COLLEGE OF ENGINEERING

Chemical, Biological, and Environmental Engineering

DESIGN OF A LEACHATE TREATMENT SYSTEM FOR IRON AND AMMONIA REMOVAL AT THE TILLAMOOK COUNTY CLOSED LANDFILL

The Goal: Design of a passive leachate treatment system to meet iron and ammonia effluent requirements at the Tillamook Landfill.

BACKGROUND

The Tillamook Closed Landfill (TCL) has seen the accumulation of dilute, low-strength leachate from spring water and stormwater intrusions. Due to detection of high iron and ammonia concentrations, the county has requested the development of a long-term treatment solution that is hydraulically capable of discharge onto a one-acre vegetated swale located below the landfill.

Specific objectives include meeting area constraints as well as anticipated permit requirements, as seen in Table 1. Both a pilot and full-scale implementation of the selected processes will be investigated. Approximately 0.8 acres are available for full-scale construction with an additional 0.1 acres for a pilot study. Maintaining system passivity is a key design priority.

Table 1. Anticipated permit effluent limits.

Constituent	Daily Maximum	Monthly Avg.
Total Recoverable Iron	1.6 mg/L	0.95 mg/L
Total Ammonia	5.3 mg/L	3.0 mg/L
pH	6.5-8.5	
TSS	< 100 mg/L	

PROCESS SELECTION

ALTERNATIVES ANALYSIS

Iron and ammonia removal methods were evaluated using a quantitative rating scale based on the following criteria, with higher associated weights defining relative importance:

- **Primary** (~15%): size, permit limits
- **Secondary** (~10%): maintenance, cost, energy, chemical, and operational requirements
- **Tertiary** (1-5%): aesthetics, local resources, safety, scaling capability

Table 2. Summary of process alternative scores.

Iron Removal Processes	Score	Ammonia Removal Processes	Score
Aeration/Flocculation/Filtration	**3.83**	FWS Wetlands	3.76
Electrocoagulation	3.4	Sequencing Batch Reactor	3.72
Vertical Flow Reactor	3.53	Rotating Biological Contactor	3.76
HSSF Wetlands	**3.82**	**Trickling Filters**	**3.82**

FINAL DECISION: Aeration/sedimentation, trickling filters, and HSSF wetlands were selected for further investigation based on superior treatment passivity and ability to meet discharge & space requirements.

Oregon State University

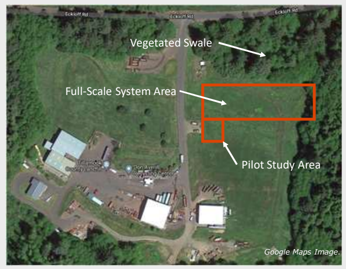

Image 1. Overhead view of the landfill, with the available space for the treatment system outlined.

Image 2. Abundant Tillamook wetlands allow access to emergent vegetation for constructed wetlands.

Image 3. Parametrix pilot study of cascade aeration, polymer flocculation, and settling experienced excess clogging and build-up from the iron precipitate.

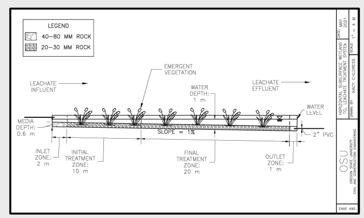

Figure 1. Design of a single horizontal subsurface flow wetland. Polishing step for iron and ammonia removal.

DESIGN METHODOLOGY

THE APPROACH

A performance-based process sizing approach used historical data to select raw leachate parameters:

- Max flow: 80 gpm
- Min flow: 5 gpm
- Temp: 10°
- Influent pH: 7
- Max influent iron: 12 mg/L
- Max. influent NH_3: 13 mg/L

Conservatism was integrated into design by selecting high temp. adjustment factors, high flow rates, low temperatures, and low rate constants from ranges.

AERATION/SETTLING: IRON REMOVAL

Oxygen transfer principles and PIRAMID (2003) guidelines for passive pollutant removal from metalliferous AMD were used to model 3 processes:

1. Oxic limestone drain (OLD) to increase leachate pH, promoting iron precipitation
2. Cascade aeration to encourage iron oxidation
3. Settling lagoon to remove iron precipitate

TRICKLING FILTERS: AMMONIA REMOVAL

Adapted from Tchobanoglous et al. (2003), the NRC method was used to model nitrification in for ammonia removal with plastic packing media. Loading rates determined filter area and bed volume.

HSSF WETLANDS: POLISHING STEP

Constituent removal processes were modeled by plug flow first-order reactions, based on standardized kinetic parameters from Kadlec & Knight's (1996) *k-C** model. Darcy's Law governed characteristic wetland width to prevent overland flow within initial and final treatment zones (30% and 70% of the active surface area, respectively).

HYDRAULIC CONSIDERATIONS

An optimal configuration provides sufficient hydraulic head to overcome energy losses from friction, valves, and fittings for direct discharge to the vegetated swale. Pipes were sized to maintain flow velocities of 1-3 m/s to prevent clogging.

DESCRIPTION OF DESIGN

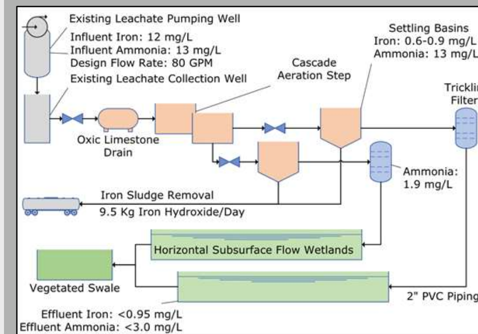

Figure 2. Full process flow diagram detailing chronological order of design elements, from influent to the collector well and discharge from wetlands.

Table 3: Design element purpose and sizing information

Design Element	Purpose	Dimensions
Oxic Limestone Drain	Alkalinity Generation	3 m x 1 m x 1 m
Cascade Aeration Step	Iron Oxidation	2 m x 1 m x 2 m
Settling Basin (2)	Iron Removal	Total Area – 500 m^2 25 m x 10 m x 1 m
Trickling Filter (2)	Ammonia Removal; Supply DO	Total Area - 84 m^2 Diameter – 5.2 m Depth – 1 m
HSSF Wetlands (2)	Polishing	Total Area – 1500 m^2 30 m x 25 m x 1 m

CONCLUSIONS

The leachate treatment design is expected to meet iron & ammonia discharge limits and space constraint.

- Triangular trough in OLD design could prevent clogging
- Single-step cascade aeration system (0.8-m falling jet) provides aeration for 95% iron removal during settling
- Trickling filters sized to achieve ~86% nitrification, reducing effluent ammonia to 1.86 mg/L.
- Assuming 75% and 85% prior removal of ammonia and iron, monthly average limits are met for typical flows (10-30 gpm) and daily maximum limits are met for all flow rates through the 2 HSSF wetlands in parallel.

NEXT STEPS

Unit Process Considerations

- Hydraulic conductivity: limestone vs. crushed oysters
- Hydrolysis impacts on pH and iron removal efficiency
- Quantification of DO and carbon production by TFs to ensure ammonia removal in HSSF wetlands
- Analysis of bioconversion in the trickling filters
- Incorporate precipitation into wetland water balance

Overall System Consideration

- Finalize configuration of processes
- Hydraulic analysis to ensure gravity-driven flow:
  - Pipe lengths and associated major energy losses
  - Minor losses from fittings, valves, intake structures
- Design and layout of pilot study

ACKNOWLEDGEMENTS

Thank you to Dr. Jeff Nason for guidance and the Tillamook County Public Works Department for design input.

Please refer to attached document on project page for references.