **3.36** | **4.62** | **4.88** | **4.20** | **2.38** | **1.24** | **0.48** | **1.71** | **30.29** |
| **Volume** | **(gal/acre)** | | **39,651** | **46,983** | **65,722** | **49,591** | **91,251** | **125,334** | **132,395** | **114,036** | **64,527** | **33,757** | **13,036** | **46,304** | **822,589** |
| **Cover and Canopy Moisture Profile** | | | | | | | | | | | | | | | |
| Beginning Cover and Canopy Moisture | (inches) | [13] | 16.00 | 16.00 | 16.00 | 15.86 | 16.13 | 15.49 | 13.88 | 11.71 | 10.91 | 11.51 | 12.70 | 15.15 | |
| End of Week 1 Cover and Canopy Moisture | (inches) | | 16.00 | 16.00 | 15.97 | 16.06 | 15.97 | 15.09 | 13.33 | 11.51 | 11.06 | 11.80 | 13.32 | 15.41 | |
| End of Week 2 Cover and Canopy Moisture | (inches) | | 16.00 | 16.00 | 15.93 | 16.13 | 15.81 | 14.68 | 12.79 | 11.31 | 11.21 | 12.10 | 13.93 | 15.67 | |
| End of Week 3 Cover and Canopy Moisture | (inches) | | 16.00 | 16.00 | 15.90 | 16.13 | 15.65 | 14.28 | 12.25 | 11.11 | 11.36 | 12.40 | 14.54 | 15.92 | |
| Ending Cover and Canopy Moisture | (inches) | [14] | 16.00 | 16.00 | 15.86 | 16.13 | 15.49 | 13.88 | 11.71 | 10.91 | 11.51 | 12.70 | 15.15 | 16.00 | |
| Week 1 Percolation Below Root Zone | (inches) | | 0.16 | 0.09 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | |
| Week 2 Percolation Below Root Zone | (inches) | | 0.16 | 0.09 | 0.00 | 0.12 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | |
| Week 3 Percolation Below Root Zone | (inches) | | 0.16 | 0.09 | 0.00 | 0.20 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | |
| Week 4 Percolation Below Root Zone | (inches) | | 0.16 | 0.09 | 0.00 | 0.20 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.18 | |
| **Monthly Percolation Below Root Zone** | **(inches)** | [15] | **0.62** | **0.37** | **0.00** | **0.51** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.18** | **1.68** |
| **Monthly Percolation Below Root Zone** | **(gal/acre)** | | **16,838** | **10,048** | **0** | **13,946** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **4,821** | **45,653** |

# Table 4: Water Balance for a Grass-only Cap and 1-Foot of Silt Loam Soil, Average Climatic Conditions

## Water Balance for the Trimmer Road Landfill, Parma, New York

### Theoretical Water Balance per Acre: Grass Cover with 1-Foot of Silt Loam Soil (AWHC = 2.16 inches)

| Parameter | | | January | February | March | April | May | June | July | August | September | October | November | December | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Mean Precipitation** | | | | | | | | | | | | | | | |
| Precipitation/month | (inches) | [1] | 2.08 | 2.10 | 2.28 | 2.61 | 2.72 | 3.00 | 2.71 | 3.40 | 2.97 | 2.44 | 2.93 | 2.73 | 31.97 |
| Volume | (gal/acre) | [2] | 56,489 | 57,032 | 61,920 | 70,882 | 73,870 | 81,474 | 73,598 | 92,337 | 80,659 | 66,266 | 79,573 | 74,141 | 868,241 |
| Precipitation/Week | (inches) | | 0.52 | 0.53 | 0.57 | 0.65 | 0.68 | 0.75 | 0.68 | 0.85 | 0.74 | 0.61 | 0.73 | 0.68 | |
| **Irrigation Water Supply** | | | | | | | | | | | | | | | |
| Irrigation | (inches) | | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Volume | (gal/acre) | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Total Inputs** | **(inches)** | | **2.08** | **2.10** | **2.28** | **2.61** | **2.72** | **3.00** | **2.71** | **3.40** | **2.97** | **2.44** | **2.93** | **2.73** | **31.97** |
| **Volume** | **(gal/acre)** | | **56,489** | **57,032** | **61,920** | **70,882** | **73,870** | **81,474** | **73,598** | **92,337** | **80,659** | **66,266** | **79,573** | **74,141** | **868,241** |
| Surface Runoff | (inches) | [3] | 1.04 | 1.05 | 1.14 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 1.37 | 4.60 |
| Volume | (gal/acre) | | 28,244 | 28,516 | 30,960 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 37,071 | 124,791 |
| Uptake by Grass | | | | | | | | | | | | | | | |
| Potential Evapotranspiration (PET) for Grass | (inches) | [4] | 0.42 | 0.68 | 1.28 | 1.66 | 2.80 | 3.55 | 3.75 | 3.23 | 1.98 | 1.13 | 0.48 | 0.34 | 21.30 |
| Field Capacity of Cover | (inches) | [7] | 4.38 | 4.38 | 4.38 | 4.38 | 4.38 | 4.38 | 4.38 | 4.38 | 4.38 | 4.38 | 4.38 | 4.38 | |
| AWHC of Cover | (inches) | [8] | 2.16 | 2.16 | 2.16 | 2.16 | 2.16 | 2.16 | 2.16 | 2.16 | 2.16 | 2.16 | 2.16 | 2.16 | |
| Wilt Point of Cover | (inches) | [9] | 2.22 | 2.22 | 2.22 | 2.22 | 2.22 | 2.22 | 2.22 | 2.22 | 2.22 | 2.22 | 2.22 | 2.22 | |
| Soil Water Depletion Fraction, f | | [10] | 1.00 | 1.00 | 1.00 | 0.90 | 0.77 | 0.77 | 0.68 | 0.72 | 0.90 | 1.00 | 1.00 | 1.00 | |
| Breakpoint Moisture Level in Cover, BML | (inches) | [11] | 2.22 | 2.22 | 2.22 | 2.44 | 2.72 | 2.72 | 2.91 | 2.82 | 2.44 | 2.22 | 2.22 | 2.22 | |
| Week 1 Effective ET for Grass and Poplar | (inches) | | 0.11 | 0.17 | 0.32 | 0.42 | 0.70 | 0.89 | 0.94 | 0.65 | 0.50 | 0.28 | 0.12 | 0.09 | |
| Week 2 Effective ET for Grass and Poplar | (inches) | | 0.11 | 0.17 | 0.32 | 0.42 | 0.70 | 0.89 | 0.94 | 0.81 | 0.50 | 0.28 | 0.12 | 0.09 | |
| Week 3 Effective ET for Grass and Poplar | (inches) | | 0.11 | 0.17 | 0.32 | 0.42 | 0.70 | 0.89 | 0.94 | 0.81 | 0.50 | 0.28 | 0.12 | 0.09 | |
| Week 4 Effective ET for Grass and Poplar | (inches) | | 0.11 | 0.17 | 0.32 | 0.42 | 0.70 | 0.89 | 0.94 | 0.81 | 0.50 | 0.28 | 0.12 | 0.09 | |
| Monthly Effective ET for Grass and Poplar | (inches) | [12] | 0.42 | 0.68 | 1.28 | 1.66 | 2.80 | 3.55 | 3.75 | 3.08 | 1.98 | 1.13 | 0.48 | 0.34 | 21.15 |
| Volume | (gal/acre) | | 11,406 | 18,467 | 34,762 | 45,082 | 76,042 | 96,411 | 101,843 | 83,558 | 53,773 | 30,689 | 13,036 | 9,234 | 574,303 |
| **Total Outputs** | **(inches)** | | **1.46** | **1.73** | **2.42** | **1.66** | **2.80** | **3.55** | **3.75** | **3.08** | **1.98** | **1.13** | **0.48** | **1.71** | **25.74** |
| **Volume** | **(gal/acre)** | | **39,651** | **46,983** | **65,722** | **45,082** | **76,042** | **96,411** | **101,843** | **83,558** | **53,773** | **30,689** | **13,036** | **46,304** | **699,094** |
| **Cover and Canopy Moisture Profile** | | | | | | | | | | | | | | | |
| Beginning Cover and Canopy Moisture | (inches) | [13] | 4.38 | 4.38 | 4.38 | 4.24 | 4.38 | 4.30 | 3.75 | 2.71 | 3.03 | 4.02 | 4.38 | 4.38 | |
| End of Week 1 Cover and Canopy Moisture | (inches) | | 4.38 | 4.38 | 4.35 | 4.38 | 4.36 | 4.16 | 3.49 | 2.91 | 3.28 | 4.35 | 4.38 | 4.38 | |
| End of Week 2 Cover and Canopy Moisture | (inches) | | 4.38 | 4.38 | 4.31 | 4.38 | 4.34 | 4.03 | 3.23 | 2.95 | 3.53 | 4.38 | 4.38 | 4.38 | |
| End of Week 3 Cover and Canopy Moisture | (inches) | | 4.38 | 4.38 | 4.28 | 4.38 | 4.32 | 3.89 | 2.97 | 2.99 | 3.78 | 4.38 | 4.38 | 4.38 | |
| Ending Cover and Canopy Moisture | (inches) | [14] | 4.38 | 4.38 | 4.24 | 4.38 | 4.30 | 3.75 | 2.71 | 3.03 | 4.02 | 4.38 | 4.38 | 4.38 | |
| Week 1 Percolation Below Root Zone | (inches) | | 0.16 | 0.09 | 0.00 | 0.10 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.61 | 0.26 | |
| Week 2 Percolation Below Root Zone | (inches) | | 0.16 | 0.09 | 0.00 | 0.24 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.30 | 0.61 | 0.26 | |
| Week 3 Percolation Below Root Zone | (inches) | | 0.16 | 0.09 | 0.00 | 0.24 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.33 | 0.61 | 0.26 | |
| Week 4 Percolation Below Root Zone | (inches) | | 0.16 | 0.09 | 0.00 | 0.24 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.33 | 0.61 | 0.26 | |
| **Monthly Percolation Below Root Zone** | **(inches)** | [15] | **0.62** | **0.37** | **0.00** | **0.81** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.95** | **2.45** | **1.03** | **6.23** |
| **Monthly Percolation Below Root Zone** | **(gal/acre)** | | **16,838** | **10,048** | **0** | **21,998** | **0** | **0** | **0** | **0** | **0** | **25,889** | **66,537** | **27,837** | **169,148** |

**FIGURES**

Figure 1: Root system for a 5-year old hybrid poplar tree growing in silt-loam soil. The 7 ft deep root system provides nitrogen removal for irrigated leachate at the Riverbend Landfill, McMinnville, Oregon.

Figure 2: Planting 5 ft tall hybrid poplar whips into 4 ft of soil covering construction debris waste, Lakeside Reclamation Landfill, Beaverton, Oregon (1990).

Figure 3: Lakeside Reclamation Landfill in 1997, 7 years after planting.

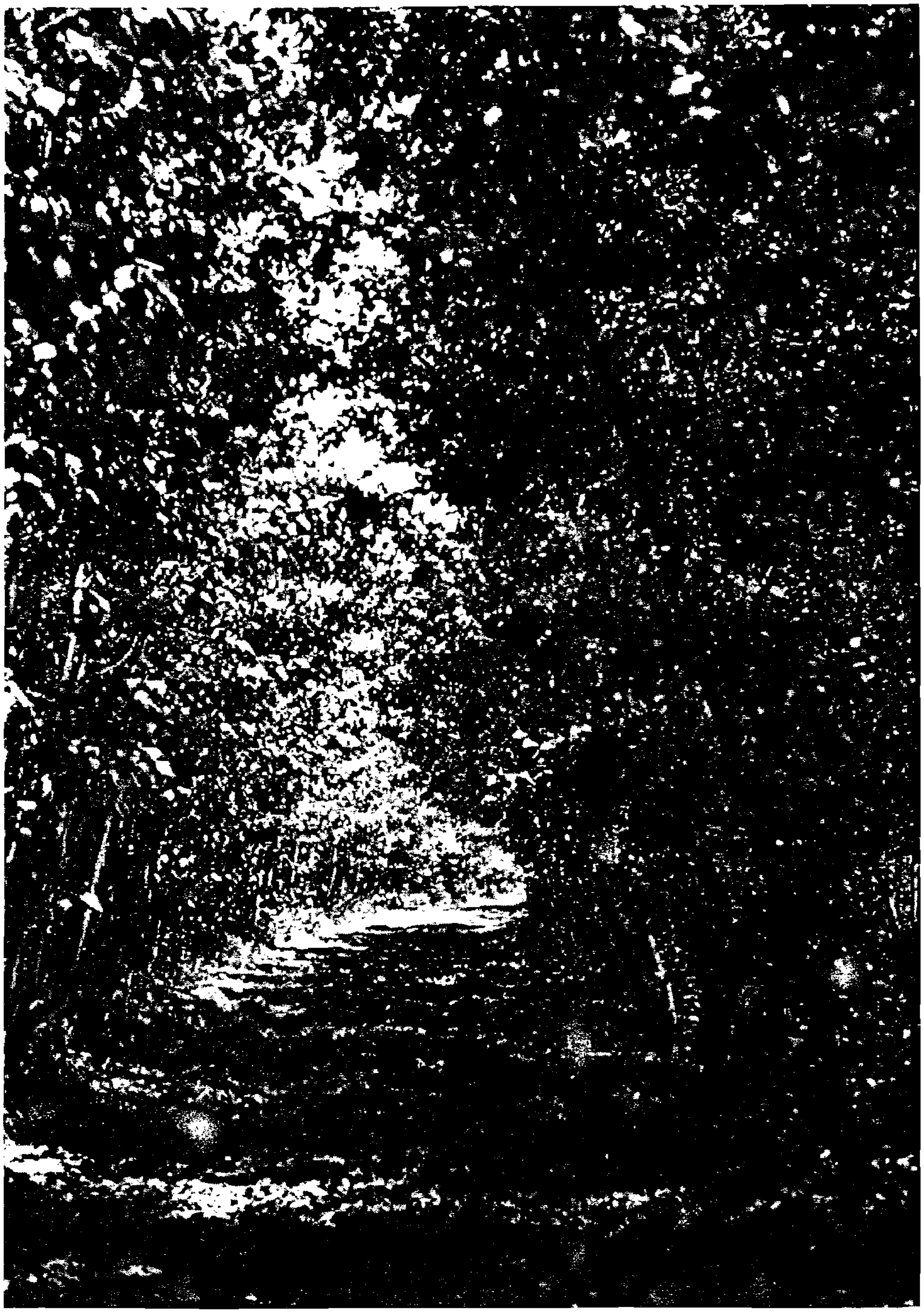

Figure 4: Conceptual ECap design showing system layout and hydrologic inputs and outputs.