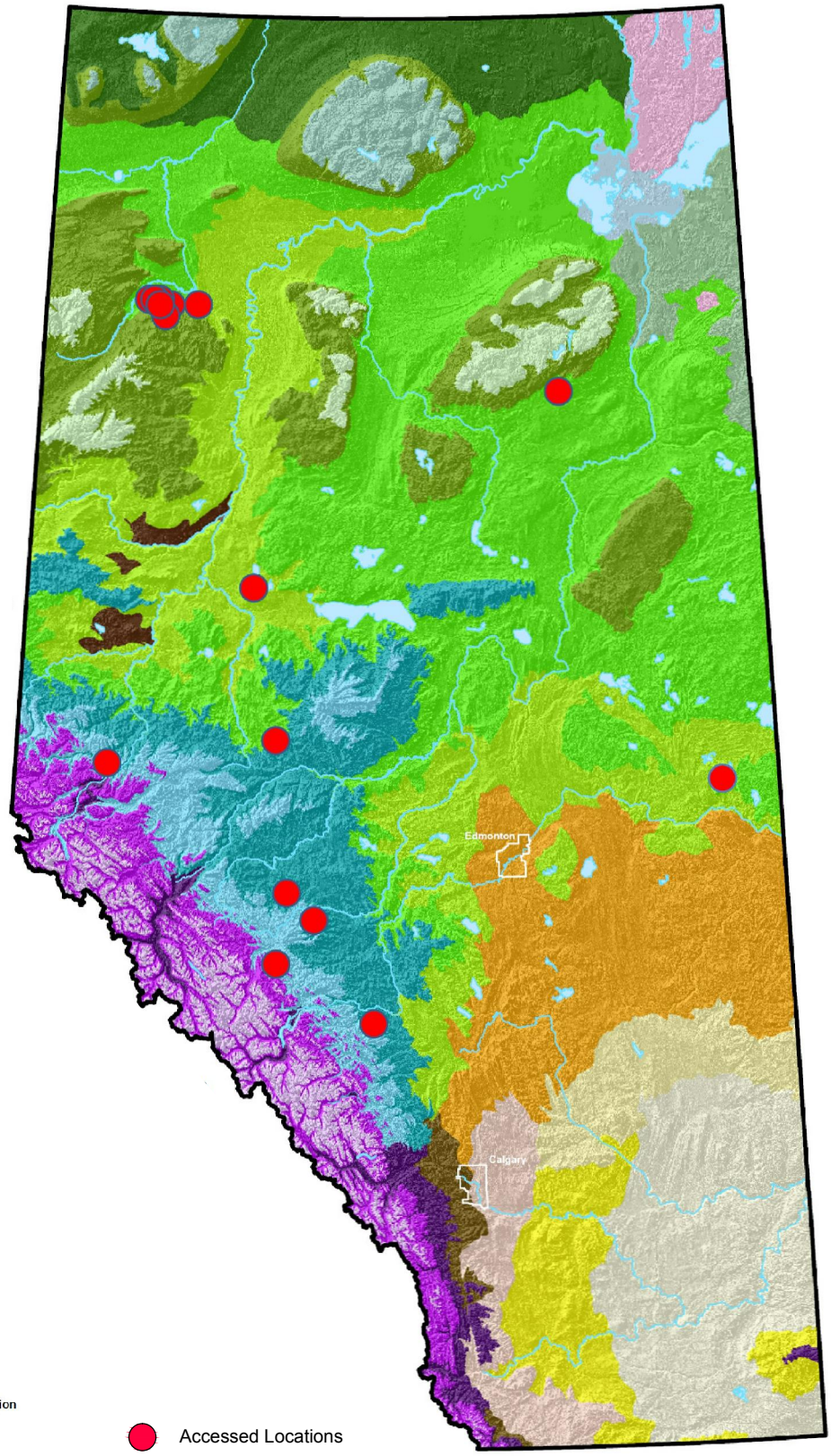
APPENDIX A: FIGURES



Alberta
GOVERNMENT OF ALBERTA

2005 Natural Regions and Subregions of Alberta

Boreal Forest Natural Region
- Central Mixedwood
- Dry Mixedwood
- Northern Mixedwood
- Boreal Subarctic
- Peace-Athabasca Delta
- Lower Boreal Highlands
- Upper Boreal Highlands
- Athabasca Plain

Rocky Mountain Natural Region
- Alpine
- Subalpine
- Montane

Foothills Natural Region
- Upper Foothills
- Lower Foothills

Canadian Shield Natural Region
- Kazan Uplands

Parkland Natural Region
- Foothills Parkland
- Peace River Parkland
- Central Parkland

Grassland Natural Region
- Dry Mixedgrass
- Foothills Fescue
- Northern Fescue
- Mixedgrass

2005 Natural Regions and Subregions of Alberta -
Alberta Sustainable Resource Development, Alberta Environment,
Alberta Community Development and Agriculture and Agri-Food Canada, June 2005

Accessed Locations

PROJECT:

Petroleum Technology Alliance Canada

MILLENNIUM
EMS Solutions Ltd.

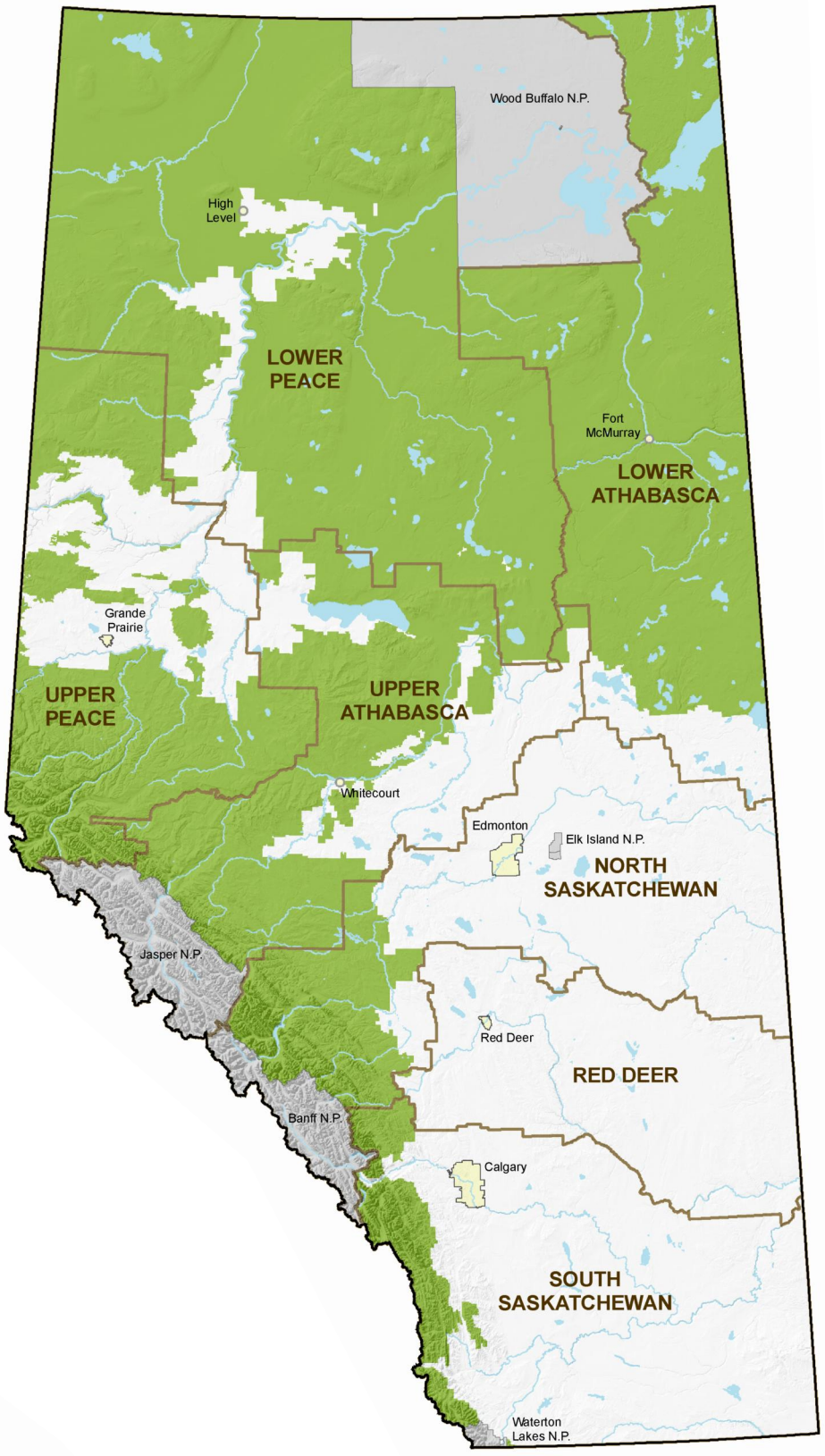
TITLE:

Location of Field Verification Sites

FILE: 11-100 PTAC.dwg

DRAWN:	JDC
CHECKED:	MT
DATE:	Jan 31/13
PROJECT:	11-100

FIGURE: **1**



Alberta

Land-use Framework Planning Regions and Green/White Management Areas

LUF Planning Regions Boundaries
Green Area
White Area
National Parks

Government of Alberta
Green/White Areas and LUF boundaries as of April 30, 2009
Produced by Sustainable Resource Development, Forestry Division, Forest Management Branch.
Base map data provided by Spatial Data Warehouse Ltd.

PROJECT:

Petroleum Technology Alliance Canada

MILLENNIUM EMS Solutions Ltd.

TITLE:

Green and White Zones of Alberta

FILE: 11-100 PTAC.dwg

DRAWN:	JDC
CHECKED:	MT
DATE:	Jan 31/13
PROJECT:	11-100

FIGURE: **2**

APPENDIX B: ROOTING DEPTH FIELD VERIFICATION METHODOLOGY

PTAC Green Zone Subsoil Project—Field Document

OBJECTIVE

The objective of this protocol is to compile a set of data regarding the maximum rooting depth of vegetative species at Green Zone sites throughout Alberta.

The primary criteria driving site selection is:

1. Site be classified as Forested Green zone/Natural Area
2. Groundwater table >2 m from surface
3. Fine-grained soil texture
4. Sites as widely distributed as possible

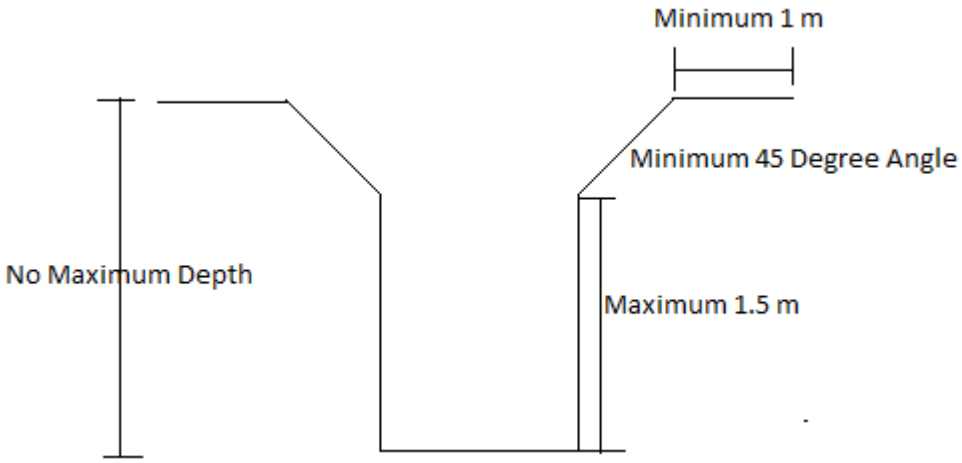
FIELD METHODOLOGY

***The following protocol should be repeated in duplicate for a given site, if possible.**

1. Make a note of the eco-site classification in which the study site is located.
2. When on-site, locate a stand of 3-5 large trees near the edge of the lease in natural vegetation (analogous to where a control would be located but still accessible by heavy equipment). It is important to choose the largest and visually healthiest trees as they will likely have the deepest maximum rooting depths.
3. Take qualitative and quantitative measurements of the trees the pit will be located adjacent too, including type, relative health, breast diameter, estimated overall height, presence of surface roots, etc. Use the supplied field sheet.
4. Using available equipment, have a trench dug as close as possible to the stand of trees in order to maximize root exposure from all tree(s) of interest. The trench should be adequate enough to occupy and at depth to identify the deepest roots (approx. 50 cm wide x 150 cm long x 150 cm deep). Have the operator construct an inclined escape ramp at one end of the trench (a safe point of entry/exit must be located no more than 8 m from the worker). Be aware of the potential for falling trees when excavating and working in the trench. Ensure the spoil pile is located at an adequate distance from the excavation to ensure it will not pose a risk of sloughing back into the excavation. A distance of at least 1 m is recommended. For further reference, please refer to MEMS SMP 17.

   If the rooting maximum is greater than 1.5 m, then the trench will need to have the walls cut back according to the following diagram:

Construction parameters for trenches >1.5 m in fine-grained/cohesive soil according to Occupational Health and Safety Code (2009).



5. Clean the face(s) of the trench. This may be done using a soil knife or using the equipment bucket/blade to scrap the face of the trench. If a trench is constructed between trees, it may be desirable to clean off both trench wall faces.
6. Provide a basic description of the soil profile using the attached field sheet. Describe as one would describe a borehole including identification and description of strata including horizon depth, color, field texture, % coarse fragments, moisture, consistence and total depth of pit. Pay particular attention to identifying any lenses of coarse soil.
7. If not already completed at Site, collect a soil sample for lab analysis (particle size analysis) from the trench face approx. 1 m below surface to verify texture (75 micron sieve).
8. Using a counting grid system, quantify the 50% total rooting depth, 80% total rooting depth, and, most importantly, the maximum depth roots are observed. For instance, if one counts 50 roots in a particular pit, determine the depth of the shallowest 25 roots for the 50% depth, the shallowest 40 roots for the 80% depth, and the deepest rooting depth for the 100% depth. ***In terms of this study, we are primarily interested in deeper rooting vegetation (tree species). Keep this in mind when calculating the % rooting depths.**
9. Identify any roots of non-tree species (forbs, grasses, shrubs, etc.). Record the number of roots by number and size as well as the root orientation and distribution. **Take photographs to illustrate root distribution.**
10. GPS the location of the trench.

***Remember, the goal of this study is to determine the maximum rooting depths of vegetation in the Green Zone of Alberta.**

PTAC Green Zone Subsoil Rooting Project

Trench ID _____ **Assessor** _____ **Date** _____

Legal Location _____ **GPS Location** _____

Ecosite _____ **Photograph ID** _____

VEGETATION ASSESSMENT

Stand/Plot Information	Tree Type	Tree Vigour/Health	Tree Height	Tree Breast Circumference	Surface Rooting	General Comments

SOIL ASSESSMENT

Pit Information	Horizon and / or Depth	Field Texture	Colour	Moisture	Consistence	General Comments

ROOT ASSESSMENT							
Stand/Plot Information	**Total Root Number**	**50% Rooting Depth**	**80% Rooting Depth**	**Maximum Rooting Depth**	***General Root Size/Abundance/Orientation**		
					50% Rooting Depth	**80% Rooting Depth**	**Maximum Rooting Depth**
Deep Rooting Vegetation (Trees)							
Shallow Rooting Vegetation (Grasses, Shrubs)							

* Terminology for deciphering root size/abundance			
vf=very fine	f=fine	vf = very few	f = few
h=horizontal	v=vertical	m=medium	c=coarse
i=inped	e = exped	c = common	m = many

Rooting Comments/Sketch

Please sketch the trench face and describe rooting depths, patterns, orientation, distribution, matting, or any other relevant features.

APPENDIX C: ROOTING DEPTH FIELD DATA SUMMARY

Date: **Oct. 7, 2010**

MEMS File No.: **10-003**

Assessor: **Johan Jensen**

Site #: **1**

PTAC Rooting Zone Study
Site Summary Sheet

Site Physiography

Land Use: Natural/Green Zone

Site Vegetation:

The Site is located in the Central Mixedwood Boreal ecoregion. According to the eco-site classification (H1), dominant vegetation in the area will include white and black spruce as well as paper birch. On-site tree and shrub species consisted of paper birch, alder and willow.

Water Table Information:

According to data collected from a groundwater monitoring event conducted on the Site in December 2010, groundwater levels ranged from 1.17 m to 10.23 m below ground surface (bgs). Borehole logs indicate wet conditions were encountered as shallow as 1.5 m. Peaty/organic topsoil horizons indicate wet surface conditions.

Soil Stratigraphy and Characteristics:

Located in the Gray and Dark Gray Soil Zones of the North Peace area. Predominant soils include Dark Gray and Gray Luvisols with minor inclusions of Solonetzic, Gleysolic and Organic soils. Soil texture was determined to be fine-grained through lab analysis.

Rooting Assessment:

- Maximum Rooting Depth:

  Betula papyrifera Marsh. (Paper birch) – Height 15 m; **Maximum rooting depth of 0.65 m**
  *Salix L. (*Willow) -- Maximum **rooting depth of 0.5 m**
  *Alnus Crispa (*Ait.) Pursh. (Green Alder) – **Maximum rooting depth 0.58 m**

Overall Root Characteristics:

Majority of roots were developed within 0.3 m of surface. Below 0.3 m to the maximum rooting depth, roots were noted to be low in numbers and very fine.

Date: **Oct. 6, 2010**

MEMS File No.: **10-004**

Assessor: **Johan Jensen**

Site #: **2**

PTAC Rooting Zone Study
Site Summary Sheet

Site Physiography

Land Use: Natural/Green Zone

Site Vegetation:

The Site is located in the Central Mixedwood Boreal ecoregion. According to the eco-site classification (C1), dominant vegetation in the area will include two-tiered canopies of jack pine and black spruce, with an understorey dominated by Labrador tea and bog cranberry. Vegetation noted on-site included jack pine, black and white spruce and aspen.

Water Table Information:

According to data collected from a groundwater monitoring event conducted on the Site in December 2010, groundwater levels ranged from 1.32 m to 5.92 m bgs in background nested wells. Borehole logs indicate generally moist conditions from surface to the completion of the boreholes. Peaty/organic topsoil horizons in a number of boreholes indicate wet surface conditions.

Soil Stratigraphy and Characteristics:

Located in the Gray and Dark Gray Soil Zones of the North Peace area. Predominant soils include Dark Gray and Gray Luvisols with minor inclusions of Solonetzic, Gleysolic and Organic soils. Soil texture was determined to be fine-grained through lab analysis.

Rooting Assessment:

- Maximum Rooting Depth:

  Pinus banksiana Lamb. (Jack Pine) – Height 20 m; **Maximum rooting depth of 1.30 m (taproot)**

  Picea mariana (Mill.) BSP. (Black Spruce) - Height 4 m; **Maximum rooting depth of 0.38 m**

  Picea glauca (Moench) Voss (White Spruce) - Height 4 m; **Maximum rooting depth of 0.55 m**

  Populus tremuloides Michx. (Aspen) – **Maximum rooting depth of 0.25 m**

Overall Root Characteristics:

Only the tap root of the jack pine reached 1.3 m. Majority of roots were developed within 0.3 to 0.4 m of surface. Below 0.3 m, roots were noted to be low in numbers and very fine. No fibrous roots were noted.

Date: **Oct. 6, 2010**

MEMS File No.: **10-005**

Assessor: **Johan Jensen**

Site #: **3**

PTAC Rooting Zone Study
Site Summary Sheet

Site Physiography

Land Use: Natural/Green Zone

Site Vegetation:

The Site is located in the Central Mixedwood Boreal ecoregion. According to the eco-site classification (D1), dominant vegetation in the area will include aspen, with some balsam poplar and paper birch, and relatively few, if any, white spruce. A Phase 2 ESA of the site indicates on-site vegetation consists of poplar, birch and willow.

Water Table Information:

According to data collected from a groundwater monitoring event conducted at the site in June 2010, groundwater levels ranged from 0.29 m to 5.64 m bgs in background wells. Borehole logs indicate generally moist conditions from surface to the completion of the boreholes with wet conditions encountered as shallow as 0.4 m. Peaty/organic topsoil horizons in a number of boreholes indicate wet surface conditions.

Soil Stratigraphy and Characteristics:

Located in the Gray and Dark Gray Soil Zones of the North Peace area. Predominant soils include Dark Gray and Gray Luvisols with minor inclusions of Solonetzic, Gleysolic and Organic soils. Soil texture was determined to be fine-grained through lab analysis.

Rooting Assessment:

- Maximum Rooting Depth:

  *Alnus Crispa (*Ait.) Pursh. (Green Alder) – Height 7 m; **Maximum rooting depth of 0.64 m**
  *Salix L. (*Willow) – Height 6 m; **Maximum rooting depth of 0.55 m**

Overall Root Characteristics:

Majority of roots were developed within 0.3 to 0.5 m of surface. Below 0.3 m, roots were noted to be lower in numbers and fine to very fine in terms of physical stature. Fibrous roots were also noted to a maximum depth of 0.52 m. These roots reflect the presence of shrubby vegetation.

Date: **Oct. 6, 2010**

MEMS File No.: **10-006**

Assessor: **Johan Jensen**

Site #: **4**

PTAC Rooting Zone Study
Site Summary Sheet

Site Physiography

Land Use: Natural/Green Zone

Site Vegetation:

The Site is located in the Central Mixedwood Boreal ecoregion. According to the eco-site classification (D1), dominant vegetation in the area will include aspen, with some balsam poplar and paper birch, and relatively few, if any, white spruce. A Phase 2 ESA of the site indicates on-site vegetation consists of poplar, birch, white spruce and willow.

Water Table Information:

Groundwater levels were monitored on-site on June 1, 2010. Recorded groundwater levels ranged from 0.2 m to 5.44 m bgs. Borehole logs indicate generally moist conditions from surface to the completion of the boreholes with wet conditions encountered as shallow as 1.1 m at one location. Peaty/organic topsoil horizons in a number of boreholes indicate wet surface conditions.

Soil Stratigraphy and Characteristics:

Located in the Gray and Dark Gray Soil Zones of the North Peace area. Predominant soils include Dark Gray and Gray Luvisols with minor inclusions of Solonetzic, Gleysolic and Organic soils. Soil texture was determined to be fine-grained through lab analysis.

Rooting Assessment:

- Maximum Rooting Depth:

  *Salix L. (*Willow) – Height 5 m; **Maximum rooting depth of 0.65 m**

  Populus tremuloides Michx. (Aspen) – Height 8 m; **Maximum rooting depth of 0.6 m**

  Picea glauca (Moench) Voss (White Spruce) - **Maximum rooting depth of 0.4 m**

Overall Root Characteristics:

Majority of roots were developed within 0.3 m of surface. Below 0.3 m, roots were lower in numbers and fine to very fine in terms of physical stature. Fibrous roots were also noted to a maximum depth of 0.5 m and followed similar orientation/physical stature patterns as the assessed tree roots.

Date: **Oct. 7, 2010**

MEMS File No.: **10-021**

Assessor: **Johan Jensen**

Site #: **5**

PTAC Rooting Zone Study
Site Summary Sheet

Site Physiography

Land Use: Natural/Green Zone

Site Vegetation:

The Site is located in the Central Mixedwood Boreal ecoregion. According to the eco-site classification (D1), dominant vegetation in the area will include aspen, with some balsam poplar and paper birch, and relatively few, if any, white spruce. For this location, on-site tree species was limited to aspen alone.

Water Table Information:

During the groundwater monitoring event completed December 5th through 9th, 2010, the recorded shallow groundwater levels ranged from 1.87 m to 4.39 m bgs. Borehole logs indicate generally moist conditions from surface to the completion of the boreholes with wet conditions encountered as shallow as 1.0 to 1.1 m at two locations. Wet conditions were not encountered in control locations. Peaty/organic topsoil horizons in a number of boreholes indicate wet surface conditions.

Soil Stratigraphy and Characteristics:

From the Phase 2 ESA, general lithology on-site consisted of admixed clay to silty clay overlying fine-grained clay. Fine to coarse sand seams less than 10 cm were noted at three assessment locations; however, evidence supporting the use of coarse-grained guidelines was lacking as sand lenses were not consistent between boreholes and across the Site. Beneath this, the main subsoil unit consisted of fine-grained clay till.

Rooting Assessment:

- Maximum Rooting Depth:

  Populus tremuloides Michx. (Aspen) – **Maximum rooting depth of 1.0 m**

Overall Root Characteristics:

The majority of roots were developed within 0.6 m of the surface. Below 0.3 m, roots were lower in numbers and fine to very fine in terms of physical stature. Fibrous roots were also noted **to a maximum depth of 1.5 m** and followed similar orientation/physical stature patterns as the assessed tree roots with the majority of fibrous roots occurring within the 0.5 m of the surface.

Date: **Oct. 7, 2010**

MEMS File No.: **10-129**

Assessor: **Johan Jensen**

Site #: **6**

PTAC Rooting Zone Study
Site Summary Sheet

Site Physiography

Land Use: Natural/Green Zone

Site Vegetation:

The Site is located in the Central Mixedwood Boreal ecoregion. According to the eco-site classification (D1), dominant vegetation in the area will include aspen, with some balsam poplar and paper birch, and relatively few, if any, white spruce. For this location, on-site tree species included aspen and white spruce.

Water Table Information:

During the groundwater monitoring event completed December 7th, 2010, the recorded shallow groundwater levels ranged from 1.97 m to 3.17 m bgs. Borehole logs indicate generally dry to moist conditions from surface to 1.0 m followed by moist conditions to the completion of the boreholes. No wet conditions were encountered.

Soil Stratigraphy and Characteristics:

General lithology on-site consisted of admixed clay to silty clay overlying fine-grained clay. Beneath this, the main subsoil unit consisted of fine-grained clay till. Located in the Gray and Dark Gray Soil Zones of the North Peace area, predominant soils include Dark Gray and Gray Luvisols with minor inclusions of Solonetzic, Gleysolic and Organic soils. Soil texture was determined to be fine-grained through lab analysis.

Rooting Assessment:

- Maximum Rooting Depth:

  Populus tremuloides Michx. (Aspen) – Height 15 m; **Maximum rooting depth of 0.75 m**

  Picea glauca (Moench) Voss (White Spruce) – Height 9 m; **Maximum rooting depth of 0.75 m**

Overall Root Characteristics:

The majority of roots were developed within 0.2 m of the surface. Below 0.3 m, roots were lower in numbers and fine to very fine in terms of physical stature. Fibrous roots were also noted to a maximum depth of 0.63 m and followed similar orientation/physical stature patterns as the assessed tree roots with the majority of fibrous roots occurring within the 0.3 m of the surface.

Date: **Oct. 7, 2010**

MEMS File No.: **10-128**

Assessor: **Johan Jensen**

Site #: **7**

PTAC Rooting Zone Study
Site Summary Sheet

Site Physiography

Land Use: Natural/Green Zone

Site Vegetation:

The Site is located in the Central Mixedwood Boreal ecoregion. According to the eco-site classification (D1), dominant vegetation in the area will include aspen, with some balsam poplar and paper birch, and relatively few, if any, white spruce. For this location, on-site tree species included paper birch and white spruce.

Water Table Information:

According to borehole logs collected during a Phase 2 ESA of the Site, generally moist conditions extend from the surface to the completion of the borehole. However, no wet conditions were encountered at any location.

Soil Stratigraphy and Characteristics:

General lithology on-site consisted of brown admixed clay with some coarse fragments. Beneath this, the main subsoil unit consisted of fine grained clay loam overlying clay till. The soil texture was determined to be fine grained based on particle size analysis and soil profiles.

Rooting Assessment:

- Maximum Rooting Depth:

  Betula papyrifera Marsh. (Paper Birch) – Height 10 m; **Maximum rooting depth of 0.75 m.**

  Picea glauca (Moench) Voss (White Spruce) – Height 10 m; **Maximum rooting depth 0.65 m**

Overall Root Characteristics:

The majority of roots were developed within 0.3 m of the surface. Below 0.3 m, roots were lower in numbers and fine to very fine in terms of physical stature. Fibrous roots were also noted to a maximum depth of 0.7 m and followed similar orientation/physical stature patterns as the assessed tree roots with the majority of fibrous roots occurring within the 0.3 m of the surface.

Date: **Jan. 30, 2012**

MEMS File No.: **08-1220**

Assessor: **Cory Kartz**

Site #: **8**

PTAC Rooting Zone Study
Site Summary Sheet

Site Physiography

Land Use: Natural/Green Zone

Site Vegetation:

The Site is located in the upper foothills sub eco-region. According to the eco-region classification, the site will be dominated by lodgepole pine, white and black spruce, as well as sub-alpine fir. It was noted during the site visit that spruce and pine species were the dominant natural tree species. Little or no shrubbery/grasses were noted on-site. Vegetation assessed on-site was limited to lodgepole pine.

Water Table Information:

According to GW monitoring events in 2010, the GW level ranged from 1.9 to 3.4 m below top of casing (BTOC). During the rooting depth study, generally moist conditions were encountered to the pit completion depth of 1.4 m. No wet conditions or seeping water were observed.

Soil Stratigraphy and Characteristics:

General lithology on-site consisted of FH (0.24 – 0 m) overlying 0.12 m of black-brown moist clay loam topsoil. Beneath the top soil, moist brown clay loam extended to 0.27 m followed by moist light brown silty clay to 0.47 m. Moist, light brown silty clay was then observed to the completion of the pit at 1.4 m. The soil texture was determined to be fine grained based on particle size analysis and soil profiles from the Phase 2 ESA.

Rooting Assessment:

- Maximum Rooting Depth:
  1) *Pinus contorta var. latifolia* Loudon (Lodgepole Pine) – Height 15 m, Breast Circumference 0.82 m; **Maximum rooting depth of 0.80 m.**
  2) *Pinus contorta var. latifolia* Loudon (Lodgepole Pine) – Height 14 m, Breast Circumference 0.70 m; **Maximum rooting depth of 0.90 m.**

Overall Root Characteristics:

For Trees 1 and 2 assessed, the 50 % rooting depths were 0.35 and 0.40 m, and 80% rooting depths were 0.54 and 0.67 m, respectively. Generally, the 50% rooting depth consisted of common coarse to medium sized roots extending in a horizontal plane. The maximum rooting depth consisted of very

few fine to very fine horizontal roots. There was no observable shallow rooting vegetation adjacent to the pit though observations around the site found shallow rooting orientation to stay within the FH and upper topsoil layers.

Date: **Feb. 24, 2012**

MEMS File No.: **09-1381**

Assessor: **Cory Kartz**

Site #: **9**

PTAC Rooting Zone Study
Site Summary Sheet

Site Physiography

Land Use: Assessed under Natural land use

Site Vegetation:

The Site is located in the upper foothills sub eco-region. According to the eco-region classification, the Site will be dominated by lodgepole pine, white and black spruce, as well as sub-alpine fir. It was noted during the site visit that pine, spruce and poplar species were the dominant natural tree species. Woody shrubbery dominated the understorey. Vegetation assessed on-site was limited to lodgepole pine.

Water Table Information:

During the rooting depth study, generally moist conditions were encountered to the pit completion depth of 1.5 m. No wet conditions or seeping water were observed though conditions were quite moist. No water table information pertaining to the Site was available for review. A prior Phase 2 ESA completed on the Site, however, noted generally moist conditions in the majority of boreholes.

Soil Stratigraphy and Characteristics:

General lithology on-site consisted of LFH (0.14 to 0 m) overlying 0.12 m of brown dry sandy loam to sandy clay loam topsoil. Beneath the top soil, dry light grey sandy clay loam extended to 0.18 m followed by moist dark brown clay loam to 0.64 m. Moist dark brown to grey clay loam/till was then observed to the completion of the pit at 1.5 m. Extensive mottling was noted at 0.18 m below surface. The soil texture was determined to be fine grained based on particle size analysis and soil profiles from the Phase 2 ESA.

Rooting Assessment:

- Maximum Rooting Depth:
  1) *Pinus contorta var. latifolia* Loudon (Lodgepole Pine) – Height 18 to 22 m, Breast Circumference 1.43 m; **Maximum rooting depth of 1.0 m.**

Overall Root Characteristics:

The 50% and 80% rooting depths were 0.36 and 0.63 m, respectively. Generally, the 50% rooting depth consisted of medium to coarse abundant roots extending in a horizontal plane. The maximum

rooting depth consisted of very few very fine horizontal roots. A clear border for tree roots was evident at 0.8 m. Shallow rooting vegetation around the pit consisted of smaller saplings and woody shrubs. The root orientation of these shallow rooting vegetation species was determined to stay within the LFH and upper topsoil layers.

Date: **Feb. 24, 2012**

MEMS File No.: **09-1296**

Assessor: **Cory Kartz**

Site #: **10**

PTAC Rooting Zone Study
Site Summary Sheet

Site Physiography

Land Use: Natural/Green Zone

Site Vegetation:

The Site is located in the upper foothills sub eco-region. According to the eco-region classification, the Site will be dominated by lodgepole pine, white and black spruce, as well as sub-alpine fir. It was noted during the site visit that pine was the dominant natural tree species. Little or no shrubbery/grasses were noted on-site due to snow cover. Vegetation assessed on-site was limited to lodgepole pine.

Water Table Information:

No previous groundwater monitoring events at the Site were available for review. During the rooting depth study, generally dry to moist conditions were encountered to the pit completion depths of 1.65 and 1.75 m. No wet conditions or seeping water were observed in either pit.

Soil Stratigraphy and Characteristics:

General lithology on-site consisted of FH (0.22 to 0 m) overlying 0.12 m of light brown to red-brown dry sandy to silty loam topsoil. Beneath the top soil, dry light brown to grey silt to silty loam extended to 0.24 m followed by moist dark grey to brown clay loam to 0.65 m. Moist dark brown to grey clay till was then observed to the completion of the pits at 1.65 to 1.75 m. The soil texture was determined to be fine grained based on field observation.

Rooting Assessment:

- Maximum Rooting Depth:
  1) *Pinus contorta var. latifolia* Loudon (Lodgepole Pine) – Height 18 m, Breast Circumference 0.75 m; **Maximum rooting depth of 1.2 m.**
  2) *Pinus contorta var. latifolia* Loudon (Lodgepole Pine) – Height 14 m, Breast Circumference 0.53 m; **Maximum rooting depth of 1.15 m.**
  3) *Pinus contorta var. latifolia* Loudon (Lodgepole Pine) – Height 17 m, Breast Circumference 0.73 m; **Maximum rooting depth of 1.4 m.**

Overall Root Characteristics:

The maximum rooting depth of each tree was measured to the top of the LFH layer. For the three trees, the 50% rooting depth consisted of medium to coarse abundant roots in both the horizontal and vertical planes. The 80% rooting depth consisted of fine to medium few to plentiful horizontal roots. Only very fine very few (<5) roots were seen at the maximum depth for all trees assessed. It was not possible to confirm whether the observed deepest roots were attached to actively growing vegetation.

Date: **Feb. 23, 2012**

MEMS File No.: **07-1182**

Assessor: **Cory Kartz**

Site #: **11**

PTAC Rooting Zone Study
Site Summary Sheet

Site Physiography

Land Use: Natural/Green Zone

Site Vegetation:

The Site is located on the border of the upper foothills and sub-alpine sub eco-regions. According to the eco-region classification, the Site will be dominated by lodgepole pine, spruce, as well as sub-alpine fir. It was noted during the site visit that spruce and pine were the dominant natural tree species. Little or no shrubbery/grasses were noted on-site due to snow cover.

Water Table Information:

A groundwater monitoring event in 2012 identified a water table at 9.0 m bgl. During the rooting depth study, generally dry to moist conditions were encountered to the pit completion depths of 1.5 m. No wet conditions or seeping water were observed in either pit.

Soil Stratigraphy and Characteristics:

General lithology on-site consisted of FH overlying dry light brown sandy clay loam topsoil. Beneath the top soil, dry brown sandy clay loam was observed overlying dry grey clay till to the completion of the pits at 1.5 m. An increase in gravel-sized coarse fragments was noted at 0.8 m. The soil texture was determined to be fine grained based on particle-size analysis data collected during a previous Phase 2 ESA.

Rooting Assessment:

- Maximum Rooting Depth:
  1) *Pinus contorta var. latifolia* Loudon (Lodgepole Pine) – Height 20 to 25 m, Breast Circumference 0.85 m; **Maximum rooting depth of 1.2 m.**
  2) *Pinus contorta var. latifolia* Loudon (Lodgepole Pine) – Height 20 to 25 m, Breast Circumference 0.90 m; **Maximum rooting depth of 1.1 m.**
  3) *Picea mariana* (Mill.) BSP. (Black Spruce)– Height 25 to 30 m, Breast Circumference 1.40 m; **Maximum rooting depth of 1.2m.**

Overall Root Characteristics:

The maximum rooting depth of each tree was measured to the top of the FH layer. The 50% rooting depth consisted of medium to coarse plentiful to abundant roots in the horizontal plane. The 80% rooting depth for the pine trees consisted of fine to medium plentiful horizontal roots; the spruce tree displayed a few medium to coarse horizontal and vertical rooting pattern. The vast majority of observable roots were above 0.7 to 0.8 m for all three trees assessed. Only very fine very few (<2) roots were seen at maximum depth. It was not possible to confirm whether the observed deepest roots were attached to actively growing vegetation.

Date: **Feb. 2, 2012**

MEMS File No.: **09-1284**

Assessor: **Lonnie Sweet**

Site #: **12**

PTAC Rooting Zone Study
Site Summary Sheet

Site Physiography

Land Use: Natural/Green Zone

Site Vegetation:

The Site is located in the upper foothills sub eco-region. According to the eco-region classification, the Site will be dominated by lodgepole pine, white and black spruce, as well as sub-alpine fir. It was noted during the site visit that spruce was the dominant natural tree species.

Water Table Information:

A groundwater monitoring event in 2010 identified a water table ranging between 2.31 and 2.8 m bgl.

Soil Stratigraphy and Characteristics:

General lithology on-site consisted of sandy to silty clay from surface to 0.3 m bgl overlying sandy clay from 0.3 to 1.2 m. Sandy clay with gravel and cobbles was observed from 1.2 m to the completion of the three pits at 1.5 m. Soil texture on Site was determined to consist of both fine and coarse-grained soils based on particle size analysis and soil profiles from a previous Phase 2 ESA completed on-site

Rooting Assessment:

- Maximum Rooting Depth:
  1) *Picea mariana* (Mill.) BSP. (Black Spruce) - **Maximum rooting depth of 0.5 to 0.6 m.**
  2) *Picea mariana* (Mill.) BSP. (Black Spruce) - **Maximum rooting depth of 0.5 to 0.6 m.**
  3) *Picea mariana* (Mill.) BSP. (Black Spruce) - **Maximum rooting depth of 0.5 to 0.6 m.**

Overall Root Characteristics:

The 50% rooting depth for all three trees was observed to be 0.3 m and the 80% rooting depth was observed to be approximately 0.45 m.

Date: **Feb. 23, 2012**

MEMS File No.: **NWLR**

Assessor: **Derek Flewell**

Site #: **13**

PTAC Rooting Zone Study
Site Summary Sheet

Site Physiography

Land Use: Natural/Green Zone

Site Vegetation:

The Site is located within the central mixedwood sub eco-region. According to the eco-region classification, the Site will be dominated by aspen, black and white spruce. It was noted during the site visit that poplar and pine were the dominant natural tree species.

Water Table Information:

During the rooting depth study, generally moist conditions were encountered to the pit completion depths of 1.5 m. No wet conditions or seeping water were observed in either of the two assessed pits.

Soil Stratigraphy and Characteristics:

General lithology on-site consisted of brown to black moist topsoil to 0.3 m overlying moist brown silty clay to 1.5 m. The soil texture was determined to be fine grained based on field texturing.

Rooting Assessment:

- Maximum Rooting Depth:
  1) *Populus tremuloides* Michx. (Aspen) – Height 24 m, Breast Circumference 1.2 m; **Maximum rooting depth of 0.3 m.**
  2) *Populus tremuloides* Michx. (Aspen) – Height 24 m, Breast Circumference 1.2 m; **Maximum rooting depth of 0.3 m.**
  3) *Populus tremuloides* Michx. (Aspen) – Height 24 m, Breast Circumference 0.9 m; **Maximum rooting depth of 0.3 m.**
  4) *Pinus contorta var. latifolia* Loudon (Lodgepole Pine) – Height 18 m, Breast Circumference 0.9 m; **Maximum rooting depth of 0.3 m.**
  5) *Pinus contorta var. latifolia* Loudon (Lodgepole Pine) – Height 24 m, Breast Circumference 0.9 m; **Maximum rooting depth of 0.3 m.**

Overall Root Characteristics:

The 50% rooting depth consisted of few coarse roots in the horizontal plane. The 80% rooting depth consisted of few coarse horizontal roots. During the survey, it was noted that the larger tree roots

followed the horizon between the topsoil and lower clay horizon and did not extend further than 0.05 m into the clay.

Date: **Mar. 9, 2012**

MEMS File No.: **06-1048**

Assessor: **Drew Lockwood**

Site #: **14**

PTAC Rooting Zone Study
Site Summary Sheet

Site Physiography

Land Use: Assessed under Agricultural land use

Site Vegetation:

The Site is located within the dry mixedwood sub eco-region. According to the eco-region classification, the Site will be dominated by aspen and white spruce. It was noted during the site visit that poplar was identified as the dominant natural tree species.

Water Table Information:

A previous Phase 2 ESA completed on the Site identified a water table varying between 1.66 and 4.02 m bgs. During the rooting depth study, generally moist conditions were encountered to the pit completion depths of 1.5 m. No wet conditions or seeping water were observed in either pit.

Soil Stratigraphy and Characteristics:

General lithology on-site consisted of brown moist silt loam topsoil to 0.16 m overlying moist brown clay to 0.55 m. A dark brown C horizon completed the pit to a depth of 1.5 m. The soil texture was determined to be fine-grained based on field texturing and particle size analysis.

Rooting Assessment:

- Maximum Rooting Depth:
  1) *Populus balsamifera* L. (Balsam poplar) – Height 13 m, Breast Circumference 0.75 m; **Maximum rooting depth of 0.9 m.**
  2) *Populus balsamifera* L. (Balsam poplar)– Height 12 m, Breast Circumference 0.71 m; **Maximum rooting depth of 0.9 m.**

Overall Root Characteristics:

The 50% rooting depth consisted of abundant medium to coarse roots in the horizontal plane. The 80% rooting depth consisted of plentiful fine to medium horizontal roots. The maximum rooting depth featured a few medium horizontal roots.

Date: **July 18, 2012**

MEMS File No.: **11-232/233**

Assessor: **V. Lyzhin, J. Kaufmann**

Site #: **15**

PTAC Rooting Zone Study
Site Summary Sheet

Site Physiography

Land Use: Natural/Green Zone

Site Vegetation:

The Site is located in the Central Mixedwood Boreal eco-region. According to the eco-site classification (D2), dominant vegetation in the area will include aspen, with some balsam poplar and paper birch, and relatively few, if any, white spruce. At the time of assessment, black spruce was noted in a transitional area between a D2 and G1 eco-site.

Water Table Information:

During the rooting depth study, generally moist conditions were encountered to the pit completion depths of 1.5 m. Of the three pits assessed, wet conditions were observed in a single pit from surface to 1.0 m. No wet or seeping conditions were noted in any of the three pits below 1.0 m.

Soil Stratigraphy and Characteristics:

General lithology on-site consisted of brown to dark brown moist to wet silt loam to sandy loam topsoil to approximately 0.11 m overlying moist to wet brown silty clay loam to sandy clay loam to 0.30 to 0.46 m. A dark brown clay loam to clay BC or C horizon completed the pits to a depth of 1.5 m. The soil texture was determined to be fine grained based on field texturing and particle size analysis.

Rooting Assessment:

- Maximum Rooting Depth:
  1) *Populus tremuloides* Michx. (Aspen) – Height 18 m, Breast Circumference 0.94 m; **Maximum rooting depth of 1.24 m.**
  2) *Picea mariana* (Mill.) BSP. (Black Spruce) - Height 16 m, Breast Circumference 0.64 m; **Maximum rooting depth of 0.94 m.**
  3) *Populus tremuloides* Michx. (Aspen) – Height 17 m, Breast Circumference 0.56 m; **Maximum rooting depth of 1.05 m.**

Overall Root Characteristics:

The 50% rooting depth consisted of abundant medium to coarse roots in the horizontal plane. The 80% rooting depth consisted of plentiful coarse horizontal and vertical roots. The maximum rooting depth featured a few medium horizontal and vertical roots.

Date: **July 31, 2012**

MEMS File No.: **11-033**

Assessor: **J. Jensen, P. Martin**

Site #: **16**

PTAC Rooting Zone Study
Site Summary Sheet

Site Physiography

Land Use: Natural/Green Zone

Site Vegetation:

The Site is located in the Dry Mixedwood Boreal eco-region. According to the eco-site classification (D2), dominant vegetation in the area will include aspen, with some balsam poplar and paper birch, and relatively few, if any, white spruce. At the time of assessment the dominant vegetation in the study area included aspen, white spruce, alder and willow.

Water Table Information:

During the rooting depth study, generally moist conditions were encountered to the pit completion depths of 1.5 m. No wet or seeping conditions were encountered to a depth of 1.5 m.

Soil Stratigraphy and Characteristics:

General lithology on-site consisted of sandy loam topsoil to approximately 0.14 m overlying sandy clay loam to 0.26 m. Firm clay loam was then encountered to a depth of 0.74 m. From 0.74 m to 1.01 m a sandy clay loam BC layer was observed followed by a massive sandy clay loam C horizon to the completion of the borehole at 1.5 m. The soil texture was determined to be fine grained based on field texturing.

Rooting Assessment:

Maximum Rooting Depth:

1) *Populus tremuloides* Michx. (Aspen) – Height 21 m, Breast Circumference 1.23 m; **Maximum rooting depth of 1.38 m.**

Overall Root Characteristics:

The 50% rooting depth consisted of abundant fine to coarse roots in the horizontal or random plane. The 80% rooting depth consisted of abundant fine to coarse horizontal and random roots.

APPENDIX D: MILLENNIUM EMS SOLUTIONS LTD. THIRD PARTY RELIANCE AGREEMENT

Professional Services Agreement
Third Party Reliance

This Document is intended for Third Parties wishing to rely on the information contained within this report.

PARTIES
This Agreement made this ___ day of _____ between:

and **Millennium EMS Solutions Ltd.**
6111 – 91st Street
Edmonton AB
T6E 6V6

Attn.:

Attn: Steve Ferner

hereinafter called "THIRD PARTY"

hereinafter called "MILLENNIUM"

THIRD PARTY engages MILLENNIUM to provide a right of reliance to the THIRD PARTY in connection with Millennium report entitled **"Proposed Exclusion Depths for the Ecological Direct Contact Exposure Pathway at Remote Alberta Green Zone Sites"**

SCOPE OF SERVICES
MILLENNIUM agrees to allow the THIRD PARTY to rely on information presented within this report.

COMPENSATION
THIRD PARTY agrees to compensate MILLENNIUM for $1.00 for right to rely on the information, the receipt of which is acknowledged.

TERMS AND CONDITIONS

1. EXTENT OF AGREEMENT. This Agreement represents the entire agreement between MILLENNIUM and THIRD PARTY and supersedes all prior negotiations, representations, or agreements, either written or oral. This Agreement may be altered only by written instrument signed by authorized representatives of both THIRD PARTY and MILLENNIUM.
2. STANDARD OF CARE. MILLENNIUM shall perform its services in a manner consistent with the standard of care and skill ordinarily exercised by members of the profession practicing under similar conditions in the geographic vicinity and at the time the services are performed. This Agreement neither makes nor intends a warranty or guarantee, express or implied.
3. INDEMNITY. THIRD PARTY waives any claim against MILLENNIUM, its officers, employees and agents and agrees to defend, indemnify, protect and hold harmless MILLENNIUM and its officers, employees and agents from any and all claims, liabilities, damages or expenses, including but not limited to delay of the project, reduction of property value, fear of or actual exposure to or release of toxic or hazardous substances, and any consequential damages of whatever nature, which may arise directly or indirectly, to any party, as a result of the services provided by MILLENNIUM under this Agreement, unless such injury or loss is caused by the sole negligence of MILLENNIUM. All claims by THIRD PARTY shall be deemed relinquished unless filed within one (1) year after substantial completion of the services.
4. LIMITATION OF LIABILITY. Notwithstanding any other provision of this Agreement, THIRD PARTY agrees to limit MILLENNIUM's and its officers, employees and agents liability due to professional negligence and to any liability arising out of or relating to this Agreement to $5,000. This limit applies to all services on this project, whether provided under this or subsequent agreements, unless modified in writing, agreed to and signed by authorized representatives of the parties. In addition, MILLENNIUM shall not be liable for consequential, incidental or indirect damages as a result of the performance of this Agreement.
5. RESPONSIBILITY. MILLENNIUM is not responsible for the completion or quality of work that is dependent upon or performed by the THIRD PARTY or third parties not under the direct control of MILLENNIUM, nor is MILLENNIUM responsible for their acts or omissions or for any damages resulting there from.
6. EXCLUSIVE USE. Services provided under this Agreement, including all reports, information or recommendations prepared or issued by MILLENNIUM, are for the exclusive use of the THIRD PARTY for the project specified. No other use is authorized under this Agreement. THIRD PARTY releases MILLENNIUM from liability and agrees to defend, indemnify, protect and hold harmless MILLENNIUM from any and all claims, liabilities, damages or expenses arising, in whole or in part, from such unauthorized distribution.
7. We disclaim any undertaking or obligation to advise Third Party or modify this opinion to reflect changes which may come or be brought to our attention.

THIRD PARTY acknowledges that they have read and agree to the Terms and Conditions attached to this document which are incorporated herein and made a part of this Agreement.

Third Party:

By: _____

Title: _____

Date: _____