TERRAIN CLASSIFICATION AND SENSITIVITY SERIES
LEGEND

To accompany map sheet NTS 96C (Fort Norman)

Map Unit	Name	General Description	Local Description	Permafrost, Ground Ice Conditions	Drainage (thaw season)	Hazards	Sources of Construction Material
I	ORGANIC TERRAIN (including muskeg)	Peat, fen; peat-fen complex; commonly occurring as a cover on Units II, IX and X; flat to moderately sloping.	Fenland: Wet, commonly unfrozen woody sedge peat 5-10 ft. thick over mineral soil. Surface flat to gently sloping (up to 2°), relief to 3 ft., in part with reticulate network of low ridges. Peatland: Elevated frozen sedge peat, and woody sedge peat overlain by sphagnum peat (5-15 ft. thick over mineral soil); flat to very gently sloping with numerous shallow (5-10 ft.) steep-sided depressions occupied by lakes, ponds, or bogs.	Commonly unfrozen to depths of more than 6 ft.. Little data available on segregated ice[1] content at greater depths. Ice content moderate to high; total thickness of segregated ice in mineral soil below peat zones from 1-3 ft, locally up to 5 ft. thick. Peat in wet depressions commonly thawed to 3 ft. or more.	Ground surface wet and subsurface material saturated; on sloping sites water seeps downslope on surface and subsurface; small ponds. Higher surfaces of peat platforms dry. Depressions interconnected by seepage channels.	Wet sites; material compressible and of low strength. Removal of vegetation can lead to subsidence of up to 5 ft.; unfrozen material highly compressible and of low strength.	Unsuitable
II	SILT-CLAY PLAINS (marine and lake deposits)	Clay and silt, commonly surfaced by sand or silty sand, with discontinuous organic cover (see Unit I). Principally forming plains bordering rivers and coastal areas. Highly unstable in eroded slopes.	Silt and clay 3-60 ft. thick, locally overlain by glaciolacustrine and glacio-fluvial sand (0-100 ft. thick) with minor silt (notably on the East bank of the Mackenzie River, between Fort Norman and Big Smith Creek); flat to gently sloping. Where sand is thin or absent over clay and silt, in widespread, poorly drained, thick (3-12ft.) peaty tracts that are nearly flat or depressional, the development of thermokarst topography is characteristic.	Moderate to high segregated ice as thin (<1") seams in upper 10 ft.; segregated ice as reticulate network around blocks of clay, locally tabular bodies of nearly pure ice at greater depth. Segregated ice rare in sand but common in silt and clay beneath sand.	Seepage towards ponds and lakes, intermittent seepage through fen-filled depressions between ponds and lakes.	Thermokarst[2] slumping on steep slopes around ponds; large detachment slides where often occur within glaciolacustrine sands, where they overlie glaciolacustrine silts and clays, are characteristic of the banks of the Mackenzie River. Retrogressive flow slides on valley walls and other sloping areas are not so common as the detachment slides in the Fort Norman regions (96C). Unfrozen ground is soft. Removal of vegetation can lead to rapid gullying. Accelerated gullying along small tributary streams of the Mackenzie River results from recession of the Mackenzie River bluff deepening the gradient of the tributary streams.	No sources of coarse granular material; most of the unit is a poor[3] source of fill but local coarse sands are suitable for fill.
III	THERMOKARST[2] LAKE BEDS	Clay, silt, peat, and local sand on low, flat areas formerly occupied by tundra ponds. These materials generally less than 10 feet thick over till or sand. Pingos generally confined to this unit.	Not present				
IV	BEACHES (marine and lake)	Gravel and/or sand ridges or flat areas along present or former shorelines.	Low beach ridges (<50 ft.) composed of fine to medium sand and fine gravel are located in areas bordering glacio-lacustrine plains (See Unit II). Generally absent in the Ft. Norman area.	Ground ice generally not present, except where ridges contain fine sand and silt.	Ground surface commonly dry except where ridges contain fine sand and silt.	Minor ground ice slumping and gullying on hillsides and sloping banks; principally where material is fine sand or silt.	Locally good source of coarse granular material.
V	RIVER DEPOSITS - FINE	Silt and silty sand in river channels, floodplains, low terraces adjoining rivers and alluvial fans; includes organic silt, peat and minor gravel.	Silt and fine sand (10-15 ft. +) forming floodplains and low bordering terraces, commonly with meander scars; in places with numerous channels and thermokarst ponds. The unit is flat; (overall relief) ranges from 3-15 ft. except for channel and pond margins). Peat cover is negligible on the active floodplains, but is up to 10 ft. thick in the abandoned channels and terraces. Includes modern floodplain of the Mackenzie River, and terraces within the "inner valley" of the Mackenzie River.	Ice content generally moderate to high. Permafrost is generally absent in the unvegetated part of the floodplains; elsewhere to 10ft segregated ice by volume as thin (<1") seams in upper 6-10 ft.; lakes and ponds are actively expanding through the thermokarst collapse of banks in some areas.	Many areas are wet; small thaw pools, lakes and marshy areas are common. No integrated drainage system other than that inherited from the river.	Thermokarst subsidence; ground ice slumping and gullying on margins of lakes and channels, undercutting and bank collapse along channels during high water; flooding during breakup and summer storms; channel shifts.	Gravel deposits rare and small; generally poor[3] source of borrow material.
VI	RIVER DEPOSITS - COARSE	Gravel and sand in river channels, floodplains, low terraces adjoining rivers, and alluvial fans. Includes some silt, peat and organic silt.	Floodplains and terraces consisting of sand and gravel 3-15 ft. in thickness, commonly with a veneer of silt 1-6 ft. thick. Topography is level to gently sloping (0-3°) with local relief to 15 ft. due to the presence of former channels, bars, steep scarps etc. (slopes to 35°). Alluvial fans and fan aprons consist of silt, sand and gravel to thickness of 150 ft. and form slopes of 1-12° with relief to 150 ft. (from head to toe). Peat cover is largely restricted to former river channels, and ranges in thickness from 5-10 ft. Includes modern floodplain of the Mackenzie River and terraces within the "inner valley" of the Mackenzie River.	Ice content or permafrost absent low in coarse-grained material; thin (4") ice lenses in finer sediments. Moderate to high ice content in the silt veneer. Thermokarst ponds on low terraces. In alluvial fans ice content is variable (nil to low in gravels to very high in silt); generally more ice in finer sediments at margin of fans than in coarse material at head of fans.	Surfaces of coarser-grained materials are dry; ponds and swamps in former river channels. Downslope seepage in alluvial fans.	Minor thermokarst subsidence, minor ground ice slumps on margins of lakes and channels in areas with a veneer of silt; undercutting and bank collapse along channels during high water; flooding during breakup and summer storms; channel shifts.	Includes much gravel and mixed gravel and sand; the unit contains much sandy material suitable for fill. Exploitation of sites adjoining rivers may lead to accelerated erosion or channel shifts[4].
VII	GRAVEL-SAND HILLS RIDGES, AND TERRACES	Gravel, generally till, sand and some silt. Includes eskers, and other glacio-fluvial deposits, river terraces, sand dunes, and a few small moraines consisting of deformed gravelly-sandy strata.	Plain and Terrace areas: Sand and gravel 5-50 ft. thick, locally with veneer of silt or sand; forms flat to gently sloping benches interrupted by shallow channels and low scarps (relief to 30 ft.) Hummocky and ridged areas: Sand, gravel in places more than 100 ft. thick; relief to 120 ft; slopes to 15°; includes small eskers (up to 30 ft. high) and crevasse fillings (up to 25 ft.) the latter deposits located in the SE corner of 96C. See description of unit X. Dune areas: Fine to medium sand up to 60 ft. thick. Occurring as a thin veneer or as dune ridges within, or adjacent to, areas of Unit II.	Ice content variable; typically cement ice only or segregated ice in well drained sites; locally high segregated ice in silt and below peat in channels or depressions. In dunes ice content low (probably cement ice only); segregated ice in subjacent silt and fine sand of Unit II.	Ground surface relatively dry, except on large flat areas and in channel traces; drainage mainly subsurface.	Ground ice slumping and gullying on hillsides and sloping banks, principally where material is fine sand or silt; blowing sand, and blowouts in dune areas.	Major source of gravel and mixed gravel and sand; generally suitable as borrow material.
VIII	SILT-CLAY HILLS AND RIDGES	Mainly silt and clay with minor sand and gravel in moraines; strata tilted and folded.	Not Present				
IX	TILL PLAINS	Till, occurring as ground moraine with low rolling relief or parallel drumlin ridges. Large areas are clayey to silty till as a thin veneer on shale; locally forms a thin veneer on other kinds of bedrock. Includes undifferentiated areas of Unit I.	Silty to clayey till plains, generally 0-20 ft. thick. (locally to 60 ft.) underlain by bedrock[4]. Contains small drumlin fields mainly silty to clayey till; locally gravelly. Drumlin fields are mainly developed on Tertiary bedrock west of the Mackenzie River. Individual drumlins up to 200 ft. high and 2000 ft. long. Overall, unit IX forms a sloping-rolling plain with slopes to 3° (locally to 12°); generally bedrock controlled. Local relief (due to stream incision) up to 60 ft. Discontinuous peat cover (Unit I) up to 15 ft. in depressions and as irregular patches on hills.	Ice content moderate to low in till; commonly up to 10% segregated ice as thin (4") seams in upper 5-10 ft., locally thicker ice lenses (0.5-2ft.) at depth. Generally little ice in underlying bedrock[4], except in shale where fractures are filled with ice to depth of 100-150 ft. Ice content generally low in drumlinoid features.	Ground surface commonly wet - water in depressions - no organized drainage with down-slope seepage in sub-parallel runs. Crests of drumlins and ridges relatively dry, with a well-integrated drainage system developed between the drumlins.	Minor to moderate susceptibility to thermokarst. Moderate susceptibility to gullying. Ground ice slumps and superficial mudflows on slopes, and large flow slides in clay-rich till. Drumlinoid features display a minor susceptibility to gullying.	Gravel deposits rare and small; usefulness of the silty till[3] material as fill is limited by its ice content. Where bedrock is close to the surface, it is a source of low-ice borrow material. Gravelly and sandy till in drumlins may provide minor source of borrow material.
X	HUMMOCKY TILL	Clayey to gravelly-sandy till, local gravel, forming rolling to hilly moraine composed of individual and coalescent hummocks. Local contrasts in material and ground ice between well drained hills and poorly drained depressions. Includes small undifferentiated areas of Unit I.	Mainly gravelly till to gravel along the western flanks of the "Tertiary Hills" (west of Steward Lake). Topography is hummocky, and in places ridged (typical hummocks 300-1000 ft. in diameter). Local relief ranges from 30-100 ft. (in places exceeds 150 feet), with slopes to 20°, (exceptionally to 30°). Material is mainly derived from adjacent Tertiary bedrock. Peat (Unit I) occurs in depressions to thickness of 15 ft.	Ice content highly variable depending on topographic position; crests of prominent ridges and hummocks well-drained and ice-free to depths of 5-15 ft.; lower slopes commonly up to 10% ice as thin (<1"), irregular, discontinuous seams in upper 9 ft. Thicker (0.5-2 ft.) ice lenses at depth. Parent materials mainly gravels; high ice content not expected.	Surfaces of ridges and hummocks is dry, poorly drained depressions in places containing bogs or ponds. Water moves downslope, and follows poorly defined drainage connecting depressions.	Minor susceptibility to thermokarst subsidence, and ground ice slumps; minor susceptibility to gullying.	Hummocks and ridges provide major sources of gravel and mixed gravel and sand; usefulness of till material as fill is limited by its ice content. The silty[3] till is suitable borrow material where ice content is low.
XI	UPLAND AND PIEDMONT COMPLEX	Areas of moderate to low slope, in part hilly, surfaced by till, disintegrated bedrock, and local clay, silt, sand, or gravel. Unconsolidated deposits generally form a thin veneer over rock but in places they are thick (<100 ft.).	Not Present				
XII	MOUNTAINOUS AND ROCKY AREAS	Rocky outcrop or rock thinly covered by rubble. Moderate to steep slopes.	Within mapped area, includes Paleozoic and Mesozoic carbonates and shale, and Cenozoic (Tertiary) poorly consolidated gravel, sandstone shale, and mudstone; some formations flat-lying, some tilted and faulted. Forms ridges, scarps, and hills with local relief of up to 3000 ft. Bedrock covered by rubble on lower slopes, and by alluvium in valley bottoms. "Tertiary Hills" (west of Stewart Lake) are composed of poorly consolidated conglomerates, sandstones, shales and mudstones; and are deeply dissected and extensively gullied.	Little ice in bedrock (except shale - see Unit IX); ice content low to moderate in rubble, scree, and other overburden. Local high-ice in fine debris in valley bottoms.	Downslope drainage, wet ground on local flat areas.	Rock falls slides and active creep, on steep slopes, gullying of soft materials. Mudflows and flash floods in steep gullies. Large rotational slumps common on high cliffs of shale. Large slumps also occur in poorly consolidated Teritary sediments.	Rubble and in-place rock from limestone, dolomite and harder sandstone units can serve as sources of coarse granular material. Less resistant sandstone and shale is a source of low-ice borrow material. Tertiary sands and gravels provide a good source of construction material.
XIII	ERODED AND/OR ERODING RIVER BANKS, COASTAL CLIFFS AND VALLEY WALLS - UNCONSOLIDATED MATERIALS	Various unconsolidated materials on moderate to steep slopes; generally with surface veneer of slope debris; includes unstable areas.	Same as general description. Surface colluvial debris up to 15 ft. thick. Material on upper part of slope is same as adjacent map unit; different materials commonly occur lower on the slope; locally bedrock rubble forms the base of the slope (see Unit XIIIR). Slopes generally less than 150 ft. high.	Quantity of ground ice as indicated for adjacent map unit. Ground ice visible in freshly slumped faces.	Surface of sandy and gravelly materials is generally dry; other materials commonly wet with local running water and active gullying.	Active stream erosion; major ground ice slumping and gullying. Large detachment slides in areas of unit II bordering the Mackenzie River.	Varied material; see description pertaining to adjoining unit.
XIIIR	ERODED AND/OR ERODING RIVER BANKS, COASTAL CLIFFS, AND VALLEY WALLS - BEDROCK	Bedrock outcrops or bedrock partly covered by rock detritus or unconsolidated materials; slopes commonly steep; includes unstable areas.	Steep slopes and rock faces consisting of shale, sandstone, or limestone (contains gypsum and coal seams), some partly covered by debris. Strata are flat-lying or inclined at a low angle. Unconsolidated material on upper part of slope same as adjacent map unit.	No observations of segregated ice; possibility of ice in joints and in fracture zones. Ice in overlying unconsolidated materials as indicated for the appropriate unit.	Locally water runs down rock face; gullying.	Rock falls, and superficial debris flows on steep eroded slopes; local susceptibility to extensive gullying and slumping in areas of soft Tertiary shale, or where substantial thickness of overburden covers the rock. Flooding in valley bottoms.	Rubble and in-place rock from limestone, dolomite and harder sandstone units can serve as sources of coarse granular material. Less resistant sandstone and shale is a source of low-ice borrow material.

[1] Segregated Ice: Ice as distinct lenses, layers, veins, and masses in soils, commonly, but not always, oriented normal to direction of heat loss.

[2] Thermokarst: Heat from water in thaw pits, sinks and ponds results in melting of ground ice in areas of saturated peat and underlying mineral soils. The thaw basins may enlarge to the point of coalescing. They are usually steep-sided and flat-bottomed and are best developed in peat-covered, stratified, waterlaid silt and fine sand.

[3] Clay, silt, and fine sand are commonly poor borrow materials under permafrost conditions because of their instability under the high moisture conditions that result from thawing of contained ground ice. Some improvement in properties for use as fill could be achieved by artificial drying.

[4] See bedrock map insert and legend on individual map sheets.

[5] Excess Ice: Ice in excess of the quantity that would be retained as water in the soil voids upon thawing.

[6] Little data available.

GEOLOGICAL SURVEY OF CANADA
DEPARTMENT OF ENERGY, MINES AND RESOURCES

TERRAIN SENSITIVITY AND PERFORMANCE RATING TABLE

To accompany map sheet 96C (Fort Norman).

Map Unit	Permafrost Terrain				Non-Permafrost Terrain		Flooding Hazard
	Occurrence	Degradation following disturbance of ground surface		Performance of newly thawed materials	Occurrence	Performance of unfrozen materials	
		flat ground (<3° slope)	sloping ground (<3° slope)				
I	peatlands	3K	2S, 2G	3	fenland	3	N
II	general	3K, 2G	3S, 3G	3	N	N	N
III	N	N	N	N	N	N	N
IV	general	1	1-2S, 1-2G	1-2	N	1-2	N
V	general	2K	(2-3S, 3G)	3-2	active river deposits	2-1	3-2
VI	general	1-2K	(1-2S, 1-2G)	1-2	active river deposits	1	3-2
VII	general	1	1-2S, 1-2G	1-2	local south facing slopes	1	N
VIII	N	N	N	N	N	N	N
IX	general	2K	2S, 2G	2	N	N	N
X	general	2K	2S, 2G	2	N	N	N
XI	N	N	N	N	N	N	N
XII	general	1	1-2S, 1-2G (as for unit XI where overburden is present)	1	N	N	N
XIII	general	N	2-3S, 2-3G	3-1	N	N	3-2 (valley bottoms)
XIIIR	general	N	1-3S, 1-2G (3G in Tertiary shales) (as for unit XIII where overburden is present)	1-2	N	N	3-2 (valley bottoms)
1	2	3	4	5	6	7	8

KEY TO PERFORMANCE RATING TABLE - EXPLANATORY NOTES

Sensitivity - Performance Scale

Rating Number	General	Columns 3 and 4	Columns 5 and 7	Column 8
1	good sites	low frequency, and/or low intensity	least troublesome materials	----------
2	fair sites	moderate frequency and intensity	moderately troublesome materials	flooding under extreme conditions
3	poor sites	high frequency and/or high intensity	highly troublesome materials	flooding a common occurrence
N	not applicable or not represented			no flood hazard

Degradation following disturbance of ground surface (Columns 3 and 4)

Rating applies to changes resulting from man-induced disturbance such as stripping of the surface down to mineral soil, long term ponding of water on surface, or re-routing of flowing water for substantial periods. Degradation of somewhat lesser intensity and/or frequency results from compaction or mechanical disturbance of the surface vegetation mat or peat. Earthflows may develop in sloping sites following fire on units rated as 2 or 3.

K - thermokarst depressions or ground subsidence from melting of ground ice.

S - slope failures such as ground ice slumps, earth flows, landslides, block collapse (minor sloping sites in brackets)

G - gully erosion (minor sloping sites in brackets)

Sloping ground includes:

- eroded banks in gullies, along rivers, valley walls, and eroded coasts (Note: major eroded areas mapped as unit XIII)

- slumped banks around thermokarst lakes or thermokarst depressions

- sloping hillsides (units VII, VIII, X, XI, XII, XIII)

- mountainside and escarpments (Units XII, XI)

Performance of newly thawed material (Column 5)

The rating is for performance of thawed materials under worst conditions (i.e. immediately after melting of constituent ice) when subjected to load in place, when used as fill, or when exposed on a cut slope. Rating also applies to "normal" active layer materials under the same conditions.

Performance of normal unfrozen material (Column 7)

The rating is for performance of materials under typical field moisture conditions when subjected to load in place, when used as fill, or when exposed on a cut slope.

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To accompany map 96C (Fort Norman).
Terrain sensitivity and performance rating is provisional and subject to revision and correction.