

# ADVANCES IN THE REMEDIATION OF CRUDE OIL AND PRODUCED WATER AT FIELD PRODUCTION WELL SITES IN THE BAKKEN SHALE



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- As early as 1760 Washington used crushed limestone, manure, and gypsum fertilizers and plowed crops of grass, Peas and buckwheat back into his fields.
  
- Man—despite his artistic pretensions, his sophistication, and his many accomplishments—owes his existence to a six inch layer of topsoil and the fact that it rains.

- Author Unknown

**Dig and haul soil to a landfill**

**A nation that destroys its soils, destroys itself.**

**– President Franklin D. Roosevelt, Feb. 26, 1937.**





*Great People + Great Assets = Great Opportunities*

·Do The Right Thing ·Be Passionate ·We All Succeed Together

**Lafferty-DeLuca Services, Inc.**



- This presentation will provide a brief overview of three case studies employing the patented **Cool-Ox**<sup>®</sup> process by DeepEarth Technologies
  
- And three case studies employing the patented **LCA-II**<sup>™</sup> chemical treatment by Lafferty-DeLuca Services

- All soil samples were collected as a composite sample from ground surface to to approximately eight inches below ground surface.
- Each composite sample consisted of five representative sub-samples.
- Samples were preserved in chilled coolers from the time they were collected until delivery to the lab.
- All samples were analyzed for Diesel Range Organics (nC10-nC32) and Gasoline Range Organics (nC6-nC10); Method 8015.

Released produced fluids saturated the primary containment berms inside the treater building and 12 inches below ground surface within the containment berms.



Hydrocarbon impacted berm material



Treated material used on site





Because the Cool-Ox reaction is noncorrosive we are able to treat near pipelines.



Because the chemical is applied employing a high pressure wand we are able to treat in confined spaces.





The impacted area was tilled and treated with Cool-Ox



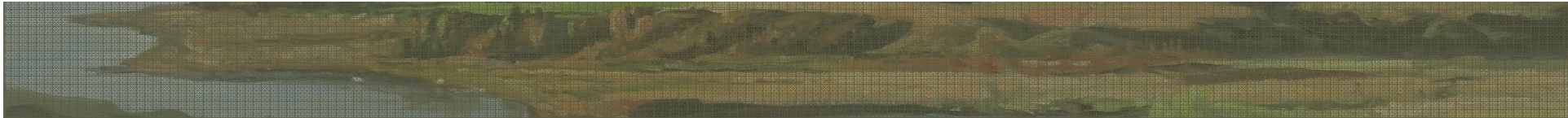




Note, free product puddled

Post treatment view





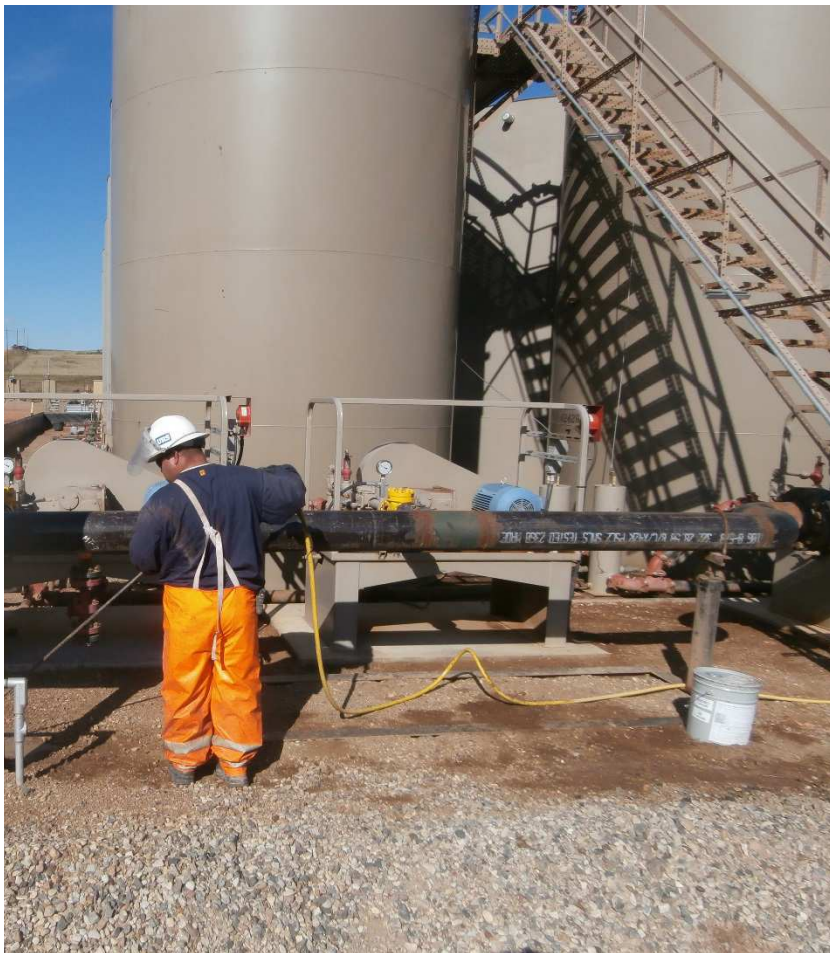
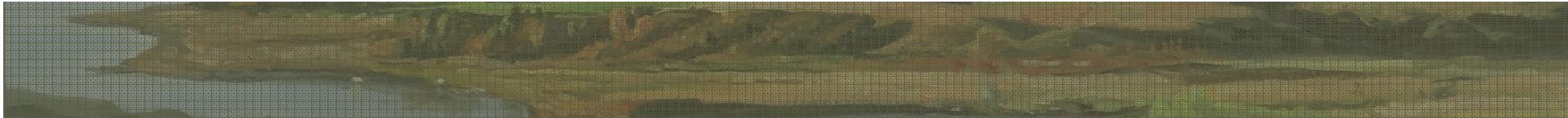
**Again puddled free product**



**Post treatment view**









## Removal of free product



## Application of Cool-Ox



Photographs taken 12 days following treatment of the impacted area with Cool-Ox.





## Summary and Cost Breakdown

Beginning August 14, 2014 DeepEarth Technologies treated 49 facilities including; 27 tank batteries, 8 treater shacks and 14 well heads.

Comparing the cost of treating these facilities with Cool-Ox as opposed to the traditional excavate and haul, DeepEarth Technologies saved **\$144,457.64** a **68% savings**.

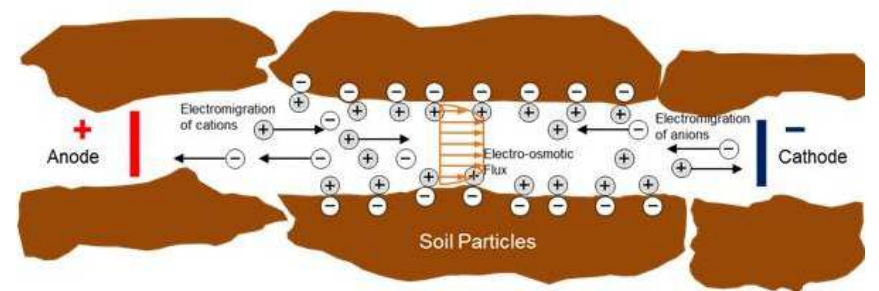
- Dig and haul



- Amend with a calcium amendment

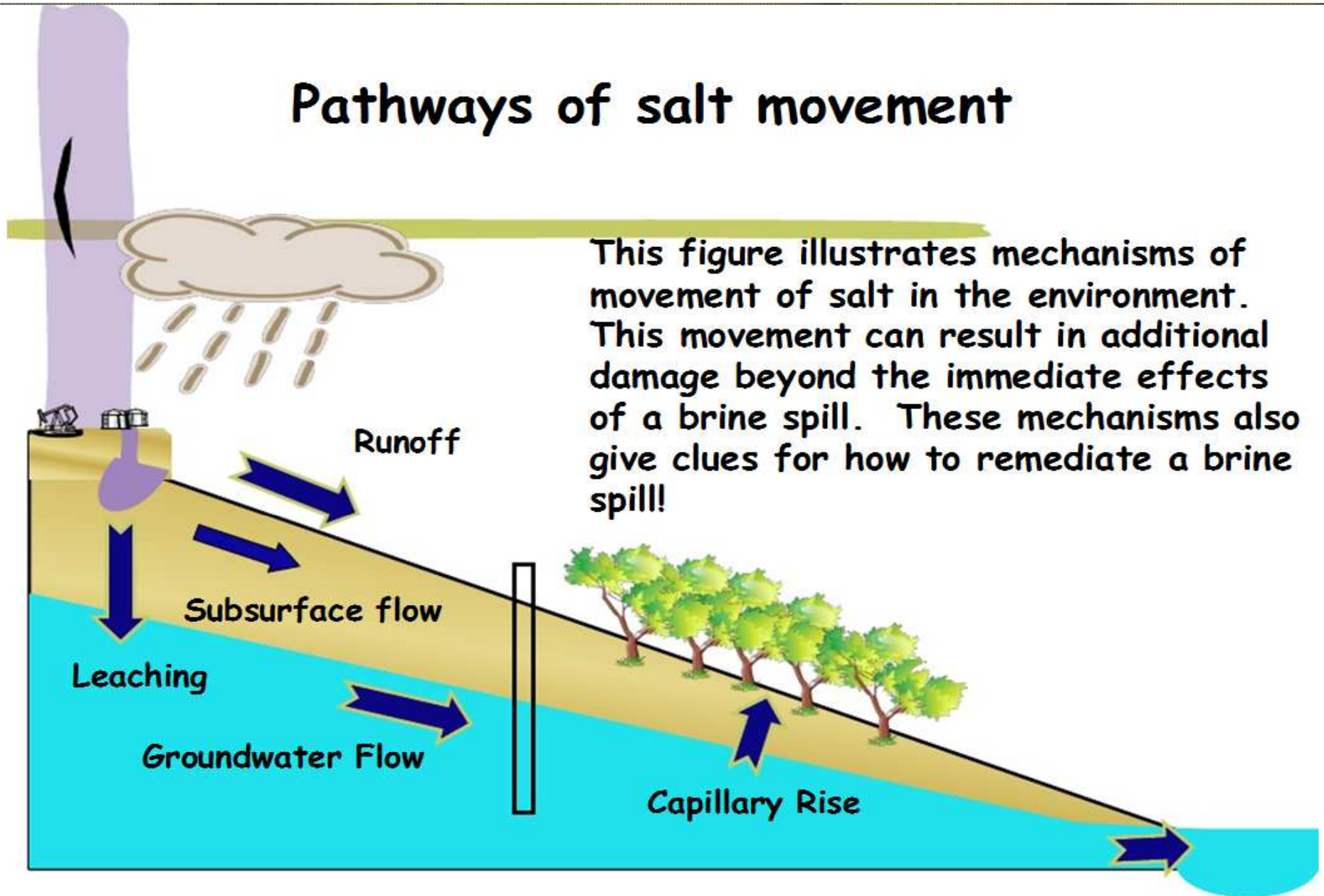


- Electrokinetics



# Pathways of salt movement

This figure illustrates mechanisms of movement of salt in the environment. This movement can result in additional damage beyond the immediate effects of a brine spill. These mechanisms also give clues for how to remediate a brine spill!



*K. Sublette Soil Rem – Brine 6-11 March 24, 2013*

The clay particles were dispersed and the soil had a very high bulk density





Straw and native grass hay was incorporated into the top 12 inches of the soil profile by deep tillage to lower the bulk density of the soil. *LCA-II™* was applied for a Ca source.



A the site was then seeded to durum wheat in late July.

## Brine location A

These photographs were taken late September. Note, there are some undesired species such as thistle present but the durum was able to thrive and develop a harvestable seed head.



## Brine location B

This site was the result of the illegal disposal of produced fluids (brine).



LCA II was topically applied two times during 2013 no addition treatments were applied.



This photograph was taken late August of 2014



## Brine location C



## Brine location C



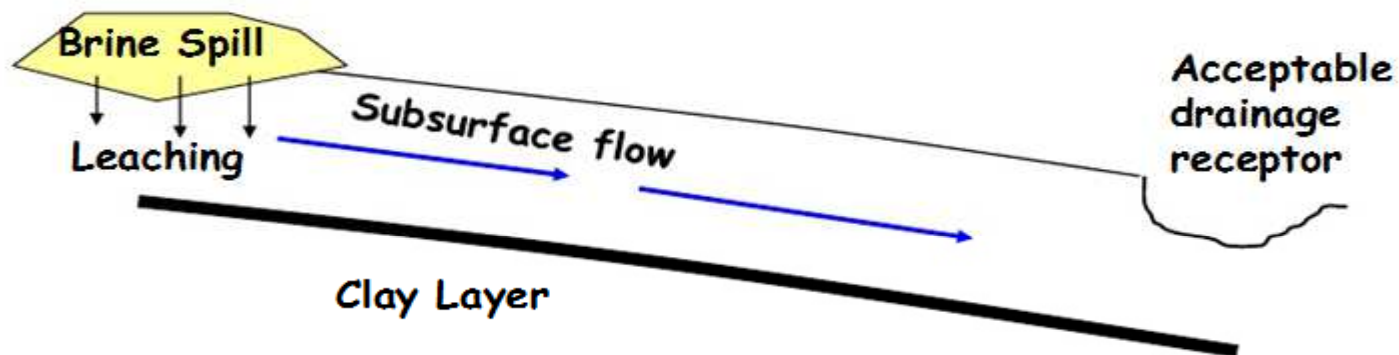


Specific conductance decreased by 48.7 %  
Chloride concentration decreased by 51%



# Lateral drainage: Using the impermeable layer for moving salt

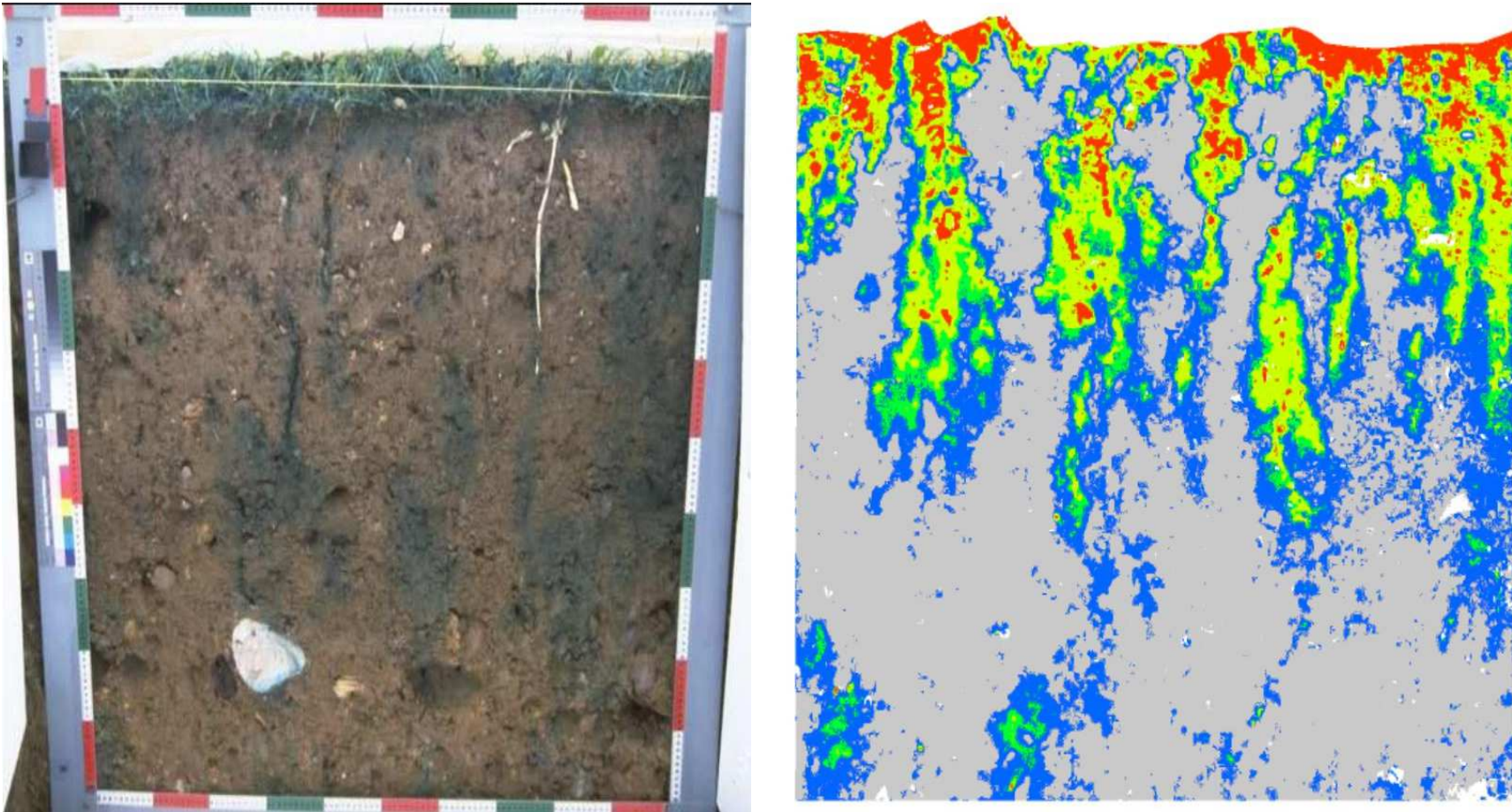
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Using natural drainage patterns: The impermeable layer becomes a salt highway

## Soil movement in the unsaturated zone

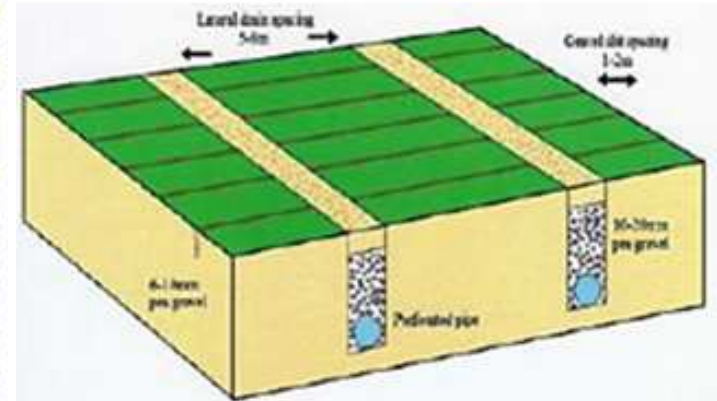
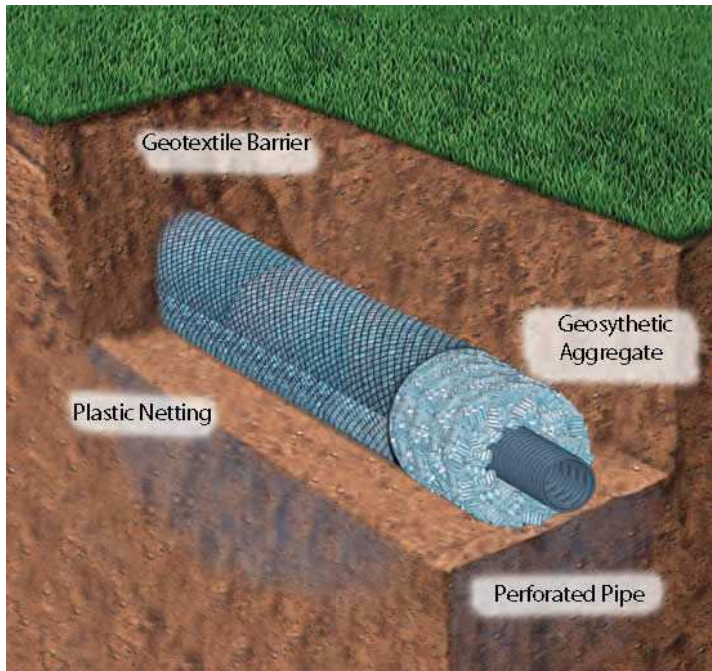
The application of water to move salts through the soil profile is key to success.

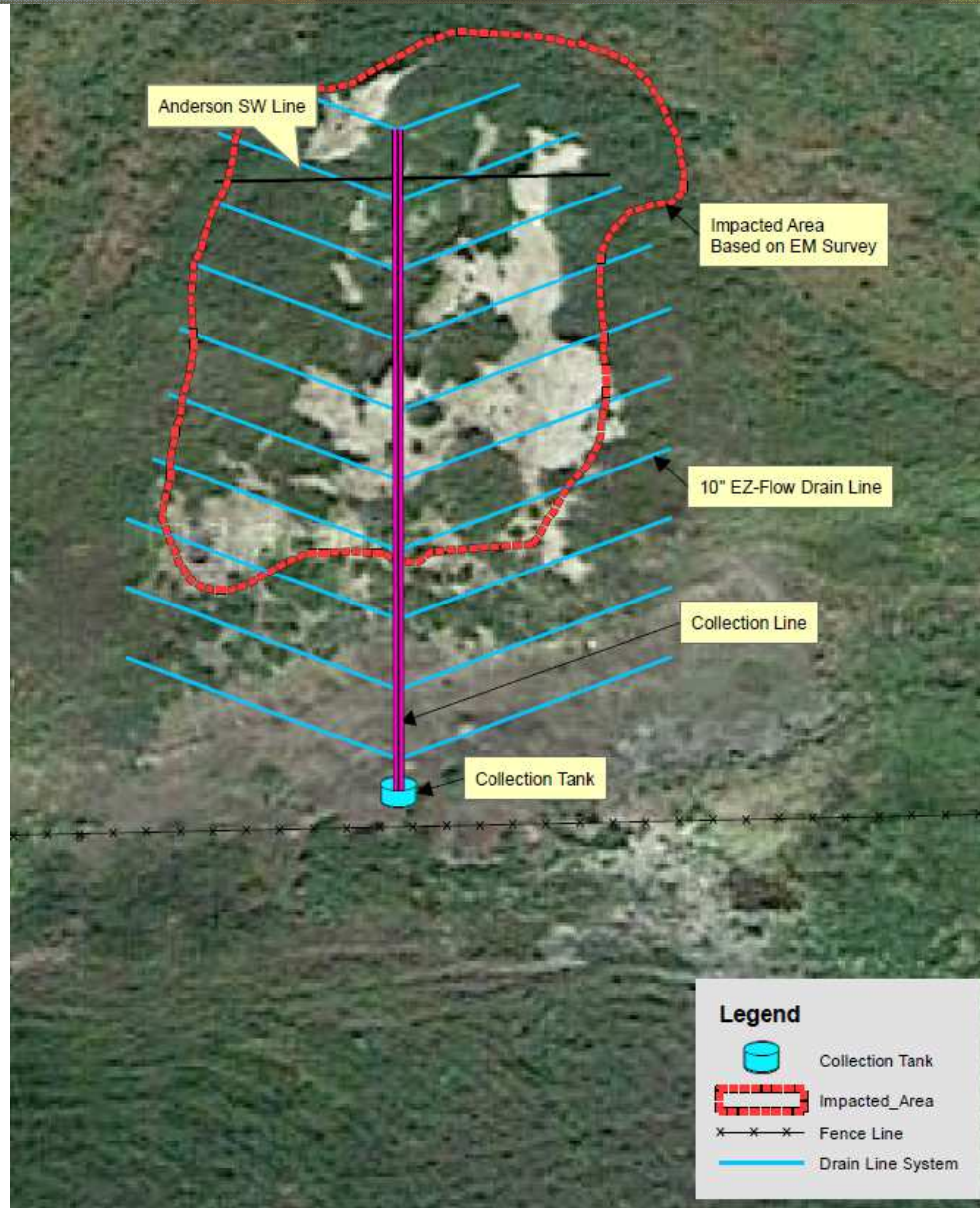


B. McGlynn, 2012 Montana State University

# Improve Natural Drainage

- Install EZ-Flow pipe 2 to 4 feet below ground surface with a 5 to 10 foot spacing.
- Collect and dispose of leachate.





# Recovery tanks



### Employing *LCA-II™* as a soil amendment:

With no recovery of the brine solution we estimate a 70 to 80 % cost savings when compared with the traditional excavation and haul to the landfill.

When a recovery system is installed we estimate a 40 to 60% cost savings. Most of this cost is consumed in the transport of recovered fluids to a disposal facility.