Map Unit Properties Table

Age	Unit Name (Symbol)	Features and Description	Erosion Resistance	Suitability for Development	Hazards	Paleontological Resources	Cultural Resources	Karst	Mineral Occurrence	Habitat	Recreation	Geologic Significance
QUATERNARY	Alluvium (Qa), Debris Flow (Qdf), Colluvium (Qc), Debris Fan (Qd).	Qa contains unconsolidated deposits of stratified silt, sand, gravel, and cobbles as much as 6 m (20 ft) thick commonly occurring along the banks of creeks and rivers. In the park area, this unit can be very coarse- grained containing massive boulders of metasandstone and gneiss. Qdf are mixed assemblages of bedrock, soil, and vegetation that occur as catastrophic downslope movements usually following heavy precipitation. Qc includes talus, boulder streams, and boulder fields of cobbles and boulders. Most large boulders are metasandstone typically 1- 3 m (3- 10 ft) long. Qd are very poorly sorted deposits of boulders and cobbles in a matrix of silt, sand, and clay. Unit occurs in lobe or fan-shaped deposits, armored against erosion by large boulders at the surface. Qd compositions and textures are directly related to the upland source of rock debris.	Very low	High porosity and permeability renders units unsuitable for waste facilities; building projects should avoid areas with slopes due to likelihood of failure. Cut road embankments exacerbate tendency for catastrophic failure.	Debris flows, slumps, slides, and mass wasting highly probably in these units. Debris flows can happen repeatedly in certain areas.	Dated plant remains in Qd around 16,000 to 18,000 ybp, potential for Pleistocene fossils and modern remains.	Land- use evolution, possible Native American sites.	None	Sand, silt, gravel, cobbles, massive boulders	At lower elevations alluvium covers broad valleys, supports hardwood forests and early agriculture (Pioneer Village). Older debris flows are slow to revegetate. Qc supports little to no vegetation, but may provide ground-dweller habitat.	Avoid debris flow areas, talus slopes, boulder streams and fields, and undercut alluvium for recreation.	Units record long history of erosion by rivers and creeks throughout the park area as well as anthropogenic influences. Isotopic dating and relative age dating provide information about the morphology of the present landscape preserved in these units. Stone streams and boulder fields typically formed in Pleistocene periglacial conditions. Debris fans reflect a long history of deposition and modification.
QUATERNARY - TERTIARY	Residuum (QTr), Sinkholes (QTs), Terrace Deposits (QTt).	QTr contains subrounded to angular cobbles and boulders of quartz and chert as lag deposits derived from veins of resistant material in dissolved limestone or dolomite. Unit is mapped up to 12 m (40 ft) thick. QTs ranges in diameter from 2 m (6 ft) to 305 m (1000 ft). Some sinkholes are still active, others are filled with jumbled rock debris. QTt contains river- cut benches of sand, gravel, and cobbles stranded 3- 36 m (10- 120 ft) above modern water levels. Most large cobbles are quartz- rich in a fine- grained sand and clay matrix.	Low	Avoid QTr for development due to likelihood of instability and high permeability associated with sinkholes.	Danger of sinkhole collapse, landslides, and rockfall associated with these units.	QTs contains Miocene vertebrate fossils 5 to 23 million years old	Jasper and chert may have been tool and trade material for Native Americans. Sinkholes may have been used as shelters.	QTs is formed as a result of intense karstification and collapse.	Clay- rich terra rosa, jasper, bauxite, kaolinite, lignite, gravel, clay, sand.	Sinkholes can harbor unique vegetation communities and different soils than surrounding areas.	Avoid QTs for recreation due to danger of collapse. Sinkhole sides may attract climbers	Units record a long history of carbonate dissolution and landscape change. QTt records the evolution of waterways throughout the area with old perched terraces as high as 61 m (200 ft) above modern waterways.
MISSISSIPPIAN	Greasy Cove and Grainger Formations, undifferentiated (Mgg), Greasy Cove Formation (Mgc), Grainger Formation (Mg).	Mgg contains rocks of both Mgc and Mg, which are intensely structurally deformed to the point of being indistinguishable. Mgc contains interbedded gray, calcareous shale, argillaceous limestone, fine- grained sandstone, and red shale. Mg contains sequences of siltstone and fine- grained sandstone that grade upward into coarser- grained feldspathic sandstone and pebble conglomerate. Upper beds are interbedded with silty shale.	Moderate	Units are associated with the Guess Creek and Great Smoky faults and should be avoided for development.	Rockfall is associated with these units.	Limestone and shale may contain Mississippian age fossils.	None documented	Minor dissolution possible in limestone beds.	Clay residuum, shale, limestone	None documented	Avoid heavily deformed or undercut areas on slopes for recreation due to danger of rockfall.	Units contain evidence of severe deformation along regional faults.
MISSISSIPPIAN – DEVONIAN	Chattagnooga Shale (MDc).	Unit consists of sandy shale and sandstone beds at the base, grading upwards into thinly fissile black shale containgin abundant sulfides and rusty concretions. In most places the shale was deformed into 3- 7.6 m (10- 25 ft) long pods.	Moderate to low	Unit is associated with some deformation and should be avoided if exposed on slopes or for basement construction.	Unit is highly fissile and is unstable on slopes. Unit may contain shrink- and- swell clays and radioactive materials.	Conodonts, liguloid brachiopods, marine megafossils.	Small borrow pits attest to early mining interest for coal.	None	Sulfide minerals, clay	Unit produces Fe and S clay- rich regolith.	Unit is unstable as trail base and should be avoided for recreation.	Unit contains record of Upper Devonian and Lower Mississippian age marine environments. Unit is also heavily deformed recording post- deposition tectonic activity.
ORDOVICIAN	Bays Formation (Ob), Sevier Formation (Os), Chota Formation (Oc), Ottosee Shale (Oo), Tellico Formation (Ot).	Ob contains calcareous mudstone and siltstone with some interbedded feldspathic and light- gray quartzitic sandstone interlayered with red finer- grained sandstone. Os contains gray, calcareous, silty and sandy shale and some sandstone interbeds. Oc consists of blue- gray calcareous sandstone and sandy limestone. Oo contains basal calcarenite and sandy limestone grading upwards into calcareous shale. Ot is gray, sandy and silty calcareous shale with interbedded calcareous sandstone, impure limestone, and fine- grained sandstone.	Moderate	Heterogeneous nature of units and slaty cleavage can render them unstable on steep slopes, avoid toe of slope areas for development. Oc is associated with the Guess Creek fault. Ot is associated with the Dumplin Valley and Great Smoky faults.	Units are prone to rockfall and landslides if exposed on steep slopes or undercut by erosion or development.	Fossil debris including brachiopods in Oc.	None documented	Calcareous cements and limestone layers are prone to dissolution.	Sandstone, limestone	None documented	Avoid heavily deformed or fissile areas for recreation.	Units are cut by several regional faults containing record of mountain building and regional tectonic changes since the Paleozoic.

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ORDOVICIAN	Chapman Ridge Sandstone (Ocr), Chapman Ridge Marble (Ocm), Blockhouse Shale (Obl), Lenoir Limestone (Olh), Jonesboro Limestone (Oj).	Ocr consists of gray calcareous sandstone and argillaceous shale. Ocm contains coarsely crystalline gray to red marble lenses that are thickly bedded to massive. Obl is fissile calcareous dark gray shale finely- laminated with cobble- rich 1- 1.5 m (3- 5 ft) thick argillaceous limestone at the base. Olh contains gray, cobble- rich argillaceous limestone and limestone conglomerate. Some limestone interbeds and basal clastic rocks are present locally. Oj is mostly gray fine- grained limestone in 8 cm- 1 m (0.5- 2 ft) thick beds that are edged with thin wavy clay and silty partings. Some massive limestone beds with abundant quartz sand grains, fossils, and dolomite containing cross hatch- patterns of calcite- filled joints are present locally.	Moderate	Avoid heavily deformed or dissolved areas of these units for development.	Fissile nature of shale units render them susceptible to slides and slumps, heavily deformed areas prone to rockfall on slopes.	Ordovician fossils are present in lower units.	Nodular chert in Oj may have provided tool and trade material for Native Americans	Some dissolution possible of calcareous cements and marble. Dissolution is likely in limestone units	Marble, black and white nodular chert	Limestone rich units weather to Ca, Mg clay- rich regolith.	Units are suitable for most recreation unless highly dissolved, fissile, or fractured on slopes.	Obl is truncated by the Great Smoky fault so it records useful information about the structural evolution of the area. Oj contains fossils from the Lower Ordovician
ORDOVICIAN - CAMBRIAN	Knox Group (OCk).	This group contains several units including the cherty dolomite of the Copper Ridge Dolomite, the limestone and subordinate dolomite and sandstone of the Chepultepec Dolomite, the chertyLongview Dolomite, and interbedded dolomite and sandstone of the Newala Limestone. Locally, this group also contains the Maynardville Limestone.	Moderate	Portions of this group may be intensely dissolved and should be avoided for heavy development especially of waste treatment facilities due to high permeability and potential karst networks.	Preferential dissolution on carbonate layers may create unstable perched ledges prone to rockfall, sinkholes are also possible.	May contain Upper Cambrian and Lower Ordovician fossils.	Chert from isolated beds and lenses in this group may have provided trade and tool material for Native Americans.	Karst dissolution is highly likely in this group.	Limestone, chert.	Units may weather to form Ca and Mg- rich regolith. Ledges within this unit may provide bird habitat if exposed on cliffs.	Units are suitable for most recreation unless highly dissolved.	Units within this group record the Cambrian to Ordovician transition in marine deposits.
CAMBRIAN	Nolichucky Shale (Cno), Maryville Limestone (Cml), Rogersville Shale (Crg), Rutledge Limestone (Crt).	Cno contains calcareous shale interlayered with oolitic limestone. Unit has a greenish- gray appearance in outcrop. Cml consists of limestone with greenish- gray shale interbeds near the base and top of the unit. Crg is variegated green and purple shale in fissile beds with a massive, 6 m (20 ft) thick limestone bed in the middle. Crt contains limestone with argillaceous partings near the base and fine- grained dolomite in the upper beds.	Moderate	Portions of this group may be intensely dissolved and should be avoided for heavy development. Fissile shale layers would provide an unstable development base.	Heterogeneity, dissolution, and fissile textures within these units render them susceptible to rockfall, landslides, and karst processes.	Oolites	None documented	Karst dissolution is highly likely for these units, especially the limestones.	Limestone	Units may weather to form Ca and Mg- rich regolith.	Avoid fissile and heavily dissolved areas for recreation.	Units record shallow marine and deeper water open marine environments during the Middle and Upper Cambrian.
CAMBRIAN	Pumpkin Valley Shale and Rome Formation (Cpr), Rome Formation (Cr), Shady Dolomite (Cs), Shady Dolomite; shaly dolomite (Css).	Cpr contains upper layers of greenish- gray and red siltstone interlayered with silty shale and thin limestone of the Pumpkin Valley Shale. Lower beds include maroon sandstone, siltstone, and shale with some quartzite, siltstone, shale, and limestone of Cr. Cr is fissile and finely- laminated, and rather weathered. Cs contains 305 m (1000 ft) of thick- bedded to massive dolomite with scant dolomitic shale interbeds in the upper third of the unit. Cs can be highly weathered. Css is a subunit within Cs with more abundant shaly layers.	Moderate	Portions of these units can be highly weathered, fissile, and dissolved and should be avoided for heavy development.	High degree of weathering, karst dissolution, and fissility within these units may render them prone to rockfall and karst processes.	None documented	Chert and jasper may have provided trade and tool material for Native Americans.	Karst dissolution is likely for dolomites, limestones, and units with calcareous cements in these units.	Limestone, chalcedonic chert, jasper	Cs and Css weather to form clay- rich regolith mixed with massive boulders of jasperoid.	Avoid highly weathered areas and heavily dissolved areas for recreation.	Units record shallow marine and deeper water open marine environments during the Lower Cambrian. Stratigraphic and structural relationships within these units render them useful to study the region's geologic history.
CAMBRIAN	Upper Part of Chilhowee Group, undifferentiated (Ccu), Helenmode Formation (Chm), Hesse Quartzite (Ch), Murray Shale (Cm), Nebo Quartzite (Cnb), Nichols Shale (Cn), Cochran Formation (Cc).	Ccu contains undifferentiated quartzite, argillaceous, silty, micaceous shale, and coarse- grained sandstone. Chm includes silty gray, micaceous shale and siltstone with interlayered thin quartzite beds near the base and coarse- grained sandstone near the top. Chis 153- 183 m (500- 600 ft) of medium to coarse- grained quartzite. Grains within the quartzite are well- rounded with some cross- bedding. Cm contains greenish- gray argillaceous to silty shale with maximum thickness of 168 m (550 ft). Some fine-grained feldspathic and glauconitic sandstone are interlayered locally. Cnb is comprised of thin- bedded (less than 25 cm, 1 ft thick) white quartzite, 61- 122 m (200- 400 ft) thick. Lower beds contain chlorite. Cn contains greenish- gray, argillaceous to silty, fissile shale with some local layers of feldspathic sandstone and quartzite. Cc includes basal gray conglomerates covered by maroon pebble- rich arkose interlayered with maroon shale and siltstone. Basal beds grade upwards into light- gray arkose, with cross- bedded sandstone and quartzite.	Moderate to high for quartzites	Heterogeneous nature of units and fissile slaty cleavage can render them unstable on steep slopes, avoid toe of slope areas for heavy development.	Dip slopes characterize beds in Ch that are prone to rockfall and blockfall. Fissile shales underlying more resistant sandstones and quartzites are natural slip surfaces.	*Skolithos linearis* tubes in Ch and Cnb. Trace fossil burrows.	Hematite nodules may have incited early mining interest.	None documented	Quartzite, glauconite, chlorite, detrital muscovite, hematite concretions.	Shale units weather into clay- rich regolith with quartz- rich residuum. Quartzites often resist erosion and cap high ground areas.	Avoid fissile areas for recreation. Shales may weather to sticky clays for unstable trail base.	Quartzite units record early life in shallow seas (intertidal to shallow subtidal) and nearshore environments of the Lower Cambrian.

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PALEOZOIC	Pegmatite (Pzp), Metadiorite and metadiabase, and altered rocks (PzZd), Metamorphosed dunite and peridotite (PzZud).	Pzp of two different ages occur throughout the map area. The older unit is foliated with aplitic and granitic compositions. Younger pegmatites are white, massive, and unfoliated. Individual bodies of pegmatites may be as much as 61 m (200 ft) thick and 153 m (500 ft) long. PzZd are subalkalic basalt or diorite with medium to coarse- grained, porphyritic to aphanitic textures. Altered rocks include chloritic greenstone, carbonate- chlorite schist, soapstone, metavolcanic rocks and tuffs. PzZud contains metamorphosed dunite and peridotite.	High to moderately low for altered rocks	Pzp is associated with the Greenbriar fault, which is an undesirable target for development. PzZd is associated with the Eagle Creek shear zone and should be similarly avoided.	Rockfall and landslides are potential hazards associated with these units especially where heavily altered.	None	Quartz filled amygdules and epidote nodules may have provided trade material. PzZud was mined for olivine, asbestos, chromite, corundum, nickel, platinum- group eleemtns, soapstone-serpentinite, talc, and vermiculite.	Some dissolution possible in carbonate-chlorite schists; probably rare.	Potassium feldspar, green epidote, white oligoclase, quartz, perthite, muscovite, biotite, hornblende and plagioclase phenocrysts, chlorite, actinolite, talc, volcanic tuff, diopside, bronzite, olivine	Residual soil and saprolite are conspicuously red and support very little vegetation. Greenstones may weather to produce Fe and Mg- rich regolith.	Units should be avoided for recreation due to high levels of alteration and friability.	Units provide time constraints on metamorphic and deformation history of the area. PzZd predates ~440 to 415 Ma metamorphism. Much of the altered rock units were associated with rift volcanics deposited with the formation of the Great Smoky Group basin.
NEOPROTEROZOIC	Sandsuck Formation (Zss), Sandsuck Formation; quartz-pebble conglomerate (Zssc), Wilhite Formation (Zw), Wilhite Formation; limestone and shale (Zwl), Wilhite Formation; carbonate rocks, limestone, and sandy limestone within argillaceous shale (Zwlc), Wilhite Formation; quartzite, sandstone, and polymictic pebble conglomerate (Zwq).	Zss contain gray, thin- bedded siltstone and shale with interlayered, cross- bedded feldspathic sandstone and conglomerate. This unit is as much as 763 m (2500 ft) thick. Zss intertongues locally with Zssc containing thick, lenticular beds of quartz- pebble conglomerate and coarse sandstone. Zw consists of fine- grained shale, slate, and siltstone. Some areas also contain interlayered sandstone, limestone, and dolomite in the upper beds. Zwl contains thick, gray limestone with sandy and conglomeratic layers. Zwlc contains clastic rocks interlayered with carbonate- rich rocks of metasiltstone and sandstone with limestone, dolomite, and ankeritic dolomite. Unit appears gray in outcrop and is more than 460 m (1500 ft) thick. Zwq contains interlayered white, vitreous quartzite, sandstone, and polymictic pebble conglomerates.	Moderate to high for quartzite	Avoid heavily dissolved areas of these units for development as well as areas with large blocks perched on slopes. Heterogeneous nature of these units may render them unstable on high slopes or near road cuts.	Units are subject to dissolution, and may be prone to rockfall.	None	Historic quarries for limestone are near Pigeon Forge.	Carbonate layers as much as 46 m (150 ft) thick in Zw may be prone to karstification.	Sandstone, conglomerate, slate, vein quartz, limestone and dolomite, white quartzite	None documented	Units are suitable for most recreation unless highly dissolved. Exposures on cliffs may attract climbing interest.	Units record marine deposition during the Neoproterozoic including broad mudflow deposits within Zw. Nearshore environments and high-energy deposits are associated with Zwq.
NEOPROTEROZOIC	Shields Formation (Zs), Shields Formation; limestone and siltstone (Zsl), Shields Formation; coarse sandstone and siltstone (Zsa), Shields Formation; coarse conglomerate of polymictic pebbles and cobbles, and pebbly sandstone (Zsc), Licklog Formation (Zll), Licklog Formation; conglomeratic sandstone (Zlls).	Zs contains thick- bedded sandstone and conglomerate ranging from 610- 763 m (2000 to 2500 ft) thick. Upper beds contain laminated siltstone, shale, and slate with some local interbedding. Zsl contains thinly bedded argillaceous limestone and siltstone. Zsa contains interlayered coarse- grained sandstone and siltstone. Zsc is the basal portion of Zs and contains distinctive coarse conglomerates with polymictic pebbles and cobbles interlayered with pebbly sandstone. Pebble lithologies include milky quartz, quartzite, granite, chert, siltstone, and limestone. Zll contains argillaceous siltstone and slate with some interbedded sandstone and pebble conglomerate. Zlls contains thick, prominent beds of conglomeratic sandstone.	Moderate	Zsl and Zll are associated with the Dunn Creek and Great Smoky faults and should be avoided for extensive development.	Fissile nature of shale and slate may make certain units unstable on slopes. Rockfall potential is high for these units.	None	Chert and milky quartz may have provided early tool and trade material for Native Americans.	Some limestone layers may be prone to dissolution.	Slate, sandstone, conglomerate, quartz, chert	None documented	Avoid fissile areas for recreation. Shales may weather to sticky clays for unstable trail base.	Units record a variety of depositional environments during the Neoproterozoic.
NEOPROTEROZOIC	Tusquitee Quartzite and Nantahala Formation (Znt), Dean Formation (Zd), Ammons Formation (Zam), Grassy Branch Formation (Zgb), Ashe Metamorphic Suite (Zams), Wehutty Formation (Zwe).	The lower beds of Znt contain black, graphitic metasiltstone and schist with interlayered white metaquartzite grading upwards into slaty rocks. Zd contains sericite schist with interlayered metagraywacke and quartz- pebble conglomerate in units 10- 100 m (33- 330 ft) thick. Zam consists of metasandstone and muscovite schist grading upwards into dark- colored, graphitic- sulfitic- mica schist and metasiltstone interlayered with metagraywacke, metasiltstone, muscovite schist, and some beds of metaquartzite and garnet- biotite porphyroblastic mica schist locally. Metasiltstone is abundant in the basal layers of this unit. Zgb consists of metasandstone with lesser amounts of interlayered muscovite schist and metagraywacke 100- 300 m (330- 984 ft) thick grading upwards to dark porphyroblastic muscovite schist and metasandstone. Zams is biotite gneiss with interlayered metagraywacke, mica schist, amphibolite, and hornblende gneiss. Zwe contains dark muscovite- staurolite- kyanite schist interlayered with metagraywacke, metaconglomerate, and metasandstone. This unit appears rusty in outcrop.	Moderate to high for gneisses	Znt is associated with faulting in North Carolina; Zd is associated with normal faulting. Avoid heavily deformed or weathered areas for development.	Units are associated with landslides and rockfall especially where undercut along foliation or bedding or highly weathered.	None	Mineral abundance in these units may have prompted early mining and exploration efforts throughout the area.	None	Quartzite, biotite, staurolite, garnet, graphite, sulfide minerals, muscovite, magnetite, epidote, sericite, chlorite, vein quartz, trondhjemite, kyanite, tremolite	Zam is exposed on cliff faces that may provide nesting and roosting habitat for birds.	Units may be highly weathered, avoid eroded outcrops for recreation.	Units record mixed sedimentation (including turbidites) and volcanism into an ancient basin as well as regional deformation and metamorphism. Zwe forms the perimeter of the regional Murphy synclinorium.

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NEOPROTEROZOIC	Copperhill Formation (Zch), Copperhill Formation; quartz- muscovite schist and phyllite interbedded with metagraywacke (Zchs), Copperhill Formation; metasiltstone, interbedded with metagraywacke (Zchsl), Anakeesta Formation (Za), Anakeesta Formation; ankerite- rich metasandstone and sandy dolomite, chloritoid metasiltstone (Zas), Anakeesta Formation; metagraywacke interbedded with metasiltstone (Zag), Anakeesta Formation; dolomite, sandy dolomite, and pisolitic dolomite (Zal), Anakeesta Formation; slate containing small dark elliptical porphyroblasts of chloritoid (Zac).	Zch is massive, coarse- grained metagraywacke and metaconglomerate. Local interbeds include quartz- garnet- muscovite phyllites and schists. Zchs consists of interlayered light- brown metagraywacke, quartz- muscovite schist and phyllite. Zchsl contains mixed, dark slaty metasiltstone and metagraywacke. Units appear rusty orange in outcrop due to weathering iron sulfides. Za includes dark- colored graphitic and sulfitic slate, metasiltstone, and phyllite interlayered with thin metasandstone and metagraywacke layers. Unit appears dark in outcrop until weathered, and then it is rusty red. Zas contains pale, fine- grained metasandstone, ankeritic metasandstone, chloritoid metasiltstone, and ankeritic sandy dolomite in thin beds. Zag consists of light- colored, coarse- grained metagraywacke conglomerate and interlayered metasiltstone in 15 m (50 ft) thick sequences. Zal includes dark fine- grained dolomite, sandy dolomite, and pisolitic dolomite in beds ranging from 0.3- 1 m (1- 3 ft) thick. Zac contains chloritoid slate with distinctive light- gray color, fine- grained, quartz- rich texture with dark tablet shaped porphyroblasts of chloritoid, ilmenite, and sericite.	Moderate	Units are associated with the Eagle Creek shear zone and heavily deformed or altered areas should be avoided for development. Zag outcrops along Oconaluftee fault and should be avoided for development.	Units may be deformed and exposed in high areas or along cliffs. They are prone to rockfall.	None, though some quartz- calcite pisolites resemble fossil *Girvanella* algae	Zag is exposed on The Chimneys, Alum Cave, "the Jumpoff", and Charlies Bunyon.	Zas contains elliptical voids up to 5- 10 mm (0.2- 4 in) long comprising as much as 50 percent of the outcrop. Dissolution of calcareous layers and cements is possible.	Garnet, muscovite, sulfide minerals, staurolite, kyanite, graphite, chloritoid, biotite, ilmenite, sericite	Za forms craggy pinnacles that provide roosting and nesting habitat	Units are in areas attractive to hikers and climbers.	Units record mixed sedimentation and volcanism into a Neoproterozoic basin as well as regional deformation and metamorphism associated with the formation of the Appalachian Mountains.
NEOPROTEROZOIC	Cades Sandstone (Zc), Cades Sandstone; siltstone interbedded with fine- grained metasandstone (Zcs), Cades Sandstone; boulder conglomerate (Zcc), Thunderhead Sandstone (Zt), Thunderhead Sandstone; graphitic metasiltstone and slate (Zts), Thunderhead Sandstone; boulder conglomerate (Ztb).	Zc contains coarse- grained feldspathic metasandstone in thin to medium beds interlayered with metagraywacke and dark metasiltstone and slate. Local conglomeratic interbeds with granitic cobbles and boulders present locally. Zcs contains dark gray siltstone with interlayered fine- grained metasandstone. Zcc is a very coarse- grained boulder conglomerate with leucocratic granite cobbles in a quartz- feldspar matrix. Zt contains coarse- grained, thick graded beds of feldspathic metasandstone and metaconglomerate interlayered with dark, graphitic metasiltstone and slate. Zts is dark, graphitic slate and interbedded metasiltstone. Ztb is very coarse- grained boulder conglomerate with 1 m (3 ft) in diameter rounded leucocratic granite clasts and some large dark slate and dolomite boulders present locally.	Moderate to moderately high for coarse- grained layers	Heterogeneous nature of these units may render them unstable on high slopes or near road cuts.	Units may be deformed and exposed in high areas or along cliffs. They are prone to rockfall.	None	Zc forms the northwestern boundary of Cades Cove.	Some dolomite boulders present in coarse- grained units, but probably not enough for dissolution concern.	Granite, blue quartz, conglomerate, sandstone, slate, graphite	Units surround Cades Cove, a sheltered valley.	Units are suitable for most recreation unless highly deformed or altered. If exposed on cliffs, units may attract climbing interest.	Units record mixed sedimentation and volcanism into a Neoproterozoic basin as well as regional deformation and metamorphism associated with the formation of the Appalachian Mountains.
NEOPROTEROZOIC	Elkmont Sandstone (Ze), Elkmont Sandstone; metasandstone and Metaconglomerate (Zes), Rich Butt Sandstone (Zr), Rich Butt Sandstone; slate and metasiltstone interbedded with fine- grained metasandstone (Zrs), Metcalf Phyllite (Zm).	Ze includes dark gray feldspathic and argillaceous metasandstone with dark gray metasiltstone interlayers. Zes is interlayered coarse- grained metaconglomerate and metasandstone. Zr contains as much as 1220 m (4000 ft) of graded, light- colored metasandstone interlayered with conglomeratic arkose and some thinly laminated, dark metasiltstone. Bedding within the metasandstone is 0.3- 6 m (1- 20 ft) thick. Zrs is thinly bedded, fine- grained feldspathic metasandstone interbedded with finely laminated metasiltstones in deposits 183- 305 m (600- 1000 ft) thick. Zm contains foliated, contorted, and sheared phyllite. The unit appears lustrous, gray- green in outcrop and contains sericite and chlorite.	Moderate	Units are associated with faulting along the Great Smoky fault and Pigeon Forge fault and should be avoided for development where highly deformed or altered.	Heterogeneous units may be deformed and exposed in high areas or along cliffs. They are prone to rockfall.	None	Ze forms the southeastern boundary of Cades Cove. Zm underlies Ze on the southeastern side of Cades Cove.	Some calcareous cement in Zr may be prone to dissolution rendering the unit friable.	Sulfide minerals, sandstone, conglomerate, slate	Units surround Cades Cove, a sheltered valley.	Units are suitable for most recreation unless highly deformed or altered.	Units record pervasive deposition and deformation in the Cades Cove area. Zm has 39Ar/40Ar geochronology dating deformation at 350 Ma.
NEOPROTEROZOIC	Pigeon Siltstone (Zp), Pigeon Siltstone; feldspathic metasandstone (Zps), Roaring Fork Sandstone (Zrf), Roaring Fork Sandstone; feldspathic metasandstone (Zrfs), Snowbird Group, undivided (Zsb), Longarm Quartzite (Zl), Wading Branch Formation (Zwb).	Zp includes foliated, massive green and blue- green laminated metasiltstone and fine- grained feldspathic metasandstone locally. Remnant bedding is recognizable. Zps includes fine- grained, thickly bedded feldspathic metasandstone. Zrf contains interbedded fine- grained greenish- gray, feldspathic metasandstone and dark gray chloritic metasiltstone and phyllite. Zrfs consists of fine- grained feldspathic metasandstone in prominent beds. Zsb contains reworked residuum of granitic rocks. Zl contains 15- 1525 m (50- 5000 ft) thick sequences of light- colored, medium- grained quartzite and arkose with relict sedimentary structures. Colors of cross- beds are pink, blue, and purple. Unit grades upwards into fine- grained sandstone. Zwb contains heterogeneous stacks of light and dark metasedimentary rocks including basal phyllite, sandy slate, quartz- sericite- muscovite schist, and quartz pebble conglomerate. Unit ranges 3- 458 m (10- 1500 ft) thick.	Moderate to high for quartzites	Units are associated with Dunn Creek fault and are pervasively deformed, avoid for heavy development.	Foliation and localized weathering may render units unstable on moderate slopes. Units are prone to rockfall.	None	Zl was quarried for quartzite dimension stone near Ravens Ford. Stones from this unit appear in the Oconaluftee Ranger Station, Park HQ, and other structures.	Iron- bearing carbonate in Zp may be prone to dissolution	Chlorite, iron- bearing carbonate, chloritoid, garnet, magnetite, muscovite, sericite, quartzite dimension stone, slate	Units may weather to produce Fe, Mg, and Ca- rich regolith. Prominent beds of metasandstone in Zrfs may provide ledge habitat for birds.	Units are suitable for most recreation unless highly deformed or altered.	Units contain relict Neoproterozoic depositional features in addition to a record of regional deformation and metamorphism. Zsb rocks thicken to the northwest recording a deepening ancient basin caused by normal faulting.

Age	Unit Name (Symbol)	Features and Description	Erosion Resistance	Suitability for Development	Hazards	Paleontological Resources	Cultural Resources	Karst	Mineral Occurrence	Habitat	Recreation	Geologic Significance
MESOPROTEROZOIC	Biotite augen gneiss (Ybg), Granodiorite (Ygd), Porphyritic granite (Ypg), Monzogranite gneiss (Ymp), Granitic gneiss (Yg), Spring Creek Granitoid Gneiss (Ysg).	Ybg contains dark, mottled, coarse- grained biotite augen gneiss. Augen are 3 cm (* in) long composed of white and pink microcline and oligoclase encased in a foliated quartz and plagioclase matrix. Unit contains biotite gneiss and metagraywacke xenoliths. Ygd is weakly foliated granulite facies granodiorite. Textures are medium to coarse- grained with light and dark brown colors in outcrop. Ypg contains coarse augen, sparse biotite, granite with characteristic potassium feldspar porphyroblasts 3 cm (* in) in length. Ymp is heavily deformed (mylonitic) monzogranite gneiss with bands of pink and purple feldspars mixed with gray- blue quartz grains. Yg includes well- foliated biotite granite gneiss. Foliation is defined by irregular blobs and streaks of biotite. Local dikes of monzogranite locally intrude Yg. Ysg contains a heterogeneous metaigneous mixture of biotite granite gneiss intermixed with biotite granodiorite gneiss, tonalitic gneiss, quartz monzodiorite gneiss, amphibolite, biotite gneiss, and biotite schist.	High	Ygd is fault- bounded and pervasively cut by brittle faults and should be avoided for heavy development. Ymp is pervasively deformed and may be preferentially weathered to instability on slopes.	Alteration and weathering in addition to strong fabrics such as cleavage and foliation may render units susceptible to rockfall if undercut on slopes or oriented parallel to the slope face. K- bearing clays weathered from granitic units may pose radon hazard.	None	None documented	None	Microcline, oligoclase, biotite, quartz, orthopyroxene, microperthite, plagioclase, muscovite	Granitic units may weather to produce K, Na, and Al rich clayey regolith.	Units are suitable for most recreation unless highly deformed or altered.	Ybg has a U- Pb zircon age of 1029 Ma. Ygd has a U- Pb date on zircon of 1040 Ma. Ypg has a zircon U- Pb age of 1056 Ma. A granitoid from Ymp had a preliminary U- Pb zircon age of 1148 Ma. Yg has a U- Pb zircon age of 1163 Ma. Ysg had a zircon U- Pb age date of 1178 Ma.
MESOPROTEROZOIC	Migmatitic biotite gneiss (Ym), Hornblende- biotite gneiss (Yh), Amphibolite (Ya), Ultramafic rock (Yu).	Ym is heavily deformed gray, medium to coarse- grained biotite gneiss including a variety of other metamorphic rocks such as biotite schist, muscovite- biotite gneiss, muscovite- biotite schist, and mica- feldspar quartz gneiss. Foliation varies and is defined by flakes and streaks of biotite. Migmatitic textures locally make the rocks appear “mixed”. Yh contains dark hornblende- biotite gneiss, biotite- hornblende gneiss, quartz- bearing hornblende gneiss, layered biotite- poor amphibolite containing, and granoblastic calc- silicate granofels. Metamorphic layering is defined by thin slivers of biotite, garnet, and hornblende crystals. Ya occurs in dark, irregular pods and layers within the Yh and Ym units. The largest body is more than 610 m (2000 ft) long and 274 m (900 ft) wide. The amphibolite appears green to brown with fine to medium- grained textures and well- developed foliation. Yu contains mafic and ultramafic rocks as xenoliths in other Mesoproterozoic units. Units appear deeply weathered in outcrop and rusty colored.	Moderately high, lower for more altered units	Some Yu bodies are associated with the Greenbriar fault. These faulted areas should be avoided for heavy development. Avoid heavily deformed or altered areas for development due to instability.	Strong foliation may render units susceptible to rockfall if undercut on slopes or oriented parallel to the slope face. Altered areas are prone to weakness.	None	Large phenocrysts or augen in these rocks may have provided early trade material.	None	Quartz, plagioclase, biotite, potassium feldspar, muscovite, almandine garnet, kyanite, microperthite, oligoclase, epidote, clinopyroxene, sphene, ilmenite, apatite, hornblende, chlorite, actinolite, tremolite, magnetite, olivine, talc	Mafic and ultramafic units weather to produce Fe, Mg rich regolith.	Suitable for most recreation unless highly sheared or altered.	Ym zircons yielded U- Pb age dates of 1194 Ma. Yu may be remant chunk of oceanic crust accreted onto the North American continent during collision events.