

EXHIBIT O

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SOIL SURVEY

Grand Traverse County Michigan



Compliments of
Your United States Senator
PATRICK V. McNAMARA

UNITED STATES DEPARTMENT OF AGRICULTURE
Soil Conservation Service
In Cooperation With
MICHIGAN AGRICULTURAL EXPERIMENT STATION

SOIL MANAGEMENT UNIT 5aD (VIIa)

This unit consists of strongly sloping, light-colored, well-drained sands, loamy sands, and gravelly loamy sands. In most places these soils are underlain by sand, gravel, or a mixture of both. Natural fertility and moisture-supplying capacity are low. The soils are—

- Alpena-East Lake gravelly loamy sands, 12 to 18 percent slopes (East Lake part).
- East Lake-Mancelona loamy sands, 12 to 18 percent slopes (East Lake part).
- Kalkaska loamy sand, 12 to 18 percent slopes.
- Kalkaska loamy sand, 12 to 18 percent slopes, moderately eroded.
- Kalkaska sand, 12 to 18 percent slopes.
- Kalkaska sand, 12 to 18 percent slopes, moderately eroded.
- Leelanau-Kalkaska loamy sands, 12 to 18 percent slopes (Kalkaska part):
- Leelanau-Kalkaska loamy sands, 12 to 18 percent slopes, moderately eroded (Kalkaska part):
- Mancelona-East Lake loamy sands, 12 to 18 percent slopes (East Lake part).
- Mancelona-East Lake loamy sands, 12 to 18 percent slopes, moderately eroded (East Lake part).
- Montcalm-Kalkaska loamy sands, 12 to 18 percent slopes (Kalkaska part).
- Montcalm-Kalkaska loamy sands, 12 to 18 percent slopes, moderately eroded (Kalkaska part).
- Rubicon-Menominee loamy sands, 12 to 18 percent slopes.

Because of low yields and unfavorable slopes, these soils are not suitable for general farming. They can be used for permanent pasture, but yields are generally low, even under good management. To maintain a stand of plants dense enough to prevent erosion, grazing should be carefully controlled and fertilizer applied annually.

The soils in this unit are generally too steep and too rough for orchards, but where they occur in that part of the county used for commercial orchards, some areas can be planted to fruit trees if they are smoothed and are leveled to a more gentle grade. Then, mechanized equipment can be operated in orchards, and practices for controlling erosion can be applied. The surface layer and subsoil are likely to be removed in deeply cut parts of a field. In areas of deep cuts, restoring fertility and establishing a protective cover of plants are major problems that may be difficult to solve unless technical help is obtained.

SOIL MANAGEMENT UNIT 4aF (VIIe)

This unit is made up of very steep, well-drained loamy sands that are underlain by sand, loamy sand, or sand and gravel. These soils have moderately low to low fertility and moisture-supplying capacity. The soils are—

East Lake-Mancelona loamy sands, 25 to 35 percent slopes (Mancelona part).

Karlin loamy sand, 25 to 45 percent slopes.

Karlin loamy sand, 25 to 45 percent slopes, moderately eroded.

Leelanau-Kalkaska loamy sands, 25 to 45 percent slopes (Leelanau part).

Leelanau-Kalkaska loamy sands, 25 to 45 percent slopes, moderately eroded (Leelanau part).

Mancelona-East Lake loamy sands, 25 to 45 percent slopes (Mancelona part).

Mancelona-East Lake loamy sands, 25 to 45 percent slopes, moderately eroded (Mancelona part).

Montcalm-Kalkaska loamy sands, 25 to 45 percent slopes (Montcalm part).

Montcalm-Kalkaska loamy sands, 25 to 45 percent slopes, moderately eroded (Montcalm part).

These soils are too steep for cultivated crops and, in places, are too steep for pasture. Generally, they are suitable only as woodland and as wildlife habitat. Areas not in trees are likely to erode severely unless they are protected by a permanent cover of grasses, shrubs, or other plants.

Uneroded and slightly eroded areas can be managed so that native plants cover the soils through natural reseeding. Plantings of suitable grasses, shrubs, or trees are needed to stabilize areas where erosion is moderate or severe and is still active.

In wooded areas the stand consists chiefly of sugar maple, beech, and hornbeam, and there are smaller amounts of elm, basswood, aspen, white ash, hemlock, and white pine. Suitable trees for planting are white pine, red pine, and Norway spruce.

SOIL MANAGEMENT UNIT 4aE (VIe)

This unit consists of steep, well-drained loamy sands that are underlain by sand, loamy sand, or sand and gravel. The soils are—

East Lake-Mancelona loamy sands, 18 to 25 percent slopes (Mancelona part).

East Lake-Mancelona loamy sands, 18 to 25 percent slopes, moderately eroded (Mancelona part).

Karlin loamy sand, 18 to 25 percent slopes.

Karlin loamy sand, 18 to 25 percent slopes, moderately eroded.

Leelanau-Kalkaska loamy sands, 18 to 25 percent slopes (Leelanau part).

Leelanau-Kalkaska loamy sands, 18 to 25 percent slopes, moderately eroded (Leelanau part).

Mancelona-East Lake loamy sands, 18 to 25 percent slopes (Mancelona part).

Mancelona-East Lake loamy sands, 18 to 25 percent slopes, moderately eroded (Mancelona part).

Montcalm-Kalkaska loamy sands, 18 to 25 percent slopes (Montcalm part).

Montcalm-Kalkaska loamy sands, 18 to 25 percent slopes, moderately eroded (Montcalm part).

The soils of this unit are too steep for farming with heavy farm machinery. If cultivated crops are grown, runoff causes severe erosion. Except on the moderately eroded soils, permanent pasture of suitable forage crops can be grown on these soils. Pasture needs to be fertilized annually and renovated periodically. To control erosion, regulate grazing and leave enough growth of plants to maintain a moderately dense sod.

In cleared areas where erosion is slight or none, native grasses, shrubs, and trees are likely to reseed naturally. Moderately eroded areas and severely eroded spots are stabilized by native plants, they should be planted to suitable trees, shrubs, or grasses.

SOIL MANAGEMENT UNIT 5aE (VIIe)

This unit consists of steep, light-colored, well-drained loamy sands and sands that are underlain by sand, gravel, or a mixture of both. Fertility and moisture-supplying capacity are very low. The soils are—

East Lake-Mancelona loamy sands, 18 to 25 percent slopes (East Lake part).

East Lake-Mancelona loamy sands, 18 to 25 percent slopes, moderately eroded (East Lake part).

Kalkaska loamy sand, 18 to 25 percent slopes.

Kalkaska loamy sand, 18 to 25 percent slopes, moderately eroded.

Kalkaska sand, 18 to 25 percent slopes.

Leelanau-Kalkaska loamy sands, 18 to 25 percent slopes (Kalkaska part).

Leelanau-Kalkaska loamy sands, 18 to 25 percent slopes, moderately eroded (Kalkaska part).

Mancelona-East Lake loamy sands, 18 to 25 percent slopes (East Lake part).

Mancelona-East Lake loamy sands, 18 to 25 percent slopes, moderately eroded (East Lake part).

Montcalm-Kalkaska loamy sands, 18 to 25 percent slopes (Kalkaska part).

Montcalm-Kalkaska loamy sands, 18 to 25 percent slopes, moderately eroded (Kalkaska part).

These soils are too steep for mechanized farming. They are poor soils for permanent pasture because it is difficult to keep grasses and legumes growing in stands dense enough to provide fair grazing and to control erosion. Uneroded and slightly eroded areas should be managed so that native grasses, shrubs, or trees cover the soils naturally. In moderately eroded areas and severely eroded spots, further erosion can be controlled by planting suitable trees, shrubs, or grasses.

The main trees in the original forest were sugar maple, beech, and hornbeam; they grew in mixture with basswood, aspen, white ash, and hemlock. Conifers suitable for planting are white pine and red pine.

TABLE 11.—*Engineerin*

Soil series	Suitability as source of—					Soil features affecting suitability for—		
	Topsoil ¹	Sand ¹	Gravel ¹	Road fill for highway subgrade	Impermeable material	Highway location	Foundations for low buildings	Farm ponds Reservoir area
Iosco-----	Very poor; sandy and droughty; low organic-matter content.	Fair to not suitable; limited source of sands with fines to depth of 3½ feet.	Not suitable.	Subsoil: Fair to good; low volume change; good to fair bearing capacity. Substratum: Poor to fair; moderate to high volume change; difficult to work when wet.	Subsoil: Fair to not suitable. Substratum: Good; periodically high water table.	Seasonally high water table; wetness hinders construction; substratum subject to frost heaving.	Seasonally high water table; fair to poor bearing capacity; moderate to high volume change on wetting or drying; medium compressibility and shear strength.	Seepage rapid in sandy material, slow in substratum.
Kalkaska-----	Very poor; sandy and droughty; subject to wind erosion.	Good; some fines.	Not suitable.	Good; low volume change; good to fair bearing capacity.	Not suitable; too porous.	Some cuts and fills; loose sand easily excavated but sometimes difficult to haul; good bearing capacity; subject to wind erosion.	Good to fair bearing capacity; low volume change on wetting or drying; very low compressibility; soil flows when wet.	Rapid seepage; too sandy and porous to hold water unless seal blanket is used.
Karlin-----	Poor to very poor; sandy and droughty; subject to wind erosion.	Good; some fines.	Not suitable.	Good; low volume change; good to fair bearing capacity.	Not suitable; too porous.	Cuts and fills commonly needed; loose sand easily excavated but sometimes difficult to haul; good bearing capacity; subject to wind erosion.	Good to fair bearing capacity; low volume change on wetting or drying; very low compressibility; soil flows when wet.	Rapid seepage; too sandy and porous to hold water unless seal blanket is used.
Kerston-----	Poor; erodible; oxidizes readily; fair to good if mixed with mineral material.	Not suitable.	Not suitable.	Not suitable; unstable.	Not suitable; unstable.	High water table; organic material unstable and must be removed; subject to flooding.	High water table; poor bearing capacity; unstable organic material; subject to flooding.	High water table; rapid seepage; suitable for pit-type ponds; flotation of organic material possible.

See footnote at end of table.

7 interpretations of soils—Continued

Soil features affecting suitability for—Continued							Corrosion potential for conduits
Farm ponds—Continued	Winter grading	Septic tank disposal field	Agricultural drainage	Irrigation ²	Terraces and diversions	Grassed waterways	
Embankment							
Sandy material: Fair stability; medium to rapid seepage; piping a hazard. Substratum: Fair to good stability and compaction; slow seepage.	Moisture content often too high for good compaction; poor stability on thawing.	Seasonally high water table; variable percolation; on-site investigation needed.	Drainage generally needed; moderately slow permeability below depth of 18 inches; wet depressions require surface drains or random tile.	Low to medium water-holding capacity; very rapid intake rate; moderately slow to slow permeability within 18 to 42 inches of the surface.	Generally not needed; level to gently sloping sandy soil with little runoff.	Generally not needed; sandy soil; level to gentle slopes with little runoff.	High.
Rapid seepage; fair stability and compaction; subject to piping; low volume change on wetting or drying.	Sandy; moisture content usually low; good stability on thawing.	Possible pollution of water supplies by percolating effluent; construction difficult and sidehill seepage possible on slopes of more than 10 percent.	Not needed; well drained.	Very low water-holding capacity; very rapid intake rate; frequent water applications required; subject to wind erosion.	Sandy; difficult to vegetate; layout and construction difficult on slopes of more than 12 percent.	Sandy; difficult to vegetate; steep slopes erode readily.	Low.
Rapid seepage; fair stability and compaction; subject to piping; low volume change on wetting or drying.	Sandy; moisture content usually low; good stability on thawing.	Pollution of water supplies possible by percolating effluent; construction difficult and sidehill seepage possible on slopes of more than 10 percent.	Not needed; well drained.	Very low water-holding capacity; very rapid intake rate; frequent water applications required; subject to wind erosion.	Sandy soils; difficult to vegetate; layout and construction difficult on slopes of more than 12 percent.	Sandy soils; difficult to vegetate; steep areas subject to rapid runoff and severe erosion.	Low.
Unstable organic material; high water table.	High water table; unstable organic material and wetness hinder construction.	High water table restricts percolation of effluent; subject to stream overflow.	Normally not suited for agriculture because of flooding and poor quality of soil; subsidence likely if overdrained.	High water-holding capacity; very rapid intake rate; drainage and protection from flooding required.	Not needed; nearly level soil on flood plains with high water table; diversions help prevent overflow from adjacent areas.	Not needed; nearly level flood plains; high water table.	High to very high.

TABLE 11.—Engineering

Soil series	Suitability as source of—					Soil features affecting suitability for—		
	Topsoil ¹	Sand ¹	Gravel ¹	Road fill for highway subgrade	Impermeable material	Highway location	Foundations for low buildings	Farm ponds
								Reservoir area
East Lake	Very poor; sandy; low organic-matter content.	Good to fair; screening required to remove gravel.	Good to fair; appreciable sand.	Excellent; low volume change; good bearing capacity; excellent shear strength.	Not suitable; sandy and gravelly; porous.	Cuts and fills commonly needed; good bearing capacity; good source of material for subbase and fill.	Good bearing capacity; low volume change on wetting or drying; very low compressibility; medium to high shear strength.	Rapid seepage; too sandy and porous to hold water unless seal blanket is used.
Eastport	Very poor; sandy; low organic-matter content.	Good; medium and fine sands.	Not suitable.	Good; low volume change; good to fair bearing capacity.	Not suitable; sandy and porous.	Loose sand easily excavated but sometimes difficult to haul; good bearing capacity; subject to wind erosion.	Good to fair bearing capacity; low volume change on wetting or drying; very low compressibility; soil flows when wet.	Rapid seepage; too sandy and porous to hold water unless seal blanket is used.
Edwards	Poor; erodible; oxidizes readily; fair to good if mixed with mineral material.	Not suitable.	Not suitable.	Not suitable; unstable.	Not suitable; unstable.	High water table; organic material is unstable and must be removed.	High water table; very high compressibility; unstable.	High water table; rapid seepage; suitable for pit-type ponds; flotation of organic material possible.
Emmet	Fair	Not suitable.	Not suitable.	Good to fair; low volume change; fair bearing capacity.	Fair	Cuts and fills commonly required; stones hinder grading in some areas; good to fair bearing capacity.	Good to fair bearing capacity; low volume change on wetting or drying; low compressibility; may flow when wet.	Medium to rapid seepage; seal blanket commonly required.
Gladwin	Fair	Good to fair; variable content of sand; sieving required to remove gravel.	Good; well-graded gravel; considerable sand.	Subsoil: Fair to good; low volume change; good to fair bearing capacity. Substratum: Excellent; low volume change; good bearing capacity; water table periodically high.	Subsoil: Fair; thin. Substratum: Not suitable; porous; periodically high water table.	Cuts and fills required in some areas; seasonally high water table; wetness may hinder construction; substratum has good bearing capacity.	Seasonally high water table; good bearing capacity; low volume change on wetting or drying; very low compressibility; high shear strength.	Substratum too porous to hold water unless seal blanket is used.

See footnote at end of table.

interpretations of soils—Continued

Soil features affecting suitability for—Continued							Corrosion potential for conduits
Farm ponds—Continued	Winter grading	Septic tank disposal field	Agricultural drainage	Irrigation ²	Terraces and diversions	Grassed waterways	
Embankment							
Rapid seepage; good stability and compaction; subject to piping; low volume change on wetting or drying.	Moisture content usually low; good stability on thawing.	On slopes of more than 10 percent, construction is difficult and sidehill seepage is possible; rapid percolation may allow pollution of water supplies by effluent.	Not needed; well drained.	Low water-holding capacity; very rapid intake rate; frequent water applications required; subject to wind erosion.	Moderate depth to sand and gravel; erodible; difficult to vegetate.	Sandy; little runoff, but steep slopes erode readily; difficult to vegetate.	Low to moderate.
Rapid seepage; fair stability and compaction; subject to piping; low volume change on wetting or drying.	Sandy; moisture content usually low; good stability on thawing.	No restrictions other than possible pollution of water supplies by percolating effluent.	Not needed; well drained.	Very low water-holding capacity; very rapid intake rate; frequent water applications required; subject to wind erosion.	Not needed; sandy; little runoff; difficult to vegetate.	Generally not needed; sandy; little runoff; difficult to vegetate.	Low.
Organic material unstable; high water table.	Unstable organic material; high water table.	High water table; unstable.	High water table and moderate depth to marl; controlled drainage desirable; organic material subsides and oxidizes readily.	Very high water-holding capacity; very rapid intake rate; drainage required; high water table.	Not needed; level organic soil with poor stability and high water table; diversions helpful on adjacent areas.	Not needed; high water table; organic material with low stability; level or depressional relief.	Very high.
Fair stability; fair to good compaction; medium seepage; subject to piping.	Water content often medium; difficult to compact; fair stability on thawing.	On slopes of more than 10 percent, construction is difficult and sidehill seepage is possible; percolation moderate.	Not needed; well drained.	Low to medium water-holding capacity; rapid intake rate; steep slopes are subject to rapid runoff and severe erosion.	Generally no limitations, but layout and construction difficult where slopes exceed 12 percent.	No limitations, but steep slopes have rapid runoff and erode readily.	Low to moderate.
Subsoil: Fair stability; fair to good compaction; medium seepage. Substratum: Fair stability and compaction; rapid seepage.	Moisture content may be high and hinder operations.	Seasonally high water table; pollution of water supplies possible from percolating effluent; on-site study needed.	Drainage generally needed; seasonally high water table; special blinding of tile may be needed because of silt and sand substratum.	Low-water holding capacity; rapid intake rate.	Generally not needed; sandy soil with little runoff.	Generally not needed; sandy soils with little runoff.	Moderate.

TABLE 11.—*Engineering*

Soil series	Suitability as source of—					Soil features affecting suitability for—		
	Topsoil ¹	Sand ¹	Gravel ¹	Road fill for highway subgrade	Impermeable material	Highway location	Foundations for low buildings	Farm ponds Reservoir area
Lake beach-----	Very poor; sandy; low organic-matter content.	Good; some gravel.	Not suitable; high content of sand.	Good; low volume change; good to fair bearing capacity.	Not suitable.	Loose sand easily excavated but sometimes difficult to haul; good bearing capacity; subject to wind erosion.	Good to fair bearing capacity; low volume change on wetting or drying; very low compressibility; material flows when wet; fluctuating water table.	Generally not suitable; occurs along Grand Traverse Bay.
Leelanau-----	Very poor; sandy; low organic-matter content.	Fair to not suitable; considerable fines.	Not suitable.	Good to fair; low volume change; good to fair bearing capacity.	Fair to not suitable.	Cuts and fills commonly needed; material easily excavated, but loose sands sometimes hinder hauling.	Good to fair bearing capacity; low volume change on wetting or drying; low compressibility; may flow when wet.	Rapid seepage; generally too porous to hold water unless seal blanket is used.
Lupton-----	Poor; erodible; oxidizes readily; fair to good if mixed with mineral material.	Not suitable.	Not suitable.	Not suitable; unstable.	Not suitable; unstable.	High water table; unstable organic material must be removed.	High water table; unstable organic material; very high compressibility.	High water table; rapid seepage; suitable for pit-type ponds; flotation of organic material possible.
Mancelona----	Very poor; sandy and droughty; low organic-matter content.	Good; some gravel.	Good; considerable sand.	Subsoil: Fair to good; low volume change; fair bearing capacity. Substratum: Good; low volume change; good to fair bearing capacity.	Subsoil: Fair. Substratum: Not suitable.	Cuts and fills commonly needed; substratum has good bearing capacity; good source of material for subbase and fill.	Good bearing capacity; low volume change on wetting or drying; very low compressibility; medium to high shear strength.	Material too porous to hold water unless seal blanket is used.
Markey-----	Poor; erodible; oxidizes readily; fair to good if mixed with mineral material.	Fair; some fines; high water table.	Not suitable.	Not suitable; unstable organic material.	Not suitable; unstable and too porous to hold water.	High water table; unstable organic material must be removed; sandy substratum.	High water table; 18 to 42 inches of unstable organic material; sandy substratum has low volume change and compressibility; often flows when wet.	High water table; rapid seepage; suitable for pit-type ponds; flotation of organic material possible.

See footnote at end of table.

interpretations of soils—Continued

Soil features affecting suitability for—Continued							Corrosion potential for conduits
Farm ponds—Continued	Winter grading	Septic tank disposal field	Agricultural drainage	Irrigation ²	Terraces and diversions	Grassed waterways	
Embankment							
Rapid seepage; fair stability and compaction; subject to piping; low volume change on wetting or drying.	Sandy; moisture content usually low; good stability on thawing.	Pollution of water supplies possible; fluctuating water table at depths of 2 to 10 feet.	Not needed; well drained.	Very low water-holding capacity; very rapid intake rate; frequent water applications required; subject to wind erosion.	Not needed; nearly level; little runoff; difficult to vegetate.	Generally not needed; sandy; little runoff; difficult to vegetate.	Low.
Fair stability; fair to good compaction; medium seepage; subject to piping.	Water content often medium; difficult to compact; fair stability on thawing.	Construction difficult and sidehill seepage possible on slopes of more than 10 percent.	Not needed; well drained.	Low water-holding capacity; rapid water intake rate; subject to wind erosion.	Somewhat sandy and erodible; difficult to vegetate; layout and construction difficult on slopes of more than 12 percent.	Sandy and difficult to vegetate; steep slopes erode readily.	Low to moderate.
Unstable organic material; high water table.	High water table; unstable organic material.	High water table restricts percolation of effluent; unstable organic material.	High water table; subject to subsidence if overdrained; controlled drainage desirable.	Very high water-holding capacity; very rapid intake rate; drainage required.	Level organic soil with poor stability and high water table; diversions help prevent overflow from adjacent land.	Not needed; high water table; organic material; level or depression relief.	Very high.
Subsoil: Fair stability; medium seepage; fair to good compaction. Substratum: Rapid seepage; subject to piping.	Moisture content usually low to medium; fair stability on thawing.	Pollution of water supplies possible by percolating effluent; construction difficult and sidehill seepage of effluent possible on slopes of more than 10 percent.	Not needed; well drained.	Low water-holding capacity; very rapid intake rate; frequent water applications required; subject to wind erosion.	Somewhat sandy; erodible and difficult to vegetate; layout and construction difficult on slopes of more than 12 percent.	Somewhat sandy; erodible and difficult to vegetate.	Low to moderate.
High water table; 18 to 42 inches of unstable organic material; sandy substratum has rapid permeability and is subject to piping.	High water table; unstable organic material with high moisture content.	High water table restricts percolation of effluent; unstable organic material.	High water table; sandy substratum flows when wet; ditchbanks unstable.	High water-holding capacity; very rapid intake rate; drainage required.	Level organic soils with poor stability and high water table; diversions help prevent overflow from adjacent areas.	Not needed; high water table; organic material; level or depression relief.	Very high.