APPENDIX A Special Geologic Features and Conditions Considered in Office Studies and Field Observations (EM 1110-1-1804, Department of the Army, 1984)

Geologic Feature or Condition	Influence on Project	Office Studies	Field Observations	Questions to Answer
Landslides	Stability of natural and excavated slopes	Presence or age in project area or at construction sites should be determined.	Estimate areal extent (length and width) and height of slope.	Are landslides found off site in geologic formations of the same type that will be affected by project construction?
		Compute shear strength at failure. Do failure strengths decrease with age of slopes--especially for clays and clay shales?	Estimate ground slope before and after slide (may correspond to residual angle of friction).	What are probable previous and present groundwater levels?
			Check highway and railway cuts and deep excavations, quarries, and steep slopes.	Do trees slope in an unnatural direction?
Faults and faulting; past seismic activity	Of decisive importance in seismic evaluations; age of most recent fault movement may determine seismic design earthquake magnitude, may be indicative of high state of stress that could result in foundation heave or overstress in underground works.	Determine existence of known faults and fault history from available information.	Verify presence at site, if possible, from surface evidence; check potential fault traces located from aerial imagery.	Are lineaments or possible fault traces apparent from regional aerial imagery?
		Examine existing boring logs for evidence of faulting from offset of strata.	Make field check of structures, cellars, chimneys, roads, fences, pipelines, known faults, caves, inclination of trees, offset in fence lines.	
Joints and fractures	High concentration of joints indicating weakness of bedrock and high strain.	Study aerial photos and define all available lineaments and their relationship if possible.	Investigate orientation and density of joints.	
Stress relief cracking and valley rebounding	Valley walls may have cracking parallel to valley. Valley floors may have horizontal cracking. In some clay shales stress relief from valley erosion or glacial action may not be complete.	Review pertinent geologic literature and reports for the valley area. Check existing piezometer data for abnormally low levels in valley sides and foundation; compare with normal groundwater levels outside valley.	Examine wells and piezometers in valleys to determine if levels are lower than normal groundwater regime (indicates valley rebound not complete).	

APPENDIX A, Cont'd.

Geologic Feature or Condition	Influence on Project	Office Studies	Field Observations	Questions to Answer
Sinkholes; karst topography	Major effect on location of structures and feasibility of potential site.	Examine aerial photos for evidence of undrained depressions.	Locate depressions in the field and measure size depth and slopes. Differences in elevation between center and edges may be almost negligible or many feet. From local residents, attempt to date appearance of sinkhole	Are potentially soluble rock formations present such as limestone, dolomite, or gypsum? Are undrained depressions present that cannot be explained by glaciation? Is surface topography rough and irregular without apparent cause?
Anhydrites or gypsum layers	Anhydrites in foundations beneath major structures may hydrate and cause expansion, upward thrust and buckling. Gypsum may cause settlement, subsidence, collapse or piping. Solution during life of structure may be damaging.	Determine possible existence from available geologic information and delineate possible outcrop locations.	Look for surface evidence of uplift; seek local information on existing structures. Check area carefully for caves or other evidence of solution features.	Are uplifts caused by possible anhydrite expansion or "explosion?"
Caves	Extent may affect project feasibility or cost. Can provide evidence regarding faulting that may relate to seismic design. Can result from unrecorded mining activity in the area.		Observe cave walls carefully for evidence of faults and recent faulting. Estimate age of any broken stalactites or stalagmites from column rings.	Are any stalactites or stalagmites broken from apparent ground displacement or shaking?
Erosion resistance	Determines need for total or partial channel slope protection.	Locate contacts of potentially erosive strata along drainage channels.	Note stability of channels and degree of erosion and stability of banks.	Are channels stable or have they shifted frequently? Are banks stable or easily eroded? Is there extensive bank sliding?

APPENDIX A, Cont'd.

Geologic Feature or Condition	Influence on Project	Office Studies	Field Observations	Questions to Answer
Internal erosion	Affects stability of foundations and dam abutments. Gravelly sands or sands with deficiency of intermediate particle sizes may be unstable and develop piping when subject to seepage flow.	Locate possible outcrop areas of sorted alluvial materials or terrace deposits.	Examine seepage outcrop areas of slopes and riverbanks for piping.	
Area subsidence	Area subsidence endangers long-term stability and performance of project	Locate areas of high groundwater withdrawal, oil and gas fields, and subsurface mineral extraction (coal, solution mining, and etc.) areas.	Check project area for new wells or new mining activity	Are there any plans for new or increased recovery of subsurface water or mineral resources?
Collapsing soils	Determines need for removal of shallow foundation materials that would collapse upon wetting	Determines how deposits were formed during geologic time and any collapse problems in area	Examine surface deposits for voids along eroded channels, especially in steep valleys eroded in fine-grained sedimentary formations	Were materials deposited by mud flows?
Locally lowered groundwater	May cause minor to large local and area settlements and result in flooding near rivers or open water and differential settlement of structures	Determine if heavy pumping from wells has occurred in project area; contact city and state agencies and USGS	Obtain groundwater levels in wells from owners and information on withdrawal rates and any planned increases. Observe condition of structures. Contact local water plant operators	
Abnormally low pore water pressures (lower than anticipated from groundwater levels)	May indicate effective stresses are still increasing and may cause future slope instability in valley sites	Compare normal groundwater levels with piezometric levels if data is available		Is a possible cause from past reduction in vertical stresses (e.g., deep glacial valley or canal excavations such as Panama Canal in clay shales where pore water pressures were reduced by stress relief)?

APPENDIX A, Cont'd.

Geologic Feature or Condition	Influence on Project	Office Studies	Field Observations	Questions to Answer
In situ shear strength from natural slopes	Provides early indication of stability of excavated slopes or abutment, and natural slopes around reservoir area.	Locate potential slide areas. Existing slope failures should be analyzed to determine minimum in situ shear strengths.	Estimate slope angles and heights, especially at river bends where undercutting erosion occurs. Determine if flat slopes are associated with mature slide or slump topography or with erosion features.	Are existing slopes consistently flat, indicating residual strengths have been developed?
Swelling soils and shales	Highly preconsolidated clays and clay shales may swell greatly in excavations or upon increase in moisture content..	Determine potential problem and location of possible preconsolidated strata from available information.	Examine roadways founded on geologic formations similar to those at site. Check condition of buildings and effects of rainfall and watering.	Do seasonal groundwater and rainfall or watering of shrubs or trees cause heave or settlement?
Varved clays	Pervious layers may cause more rapid settlement than anticipated. May appear to be unstable because of uncontrolled seepage flow through pervious layers between overconsolidated clay layers or may have weak clay layers. May be unstable in excavations unless well points are used to control groundwater.	Determine areas of possible varved clay deposits associated with prehistoric lakes. Determine settlement behavior of structures in the area.	Check natural slopes and cuts for varved clays; check settlement behavior of structures.	
Dispersive clays	A major factor in selecting soils for embankment dams and levees.	Check with Soil Conservation Service and other agencies regarding behavior of existing small dams.	Look for peculiar erosional features such as vertical or horizontal cavities in slopes or unusual erosion in cut slopes. Perform "crumb" test.	
Riverbank and other liquefaction areas	Major effect on riverbank stability and on foundation stability in seismic areas.	Locate potential areas of loose fine-grained alluvial or terrace sand; most likely along riverbanks where loose sands are present and erosion is occurring.	Check riverbanks for scallop-shaped failure with narrow neck (may be visible during low water). If present, determine shape, depth, average slope and slope of adjacent sections. Liquefaction in wooded areas may leave trees inclined at erratic angles. Look for evidence of sand boils in seismic areas.	

APPENDIX A, Cont'd.

Geologic Feature or Condition	Influence on Project	Office Studies	Field Observations	Questions to Answer
Filled areas	Relatively recent filled areas would cause large settlements. Such fill areas may be overgrown and not detected from surface or even subsurface evidence.	Check old topo maps if available for depressions or gullies not shown on more recent topo maps.		Obtain local history of site from area residents
Local overconsolidation from previous site usage	Local areas of a site may have been overconsolidated from past heavy loadings of lumber or material storage piles.			Obtain local history from residents of area

APPENDIX B Sources of Geologic Information (EM 1110-1-1804, Department of the Army, 1984)

Agency	Type of Information	Description	Remarks
USGS	Topographic maps	U.S. 7.5-minute series 1:24,000 (supersedes 1:31,680). Puerto Rico 7.5-minute series 1:20,000 (supersedes 1:30,000) Virgin Island 1:24,000 series. U.S. 15-minute series 1:62,500 (1:63,360 for Alaska) U.S. 1:100,000-scale series (quadrangle, county, or regional format) U.S. 1:50,000-scale county map series U.S. 1:250,000-scale series Digital elevation models are available for entire U.S. at 1:250,000, and for certain areas at 1:100,000 and 1:24,000 scales. Digital line graphs are available for some areas at 1:24,000 and 1:65,000 for: - Hydrography - Transportation - U.S. Publication Survey - Boundaries - Hypsography	Orthophotoquad monocolor maps also produced in 7.5-minute and 15-minute series. New index of maps for each state started in 1976. Status of current mapping from USGS regional offices and in monthly USGS bulletin, "New Publications of the U.S. Geological Survey."
USGS	Geology maps and reports	1:24,000 (1:20,000 Puerto Rico), 1:62,500, 1:100,00, and 1:250,000 quadrangle series includes surficial bedrock and standard (surface and bedrock) maps with major landslide areas shown on later editions 1:500,000 and 1:2,500,000 (conterminous U.S., 1974).	New index of geologic maps for each state started in 1976. List of geologic maps and reports for each state published periodically.
USGS	Miscellaneous maps and reports	Landslide susceptibility rating, swelling soils, engineering geology, water resources, and groundwater.	Miscellaneous Investigation Series and Miscellaneous Field Studies Series, maps and reports, not well cataloged; many included as open file.
USGS	Special maps	1:7,500,000 and 1:1,000,000: Limestone Resources, Solution Mining Subsidence, Quaternary Dating Applications, Lithologic Map of U.S., Quaternary Geologic Maps.	
USGS	Hydrologic maps	Hydrologic Investigations Atlases with a principal map scale of 1:24,000; includes water availability, flood areas, surface drainage precipitation and climate, geology, availability of ground and surface water, water quality and use, and streamflow characteristics.	Some maps show groundwater contours and location of wells.

APPENDIX B, Cont'd.

Agency	Type of Information	Description	Remarks
USGS	Earthquake hazard	Seismic maps of each state (started in 1978 with Maine); field studies of fault zones; relocation of epicenters in eastern U.S.; hazards in the Mississippi Valley area; analyses of strong motion data; state-of-the-art workshops	Operates National Strong-Motion Network and National Earthquake Information Service publishes monthly listing of epicenters (worldwide).
USGS	Mineral resources	Bedrock and surface geologic mapping; engineering geologic investigations; map of power generating plants of U.S. (location of built, under construction, planned, and type); 7.5-minute quadrangle geologic maps and reports on surface effects of subsidence into underground mine openings of eastern Powder River Basin, Wyoming	
USGS	Bibliography	"Bibliography of North American Geology" North American, Hawaiian Islands, and Guam	Published until 1972
Geological Society of America (GSA)	Bibliography	"Bibliography and Index of Geology Exclusive of North America"	1934-1968
		"Bibliography and Index of Geology" Decade of North American Geology series	1969 to present, 12 monthly issues plus yearly cumulative index
NOAA	Earthquake hazards	National Geophysical Data Center in Colorado contains extensive earthquake hazard information	
NASA	Remote sensing data	Landsat, Skylab imagery	
NOAA	Remote sensing data		
Space Imaging	Remote sensing data	Multi-band satellite imagery with meter resolution	
USFWS	Wetlands	The National Wetlands Inventory maps at 1:24,000 for most of the contiguous U.S.	Available as maps or mylar overlays
USGS	Flood-prone area maps	1:24,000 series maps outlining floodplain areas not included in Corps of Engineers reports or protected by levees	Stage 2 of 1966 89th Congress House Document 465
US Army Engineer Waterways Experiment Station (USAEWES)	Earthquake hazard	"State-of-the-Art for Assessing Earthquake Hazards in the United States," Miscellaneous Paper S-73-1	Series of 19 reports, 1973 to present

APPENDIX B, Cont'd.

Agency	Type of Information	Description	Remarks
IUGS	Worldwide mapping	Commission for the Geological Map of the World publishes periodic reports on worldwide mapping in "Geological Newsletter"	
NRCS	Soil survey reports	1:15,840 or 1:20,000 maps of soil information on photomosaic back-ground for each country. Recent reports include engineering test data for soils mapped, depth to water and bedrock, soil profiles grain-size distribution, engineering interpretation and special features. Recent aerial photo coverage of many areas. Soils maps at 1:7,500,000, 1:250,000, and 1:12,000 scale are available in digital format for some areas.	Reports since 1957 contain engineering uses of soils mapped, parent materials, geologic origin, climate, physiographic setting, and profiles.
FEMA	Earthquake hazard	NEHRP "Recommended provisions for Seismic Regulations for New Buildings and Older Structures," 1997, includes seismic maps.	
State Geologic Agencies	Geologic maps and reports	State and county geologic maps; mineral resource maps; special maps such as for swelling soils; bulletins and monographs; well logs; water resources, groundwater studies	List of maps and reports published annually, unpublished information by direct coordination with state geologist
DMA	Topographic Maps	Standard scales of 1:12,500, 1:50,000, 1:250,000 and 1:1,000,000 foreign and worldwide coverage including photomaps	Index of available maps from DMA
AAPG	Geological highway map series	Scale approximately 1 ~~in~~. Inch to 30 miles shows surface geology and includes generalized time and rock unit columns, physiographic map, tectonic map, geologic history summary, and sections	Published as 12 regional maps including Alaska and Hawaii
TVA	Topographic maps, geologic maps and reports	Standard 7.5-minute TVA-USGS topographic maps, project pool maps, large-scale topographic maps of reservoirs, geologic maps and reports in connection with construction projects	Coordinate with TVA for available specific information