APPLIED ECOLOGICAL SERVICES, INC.

631 WRIGHT DeBOW ROAD, JACKSON, NJ 08527
PHONE: (732)833-2140 FAX: (732)928-0660
email: info@appliedeco.com

SPECIALISTS IN ENVIRONMENTAL MANAGEMENT AND RESEARCH

December 5, 2006

TO: AES team
FROM: Bill Young, Ted Hartsig
RE: Soil Characterization Memo Report

Background

The Albany Landfill lies within the Albany Pine Bush, a system so unique and rare that it is ranked G2 (Globally Imperiled thoughout its range due to rarity or highly vulnerable to extinction due to biological factors) and S1 (Critically imperiled in New York State because of extreme rarity (5 or fewer sites or very few remaining individuals) or extremely vulnerable to extirpation from New York State due to biological factors). Pitch pine-scrub oak communities dominate the Albany Pine Bush landscape and have been the focus of conservation efforts to date. Pitch pine (*Pinus rigida*) and its scrub associates depend on frequent disturbance from fire and sandy, low nutrient soils. These communities, in turn, harbor rare animals such as the Buck moth, Karner Blue butterfly and several birds such as rufus-sided towhee, prairie warblers and whip-poor-will.

Gebaurer et al (1996) described three variants of the pitch pine-scrub oak community in the Albany Pine Bush:

1. Pitch pine scrub oak barrens: savannah community with 20-60% cover of pitch pine, scrub oak, huckleberry and blueberry (Schneider et al (1991).
2. Pitch pine scrub oak thickets: resemble barrens as above, but with a much higher density of scrub oak (Quercus ilicifolia and Q. prinoides)
3. Pitch pine scrub oak forests: also contain similar species but also contain White oak (*Quercus alba*), red oak (*Q. rubra*), or black oak (*Q. velutina*). The shrub and herbaceous layers may be sparser than in the two variants described above. (Gebauer et al., 1996).

These rare vegetative communities formed in a unique soils environment; unique not just for its sandy characteristic, but also the chemical and hydrological components that underlie and sustain this ecological system. Soils of the Albany Pine Bush formed in alluvial glacial sands that were modified by wind, creating rolling dunes. During the last ice age (Wisconsin), several rivers emptied into the glacial Lake Albany, carrying sediment ground by glacial advances. Large amounts of sand and gravel were deposited close to the lakeshore where these rivers joined with the lake, forming a large delta. After the glaciers retreated, Lake Albany drained, exposing the sandy delta. Winds further eroded and sculpted the sand into dunes characteristic of the existing soils now found in the Albany Pine Bush [1].

The Albany Pine Bush is dominated by four soils series: Colonie loamy fine sand, Granby loamy fine sand, Stafford loamy fine sand, and Adrian muck. Generally, these series are described by deep, excessively drained loamy fine sand to sand, with variation between horizons stemming from small gradations in texture and/or organic matter content. The soil horizons are deep, typically much greater than 60 inches, and are generally described in the following sequence:

0 to 12 inches (+/- 3 inches):	loamy fine sand
12 to 25 inches (+/- 5 inches):	fine sand to loamy fine sand
25 to 60+ inches:	sand to fine sand

One of the dominant soil series of the Albany Pine Barrens is the Colonie loamy fine sand, of which the horizon description is of loamy fine sand through its entire depth.

This memorandum provides a summary of the characterization and assessment of soils at the Albany Pine Bush and Landfill completed September 28, 2006. The purpose of the soils characterization and assessment was to provide information of the condition of surrounding soils near the landfill, and of native soil characteristics that contribute to the existing vegetative communities in the Pine Barrens at the Albany Landfill. This information will be used for development of restoration plans with expansion of the landfill.

Data Collection

To recreate the specialized plant communities on site, AES studied reference areas and compiled data on soils, vegetation and hydrology. Soils were examined in the area of the planned landfill expansion east and southeast of the current operations, and in reference areas both north and west of the landfill in the Pine Bush. Soil cores were extracted along transects (Transects E-1 through E – 6, and in the former trailer court) established in the expansion area using a 33-inch long soil probe. The soil probe collects a core in an approximate 15-inch open-side barrel. Cores were collected in approximate 15-inch intervals, with cores extracted for evaluation. Photographs (digital) of each core from the 0 to 15-inch depth were recorded, soil profile characteristics were documented onto data sheets (Appendix A), and soil samples collected for analysis of target constituents (calcium, magnesium, phosphorous, potassium, percent organic matter, cation exchange capacity, and pH). Soils were examined along transects established [in the area of the expected landfill expansion north of the current landfill,] in rolling topography dominated by pine woodland, including an adjacent trailer court; and from individual locations selected as representative of the varied vegetative communities in the Pine Bush.

Summary of Results

Essentially, because the soils examined formed in a common parent material, typical profile characteristics are similar across the entirety of the Albany Pine Bush. The primary differences in soil characteristics lay in their relational aspect: Lowland including fens, bogs, and ponds; and uplands on hilltops and sideslopes. This summary describes the results of the soil characterization completed in September related to their relational aspect, with comparison of soil profiles in the expansion area to reference sites.

Detailed field and laboratory data and descriptions of soil characteristics is provided in attachment A. Our initial evaluation of Albany Pine Bush soils focuses on their characteristics by spatial distribution. We then examined soil characteristics in their relationship with plant communities in the Pine Bush. By spatial distribution, lowland and upland soils are described by:

1. Lowland Soils

The lowlands mapped include soils found in fens, bogs, and ponds, typically where water flows and collects, or where the topographical aspect is low and intercepts the water table, creating perennially wet conditions. Typically, the soil underlaying the inundated areas of ponds and bogs was found to consist of muck to depths greater than 40 inches. The soils examined within a sedge meadow, fens, or adjacent to ponds typically consisted of an organic layer (muck or detritus) from 0 to 4 inches thick, underlain by high organic, very fine sand to loamy fine sand to depth of approximately 14 to 24 inches below the ground surface. The A horizon of reference soils in wet areas were generally very dark brown to black (10YR 2/1 to 2.5Y 3/2, for example), had massive or granular structure, and were friable.

The B horizon at the lowland reference sites were found to also be typically dark (10YR 5/3, 10YR 3/2) with gleyed chromas. Generally, these soils were found to be composed of very fine sand and loamy fine sand.

In some locations, the B horizon had relatively low organic matter content, but in all locations, the B horizon was wet to saturated, had massive structure, and was typically friable.

Laboratory data show that the lowland areas typically have the following characteristics:

- Low pH (average 5.2 standard units) and relatively high organic matter (average 15.8 percent).
- The available P concentrations for the low-lying areas averaged 48.8 mg/kg, a value that could be considered high by most native soil standards. Extractable P is notably higher in concentration, but is only slowly available to plant utilization, if at all. A substantial portion of P in soils will be bound to iron and calcium, becoming unavailable, or slowly available, to plants.
- The potassium (K), Ca, and magnesium (Mg) concentrations in soils east of the landfill are substantially higher than soils at the reference sites. In particular, Ca appears to be extraordinarily high in these areas with concentrations ranging from 2,154 mg/kg to 6,201 mg/kg, compared to a range of 49 mg/kg to 1,574 mg/kg at the reference sites.
- The nitrogen level of all lowland soils appears to be high (concentration range in lowlands from 900 to 3,570 mg/kg). Much, if not most, of the nitrogen is bound to organic matter and only slowly becomes available for plant uptake. In wet soils, much of the nitrogen may be lost through volatilization as N_2, although sufficient nitrogen may be available to provide adequate support of native vegetative growth through slow mineralization release from soil organic matter.
- Cation Exchange Capacity (CEC) in the lowland soils averages approximately 18 cmol/kg, with higher CEC values found in soils east of the landfill, generally (but not closely) corresponding with increased organic matter content. Typically, where organic matter content is low, the CEC is also low, the exception being the soil sampled from the bottom of wetland 3, with high organic matter, but low CEC.

2. Upland Soils

The typical upland soils in the Albany Pine Bush were found on ridge tops and sideslopes. Generally, the upland soils had well-developed A horizons and thick B horizons, all consisting of fine sand and sand. In some upland profiles, mottling was noted in the upper reaches of the B horizons indicating periodic inundation or saturation, followed by periods of good aeration. These soils are well-drained, although moderate drainage was found in lower areas close to wet conditions.

The A horizon of the upland soils is typically from 0 to 7 inches (ranges from 4 to 15 inches thick) with relatively high organic matter content notable from the dark brown to black coloration (typical is 10YR 2/2 or 10YR 3/4). The A horizon, being modified by high organic matter, consists generally of very fine sand and fine sand with massive, friable structure. With higher organic matter content, the A horizon soil has a seemingly finer texture.

The B horizon of the upland soils was found to extend from immediately below the A horizon to depths greater than 36 inches (usual limit of sampling). In many locations, there is a sharp, distinct boundary between the A and B horizons, represented by sharply contrasting soil matrix colors. Other locations show a less distinct boundary between horizons, but differentiation in texture and the presence of mottles was more of a discerning factor. The B horizon of the upland soils had few hydric characteristics, generally found as faint to distinct – but few – mottles in the 4 to 10 inch depths below the ground surface (although as deep as 15 inches in one profile). The mottles were high chroma, indicating short periods of saturation/inundation, followed by largely well-aerated conditions. Occasionally, gleyed mottles were noted in the shallow B profile.

In general, laboratory data show that the upland soil characteristics demonstrate the following characteristics:

- Moderate acidity, with pH typically between 4.7 and 6.0, with some areas of stronger acidity as low as pH 4.1, or more neutral (five locations between pH 6.0 and 7.3).

- Organic matter content, typically highest in the A horizon, was generally found to be between 3.0 and 4.5 percent, with some locations with notably higher or lower organic matter concentrations.
- Similar to lowland soils, the nitrogen content in the upland soils corresponds well to the organic matter content, with concentrations ranging from 400 to 2,940 mg/kg in reference areas, to as high as 10,900 mg/kg on the landfill cap. Where nitrogen is present in higher concentrations, it is less likely to be bound in organic matter and more available for plant growth.
- Soil P concentrations were higher than what is normally expected in native soils (usually average concentrations between 10 to 25 mg/kg P would be a normal range), with concentrations generally between 20 to 80 mg/kg (the middle third of the concentration range). Nearly one-third of the samples did have concentrations below 15 mg/kg, and one-quarter of the samples with more than 80 mg/kg P.
- In contrast to P concentrations, K concentrations were lower than what would typically be expected in native soils (usually between 150 to 300 mg/kg).

Evaluation of Soils by Vegetative Community

To better understand the relationship of soils and vegetative communities in the Albany Pine Bush, soil data was compiled for evaluation by vegetative community types as determined during the September AES field study. Soil data is detailed in Table 1 on the following page.

Table 1 provides broad characterization of the chemical nature of the Albany Pine Bush soils that will provide a basis for restoring an environment similar to the existing conditions that will support re-establishment of the native vegetative communities. Soil characteristics for each community are summarized below.

Pine Bush: For restoration of the Pine Bush as described above, representative soil characteristics are moderately- to strongly acid, with an average pH of 5.1. The average organic matter content (%OM), is 4.0 percent, which may be higher than expected for a “barren” ecological system. Plant nutrients, N, P, and K, as well as Ca, are variable, and could be considered quite low compared to most other ecosystems in New York State. For example, total N (as reflected by Total Kejldahl Nitrogen – TKN) compared to organic matter content demonstrates a carbon-nitrogen ratio (CN ratio) of 15 or greater in all site soils, with the exception of the landfill cover soils. When the CN ratio is greater than 15, N tends to be organically bound and only marginally available for plant uptake. Likewise, while the available P content may be considered high to excessive in many soils, the interaction of P with the very high iron content of the Albany Pine Barren soils may render this nutrient largely unavailable to most plant species.

Trailer Park: Two soil samples were collected in the Trailer Park area east of the landfill. These soils represent modified soil conditions due to human residence, and demonstrate lower essential plant nutrient levels than found in other areas. Soil organic matter is quite low, and soil acidity measured as pH is near or at neutral. As with the Pine Bush evaluation, nitrogen as TKN appears high, but relative to organic matter content is within reasonable expectation of natural nitrogen levels, including slow mineralization of nitrogen that will become available for plants. The low organic content and corresponding relatively low nitrogen content, however, indicates that nitrogen could become depleted sooner than surrounding areas if not augmented with organic matter or other nitrogen sources. Phosphorus concentrations appear adequate in this area, and potassium concentrations are low. On a relative scale compared to other areas, Ca and Fe concentrations are low, but remain dominating factors affecting the availability and reaction of nutrients in the soil.

E Transects: Soil samples collected along transects plotted east of the landfill demonstrated, on average, moderate acidity (average pH 5.3) and high organic matter content (average 11.3 percent). These soils reflected a range of conditions, from upland soil conditions on side slopes to lowland soil conditions near streams and very wet areas. The highest average iron and calcium contents for soils in the area were found in samples from the E transects. The high iron content is expected to have a significant affect on nutrient availability and soil reaction (acidity), but this impact can be modified by the calcium content. It is expected that nitrogen (3,570 mg/kg TKN), phosphorus (765 mg/kg Total P), and sulfur (1,485 mg/kg Total

S) will be substantially bound to the high organic matter content of the soil or to the high calcium and iron mineral contents of the soil (particularly for P).

Table 1: Comparison of available and total extractable nutrients and trace minerals in Albany Pine Bush Soils.

Mean Concentrations in ppm in dry soil samples.

	pH	%OM	TKN	P	K	Ca	Mg	S	Zn	B	Mn	Fe	Cu	Al	Na
PINE BUSH N = 7															
Available	5.1	4.0		110	29	367	27								
Extractable			2942	857	828	4700	1300	800	40.5	5.52	345.6	15910	8.61	10666	72
TRAILER PARK N = 2															
Available	7.0	0.8		48	37	826	35								
Extractable			400	350	750	750	850	300	45.3	3.05	81.3	10269	2.62	7317	63
E TRANSECTS N = 20															
Available	5.3	11.3		36	48	2076	134								
Extractable			3570	765	980	6000	1485	650	41.4	4.96	374	22879	10.14	8734	74
VERNAL PONDS N = 2															
Available	5.2	3.8		43	36	408	49								
Extractable			1300	600	950	1550	1350	350	28.9	3.62	213	11785	6.16	9746	67
WETLANDS N = 5															
Wetland 1 N=1															
Available	7.6	2.0		38	17	1574	50								
Extractable			900	300	1100	4200	1500	300	24.9	7.48	144	12237	5.05	6152	74
Wetlands 2&3 N = 4															
Available	4.3	16.0		74	36	376	31								
Extractable			1550	500	800	2050	1775	300	42.3	2.24	159.1	11161	7.28	8201	69
LANDFILL CAP N = 1															
Available	6.0	1.6		78	58	615	70								
Extractable			10900	600	900	2100	700	1900	40.7	5.57	97.3	4538	55.7	6489	70

Vernal Ponds: Two vernal ponds, or pools, were sampled. At the time of sampling, both pools were dry, but the soil remained moist. In general, both pools exhibited moderate organic matter content (average of 3.8 percent) and moderate acidity (average pH 5.3 standard units). The nitrogen, phosphorus, potassium, and sulfur dynamics appear to be consistent with the nutrient dynamics of other areas, with generally low nutrient availability with relatively high total concentrations. Calcium and iron contents are slightly lower than other areas, but they do not appear to be significantly different (no statistical comparison is inferred).

Wetland 1: Wetland 1 is different from Wetlands 2 and 3, demonstrating a relatively high pH (7.6 standard units) and low organic matter content (2 percent). This wetland also demonstrated relatively low nitrogen, phosphorus, potassium, and sulfur content. Compared to other areas, particularly lowlands, the calcium content was relatively low (4,200 mg/kg total Ca), but the iron content is high (12,237 mg/kg total iron), reflecting the degree of variability of site conditions in the area.

Wetlands 2 and 3: Wetlands 2 and 3 reflect conditions typically expected of most wetland areas; high organic matter content (average of 16 percent) and strong acidity (average pH 4.3 standard units). The nitrogen (1,550 mg/kg TKN), phosphorus (500 mg/kg total P), and potassium (800 mg/kg total K) concentrations are relatively consistent with several of the other areas sampled, and the generally high iron concentration (11,161 mg/kg) indicates that most nutrients will be available for plant use in low amounts. The average calcium concentration (2,050 mg/kg total Ca) is low compared to other lowland areas, indicating that acidity in these wetlands will remain the dominant mitigating factor affecting site chemistry.

Landfill Cap: The landfill cap demonstrates soil conditions reflecting anthropogenic modifications to the soil. This soil reflects relatively low organic material content (1.6 percent) and near-neutral acidity (pH 6.0 standard units). The soil of the landfill cover is approximately 18 inches thick over the clay cap. The nitrogen concentration (10,900 mg/kg) is extraordinarily high, with phosphorus content consistent with other locations in the landfill area, and low potassium concentrations (900 mg/kg total K). Calcium and iron concentrations area also low compared to other areas in the Pine Bush and adjacent areas, indicating that the landfill cover soil is significantly different from the surrounding site conditions of the Pine Bush environment.

It is the “barren” of low nutrient, and natural fire cycles that gives rise to such unique species such as scrub oaks and pines. For instance, Pitch pine grows in “sterile sandy soil, pH 3.5 to 6.5 (Olsvig, L., Cryan J., and Whitaker, R 1979).   Tolerant of drought, salt. Intolerant of flooding or saturated soil for more than 25% of the growing season; soil compaction; shade index 0-2.   New Jersey tea, *Ceanothus americanus*, a common shrub of the Albany Pine Bush, has conditions “open, dry, sterile soil, pH 4.5 to 6. Tolerant of salt, drought. Intolerant of soil compaction, shade. It is our challenge to describe the range of soil conditions that will support our desired plant communities. We can then use this table to assess candidate soils for our program.

In our dialog with the stakeholders, we have been assured that Pine Bush soils are available from on or off site, to help recreate the pine bush ecosystems on top of the closed landfill sections.   It will be far more practicable to mine existing soils than attempt to restore them from off-site soil sources.   While there is not a substantial variation between the textural characteristics of A and B horizons, it will remain important to segregate soil by horizon while stockpiling it, preserving the integrity of the natural soil constituents for restoration purposes. For example, the top 12 inches of soils on site should be removed and stockpiled separately from soils below 12 inches.

The loamy fine sand soils, by nature of their texture, are excessively drained and droughty. Because they are so deep, in excess of well over 60 inches, water drainage will extend deep into the profile on typical upland soils at the Pine Bush. Restoration of Pine Bush soils on a landfill cap must take into account soil hydrology and drainage characteristics, and how this will affect plant growth. If restored soils are not deep enough, drainage may be sufficiently different from native conditions as to result in alterations of the expected plant communities. Consideration in placement of the soils will be topographical aspect, rooting depth, and soil development over time. For example, placement of restored soils on sideslopes of the landfill cap may present better soil drainage and therefore more native conditions than soils placed on the top of the cover. Controls such as subsurface drain tiles may provide an artificial means of recreating native soil conditions that will best support Pine Bush vegetative communities. Any and all restoration strategies should be examined closely and tested before full-scale restoration design and construction occurs.

After we have obtained and evaluated data of how potential restored soils will interact with the environment (drainage, nutrient levels, OM content, etc.), we will need to estimate feasible depth and placement of the native soils, in loose tip, over the capped landfill. We will need to consider how to undulate the fill to best emulate the Pine Bush reference areas. It will be necessary to make a thorough assessment of sand that is available for the landfill cover and restoring the Pine Bush environment, including determining testing and pre-approval of each stockpile source. Factors include the frequency of testing (1,000 c.y., 2,500 c.y.) depending on the uniformity and results.

Summary

AES characterized the vegetative communities and soil conditions of the Albany Pine Bush for the purpose of restoring this unique ecological community as the end point of the Albany Landfill expansion plans. Our goal is, as described by the New York State Natural Heritage Program, to restore an ecological community described as a Pitch pine-scrub oak barrens: a shrub-savanna community that occurs on well-drained, sandy soils that have developed on sand dunes, glacial till, and outwash plains, in which Pitch pine (*Pinus rigida*) is the dominant tree; the percent cover of pitch pine is variable, ranging from 20 to 60%, and the shrublayer dominants are scrub oaks (*Quercus ilicifolia* and *Q. prinoides*), which often form dense thickets.

To accomplish this goal, we have characterized soil conditions at the Albany Pine Bush, establishing a target upland soil restoration of loamy fine sand to sand, excessively drained, having moderately to strong reaction (pH 5.0 to 5.5), moderate organic matter content, and low- to (in some locations) moderate nutrient availability. The native soils have demonstrated additional chemical uniqueness, including high iron and manganese content that likely contribute to the vegetative speciation of the Albany Pine Bush and should be retained.

The next step of this process in the development of a detailed restoration plan, including provisions for supplemental studies of the optimal soil restoration strategies that will assure successful restoration of the Albany Pine Bush ecology.

References

1. SIGNIFICANT HABITATS AND HABITAT COMPLEXES OF THE NEW YORK BIGHT WATERSHED; Albany Pine Bush http://training.fws.gov/library/pubs5/web_link/text/apb_form.htm

2. Histosols: Their Characteristics, Classification, and Use. SSSA Special Bulletin No. 6. Soil Science Society of America. 1974

Attachment A
Summary Data Tables
Albany Pine Bush Soils

Lowland

The lowlands mapped include soils found in fens, bogs, and ponds, typically where water flows and collects, or where the topographical aspect is low and intercepts the water table, creating perennially wet conditions. Because these areas receive runoff from upland areas, they collect increased amounts of organic detritus in addition to that which grows and collects there. The abundance of organic material contributes to the water-holding capacity of the soil, maintaining poorly-drained conditions. Organic material in these areas is slow to decay, and therefore builds, creating its own horizon, and leaching into lower soil horizons. Organic acids slowly break down the mineral sands into finer sands, silts, and clay that, with silts and clays transported to these low areas, result in lower water transmissivity and higher water holding capacity.

Lowland soils in the area of the landfill expansion typically fit the following description:

A Horizon: The A horizon of the wetland/lowland soils in the expansion area average about 20.5 inches in depth (range from 6 to 38 inches), typically consisting of much intermixed with very fine sand and loamy fine sand. Occasionally, increased silt and clay content was noted, representative of the accumulation of organic materials and fine mineral matter. The A horizon in nearly all of the sampled locations consisted dominantly of organic muck (largely 80 to 100 percent organic material) in an ‘O’ or organic horizon with an A horizon with increased mineral content (typically fine sand). This horizon is black in color (< 2 chroma and value < 3 on Munsel Soil Color Charts), generally granular or massive in structure, and friable. At all locations, the organic material was always wet to saturated, and loosely-consolidated, sometimes with substantial void spaces.

B Horizon: The B horizon of the wetland/lowland soils in the expansion area is differentiated from the A or O horizons by increased amounts of mineral matter, typically fine sand. The B horizon soil tends to be dark and gleyed (reduced conditions), typically with high amounts of organic material that has leached into the sands. The B horizon was exemplified by thicknesses of 0 to 40 inches, and greater extending to depths beyond 60 inches below the surface. Soil is generally dark rown and dark grayish brown, very fine sand and loamy fine sand, with massive structure and friable. The B horizon was always wet or saturated.

Lowland soils evaluated in the expansion area include sampling points E1-B, E1-C, E1-D, E2-A, E3-C, and E4-B. Table 1 summarizes base information characterizing the sample locations for the lowland soils, and field data sheets are provided in attachment A.

Lowland soils at reference areas were examined in or very near to ponds, bogs, and fens. Soils were sampled both on wet or saturated ground, an in inundated pond/bog beds. Typically, the soil underlaying the inundated areas of ponds and bogs was found to consist of muck to depths greater than 40 inches. The soils examined within a sedge meadow, fens, or adjacent to ponds typically consisted of an organic layer (muck or detritus) from 0 to 4 inches thick, underlain by high organic, very fine sand to loamy fine sand to depth of approximately 14 to 24 inches below the ground surface. The A horizon of reference soils in wet areas were generally very dark brown to black (10YR 2/1 to 2.5Y 3/2, for example), had massive or granular structure, and were friable.

The B horizon at the lowland reference sites were found to also be typically dark (10YR 5/3, 10YR 3/2) with gleyed chromas. Generally, these soils were found to be composed of very fine sand and loamy fine sand. In some locations, the B horizon had relatively low organic matter content, but in all locations, the B horizon was wet to saturated, had massive structure, and was typically friable.

Table 1: Summary of Lowland Soil Profile Characterization					
Sample Location	**A Horizon Thickness**	**Color/texture**	**B Horizon Thickness**	**Color/texture**	**Comments**
E1-B	0 – 38	2.5Y 6/N Black muck	38 – 42+	2.5Y 6/2 Very fine sand	Largely consisted of organic muck with increasing mineral content with depth.
E1-C	0 – 22	2.5Y 6/N and 10YR 6/1 Muck and silt loam	22 – 42+	10YR 3/3 to 7.5YR 4/6 Silt loam and fine sand	A_O horizon from 0 to 4 inches, very high (histic) horizon to 22 inches. Few faint mottles in B horizon
E1-D	0 – 15	G-2 2.5/N Organic fine sand	15 – 30+	5Y 4/2 – 3 Fine sand, very fine sand	Organic A horizon, underlain by fine and very fine sand. Few, faint mottles were present
E2-A	0 – 24	10YR 2/0 Muck and loamy fine sand	24 – 34+	10YR 3/1 Very fine sand	Very high organic material content throughout the profile. 0 – 18 inch depth is the A_O horizon, all muck, underlain by sand with very high OM content
E3-C					
E4-B	0 – 6	7.5YR 2/0 Organic/fine sand	6 – 30+	10YR 2/1 and 10YR 5/2 Loamy fine sand	
Reference Locations					
Wetland 1A (Pond)	0 – 15	2.5Y 3/0 to 2.5Y 3/2 Muck and fine sand	15 – 36+	2.5Y 3/2 Organic fine sand	No mottles. Very high organic matter content in the entire depth of the sample.
Wetland 2A (Pond)	0 – 6	10YR 2/2 to 10YR 3/2 Organic matter and fine snad	6 – 38+	10YR 5/6 Fine sand	Well-oxidized B horizon, few faint mottles in lower A and upper B horizons. Sample location above pond
Wetland 2A (pond)	0 – 12	10YR 2/2 Muck and fine sand	12 – 24+	10YR 3/2 Loamy fine sand	Organic muck underlain by well consolidated fine sand. Sample from submerged pond location.
Wetland 3A (Bog)	0 – 40	10YR 2/2 Muck and silty clay	NA		Sample collected in submerged area of bog. Organic muck was underlain by stiff silty clay (confining layer).
Wetland 3A (woodland)	0 – 16	10YR 2/1 Organic matter and loamy fine sand	16 – 30+	10YR 5/3 Very fine sand	0 to 3 inches of organic detritus on surface, A horizon is very high in organic matter/muck.
Vernal Pool 1 – Point 0	0 – 8	10YR 2/1 Loamy fine sand	8 – 30+	10YR 6/2 Fine sand	A_O horizon underlain by organic/sandy B horizon. Mottles were common.

Table 1: Summary of Lowland Soil Profile Characterization					
Sample Location	**A Horizon Thickness**	**Color/texture**	**B Horizon Thickness**	**Color/texture**	**Comments**
Vernal Pool 1 – Point 0+50m	0 – 3	7.5YR 4/3 Fine sand	3 – 28+	7.5YR 4/4 to 7.5YR 6/3 Fine sand	Apparent buried horizon from the 20 to 23 inch depth bgs
Vernal Pool 4	0 – 8	10YR 2/1 to 10YR 2/2 Organic muck and loamy fine sand	8 – 30+	10YR 4/3 to 10YR 5/4 Fine sand and sand	0 to 3 inch depth is an O horizon. Few, very fine mottles noted.
Sedge Meadow PB SM1	0 – 14	10YR 3/1 Fine sandy muck	14 – 30+	10YR 3/2 2.5Y 5/3 Fine sand, very fine sand	Very high organic matter in the A horizon, few faint mottles in B horizon, grayish matrix
RH Fen (PB RHF1)	0 – 24	10YR 4/2 10YR 5/2 Very fine sand and sand	24 – 33+	10YR 5/8 2.5Y 3/6 Sand	Very loosely consolidated material in the A horizon, very high in OM content

Uplands

The typical upland soils in the Albany Pine Bush were found on ridge tops and sideslopes. Generally, the upland soils had well-developed A horizons and thick B horizons, all consisting of fine sand and sand. In some upland profiles, mottling was noted in the upper reaches of the B horizons indicating periodic inundation or saturation, followed by periods of good aeration. These soils are well-drained, although moderate drainage was found in lower areas close to wet conditions.

Upland soils have the following general profile characteristics:

A Horizon: The A horizon of the upland soils is typically from 0 to 7 inches (ranges from 4 to 15 inches thick) with relatively high organic matter content notable from the dark brown to black coloration (typical is 10YR 2/2 or 10YR 3/4). The A horizon, being modified by high organic matter, consists generally of very fine sand and fine sand with massive, friable structure. With higher organic matter content, the A horizon soil has a seemingly finer texture.

The B horizon was found to extend from immediately below the A horizon to depths greater than 36 inches (usual limit of sampling). In many locations, the there is a sharp, distinct boundary between the A and B horizons, represented by sharply contrasting soil matrix colors. Other locations show a less distinct boundary between horizons, but differentiation in texture and the presence of mottles was more of a discerning factor.

The B horizon of the upland soils had few hydric characteristics, generally found as faint to distinct – but few – mottles in the 4 to 10 inch depths below the ground surface (although as deep as 15 inches in one profile). The mottles were high chroma, indicating short periods of saturation/inundation, followed by largely well-aerated conditions. Occasionally, gleyed mottles were noted in the shallow B profile.

Upland soils in the expansion area included sampling points E1-E, E2-B, E2-C, E3-A, E3-B, E3-D, E3-E, E4-A, E4-C, E4-D, E6-B, E6-C, TP-8, TP-40, and DSI-3. Table 2 summarizes base information characterizing the sample locations for the upland soils, and field data sheets are provided in attachment A.

Reference soils in upland areas, including the scrub oak thicket (PBPP-SOT), pine woodland (PBPP-SOF1), and restored prairie (PBKBH1), had relatively shallow, thin A horizons, generally very dark brown (10YR 2/2 or 3/3) or very dark grayish brown (10YR 3/2) soil with fibrous organic matter with fine sand. The A horizons were well drained with massive, friable structure. The B horizons of the reference soils were found to be brown (7.5YR 5/8) to yellowish brown (10YR 4/6 or 5/6) fine sand, typically well-oxidized with occasional leach stains from organic material. No mottling was found in the reference upland soil locations. Soil structure in the B horizons as massive and friable.

Comparison between the reference upland locations and the upland soils in the expansion area show that the soils in the expansion area appear to be more mature with stronger horizon development and indications of more pronounced hydrologic interaction, evidenced by presence of mottles in the shallow B horizons.

Table 2: Summary of Upland Soil Profile Characterization

Sample Location	A Horizon Thickness	Color/texture	B Horizon Thickness	Color/texture	Comments
E1-A					
E1-E	0 – 10	10YR 2/2, fine sand	10 – 26+	10YR 6/2fine sand/very fine sand	Few, distinct mottles from 10 to 12 " depth
E2-B	0 – 9	10YR 2/1, very fine sand	9 – 36+	10YR 6/2 fine sand/ sand	No mottles
E2-C	0 – 6	10YR 3/2, loamy fine sand	6 – 36+	10YR 6/6 loamy fine sand	Common, faint mottles from 6 to 12" depth
E3-A	0 – 4	10YR 5/4,	4 – 30+	10YR 5/4 fine sand	Few, faint mottles
E3-B	0 – 15	10YR 4/3, fine sand	15 – 30+	10YR 5/4 fine sand	No mottles
E3-D	0 – 9	10YR 3/2, very fine sand	9 – 36+	10YR 5/6 to 7.5YR 3/3 fine sand	Few mottles in the lower A horizon, sand is tightly consolidated in lower depths
E3-E	0 – 4	10YR 2/2, fine sand	4 – 36+	10YR 4/3 to 7.5 YR 6/6 fine sand	No mottles
E4-A	0 – 4	7.5YR 2/0, loamy fine sand	4 – 30+	10YR 5/6 – 8 loamy fine sand	No mottles
E4-C	0 – 8	2.5Y 3/3 10YR 3/4 fine sand	8 – 24+	10YR 5/8 fine sand	Distinct, common mottles from 8 to 10 inch depth
E4-D	0 – 4	10YR 3/3 – 4 Loamy fine sand	4 – 24+	10YR 4/4 to 10YR 5/2 fine sand	Few distinct mottles
E6-B	0 – 5	10YR 2/2 fine sand	9 – 20+	10YR 3/3 to 10YR 6/8 fine sand	Few faint mottles, highly oxidized matrix in lower profile
E6-C	0 - 6	10YR 2/0 loamy fine sand	6 – 30+	10YR 4/2 fine sand	No mottles,
DSI – 3	0 – 6	10YR 2/1 fine sand	6 – 30+	2.5Y 4/2 to 2.5Y 5/2 very fine sand	Few faint mottles
TP – 40	0 – 2	2.5Y 3/2 fine sand	2 – 30+	10YR 4/6 to 10YR 5/2 fine sand/ sand	Few faint mottles within an intermixed A/B zone
TP – 8	0 – 4	10YR 3/3 fine sand	4 – 33+	10YR 4/4 fine sand	No mottles

Table 2: Summary of Upland Soil Profile Characterization					
Sample Location	**A Horizon Thickness**	**Color/texture**	**B Horizon Thickness**	**Color/texture**	**Comments**
Reference sites					
PBPP - SOT	0 – 2	10YR 3/2 Organic/fine sand	2 – 30+	10YR 3/3 to 10YR 5/8 fine sand	Well-oxidized B horizon with no mottles
SOT – 2	0 – 3	10YR 3/4 Organic/fine sand	3 – 30+	10YR 4/6 fine sand	No mottles
PBPP SOF	0 – 1	10YR 2/2 Organic detritus	1 – 30+	10YR 5/6 fine sand	A horizon is an organic A_O horizon underlain by well-oxidized sand
PBKBH1	0 – 4	10YR 3/3 fine sand	4 – 30+	10YR 4/6 fine sand	Lower B horizon is well-oxidized fine sand and sand, no mottles

Laboratory Analytical Results

Soil samples from the A horizon, and occasionally the B horizon, were collected for laboratory analyses of the following parameters: texture (percent sand, silt, and clay), pH, percent organic matter, phosphorous, potassium, calcium, magnesium, percent organic matter, and cation exchange capacity. Table 3 provides a summary of the data, and analytical reports are provided in Attachment B.

The laboratory data shows that soil conditions across the Pine Bush varies substantially. Soil conditions range from sand to loamy texture, with an overall, average textural classification of loamy sand. Soil pH is typically in the range of 5.2 to 5.5 standard units, with an overall range from pH 3.9 to pH 7.6. The lowland, wet areas tend to have higher organic matter and lower pH than the upland sample locations, as would be expected. Concentrations of phosphorus (P) and calcium (Ca) appear to be higher than would be expected in most soils, particularly in eastern woodlands and in sandy soil, and potassium (K) concentrations were generally low. Descriptions of soil characteristics based on laboratory analysis for lowland areas and upland areas are provided below.

Lowland Areas

Based on the laboratory data, lowland areas typically have a low pH (average 5.2 standard units) and relatively high organic matter (average 15.8 percent). The low-lying, wet soils in the area east of the landfill (along transects E1 through E6) tended to have more organic matter in the upper horizons than the low-lying reference sites. The laboratory analysis does not reflect the very high organic matter content in some of the soils in these areas where distinct histosols (organic matter greater than 18 percent by weight [2]) were present, and the upper portions of the horizon were likely greater than 80 percent organic material. In contrast, soils in the reference areas tended to have substantially less organic matter content with the exception of soil/sediment collected from the floor of Wetland 3, a bog northeast of the landfill, north of the trailer park.

The P concentrations for the low-lying areas averaged 48.8 mg/kg, a value that could be considered high by most native soil standards. It is interesting to note the contrast, again, between the soils east of the landfill and those of the reference areas within the Pine Bush. In general, the P levels of soils east of the landfill tend to be lower (average of approximately 10 mg/kg), compared to the average concentration of 53 mg/kg in the reference soils. It is possible that P is bound to the organic matter complexes and/or high calcium concentrations of the soils east of the landfill. The high P concentrations in the reference areas could be related more to the mineral origin of the sandy soils.

The potassium (K), Ca, and magnesium (Mg) concentrations in soils east of the landfill are also substantially higher than soils at the reference sites. In particular, Ca appears to be extraordinarily high in these areas with concentrations ranging from 2,154 mg/kg to 6,201 mg/kg, compared to a range of 49 mg/kg to 1,574 mg/kg at the reference sites. Because the reference sites are assumed to be non-anthropogenically impacted, the increased Ca concentrations east of the landfill could be resultant from limestone applied for odor control at the landfill that drifted onto these areas. The correspondingly high Mg levels could also be attributed to this possibility if the limestone applied to the landfill is a dolomitic limestone.

Cation Exchange Capacity (CEC) in the lowland soils averages approximately 18 cmol/kg, with higher CEC values found in soils east of the landfill, generally (but not closely) corresponding with increased organic matter content. Typically, where organic matter content is low, the CEC is also low, the exception being the soil sampled from the bottom of wetland 3, with high organic matter, but low CEC.

Table 3: Summary of Laboratory Analysis of Soil Samples Collected at the Albany Pine Bush and Landfill

Sample ID	% Sand	% Silt	% Clay	Soil Texture	pH	OM %	P ppm	K ppm	Ca ppm	Mg ppm	CEC
Lowland Locations											
E1-B	82	8	10	Loamy Sand	5.1	35.7	16.0	50.0	4403.0	169.0	60.0
E1-C	75	16	9	Sandy Loam	5.1	36.2	7.0	151.0	3507.0	363.0	43.0
E1-D	41	44	15	Loam	6.3	20.1	16.0	145.0	6201.0	355.0	56.0
E3-C	79	16	5	Loamy sand	5.6	15.8	7.0	45.0	5202.0	206.0	34.0
E4-B	87	8	5	Loamy Sand	5.6	32.3	8.0	35.0	2154.0	291.0	27.0
E4-B B HORIZON	71	24	5	Sandy Loam	5.7	12.2	4.0	17.0	5041.0	185.0	30.0
PBRHF-1 @ 25M	85	8	7	Loamy Sand	5.4	3.8	193.0	35.0	87.0	18.0	1.0
PBSM1-A	81	12	7	Loamy Sand	5.5	5.0	68.0	20.0	228.0	21.0	2.0
PBVP1 40 M TH	83	12	5	Loamy Sand	4.6	8.2	32.0	52.0	755.0	51.0	5.0
VERNAL POOL A	71	24	5	Sandy Loam	5.1	6.1	29.0	43.0	646.0	5.0	5.0
VERNAL POOL B	89	4	7	Sand	5.2	1.4	67.0	28.0	169.0	23.0	1.0
WETLAND 1-A	91	2	7	Sand	7.6	2.0	38.0	17.0	1574.0	50.0	7.0
WETLAND 2 A1	91	4	5	Sand	4.1	5.2	184.0	32.0	78.0	17.0	1.0
WETLAND 2-A	73	22	5	Sandy Loam	5.0	11.4	66.0	16.0	664.0	40.0	7.0
WETLAND 3-A1	87	8	5	Loamy Sand	3.9	11.5	34.0	65.0	49.0	23.0	1.0
WETLAND3-A	75	20	5	Sandy Loam	4.0	45.8	12.0	31.0	313.0	43.0	8.0
Average	**79**	**15**	**7**	***Loamy Sand***	**5.2**	**15.8**	**48.8**	**48.9**	**1942**	**116.3**	**18.0**
	12	**11**	**3**		**0.9**	**14.1**	**58.7**	**41.1**	**2176**	**127.1**	**20.7**
Upland Locations											
DS1-3	79	16	5	Loamy Sand	5.8	4.3	8.0	30.0	1855.0	84.0	10.0
E1-A 24A	87	8	5	Loamy Sand	5.8	4.1	82.0	43.0	1014.0	66.0	6.0
E1-A 24-B					5.7	4.4	97.0	50.0	1088.0	73.0	6.0
E1-E	63	32	5	Sandy Loam	5.1	4.4	6.0	35.0	886.0	93.0	5.0
E2-A	82	8	10	Loamy sand	5.4	14.2	20.0	87.0	6067.0	343.0	42.0
E2-B	65	26	9	Sandy Loam	5.1	6.2	6.0	39.0	1363.0	88.0	8.0
E2-C	71	24	5	Sandy Loam	5.4	7.6	5.0	19.0	1918.0	161.0	11.0
E3-A	89	6	5	Sand	7.3	1.0	74.0	38.0	1212.0	29.0	5.0
E3-B	91	4	5	Sand	5.6	1.4	115.0	35.0	507.0	46.0	2.0
E3-D	71	22	7	Sandy Loam	4.7	6.6	19.0	24.0	656.0	44.0	4.0
E3-E	77	18	5	Loamy Sand	5.0	2.3	45.0	35.0	325.0	34.0	2.0
E4-A	89	6	5	Sand	4.1	8.9	81.0	21.0	367.0	35.0	3.0
E4-C	89	6	5	Sand	5.0	4.2	8.0	29.0	581.0	47.0	3.0
E4-D	77	16	7	Sandy Loam	5.3	2.5	8.0	24.0	563.0	57.0	3.0
E6-B	89	6	5	Sand	4.6	3.3	148.0	24.0	392.0	28.0	2.0
E6-C	73	20	7	Sandy Loam	5.3	7.3	8.0	24.0	2091.0	99.0	13.0
LAND FILL CAP	91	4	5	Sand	6.0	1.6	78.0	58.0	615.0	70.0	3.0
LFTP-1	91	4	5	Sand	6.6	3.0	54.0	75.0	1043.0	66.0	6.0
LFW2 #2	79	16	5	Loamy Sand	6.9	2.0	30.0	86.0	2370.0	107.0	12.0
PBKBH1 50 M	91	4	5	Sand	4.6	3.9	177.0	29.0	176.0	15.0	1.0
PBPPSOT-1	69	26	5	Sandy Loam	4.7	2.2	11.0	23.0	109.0	16.0	1.0
PBPPSOT-2	91	2	7	Sand	5.7	3.5	157.0	22.0	1141.0	61.0	6.0
PPSOF-1 @ OM	69	26	5	Sandy Loam	5.1	1.2	134.0	24.0	21.0	7.0	
RANDOM #1	91	4	5	Sand	5.5	1.9	55.0	45.0	371.0	38.0	2.0
TP-2 @ 40 M	89	4	7	Sand	6.8	0.7	52.0	21.0	418.0	21.0	2.0
TP-8	93	2	5	Sand	7.1	0.9	43.0	53.0	1244.0	48.0	5.0
Average	**82**	**12**	**6**	***Loamy Sand***	**5.5**	**4.0**	**58.5**	**38.2**	**1092**	**68.3**	**6.5**
standard dev.	**10**	**9**	**1**		**0.8**	**3.0**	**52.5**	**19.6**	**1194**	**65.7**	**8.1**

Highlighted values are greater than 1x the standard deviation above or below the mean value

Upland Areas

Soil investigated in the upland areas tend to have relatively consistent characteristics regarding texture, organic matter content, pH, and nutrient concentrations. Analyzed values for pH, organic matter content, P, K, Ca, Mg, and CEC were typically within one standard deviation of the mean values for most of the soil locations, however, it needs to be recognized that high variability establishes correspondingly high standard deviations, and soil constituent levels such as P, Ca, and Mg varied substantially. Unlike the lowland soils that demonstrated variability related to location, the upland soils do not demonstrate similar spatial distribution.

In general, the upland soil characteristics demonstrate moderate acidity, with pH typically between 4.7 and 6.0, with some areas of stronger acidity as low as pH 4.1, or more neutral (five locations between pH 6.0 and 7.3). Organic matter content, typically highest in the A horizon, was generally found to be between 3.0 and 4.5 percent, with some locations with notably higher or lower organic matter concentrations. P concentrations were higher than what is normally expected in native soils (usually average concentrations between 10 to 25 mg/kg P would be a normal range), with concentrations generally between 20 to 80 mg/kg (the middle third of the concentration range). Nearly one-third of the samples did have concentrations below 15 mg/kg, and one-quarter of the samples with more than 80 mg/kg P. In contrast to P concentratins, K concentrations were lower than what would typically be expected in native soils (usually between 150 to 300 mg/kg).

Similar to the lowland soil locations, the high concentrations and variability of Ca in the upland soil is cause for speculation. The highest concentrations of Ca in the upland soils appear to be most closely associated with locations east and near the landfill itself. These concentrations are not as high as found in lowland soils, with the exception of sample location E2-A, located adjacent to the access road less than 150 yards from the landfill itself.

The CEC levels of the upland soils are appropriate for sandy soils with low organic matter. In the few samples with elevated organic matter concentrations, CEC also is shown to be higher.

Summary

Soil characterization of the Albany Pine Bush and Landfill Expansion area revealed relatively consistent physical attributes of the soils in this area, and strong variability in the chemical (acidity and nutrients) constituents. The soils are typically fine sand and loamy fine sand, very deep, excessively drained, and moderately acid. Upland soils have generally lower organic matter content, but often more developed horizons, showing some hydrologic flux resulting in active reduction/oxidation of the soil. The lowland soils, while sandy and capable of high amounts of water transmissivity, generally intersect the water table, and in some cases have demonstrated water retention that results in high buildup of organic material, develops gleyed conditions, and serves to collect and build organic and mineral content from runoff from higher ground.

Reference soils in the Albany Pine Bush appear to be substantially less developed than soils east and north of the landfill, suggesting that it is possible that hydrologic and possible minor anthropogenic impacts are more direct on the east side of the landfill, a result of the more severe drainages in this area, and from landfill operation and nearby human activities. Whatever the causes, more distinct development of horizons, increased organic matter content, and in some locations higher mineral content (both in silt and clay colloids, and in mineral content) was found to occur in the lower drainages occurring east and north of the landfill.

Attachment B
Supplemental Information

This community is adapted to and maintained by periodic fires; frequency of fires ranges from 6 to 15 years.
Rank: G2 S1 Cryan, J. and Olsvig, L.

From Chapter 15, Vegetational Gradients of the Pine Plains and Barrens of Long Island, NY, Olsvig, Cryan and Whittaker, 1979:

Average Canopy and Soil Characteristics for the Long Island Communities

	Oak-pine	Barrens
No. of stands sampled	4	6
Tot canopy		
Basal area (m^2/ha)	9.88	8.90
Pine basal area	4.56	6.54
Percent pine (%)	46	73
Pine height (n)	13.9	12.7
Soil texture of the B Horizon		
Coarse sand (%)	40.4	38.8
Medium sand (%)	31.2	31.6
Fine sand (%)	9.2	11.8
Silt and clay (%)	18.8	17.6
Soil profile depth (cm)		
O horizon	5.25	4.17
A horizon	7.50	5.83
B horizon	37.6	43.33
Litter biomass (g dry wt/900 cm^3)	852.5	__
Soil nutrients (ppm in the O horizon)		
Phosphorous	207.5	70.0
Potassium	757.5	138.3
Calcium	1850.0	1191.5
Magnesium	525.0	323.0
Percent Organic matter (O horizon)	40.0	37.7

If we are to restore accurate Pine Bush communities atop the landfill, we need to evaluate not only types of soil, but how deep and how to shape and grade the soil. Then we need to decide on a methodology to vegetation the land, whether by seed, plant units or a combination of both. Since we are jump starting the successional process, likely will propose early seral stages. All propagules will be collected locally with a program of partnership with the Albany Pine Bush Commission. We will develop a planting strategy that meets with the Commission Management Plan.