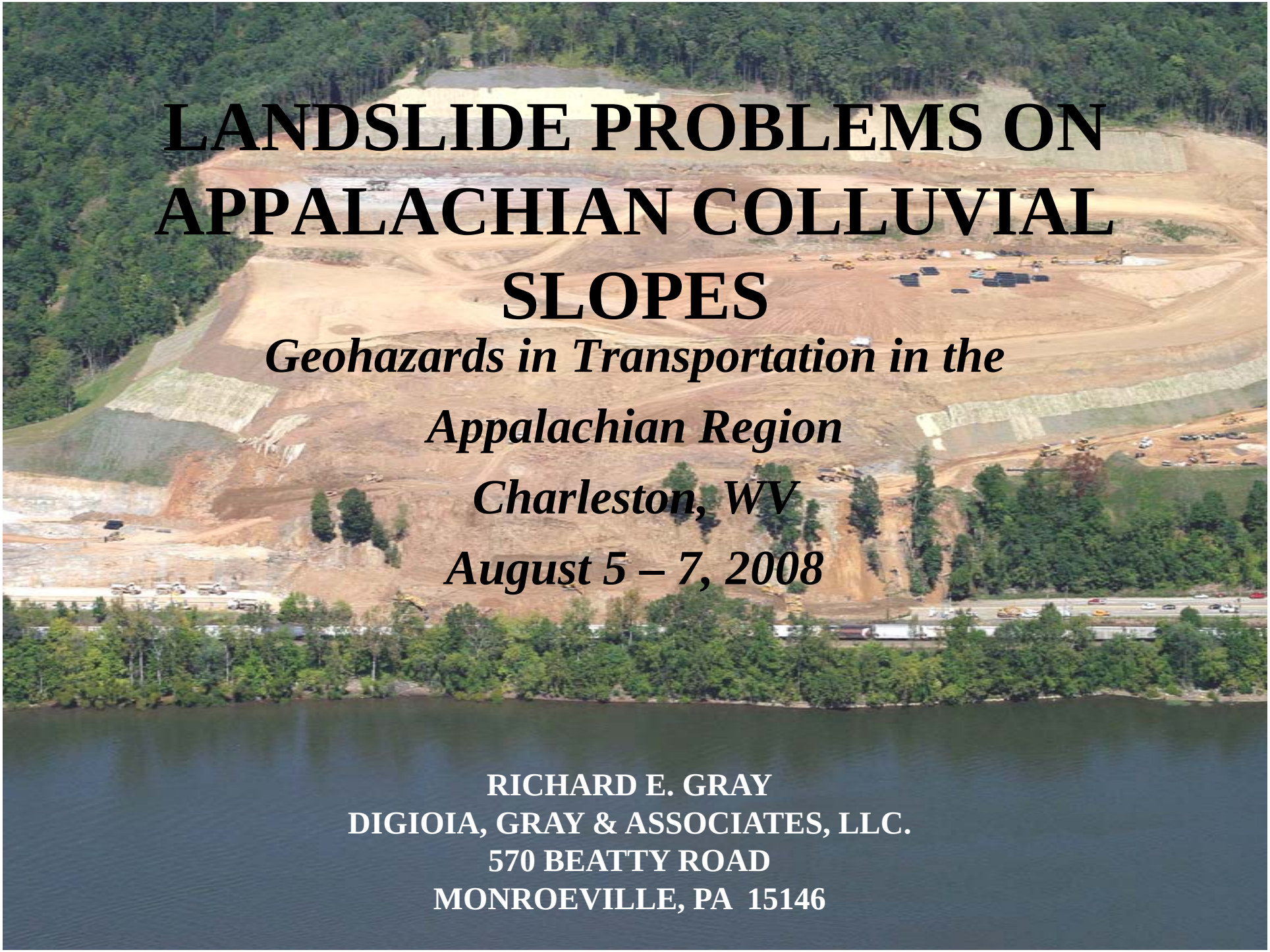

LANDSLIDE PROBLEMS ON APPALACHIAN COLLUVIAL SLOPES

Geohazards in Transportation in the Appalachian Region

Charleston, WV

August 5 – 7, 2008

RICHARD E. GRAY
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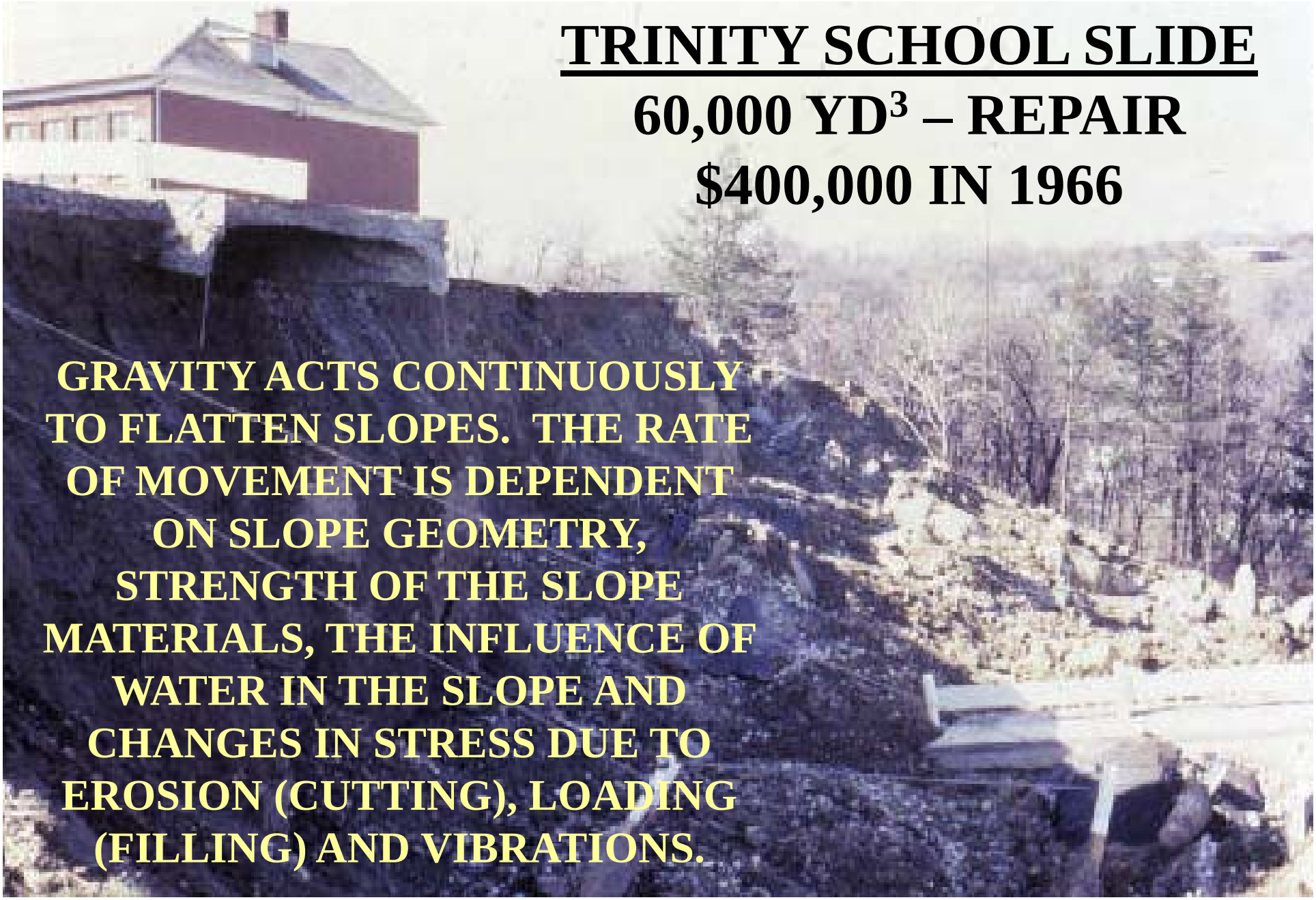
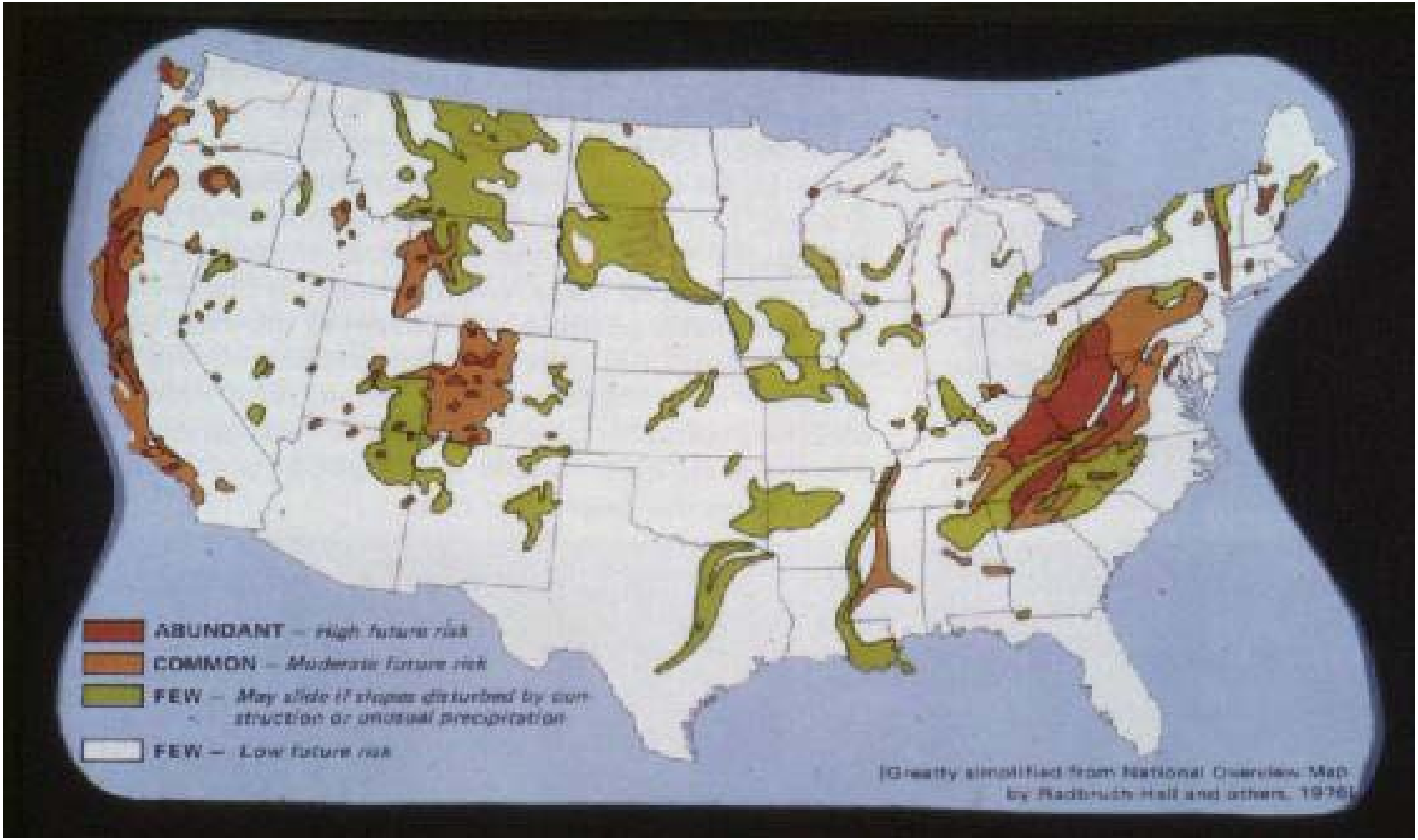


TRINITY SCHOOL SLIDE

60,000 YD^3 – REPAIR

$400,000 IN 1966

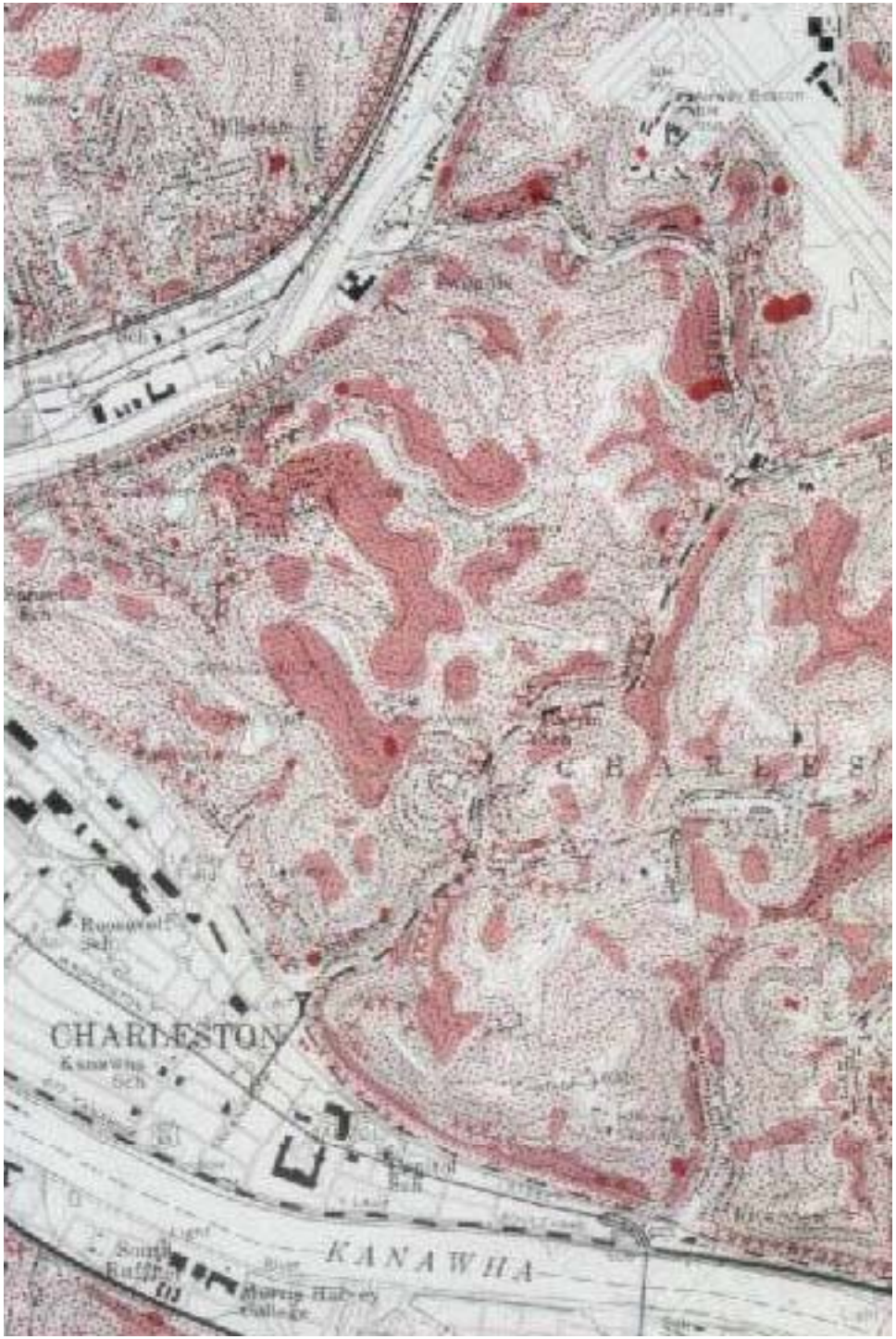
GRAVITY ACTS CONTINUOUSLY TO FLATTEN SLOPES. THE RATE OF MOVEMENT IS DEPENDENT ON SLOPE GEOMETRY, STRENGTH OF THE SLOPE MATERIALS, THE INFLUENCE OF WATER IN THE SLOPE AND CHANGES IN STRESS DUE TO EROSION (CUTTING), LOADING (FILLING) AND VIBRATIONS.



<u>LANDSLIDE RISK</u> – THE APPALACHIAN PLATEAU WITH ITS STEEP HILLSIDES, THICK SOIL COVER, AND PRECIPITATION OF 900 – 1200 MM PER YEAR, WITH THE GREATEST AMOUNTS OCCURRING IN LATE WINTER AND EARLY SPRING, HAS LONG BEEN RECOGNIZED AS AN AREA OF MAJOR LANDSLIDE SEVERITY.

THE MOST COMMON CAUSES OF LANDSLIDING:

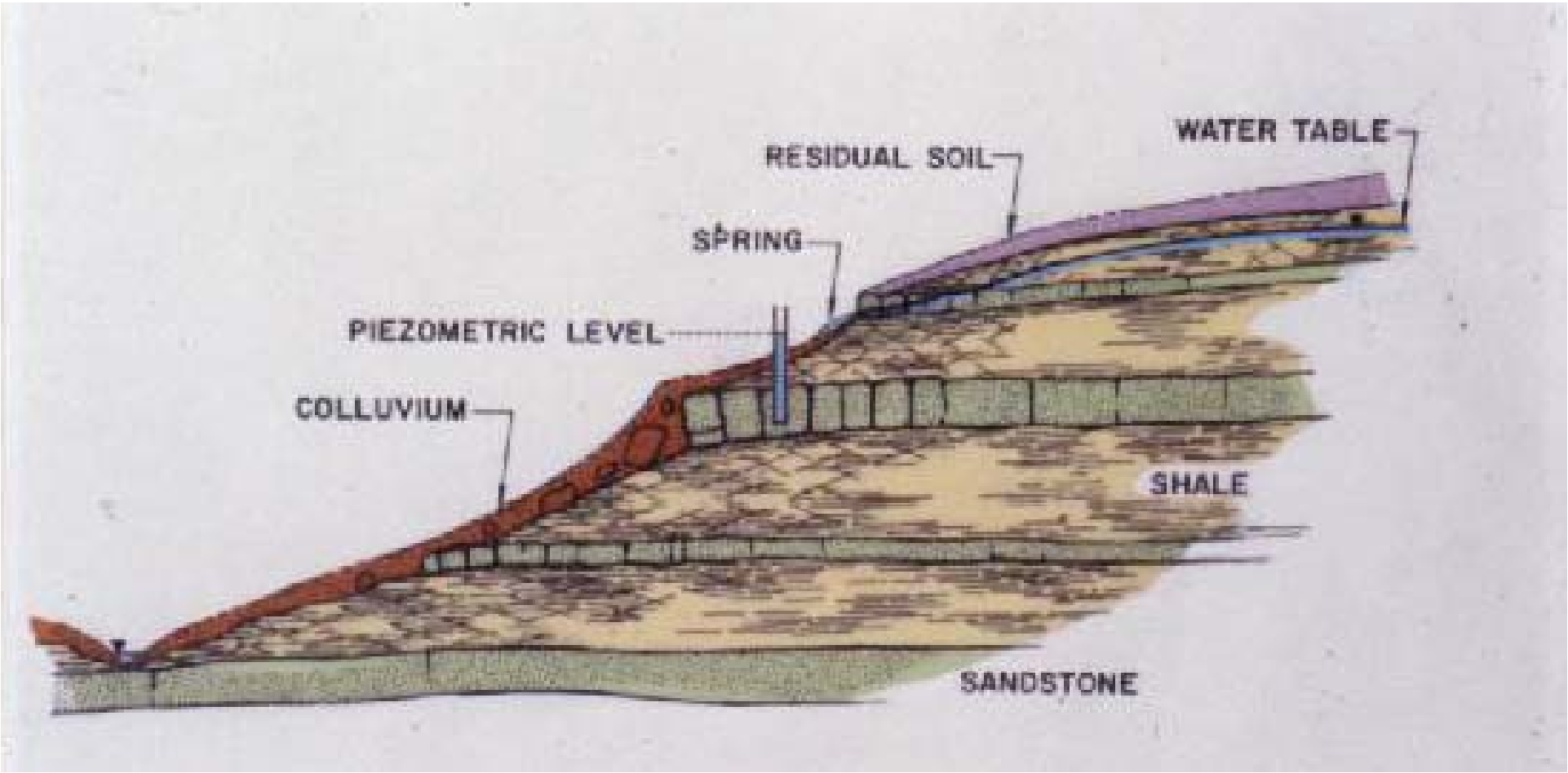
1. **REMOVAL OF LATERAL SUPPORT – BY EROSION OR EXCAVATION.**
2. **SURCHARGE – BY FILLING ON SLOPE.**
3. **CHANGES IN GROUND WATER CONDITIONS – INCREASED PRECIPITATION OR BROKEN WATER AND SEWER LINES..**



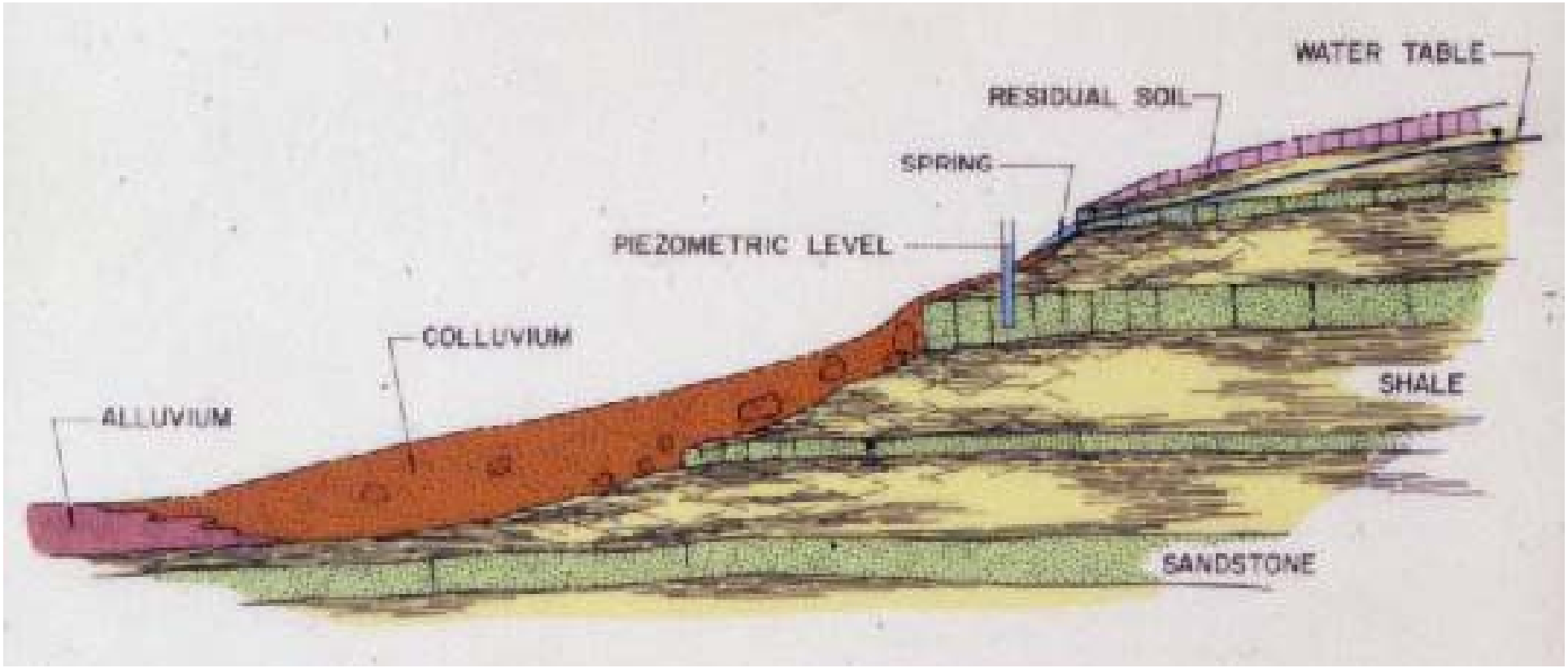
PORTION OF CHARLESTON EAST QUADRANGLE, WEST VIRGINIA, SHOWING LANDSLIDE (COLLUVIAL) MASSES AND SLIDE PRONE AREAS: ACTIVE – OLD AND POTENTIAL.

LANDSLIDE ON DAISY-CLOVER FORK 69 kV LINE EASTERN KENTUCKY – JUNE 2006.

EXCEPT LOCALLY WHERE SANDSTONE MAY BE ABUNDANT THE PREDOMINANCE OF FINE-GRAINED ROCK (SHALE AND CLAYSTONE) IN THE GEOLOGIC SECTION RESULTS IN SOILS BEING SILTY CLAY OR CLAYEY SILT WITH ROCK FRAGMENTS. RESIDUAL SOILS ARE CHARACTERISTIC OF THE FLAT UPLAND SURFACES WITH COLLUVIALSOILS FORMED ON SLOPES.

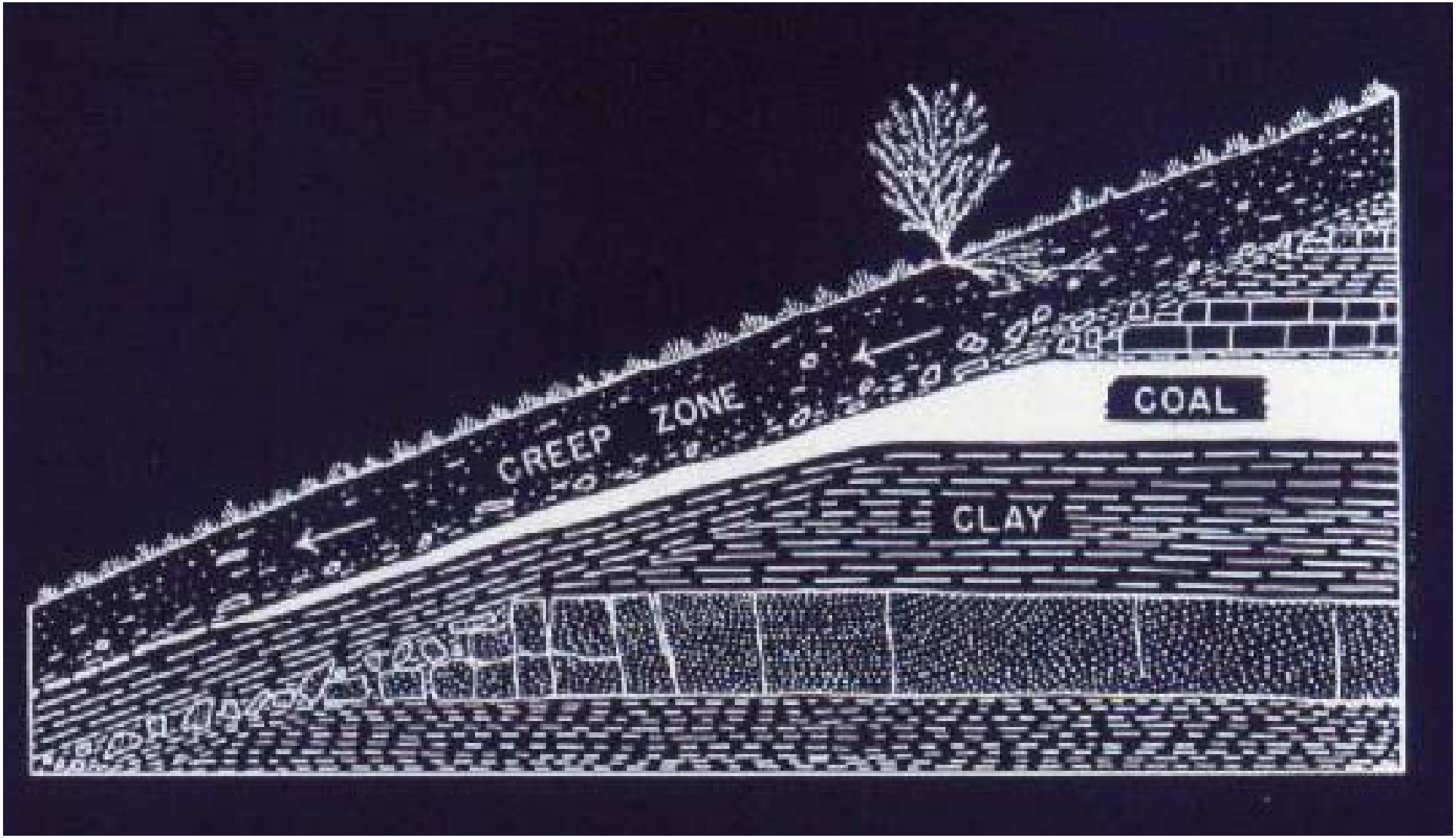


<u>THIN COLLUVIAL COVER</u> – MOST LANDSLIDES OCCUR IN CLAYEY, COLLUVIAL SOIL DEVELOPED ON SLOPES UNDERLAIN BY RELATIVELY FLAT LYING SEDIMENTARY ROCK STRATA. WITH ACTIVE EROSION, THERE IS LITTLE ACCUMULATION OF COLLUVIUM AT THE TOES OF SLOPES.



<u>THICK COLLUVIAL COVER</u> - COLLUVIAL MASSES DEVELOP HAVING VOLUMES OF SEVERAL MILLION M^3 AND THICKNESS OF UP TO 30 m. MATURE COLLUVIAL SLOPES MAY EXHIBIT ANGLES AS FLAT AS 7 – 10°. MANY LARGE COLLUVIAL MASSES INTERFINGER WITH GLACIAL OUTWASH AND RADIOCARBON DATING INDICATES THEY MAY HAVE FORMED UNDER PERIGLACIAL CONDITIONS.

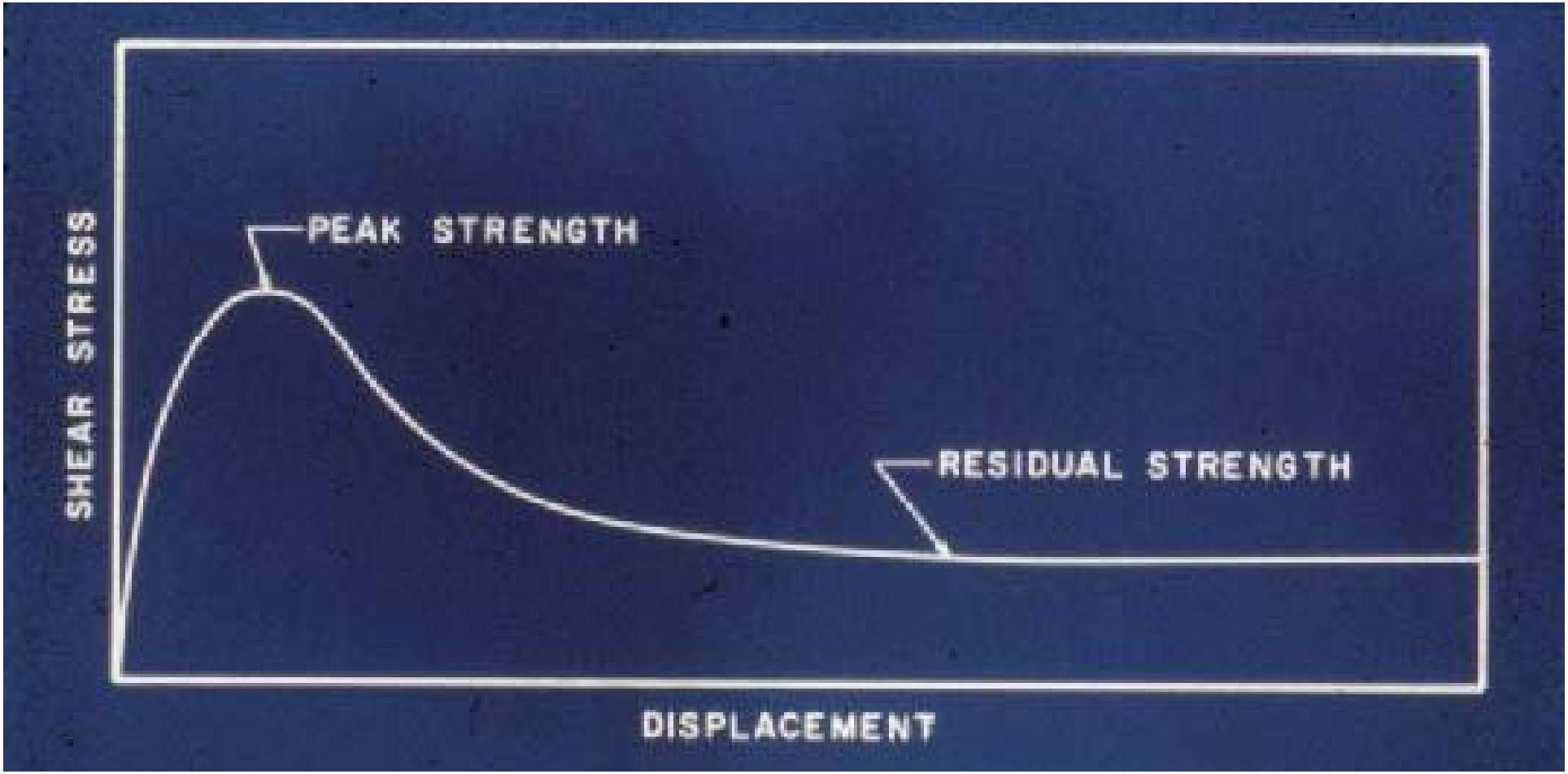
<u>THICK COLLUVIUM</u> – KEYSTONE PROJECT. COLLUVIAL SOILS ARE GENERALLY STIFF TO HARD AND INDIVIDUAL SAMPLES HAVE RELATIVELY HIGH SHEAR STRENGTHS



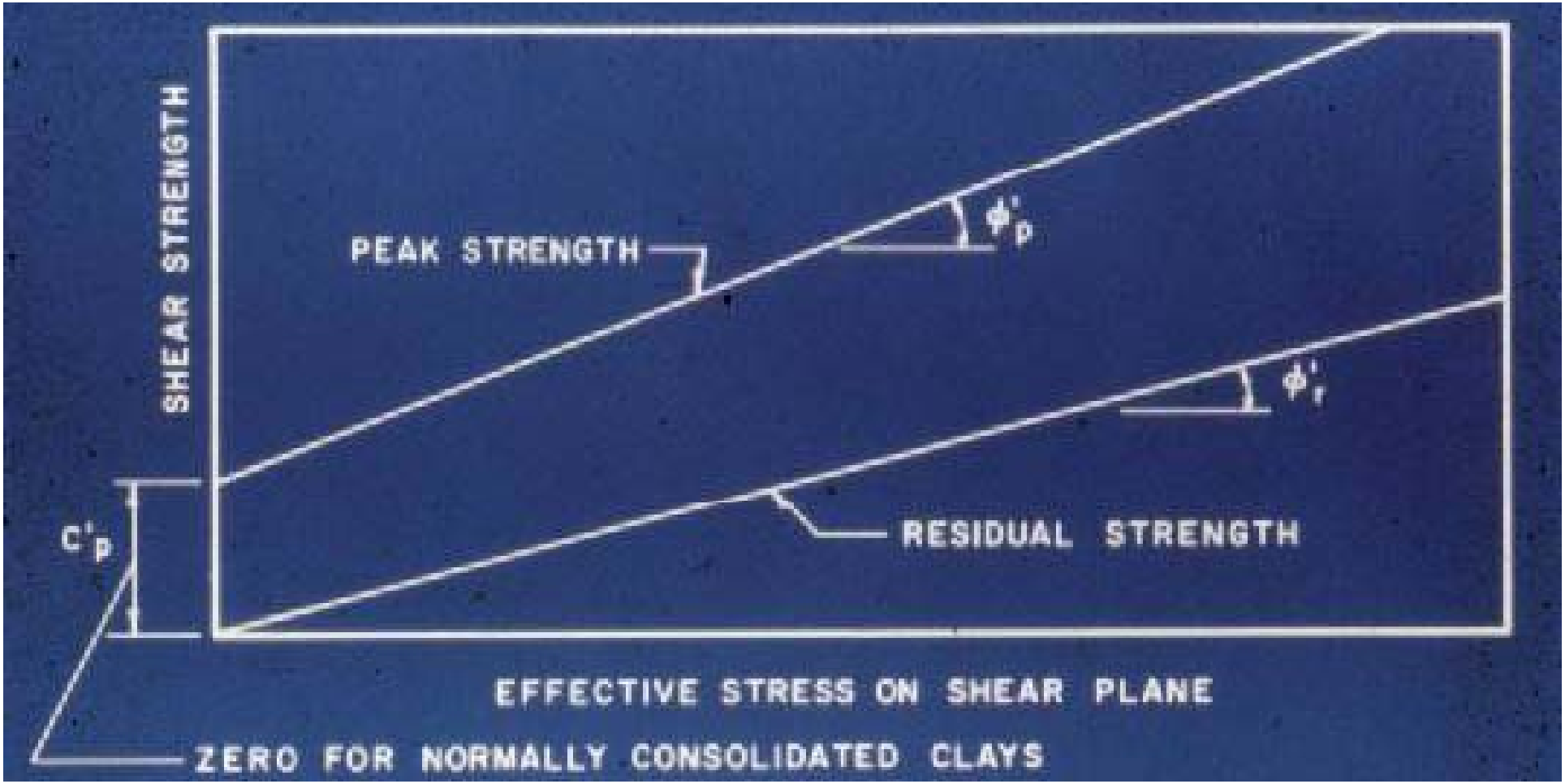
<u>SOIL CREEP</u> – CREEP AND OTHER FORMS OF MASS WASTING PRODUCE THE COLLUVIAL SOIL WHICH BLANKETS SLOPES. SLOW DOWN SLOPE MOVEMENT, A FEW CM/YR, USUALLY IMPERCEPTIBLE EXCEPT TO OBSERVATIONS OF LONG DURATION. THIS MOVEMENT FORMS SLICKENSLIDES.

EXPOSED MOVEMENT SURFACE IN A COLLUVIAL SOIL
WEIRTON, W. VA

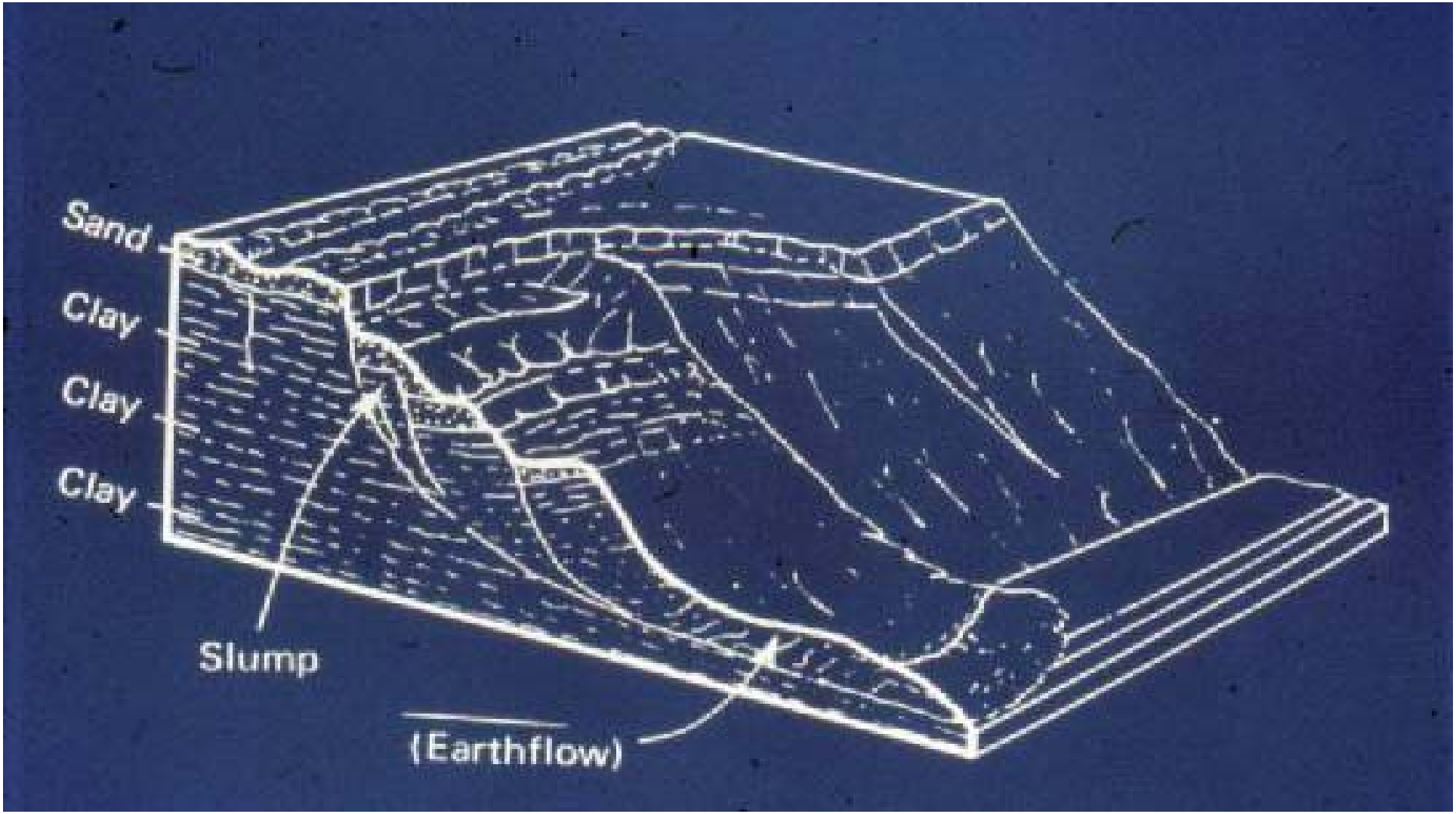
EXPOSED MOVEMENT (SLICKENSLIDED) SURFACE WEIRTON, W. VA. CREEP OR SLIDING PROCESSES (OR BOTH) DURING SLOPE FORMATION HAS GENERALLY REDUCED THE SHEAR STRENGTH ALONG MOVEMENT SURFACES TO RESIDUAL OR NEAR RESIDUAL VALUES



TYPICAL SHEAR STRESS – DISPLACEMENT RELATIONSHIP. RESIDUAL (LARGE DISPLACEMENT) SHEAR STRENGTH IS GENERALLY LESS THAN HALF ITS PEAK (SMALL DISPLACEMENT) STRENGTH AT A GIVEN EFFECTIVE NORMAL STRENGTH.



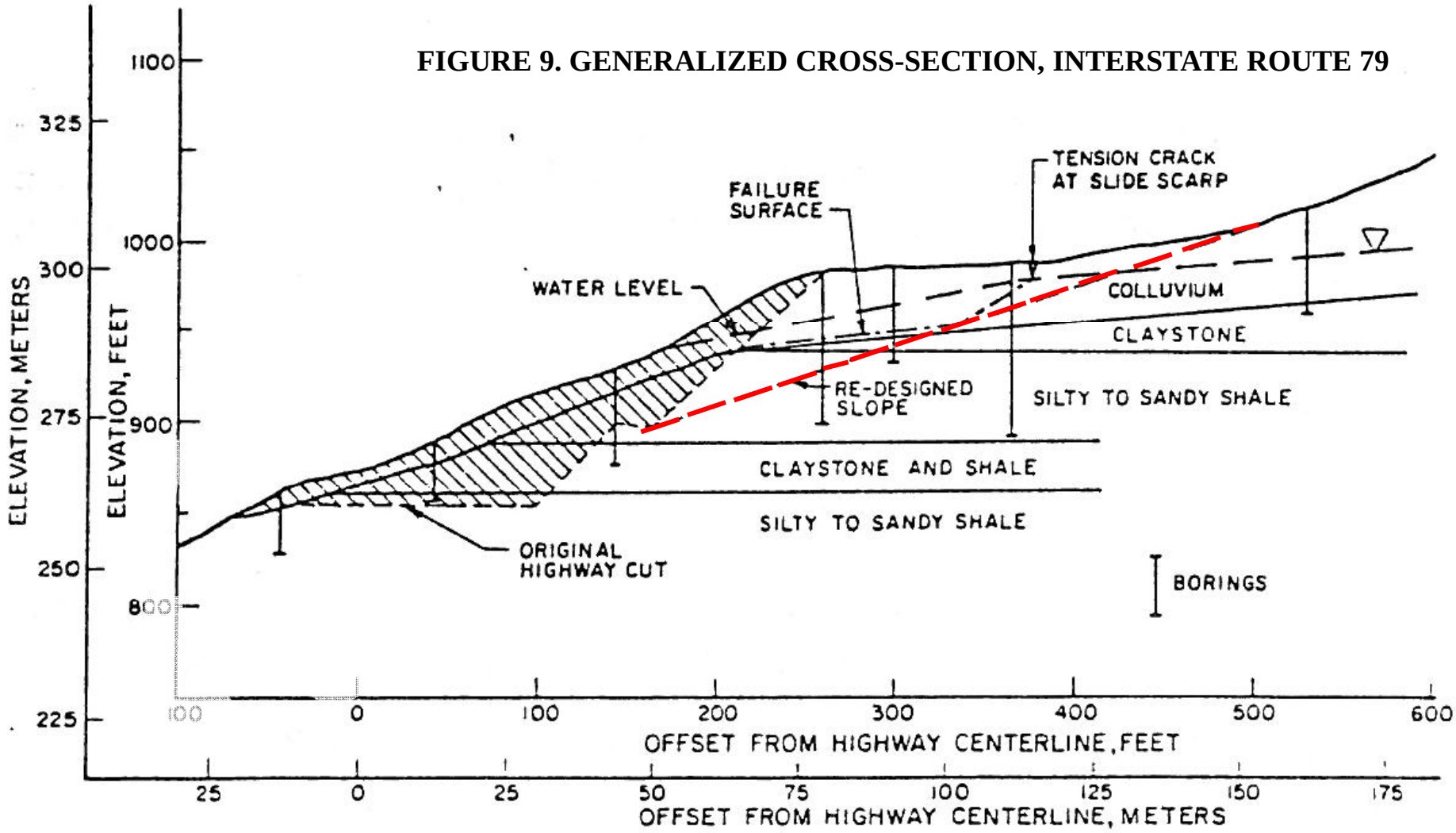
TYPICAL SHEAR STRENGTH - (EFFECTIVE STRESS RELATIONSHIP)
<u>PEAK & RESIDUAL SHEAR STRENGTHS</u> – THE PEAK STRENGTH OF CLAYSTONE DERIVED COLLUVIUM IS CHARACTERIZED BY COHESION INTERCEPTS OF 1 TO 5 psi AND FRICTION ANGLES OF 20 TO 25°, WHILE THE RESIDUAL STRENGTH IS CHARACTERIZED BY NEGLIGIBLE COHESION INTERCEPTS AND FRICTION ANGLES OF 8°TO 16°.



SINCE THE RELATIVELY THIN, LOW STRENGTH ZONES IN COLLUVIUM ARE NOT READILY APPARENT IN CONVENTIONAL BORINGS, GEOTECHNICAL ENGINEERS NEED TO REMEMBER HOW THE COLLUVIUM WAS FORMED AND ANTICIPATE LOW SHEAR STRENGTHS.

ON A MAJOR ROAD PROJECT IN THE APPALACIAN PLATEAU THE GEOTECHNICAL ENGINEER INITIALLY CLASSIFIED THE 9 METERS OF COLLUVIUM AS RESIDUAL SOIL. HE PLANNED TO SUPPORT THE ABUTMENT OF A 200 – FOOT HIGH BRIDGE ON THE RESIDUAL SOIL.

FIGURE 9. GENERALIZED CROSS-SECTION, INTERSTATE ROUTE 79



NUMEROUS LANDSLIDES WERE INITIATED ALONG ANCIENT SLIDE SURFACES WHEN THE TOES OF DEEP COLLUVIAL MASSES WERE EXCAVATED DURING HIGHWAY CONSTRUCTION IN 1968-69. COLLUVIUM THICKNESSES RANGED FROM LESS THAN 2 m TO MORE THAN 30 m AND AVERAGED ABOUT 15m. SHEAR STRENGTH VALUES CALCULATED FOR LIMITING EQUILIBRIUM OF TWO OF THE SLIDE MASSES WERE $\phi' = 14 - 15°$ **WITH** $c' = 0.$

GUIDELINES FOR LANDSLIDE STUDIES

- **MOST LANDSLIDES CAN BE PREDICTED IF PROPER INVESTIGATIONS ARE PERFORMED IN TIME.**
- **THE COST OF PREVENTING LANDSLIDES IS LESS THAN THE COST OF CORRECTING THEM.**
- **MASSIVE SLIDES THAT MAY COST MANY TIMES THE COST OF THE ORIGINAL FACILITY SHOULD BE AVOIDED.**
- **THE OCCURRENCE OF THE INITIAL SLOPE MOVEMENT CAN LEAD TO ADDITIONAL UNSTABLE CONDITIONS.**

From TRB Special Report 176