CREATING AND DELIVERING BETTER SOLUTIONS

An Integrated On-site Approach to the Conservation of Soil and Groundwater at a Hydrocarbon and Salt Affected Site

Presented by

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EBA ENGINEERING CONSULTANTS LTD.

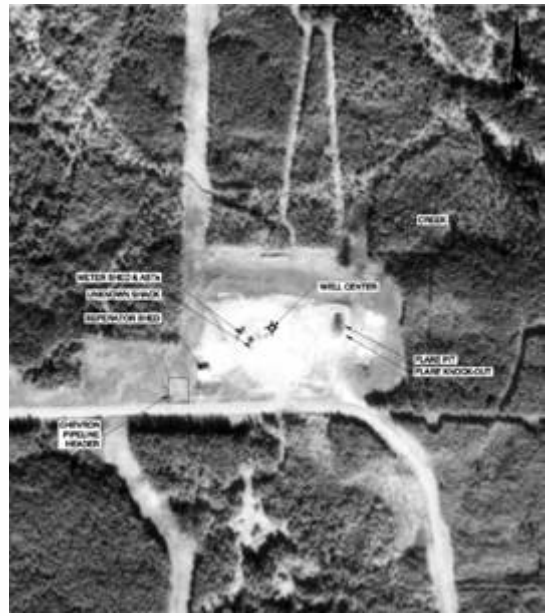
ENVIRONMENTAL SETTING

Remote Site Location

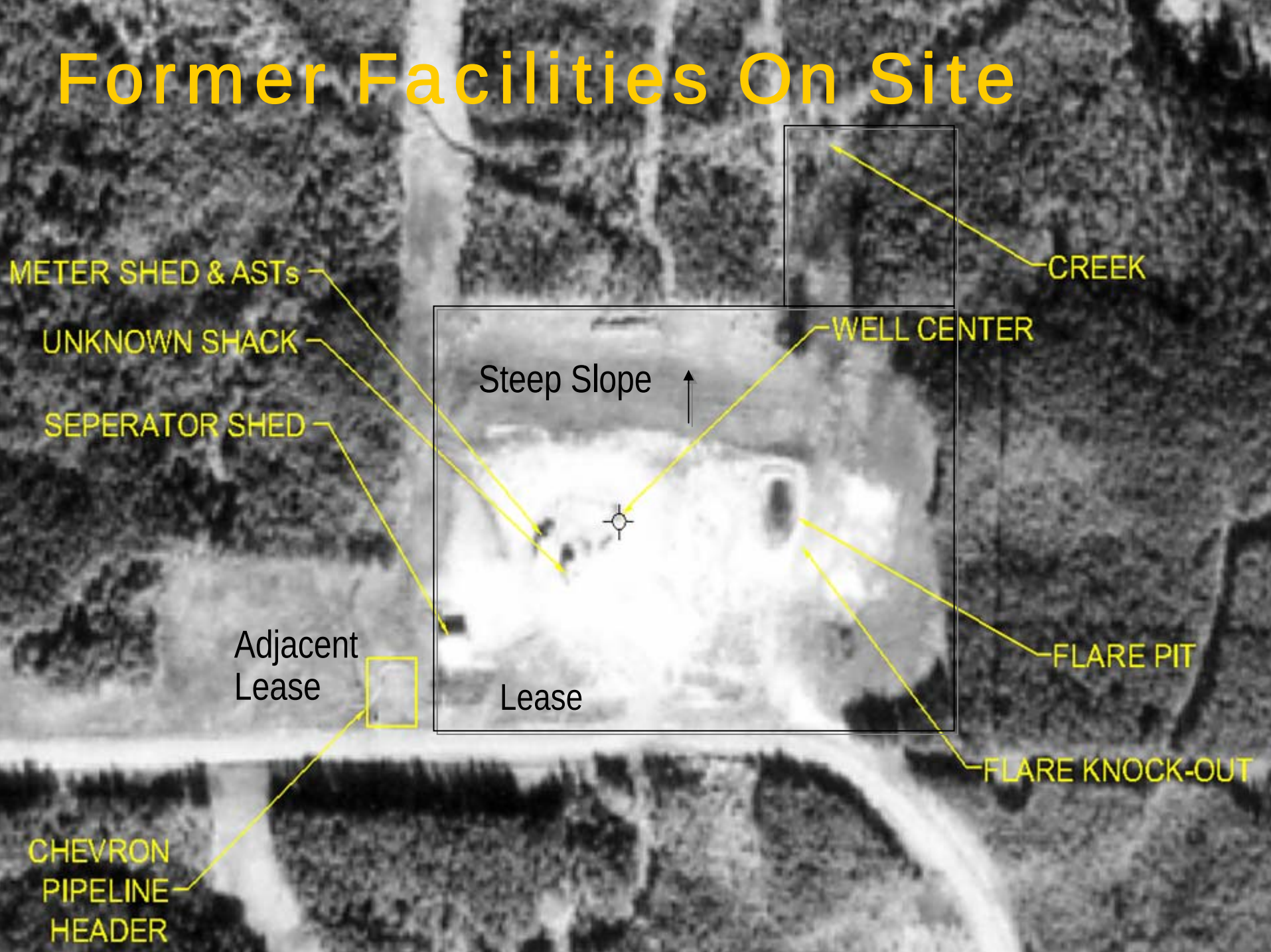
- Located 65 km southeast of Fox Creek, Alberta and 85 km southwest of Whitecourt, Alberta.
- 1-hour drive on rough, windy oil field gravel road with washboard, steep slopes and narrow one lane bridges with limited load rates.
- Site has high annual precipitation.

Site Attributes

- Former well drilled in 1987.
- Decommissioned in 2001.
- Forested Crown (public) Land.
- Lease is cut and fill construction.
- South portion of the lease is a flat terrace, north portion is a steep slope 40 m upgradient of a creek.



Former Facilities On Site



NEED FOR PROACTIVE MANAGEMENT

- Decrease environmental liability.
- Understand financial status of companies and partners.
- Lifecycle project management.
- Proactive management creates favorable company reputation.

Over-riding Goals and Issues

- Reforestation and restoration of the flora and fauna.
- Conserve and reuse existing natural resources.
- Obtain a reclamation certificate.
- Recognize affects of current and potential land use for remote sites.
- Work safely.

Valued Ecosystem Components Needing Conservation

- Aquatic Ecosystem.
  - (Creek approx. 40 m from north edge of lease)
- Existing forest vegetation.
- Soils for forest production.

PRINCIPLE CONCERNS

Regulatory and Landowner Concerns

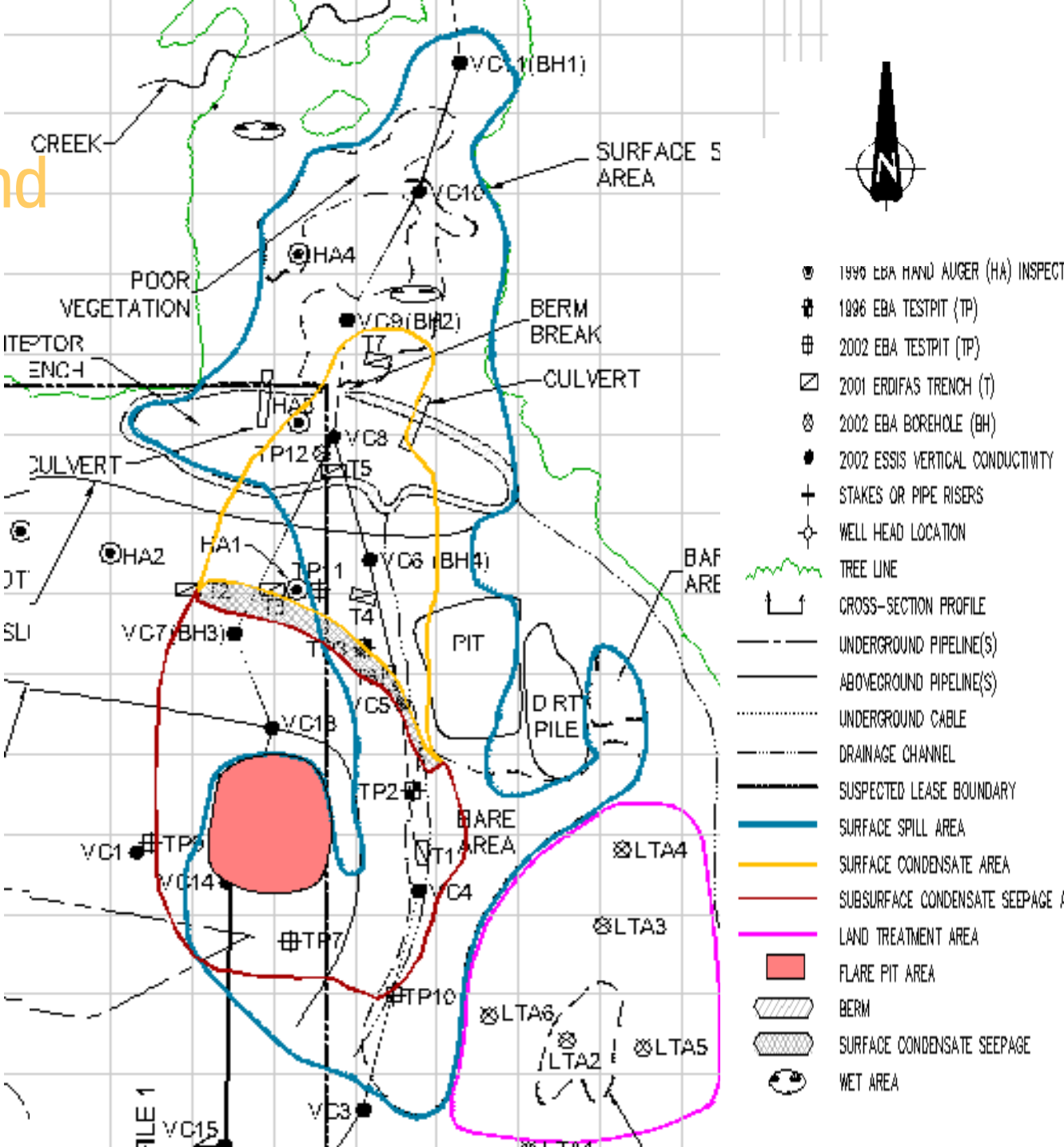
- EUB – doesn't allow partial treatment of oilfield waste.
- AENV – advisor for risk reviews should in situ materials have residual contamination.
- ASRD – do not want to accept lands with residual liability or potential future "adverse affect".
- Alberta Forestry Service – equivalent capability for forestry production of lodgepole pine.
- Agreement that steep slope and land use eliminate groundwater as a receptor. Receptor pathway of concern is the freshwater aquatic life in the adjacent creek.

Volume of Affected Soil and Distribution On Site

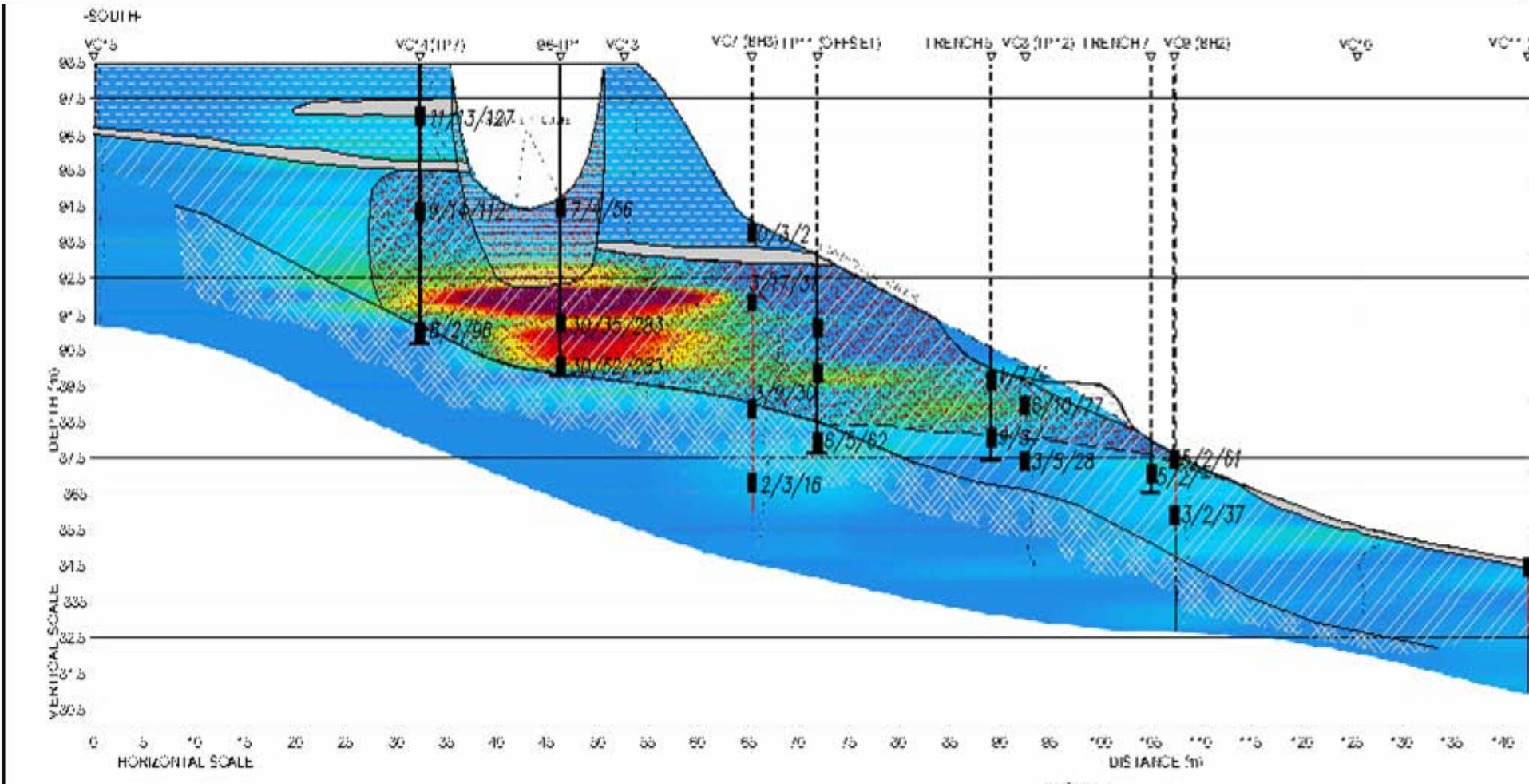
43,000 tonnes – salts and PHCs

18,500 tonnes -PHCs

61,500 tonnes total



Cross-section through Flare Pit



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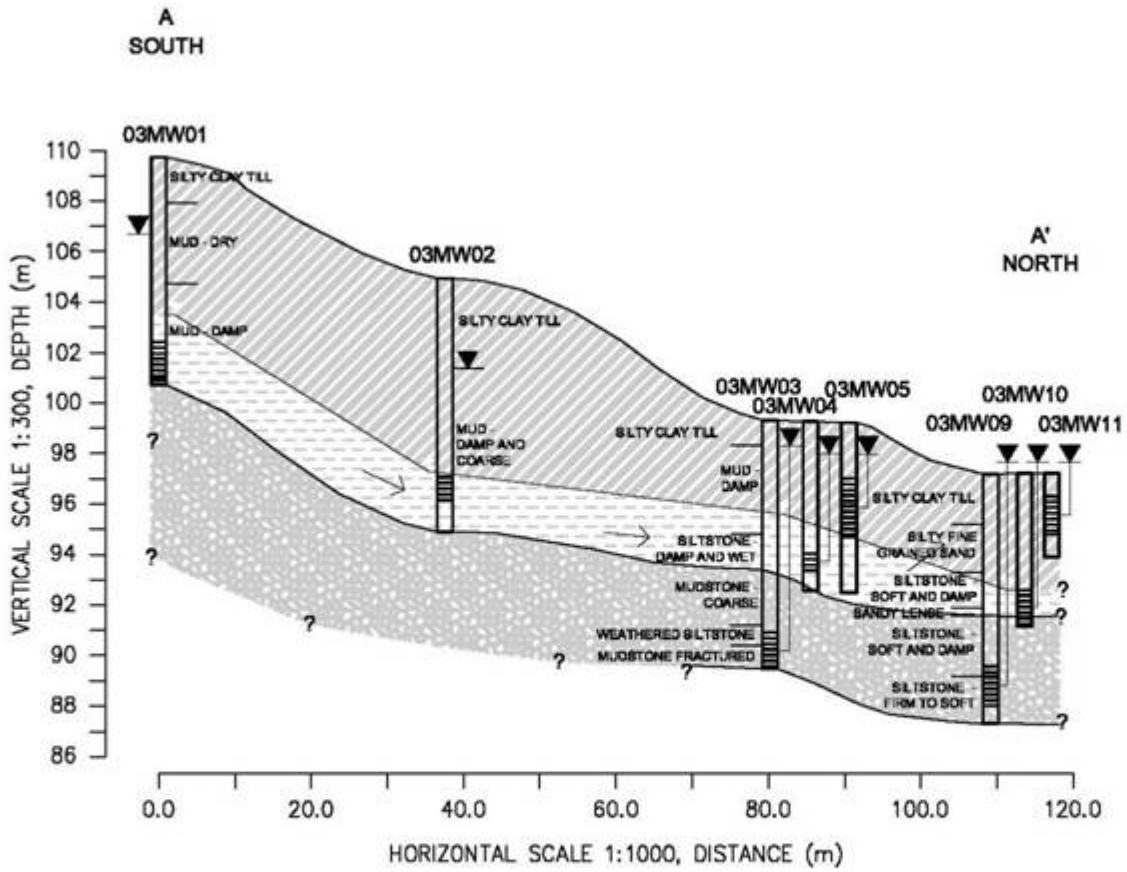
Soil Contamination

- Total PHC concentrations in soil ranged from 2,880 ppm to 78,000 ppm (BTEX, F1 to F4).
- Chloride concentrations in soil ranged from 0 ppm to 2,500 ppm.
- EUB required treatment of both contaminants upon excavation.
- PHC contaminant distribution allowed for some segregation of contaminant types.
- Salt contamination associated with F3 to F4 hydrocarbons and condensate releases.

Groundwater Flow Patterns

- Investigated groundwater flow direction and rates.
- Application of groundwater contaminant distribution modelling (Visual ModFlow).
- Installed 12 monitoring wells on site, 4 drive-point wells off site.
- Stratigraphic units:
  - Till
  - Weathered siltstone – water bearing unit
  - Mudstone and siltstone
- Strong upward gradient on northside of lease.

Groundwater Flow Patterns



LEGEND:

- LAYER 1 – TOP SILTY CLAY TILL
- LAYER 2 – WATER BEARING ZONE
- LAYER 3 – BEDROCK
- DIRECTION OF FLOW

LEGEND:

- MONITORING WELL
- SCREENED INTERVAL
- WATER LEVEL, SEPTEMBER 03

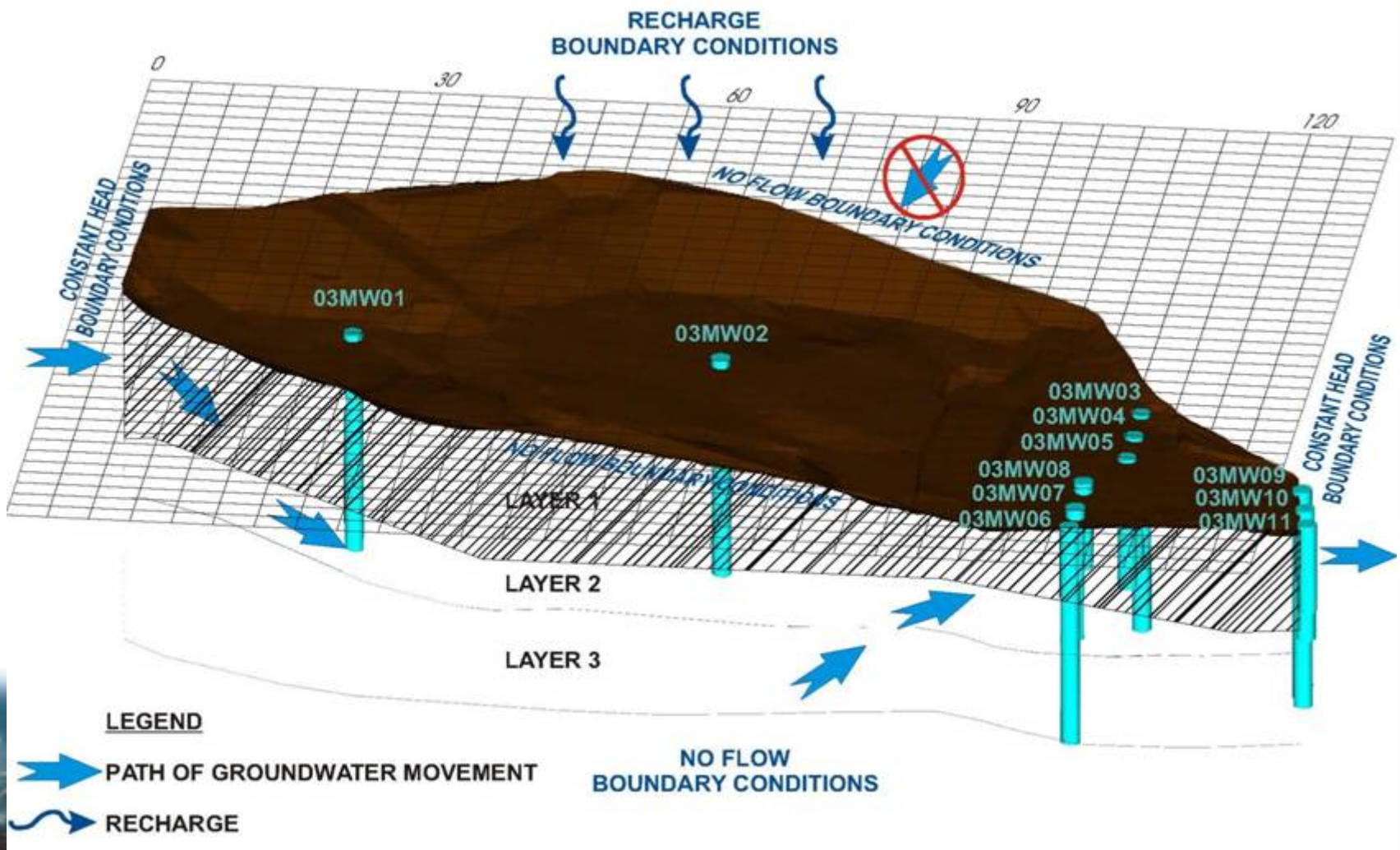
NOTE:

THE GEOLOGIC AND STRATIGRAPHIC SECTIONS SHOWN ON THIS DRAWING ARE INTERPRETED FROM BOREHOLE LOGS. STRATIGRAPHY IS KNOWN WITH CERTAINTY ONLY AT THE BOREHOLE LOCATIONS. ACTUAL STRATIGRAPHY AND GEOLOGIC CONDITIONS BETWEEN BOREHOLES MAY VARY FROM THAT INDICATED ON THIS DRAWING.

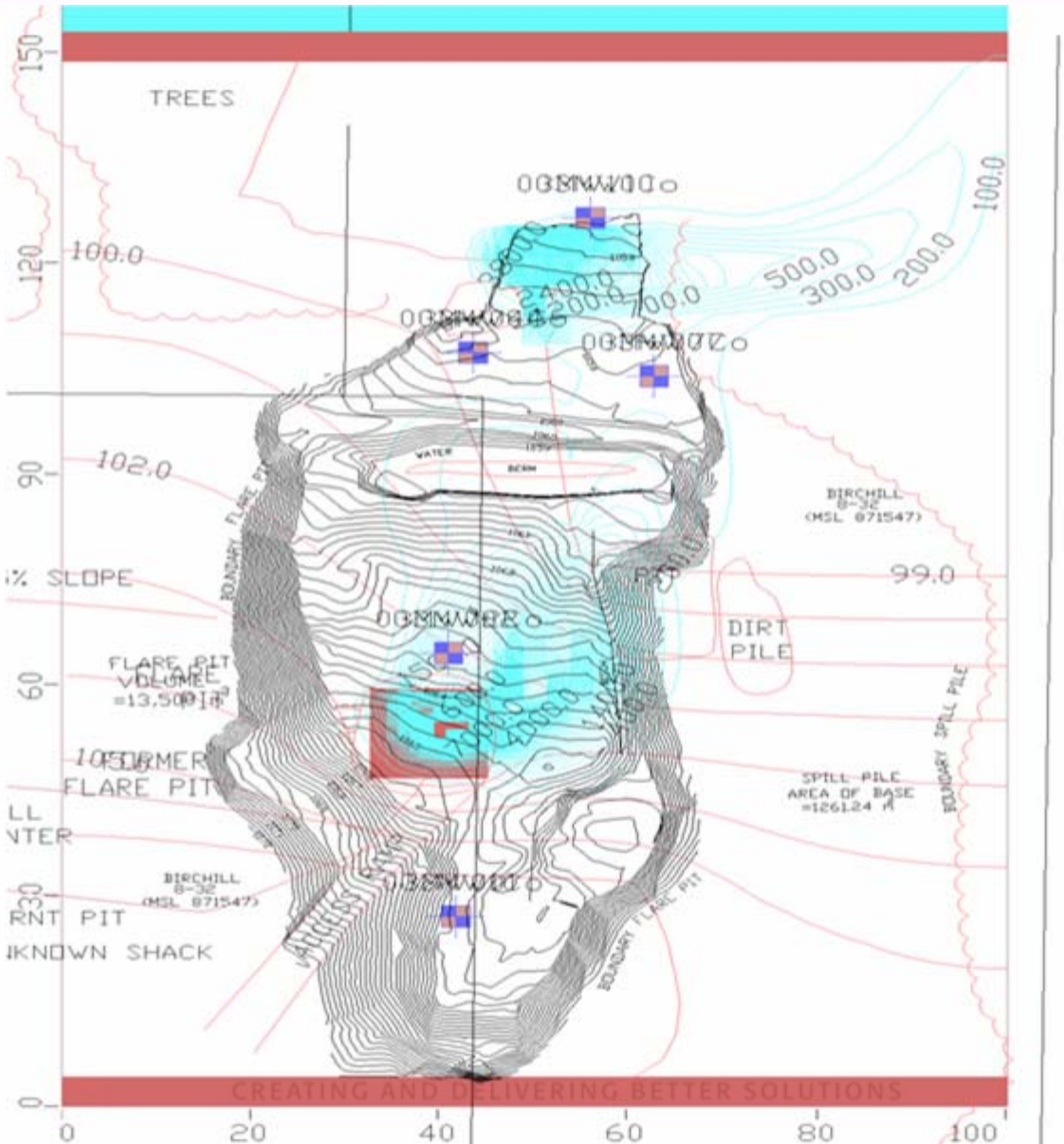
Groundwater Quality

- Chloride concentration between 93 ppm and 1,340 ppm.
- Discharge criteria of 230 ppm continuous release (Surface Water Quality Guidelines for the Protection of Aquatic Life, 1999 for use in Alberta).
- Greatest concentration at shallow depth – mixing with upward moving non-saline groundwater.

Groundwater Modelling



Groundwater Modelling



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Groundwater Modelling

- The salt leaching pad would not change the pattern of recharge and discharge at the site.

- Following chloride source removal chloride concentrations remaining would be rapidly dispersed – groundwater remediation not required to protect the creek.

REMEDIAL ALTERNATIVES

Hydrocarbon Remedial Options

- On-site remediation by biotreatment.
- On-site remediation by thermal desorption.
- Off-site disposal to a Class 2 landfill facility.

Landfilling Concerns

- Expensive due to remoteness and access conditions.
- Safety concerns associated with remote site and access route (i.e., high risk of vehicle accidents).
- No soil conservation.

Proposed Remediation Action Plan (RAP)

- Combined thermal desorption and biotreatment.
- Thermally desorbed material will be placed into a salt leaching cell for salt treatment.
- Some salt impacted material with no hydrocarbon impact will be left in situ and treated.
- Risk assessment will be undertaken on the residual salt remaining if it exceeds soil criteria (Salt Contamination and Remediation Guidelines, AENV, 2001).

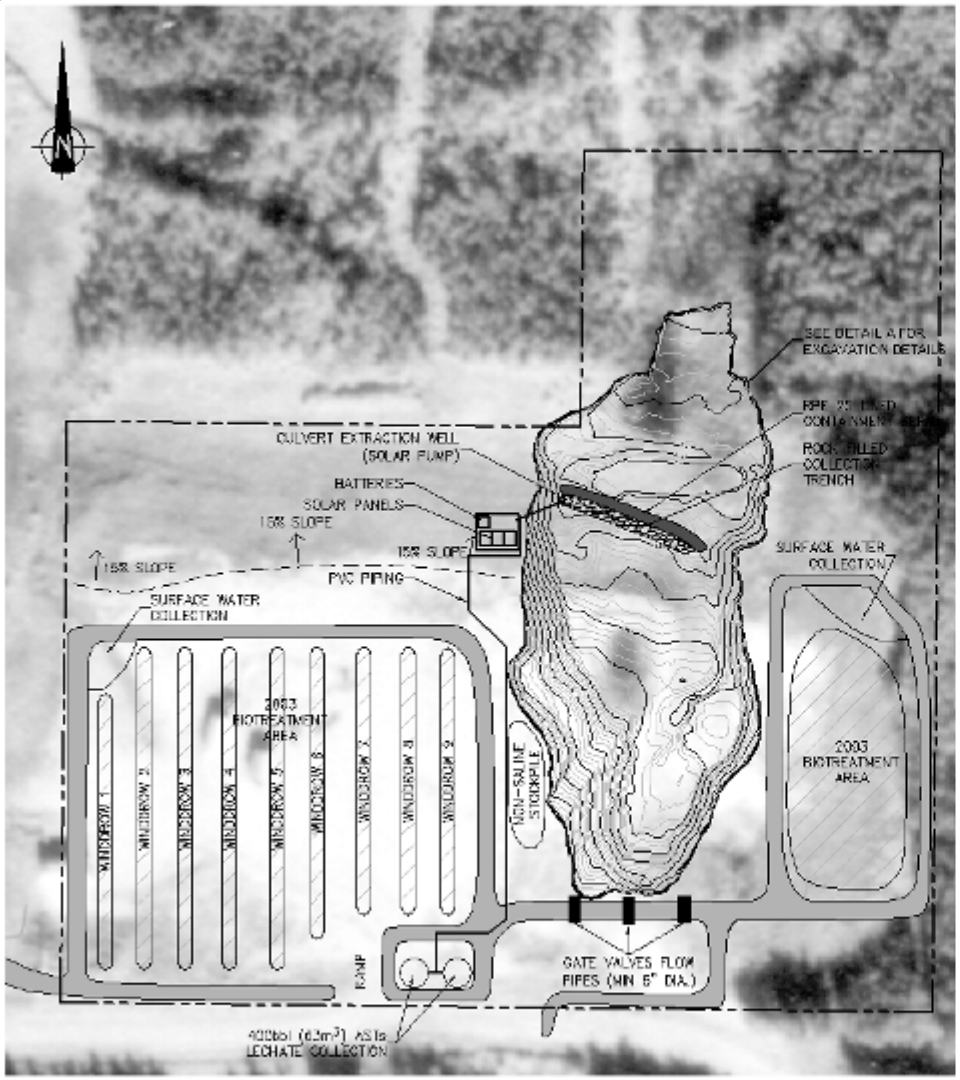
Thermal Desorption

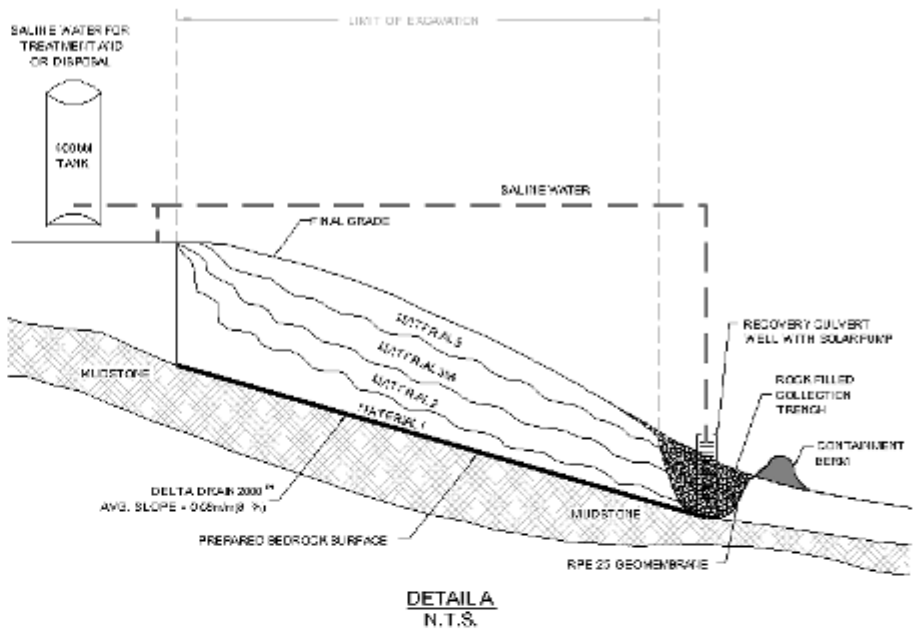
- Less space required than landfilling or biotreatment.
- Treats PHCs but not salts.
- Treatment vs. disposal – conserves soil.

Benchscale Test for Salt Leaching

- Assessed whether calcium amendment was required and, if so, at what rate.
- Assessed affect of bulk density.

Conceptual Salt Leaching Cell Design





DETAIL A
N.T.S.

LEGEND
SUSPECTED LEASE BOUNDARY
CONTAINMENT BERM
BIO TREATMENT WINDROWS

PROJECT TITLE
BIRCHILL RESOURCES PARTNERSHIP LTD.
SUMMARY OF REMEDIAL ACTIVITIES
100/08-32-058-17 W5M

NOTE
ALL UNDERGROUND FACILITIES SHOWN WERE LOCATED INDEPENDENTLY BY SURVEYORS IN THE FIELD PRIOR TO BEGINNING GROUND DISTURBANCE.

BASE SOURCE:
ESRI (2002) - DRGed BASE MAP OF FEATURES
UNIVERSAL SURVEYS INC. - TOPOGRAPHY & CONTOURS
98/08/27 LN 10 AS4556 211 - AERIAL PHOTOGRAPH

DRAWN/CHECKED BY
ANS/RWA/MSW

DATE/EBA PROJECT NO.
04/01/27
5390119

EBA Engineering Consultants Ltd.

SCALE
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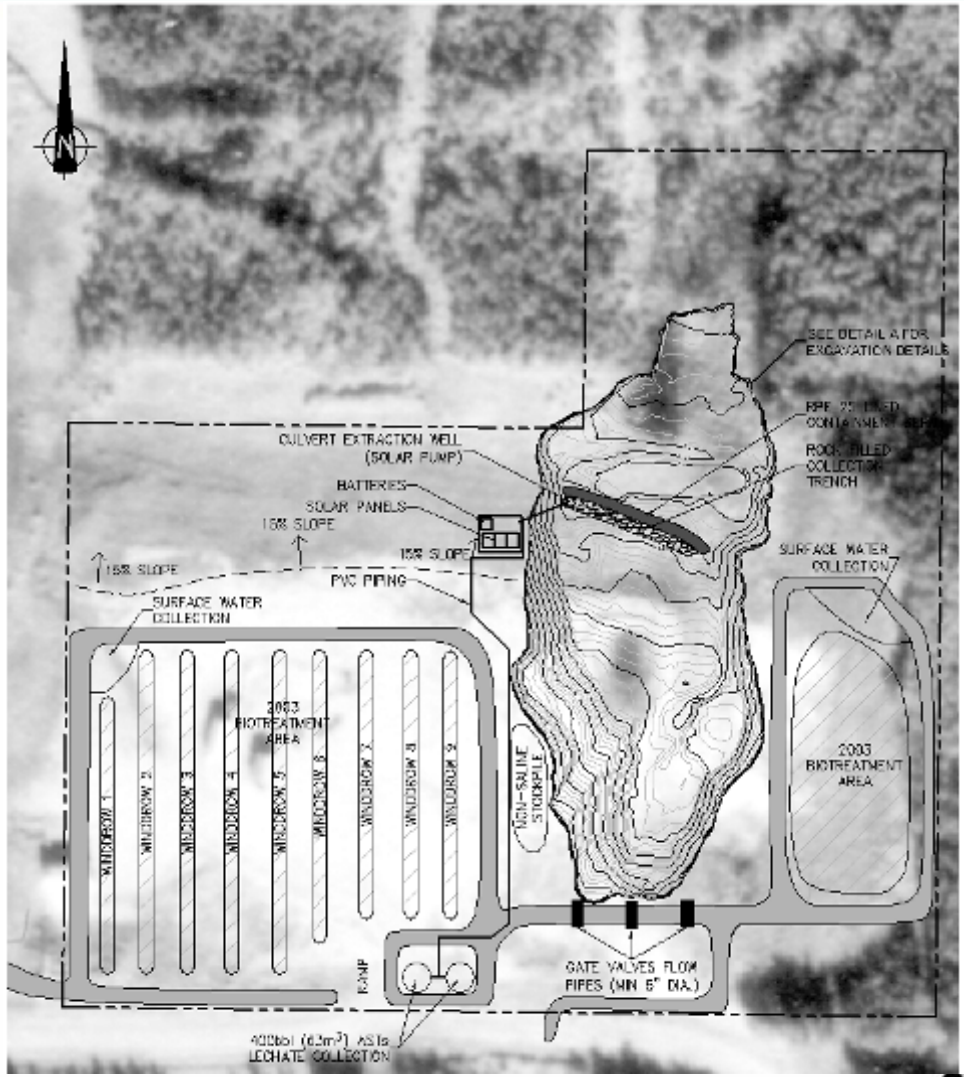
TITLE/EBA DRAWING NO.
DETAILED SALT LEACHING DESIGN
FIGURE 5

Salt Leaching Cell

- Constructed to maximize leaching capacity.
- Collection of leachate downgradient.
- Solar electrical system pumped leachate upslope to treatment:
  - low maintenance costs;
  - low energy usage; and
  - reduced potential for additional fuel spills.
- Water disposal and treatment options were:
  - disposal by injection well (70 km away);
  - reverse osmosis or other treatment; and
  - recycled on site.

Site Organization and Management

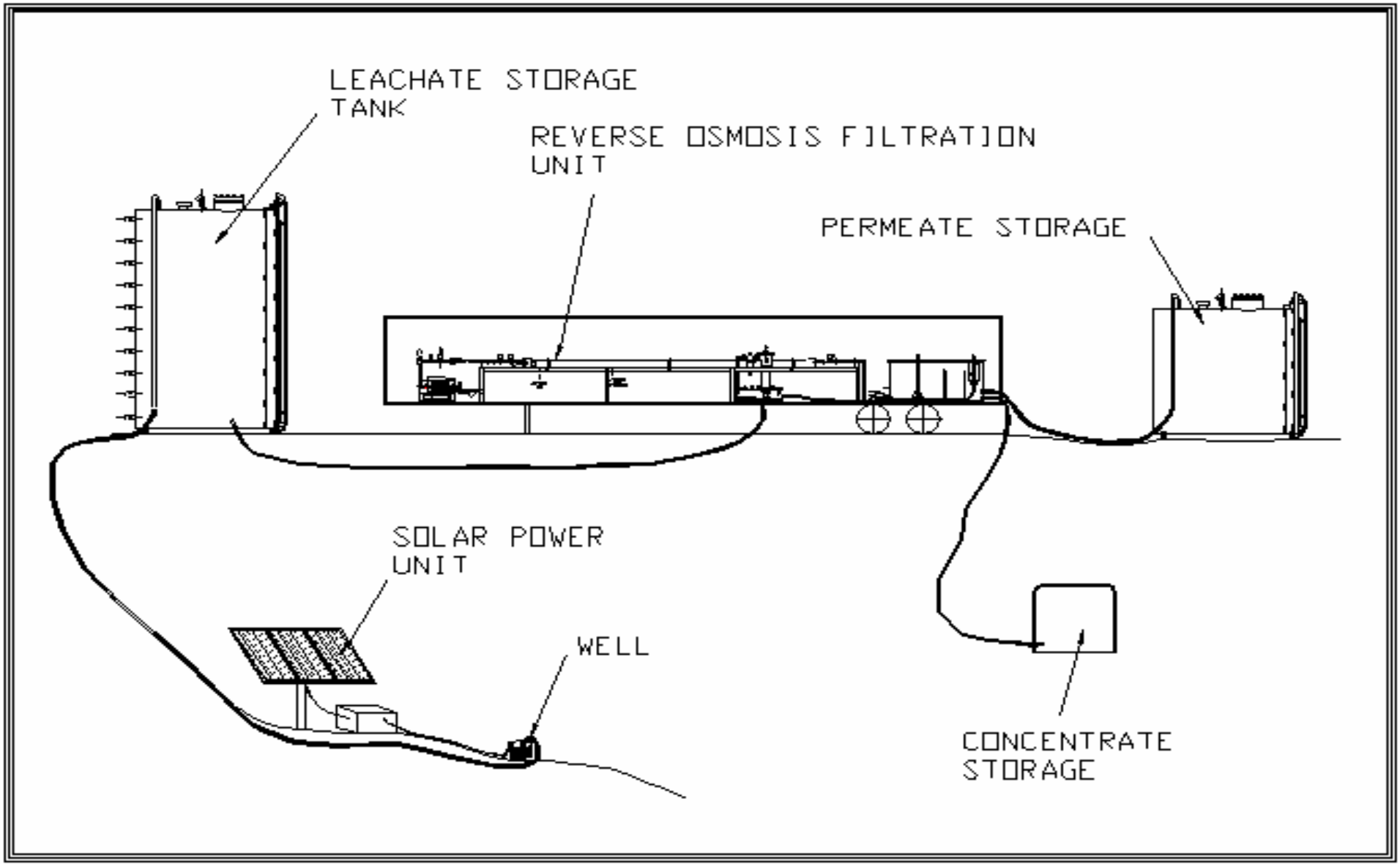
- Captured Surface Water for Leaching.
- Constructed Leaching cell in flare pit excavation.
- Recovered Leachate in collection trench with solar powered pumping system.



Reverse Osmosis Testing

- Pilot Test by Candesal Mobile Treatment Unit
  - Pilot test chosen to determine maximum efficiency of recirculation through RO.
- Water needed prefiltration prior to reverse osmosis for maximum membrane efficiency.

Pilot Reverse Osmosis Schematic CANDESAL International Corporation



- Result: Leachate volume was reduced by 95% through RO treatment. Disposal of 5% of concentrate.

Conservation of Soils

- Soil treated on site to remove hydrocarbons (thermal desorption) and salt (leaching).
- Soil treated on site to remove hydrocarbons (biotreatment).
- All treated soils where used on site to recontour natural site drainage.

Protection of Aquatic Habitat

- Leachate discharge chloride concentrations are expected to reduce to acceptable levels for surface water discharge.
- All water used for salt leaching was treated on site and released on site.
- All leachate water concentrations at the point of release were equal to or less than 230 ppm (Surface Water Quality Guidelines for the Protection of Aquatic Life, 1999 for use in Alberta).

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