

Design Problem

- Design Problem:** The Client desires an on-site leachate disposal or treatment design to supplement or replace the existing practice of trucking leachate off-site from the Twin Creeks Landfill (TCLF) in Watford, ON
- Leachate is a liquid by-product of landfills, created when infiltrating water percolates in waste storage cells
- The annual leachate volume output from the site ranges up to 35 million litres and is expected to increase as operations grow

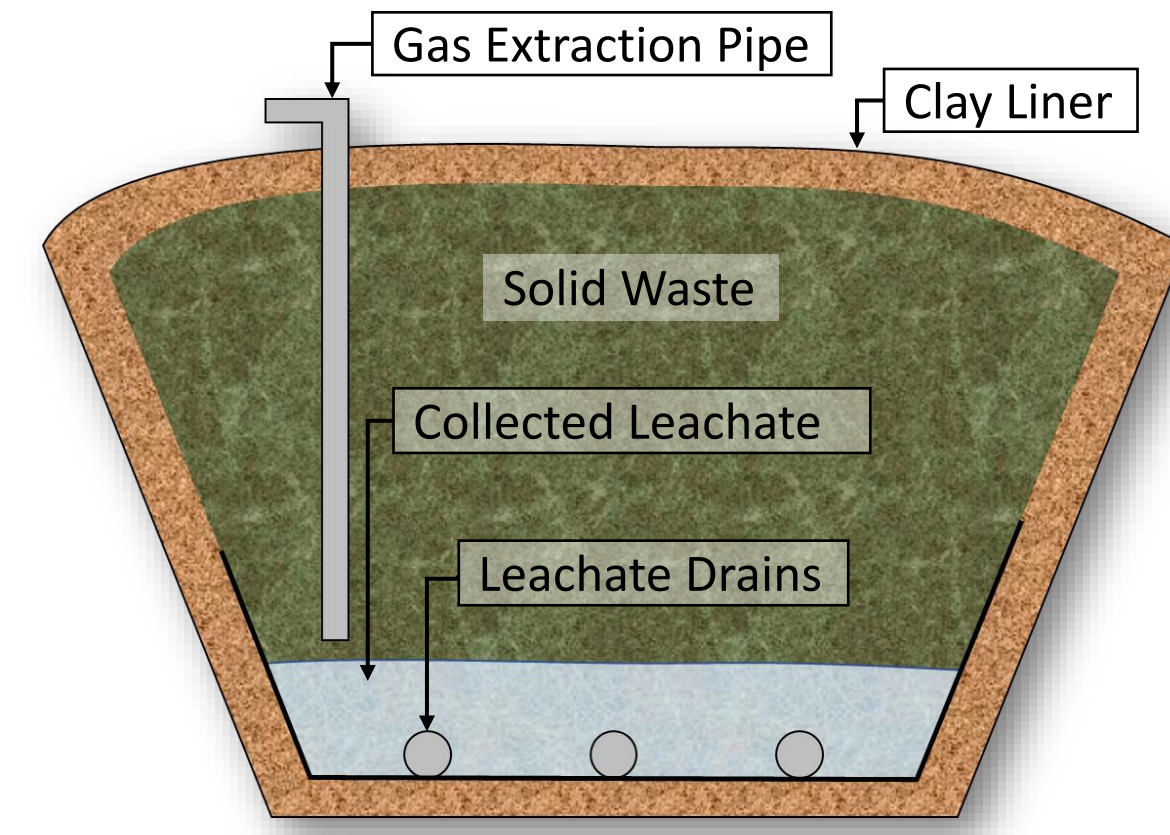


Figure 1. Typical Leachate Collection System in Landfill Cell

Project Site: Twin Creeks Landfill, Ontario

- TCLF is located nearly 2hrs southwest of Waterloo in Watford, Ontario
- The landfill receives more traffic than any in Ontario, with approximately 1.4 million tonnes of waste imported annually
- On-site leachate disposal is limited to an existing poplar tree irrigation system

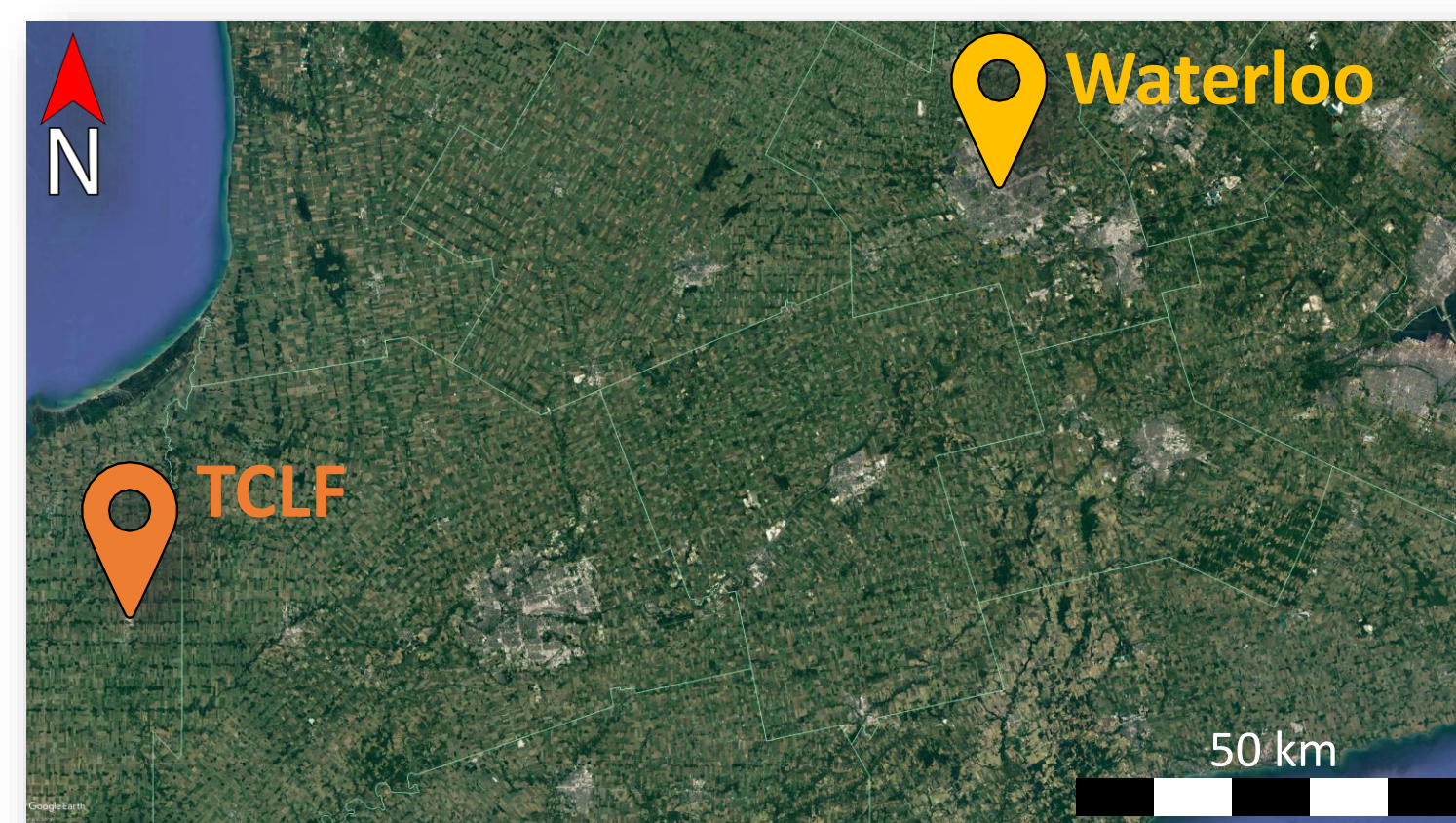


Figure 2. Geographical Site Location of TCLF in Watford, Ontario

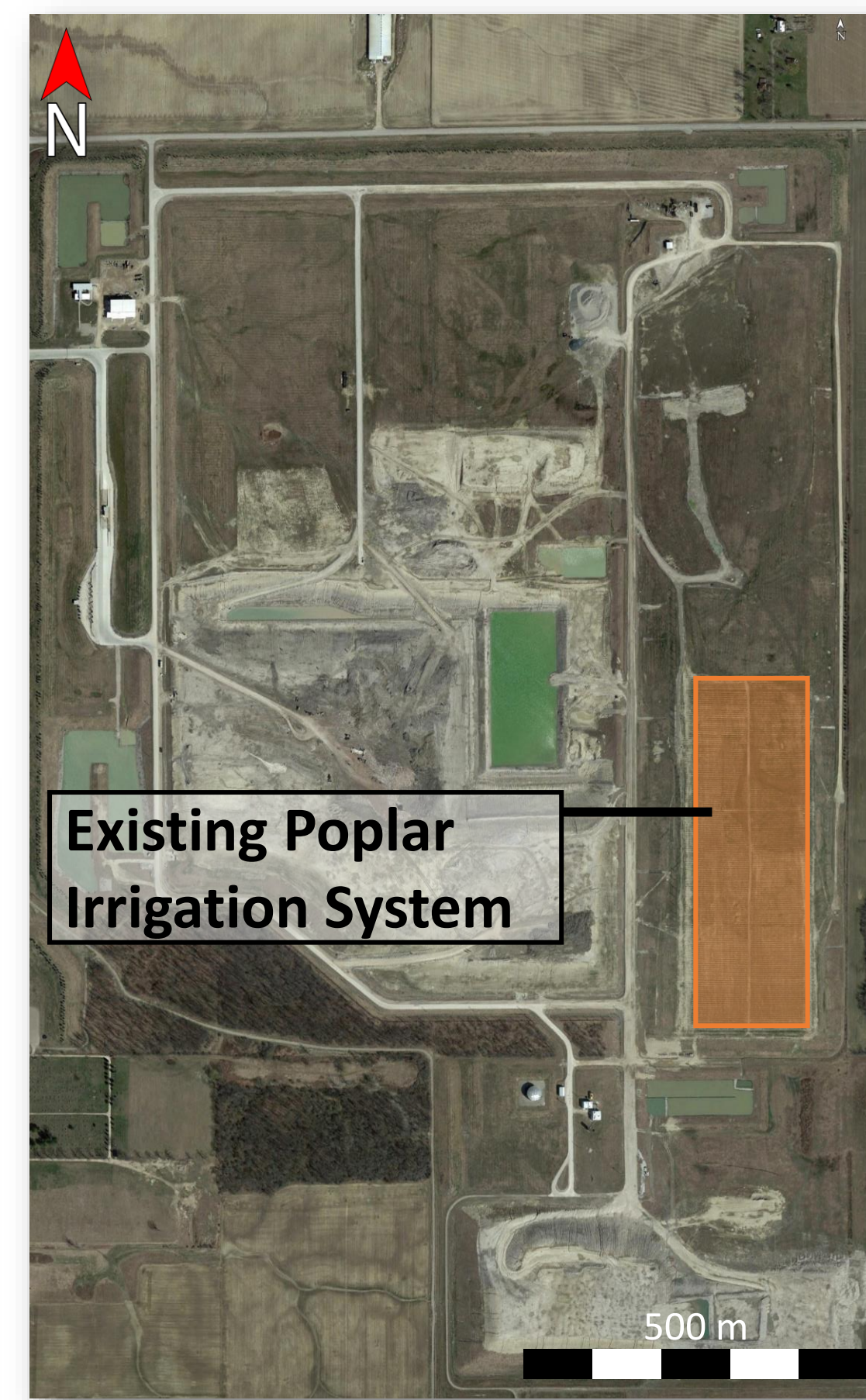


Figure 3. Existing Phytoremediation system

Existing System

- The traditional method of landfill leachate treatment is to export it off-site to a wastewater treatment facility, but this is an expensive solution
- To reduce costs associated with leachate disposal, TCLF constructed a poplar tree phytoremediation system as a solution an alternative
- Since installation, the system has failed to achieve projected leachate irrigation volumes by a significant margin (achieving less than 13% estimated capacity annually)
- The primary reasons for this performance are thought to be channel formation and erosion from uneven grading and poor infiltration
- Due to the toxic nature of leachate, when ponding is detected on the ground surface, the irrigation is immediately be shut off
- Localized ponding therefore may lead to system inefficiencies, despite the system not reaching its leachate uptake capacity

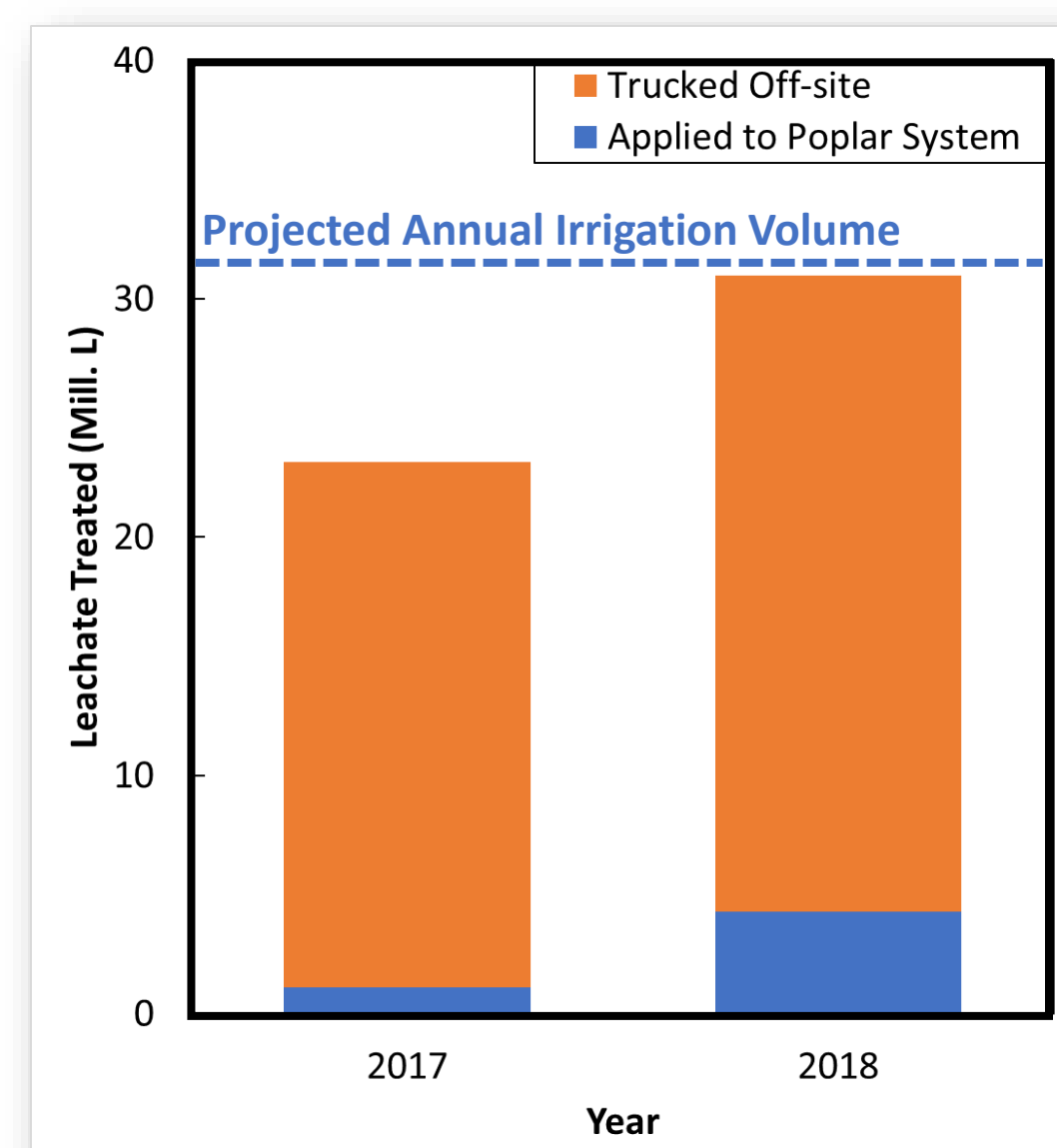


Figure 4. Existing phytoremediation system (Source: RWDI, 2019)

Design Selection Process

Design Alternatives

- On-Site Leachate Treatment Plant
- On-Site Aerated Wastewater Lagoon
- Expansion of the On-Site Poplar Tree Phytoremediation System
- Do Nothing

Design Criteria

- Overall Cost**
 - Construction, Maintenance & Operation
- Contaminant Removal Robustness**
- Environmental Impact**
 - Wetlands & Aquatic Habitats
 - Terrestrial Vegetation & Wildlife
 - Groundwater Contamination
- Societal Impact**
 - Odours
 - Noise
 - Air Quality
 - Effect on Future Developments
- Land Use Constraints**

Design Criteria	Weighting
Overall Cost	0.25
Contaminant Removal Robustness	0.2
Environmental Impact	0.15
Societal Impact	0.1
Land Constraints	0.1

DESIGN RECOMMENDATION:
Based on a multi-criteria decision matrix of the project criteria analysis is the **Expansion of the Poplar Tree Phytoremediation System**

Design Objective

- Design Objective:** Expanding the existing poplar phytoremediation system with a primary focus on increasing overall leachate treatment efficiency and minimizing trucking costs
- Technical Components:
 - Determine poplar tree layout
 - Design a leachate distribution network system
 - Establish the ideal soil conditions



Figure 5. TCLF front gate (Source: Township of Warwick, 2018)

Technical Components

Poplar Trees

- Poplar tree variants were chosen for their resiliency and water uptake capacity
- Multiple satisfactory poplar variants selected to increase crop resiliency
- Tree orientation was modified to match site topography, with rows oriented perpendicular to sloping direction to ensure water moving downslope will cross contact multiple tree rows

Irrigation System

- Irrigation system is organized into zones
- Each zone has electric shutoff valves with remote control capabilities
- Zones are divided based on topography with irrigation lines oriented perpendicular to slope to promote targeted watering/irrigation on topographical highs when lows become oversaturated
- In addition to supply forcemains, flushing mains for daily system clearance will be installed

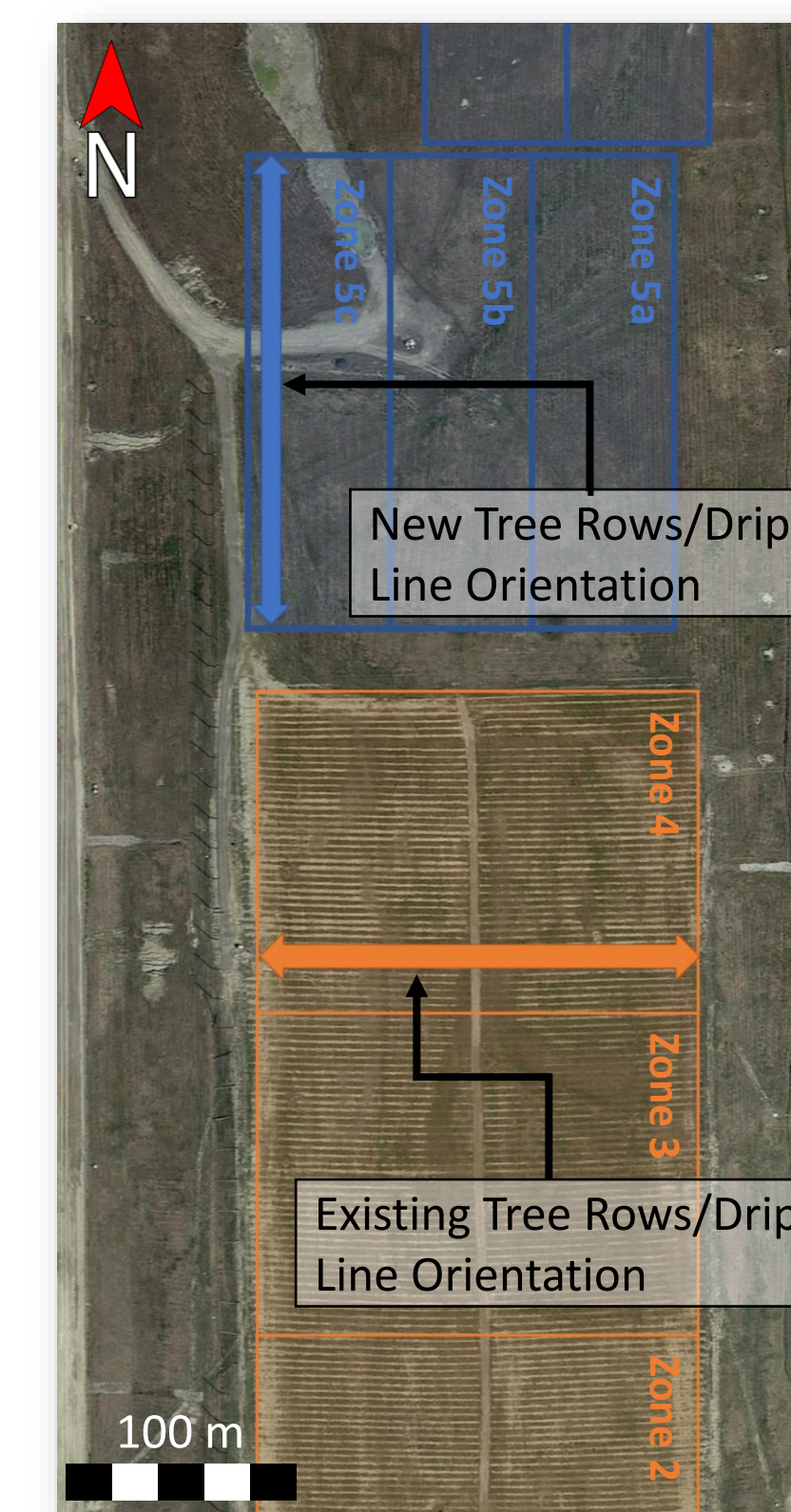


Figure 6. New Tree row & drip line orientation is parallel to slope to enable targeted irrigation

Soil Conditions

- Expanded cell will be uniformly regraded to approximately 4.2 % to prevent channel formation, erosion, and leachate ponding
- The clay soil layer under the overlying topsoil will be replaced with a sandy loam to promote infiltration and minimize ponding

System Modelling

- A stormwater management model (EPA SWMM) was created for both the existing and proposed phytoremediation designs in order to compare their treatment efficiencies
- Leachate irrigation was modelled over eight-hour periods simulating a workday with soil characteristics, grading, evaporation rates, poplar tree evapotranspiration rates, and irrigation rates being included
- A 110-day irrigation season was assumed for this analysis



System Modelling Results

- Two suspected reasons for underperformance of the existing system were excessive leachate runoff and ponding from poor grading and low soil infiltration rates.
- Modelled results showed the new phytoremediation design has:
 - 29 % higher infiltration
 - 13 % less runoff
 - 7% higher leachate treatment efficiency per square metre
- The new system model theoretically has the capability to treat 9.5 million litres of leachate annually



Figure 7. EPA SWMM model of proposed design (left) and existing design (right)

Conclusions and Recommendations

- During Phase I, Globex determined that an expansion of the on-site poplar tree phytoremediation system best suits the Client's design problem
- Globex based its phytoremediation design on literature and an EPA SWMM irrigation analysis during Phase II
- With the addition of the new phytoremediation system, TCLF will have the capability of treating a combined 23 million litres of leachate on-site annually, saving an additional \$95,000 annually in trucking costs
- This would be capable of treating the average TCLF leachate production over the last 13 years
- However, the cumulative systems would treat approximately 65 % of the leachate produced by the landfill annually based on 2018 figures, which is important since leachate production will increase over the next 25 years of landfill operation

Acknowledgements



Guidance from: Dr. Wayne Parker and Dr. Anh Pham