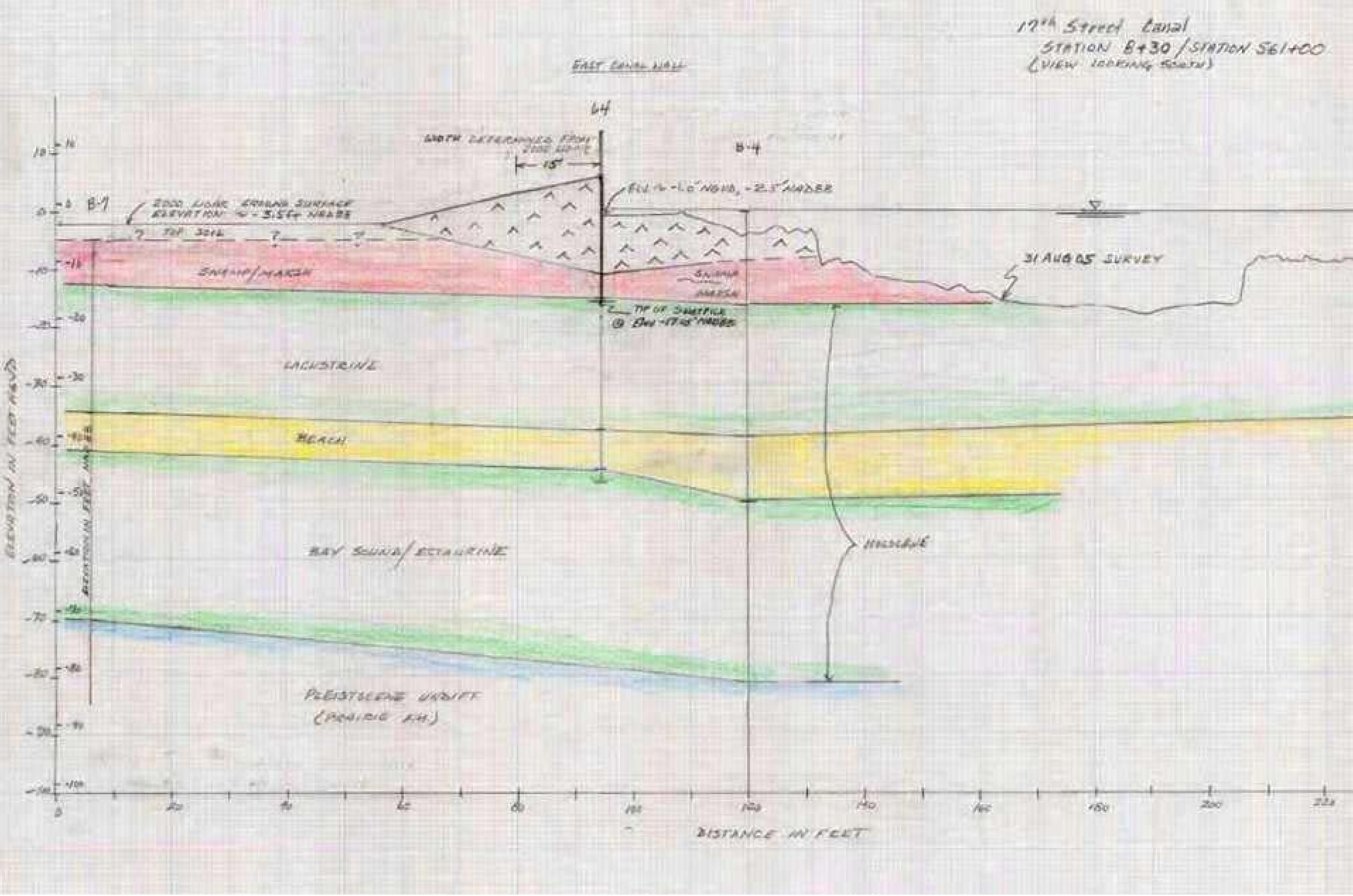
17th Street Canal I-wall Soil Strength and Stability

Outline

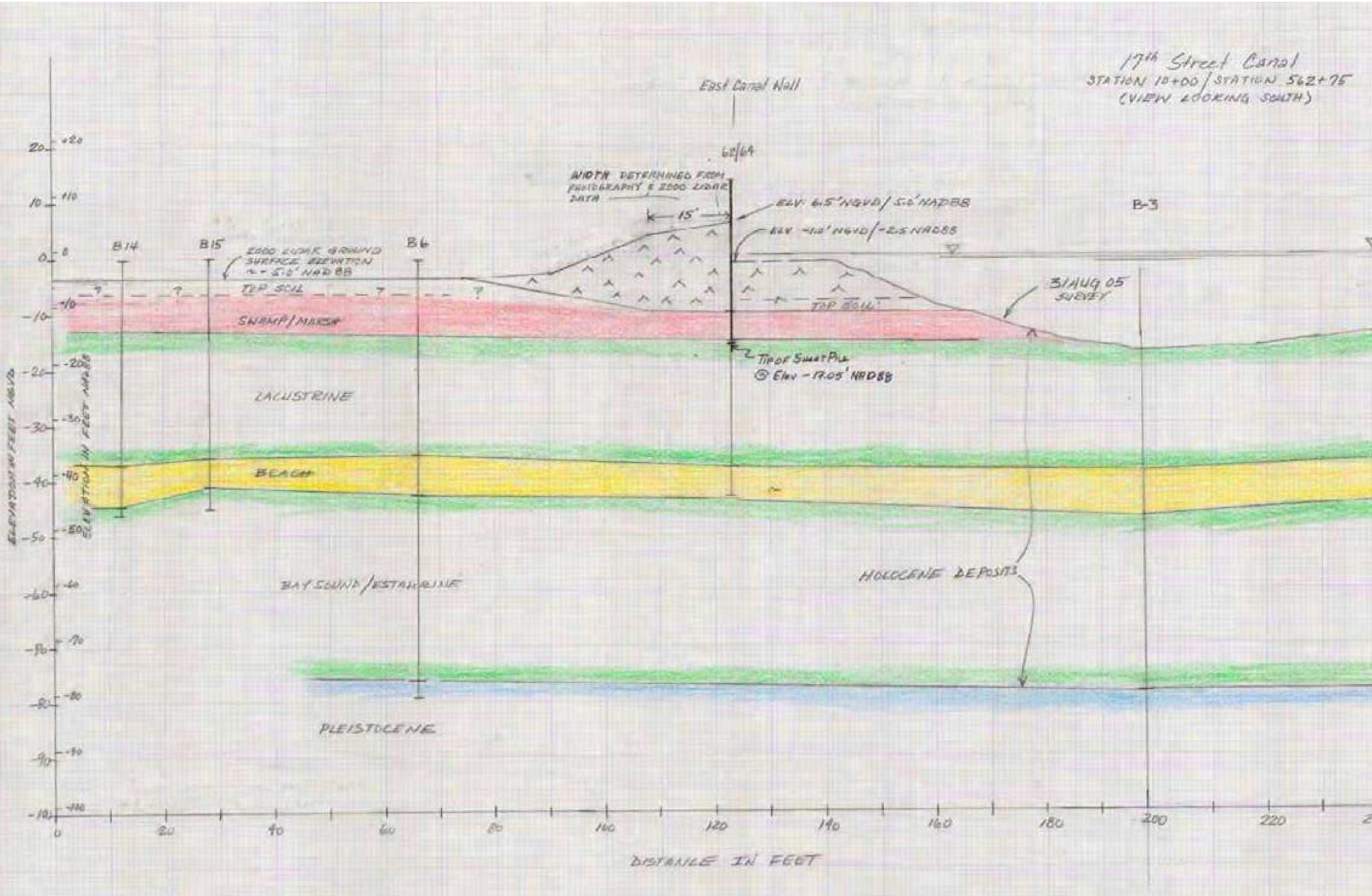
- Cross sections
- Soil strengths
- Wall stability in breach area
- Wall stability in adjacent areas
- Probabilities of failure
- Summary

Station 8+30

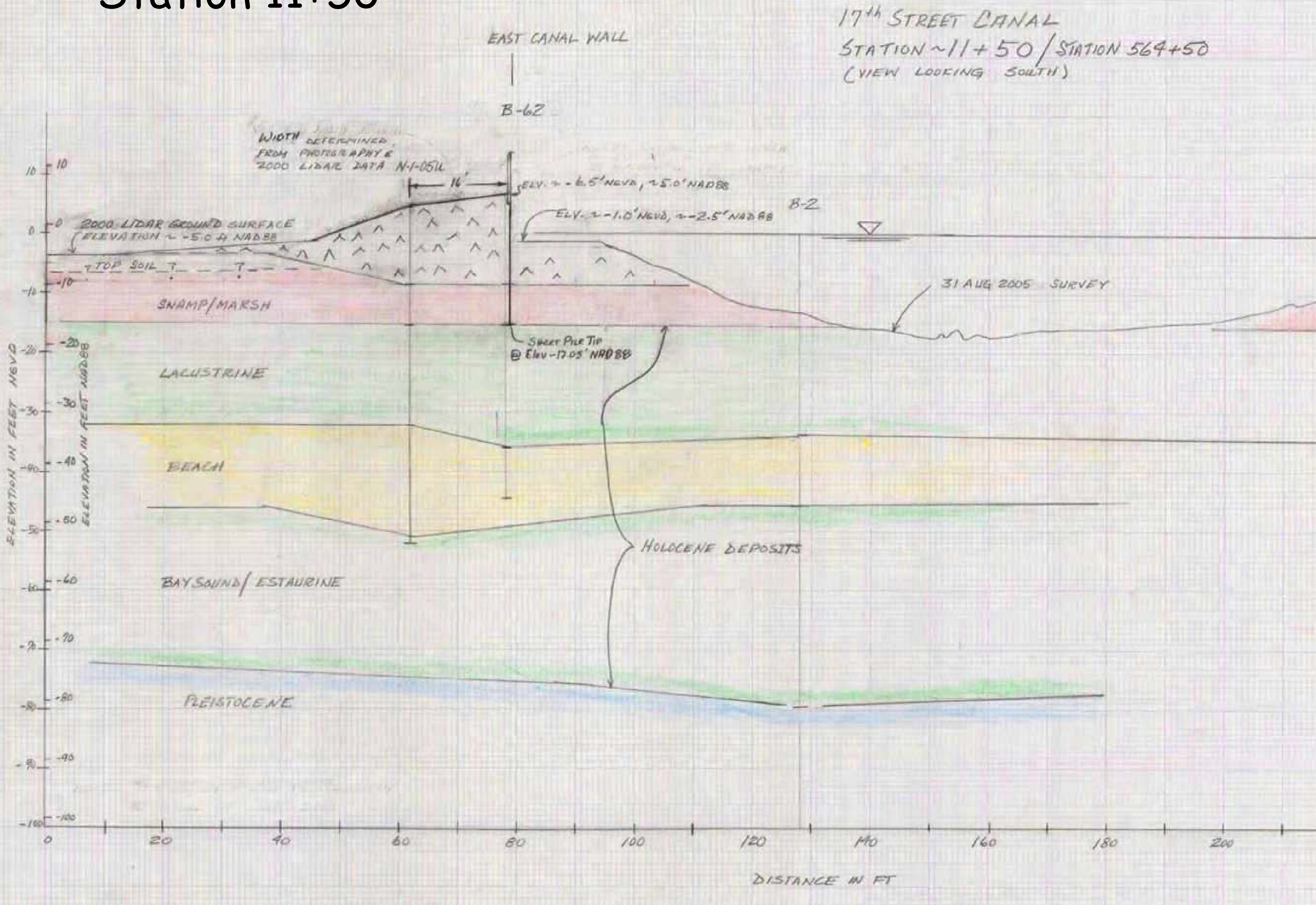


17th Street Canal
STATION 8+30 / STATION 561+00
EAST CANAL WALL
B-7
B-4
15'
2000 LIDAR GROUND SURFACE
TOP SOIL
SWAMP/MARSH
SWAMP
MARSH
LACUSTRINE
BEACH
BAY SOUND/ESTUARINE
PLEISTOCENE UNIT
31 AUG 05 SURVEY
DISTANCE IN FEET

Station 10+00



Station 11+50



Levee fill properties

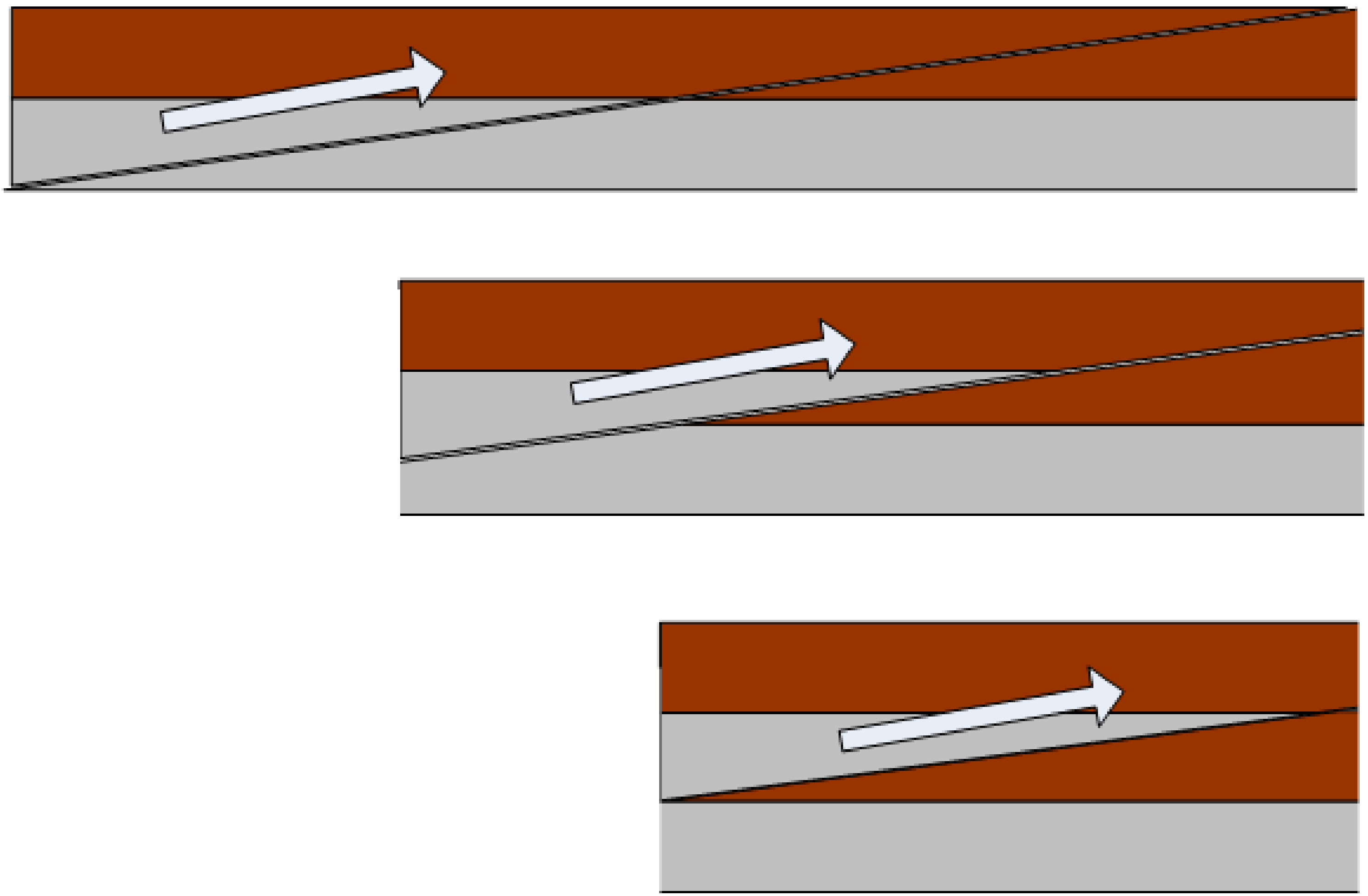
Property	Low	High	Average
Water content	%	%	%
Liquid Limit	40	105	70
Plasticity Index	20	75	50
Unit weight	85 pcf	125 pcf	109 pcf
S_u (ϕ = 0)	120 psf	5,000 psf	900 psf

Peat properties

Property	Low	High	Average
Water content	100%	700%	200%
Liquid Limit	80	380	220
Plasticity Index	55	260	150
Unit weight	60 pcf	95 pcf	80 pcf
S_u (ϕ = 0)	50 psf	900 psf	350 psf varies laterally


20 11:08AM

17th Street Slide Block



Clay (lacustrine) properties

Property	Low	High	Average
Water content	%	%	%
Liquid Limit	40	105	80
Plasticity Index	20	75	55
Unit weight	90 pcf	118 pcf	109 pcf
S_u (ϕ = 0)	100 psf	500 psf	300 psf varies laterally and vertically

Mayne's method for determining s_u from CPTU test results

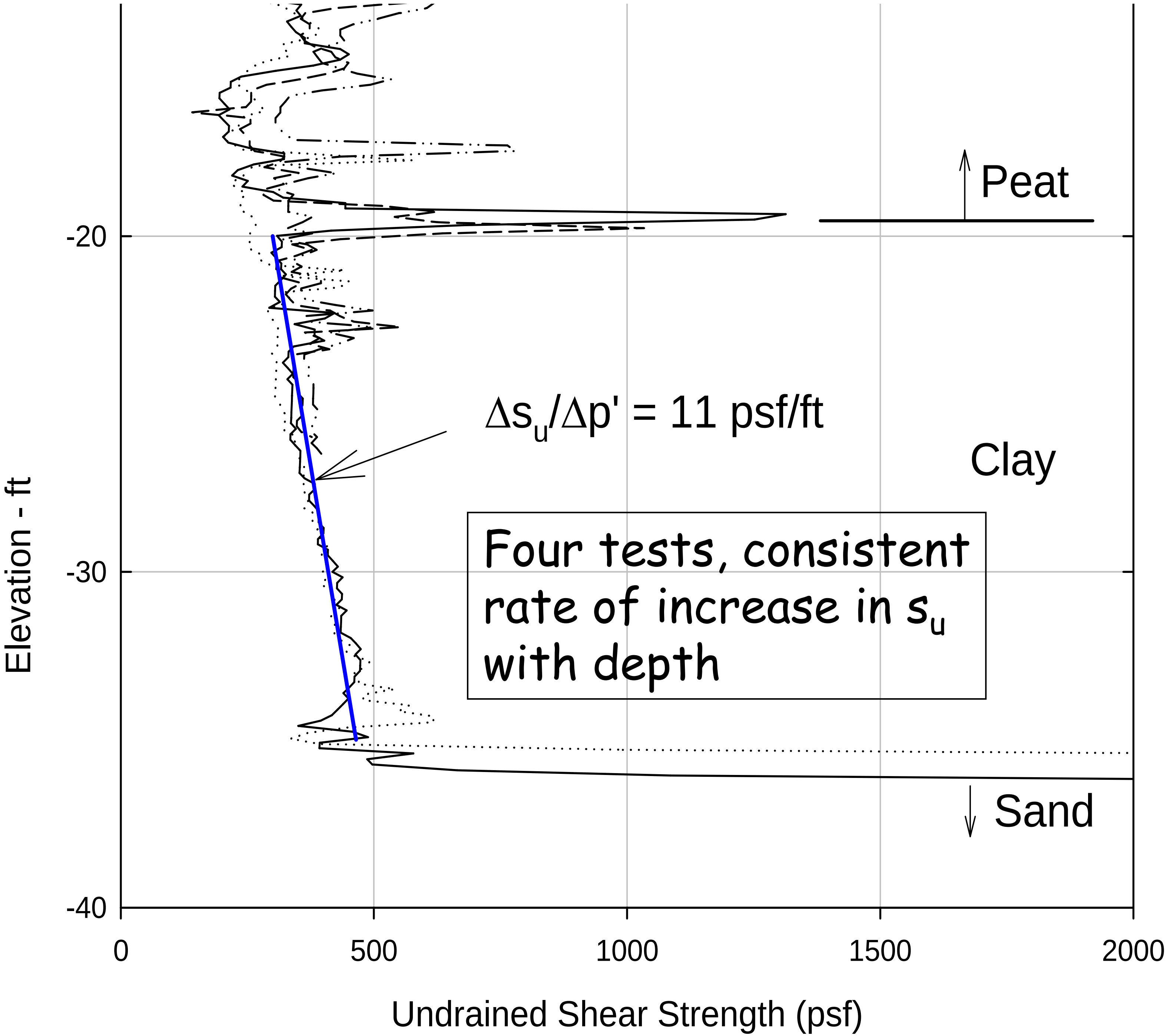
$$s_u = 0.091(\sigma'_v)^{0.2}(q_t - \sigma_v)^{0.8}$$

σ'_v = effective vertical stress

q_t = cone tip resistance corrected for pore pressure

σ_v = total overburden pressure

Corresponds to DSS lab tests - horizontal shear

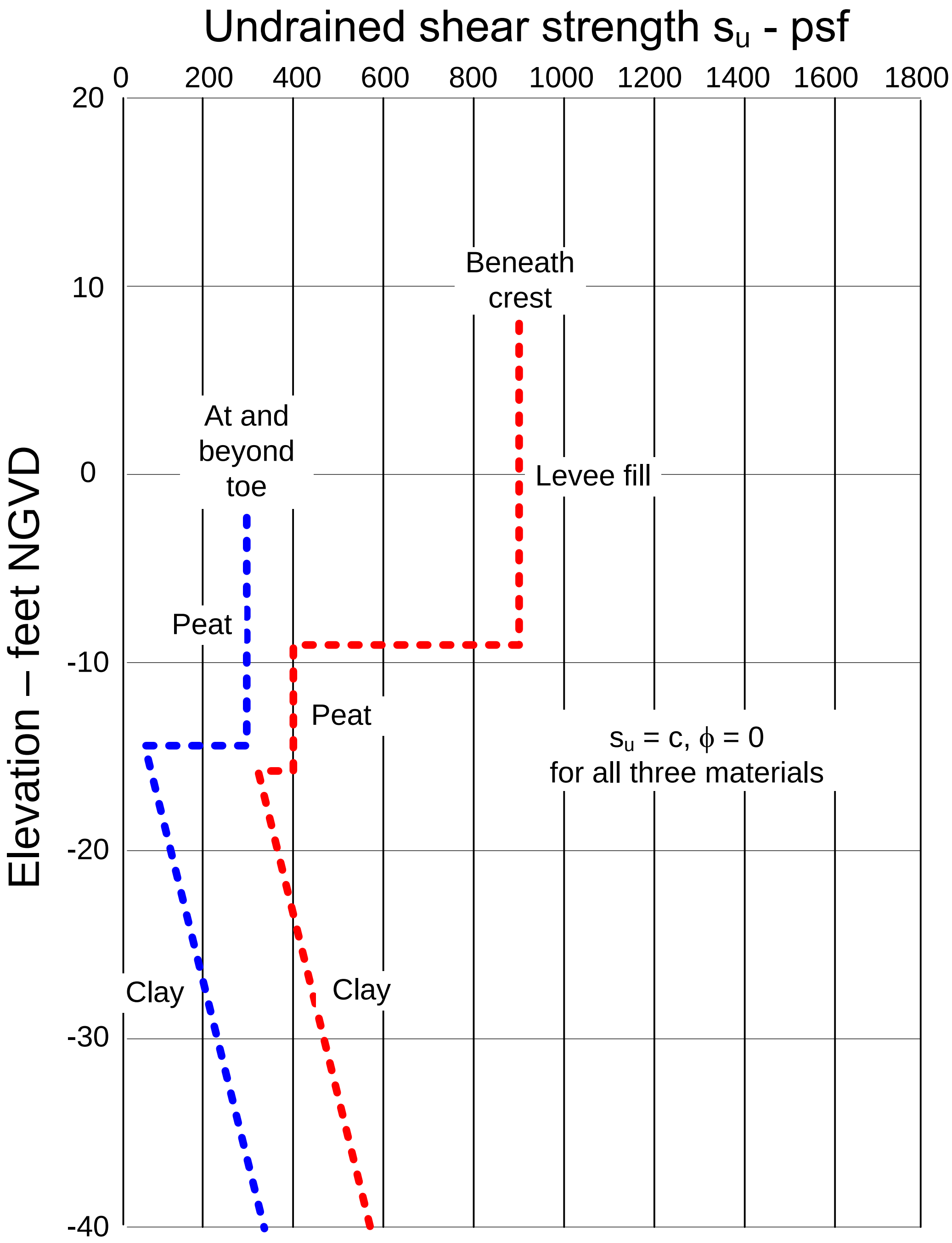


Peat
Clay
Sand
Δs_u/Δp' = 11 psf/ft
Four tests, consistent rate of increase in s_u with depth
Elevation - ft
-20
-30
-40
0
500
1000
1500
2000
Undrained Shear Strength (psf)

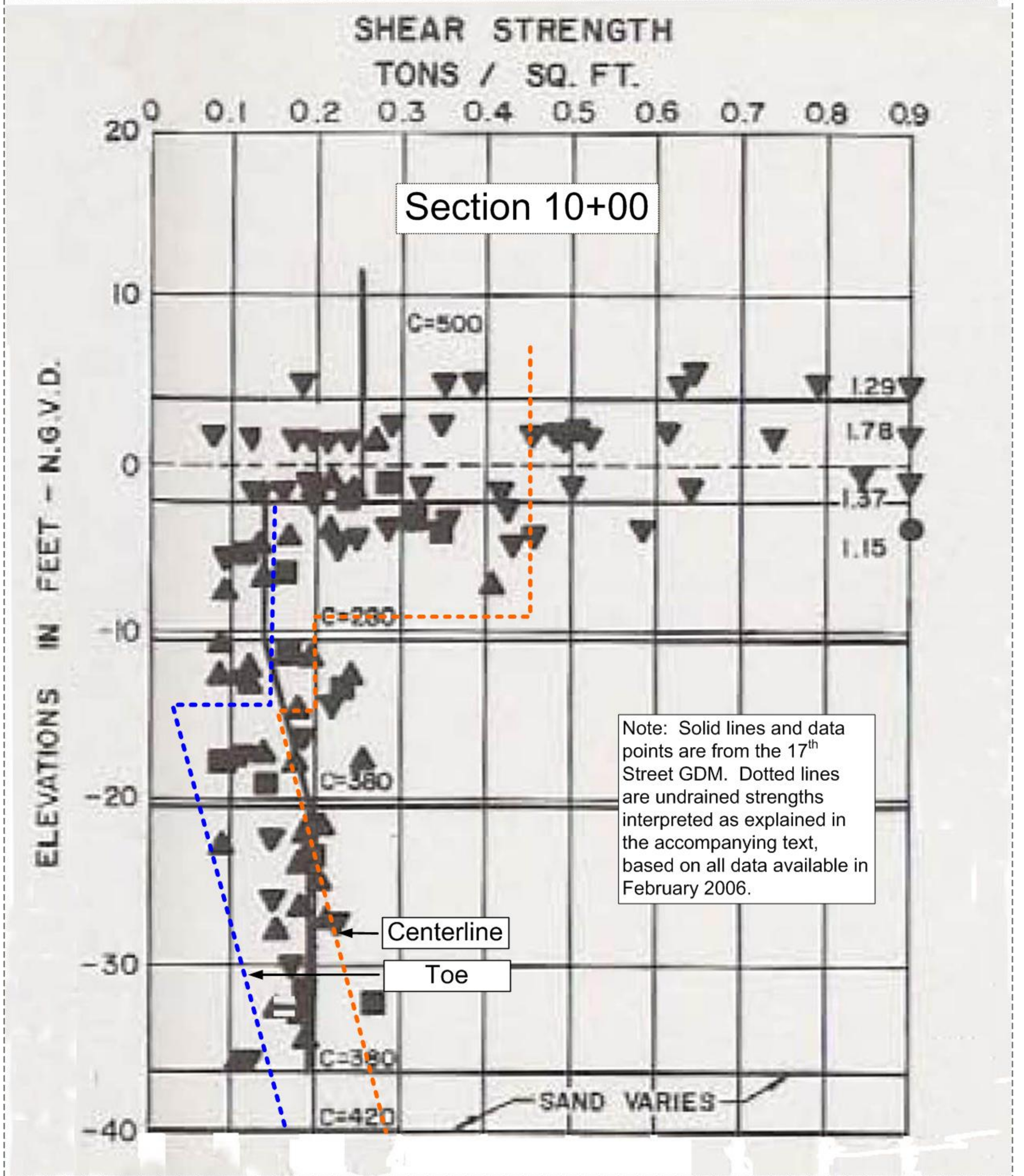
$$\frac{s_u}{p'} = \frac{\text{rate of increase of } s_u \text{ with depth}}{\text{rate of increase of } p' \text{ with depth}} = \frac{\Delta s_u / \Delta z}{\gamma_{buoyant}}$$

$$\frac{s_u}{p'} = \frac{11 \text{ psf per ft}}{46.6 \text{ pcf}} = 0.24$$

IPET shear strength model



Comparison of IPET shear strength model with design shear strengths



IPET and design strengths

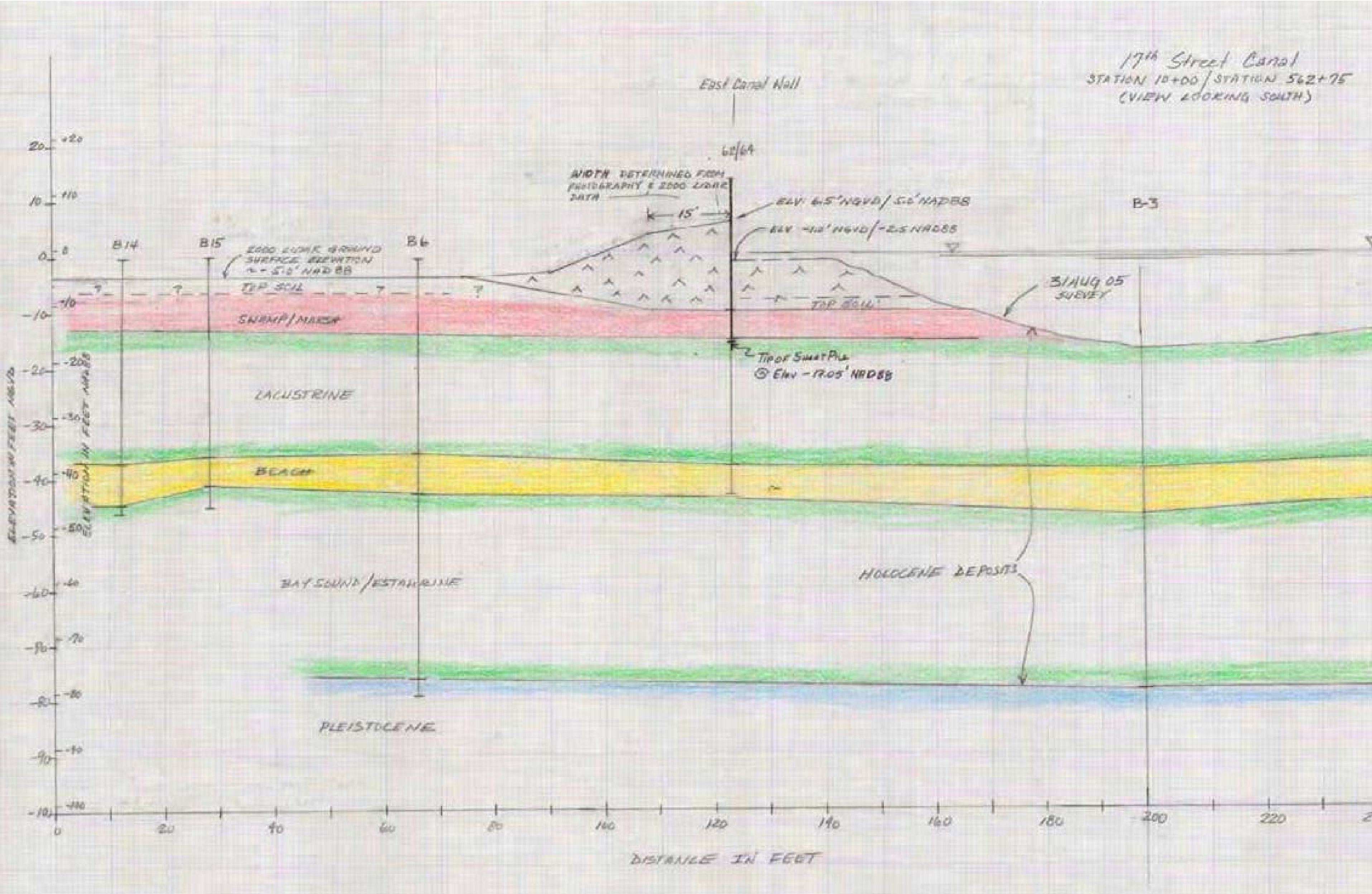
- <u>Beneath the embankment crest</u>, the design strengths are the same as IPET strengths at the top, and lower than the IPET strengths below elevation -20 ft
- <u>Beneath the embankment slopes, and beyond the toe</u>, the design strengths are higher than the IPET strengths

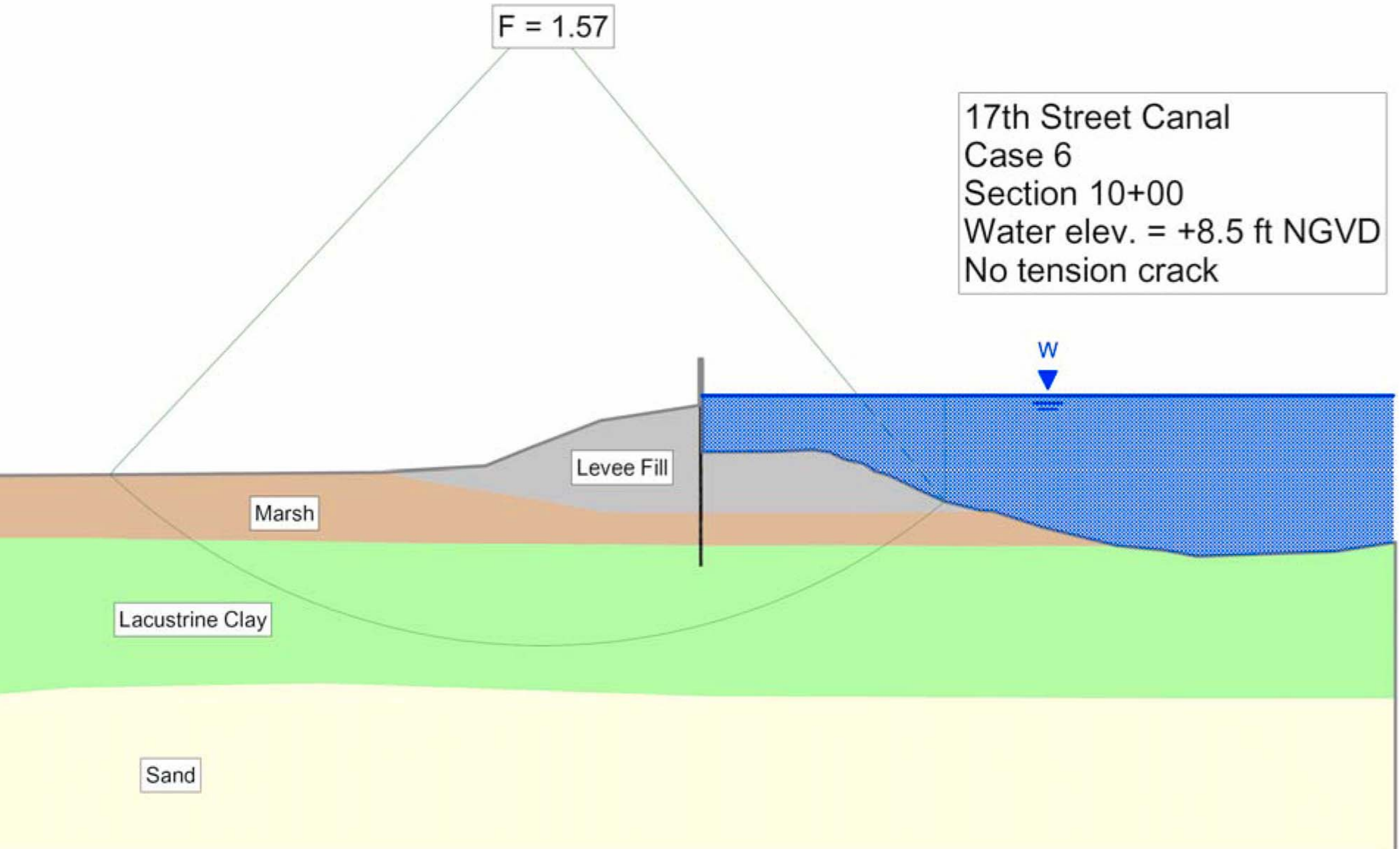
Clay Strengths in breach and adjacent areas

- Data are sparse and scattered
- Based on five UC and one UU-1 tests from two borings in the breach area, the average s_u is 260 psf
- Based on three UC, three UU, and one UU-1 tests from two borings north of the breach area, the average s_u is 335 psf
- Based on nine UC, two UU, and one UU-1 tests from three borings south of the breach, s_u 318 psf

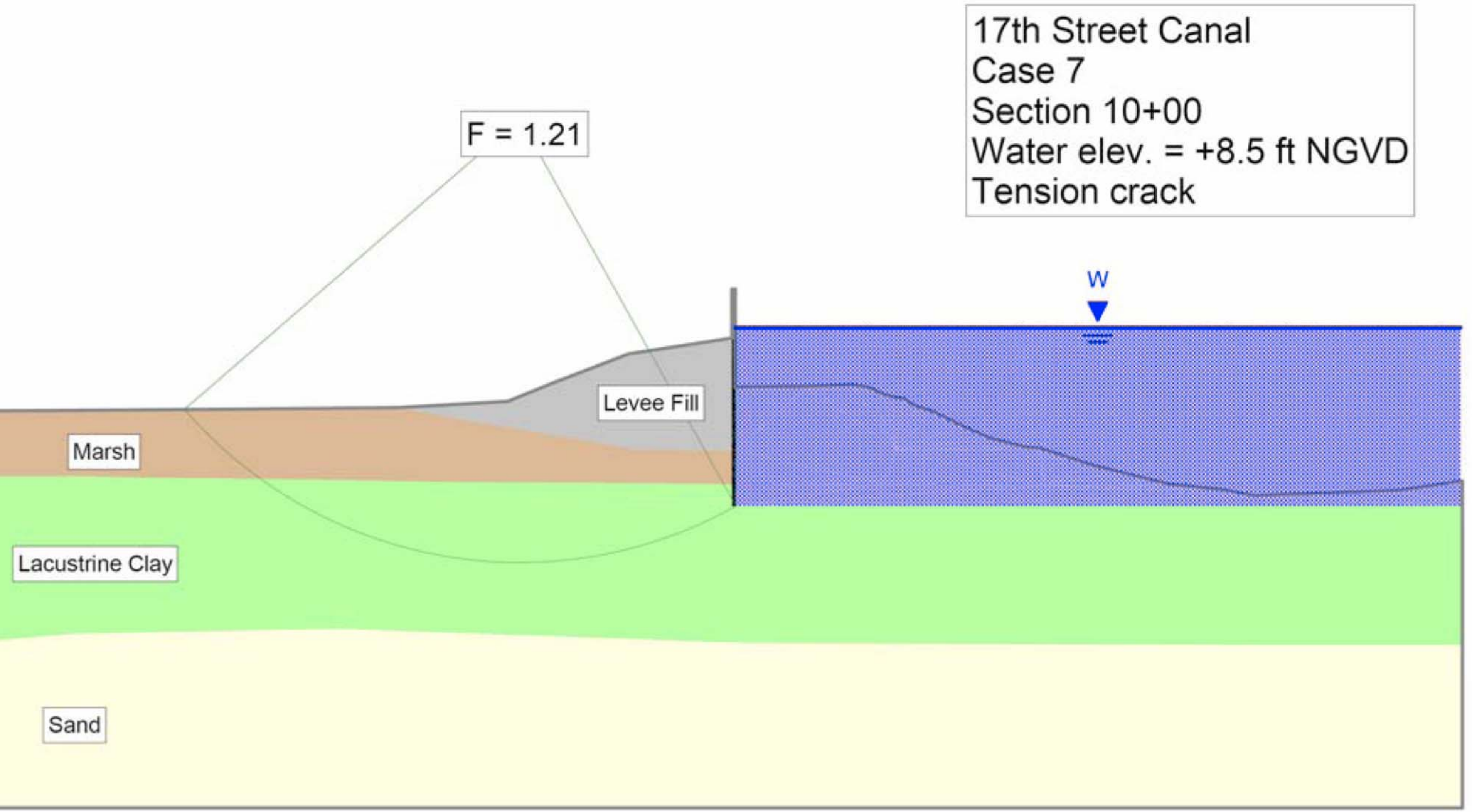
- Average s_u in breach = 260 psf
- Average s_u south of breach = 20% higher
- Average s_u north of breach = 30% higher

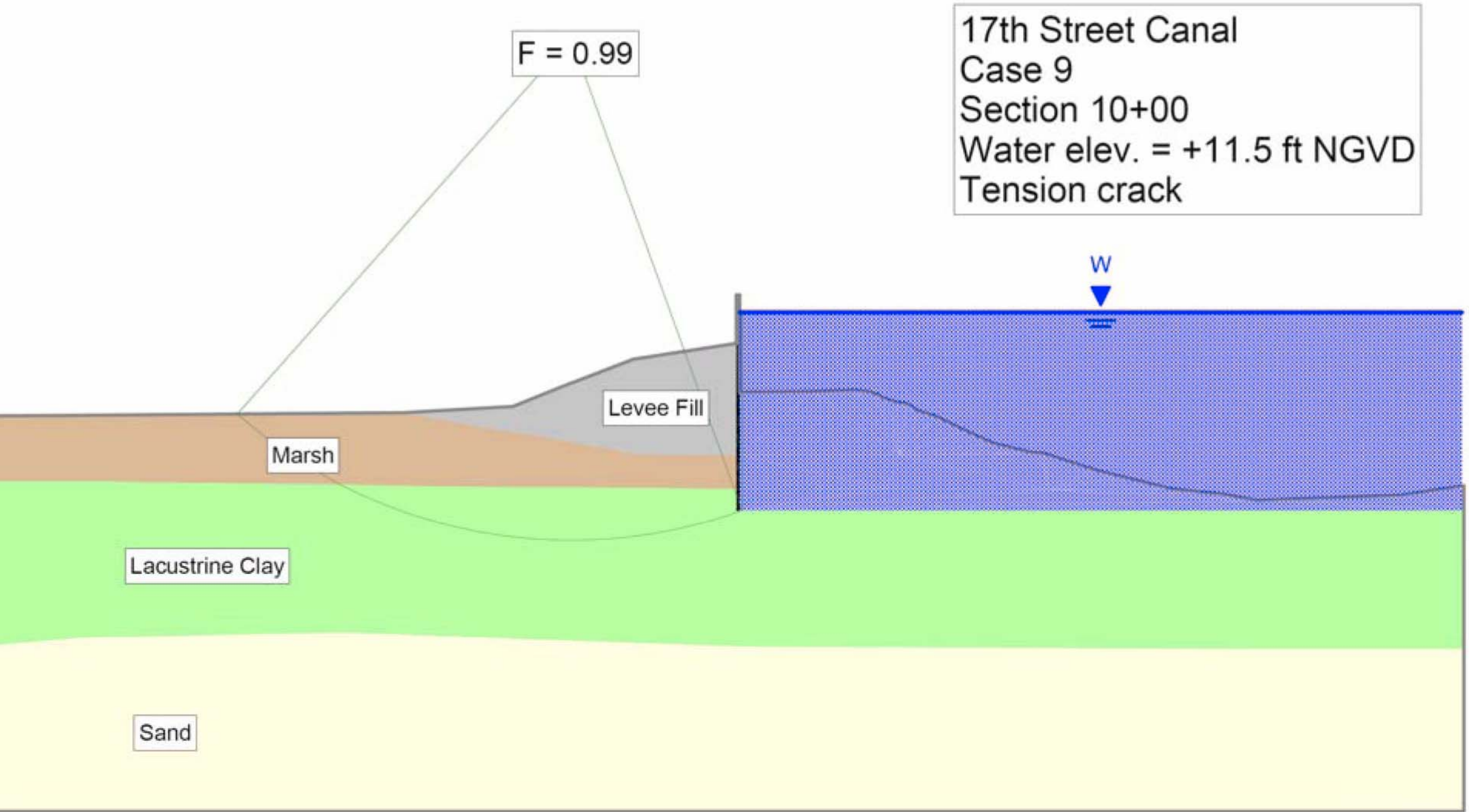
Station 10+00





F = 1.57
17th Street Canal
Case 6
Section 10+00
Water elev. = +8.5 ft NGVD
No tension crack
W
Levee Fill
Marsh
Lacustrine Clay
Sand


17th Street Canal
Case 7
Section 10+00
Water elev. = +8.5 ft NGVD
Tension crack
F = 1.21
W
Levee Fill
Marsh
Lacustrine Clay
Sand



F = 0.99
17th Street Canal
Case 9
Section 10+00
Water elev. = +11.5 ft NGVD
Tension crack
W
Levee Fill
Marsh
Lacustrine Clay
Sand

Water levels (NGVD)

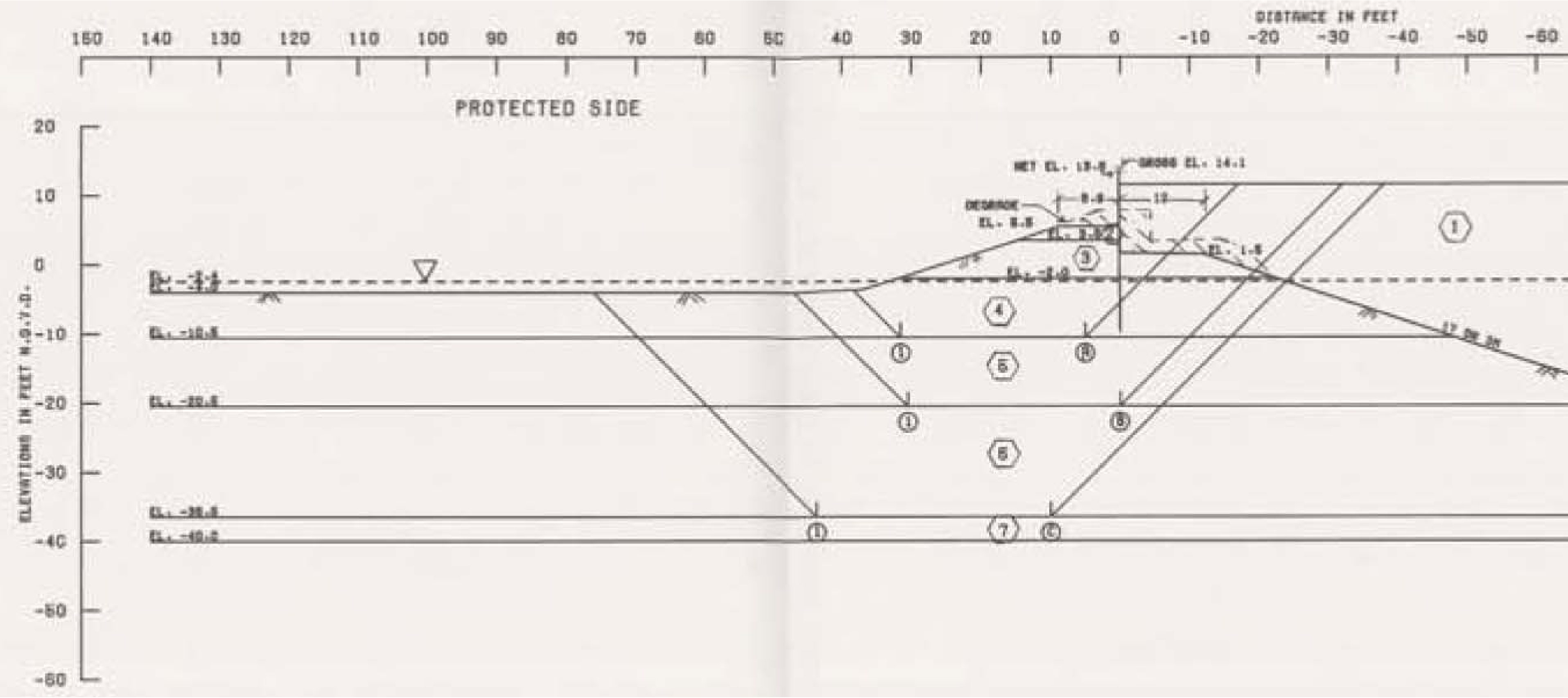
- W. L. = 11.3 ft, with crack, F = 1.00
- W. L. was 8.3 ft to 9.3 ft, plus wave effects, at time of failure
- Wave effects may be + 1.0 ft
- W. L. for F = 1.0 is one to two feet higher than estimated effective water level at time of failure

Design cross section for breach area

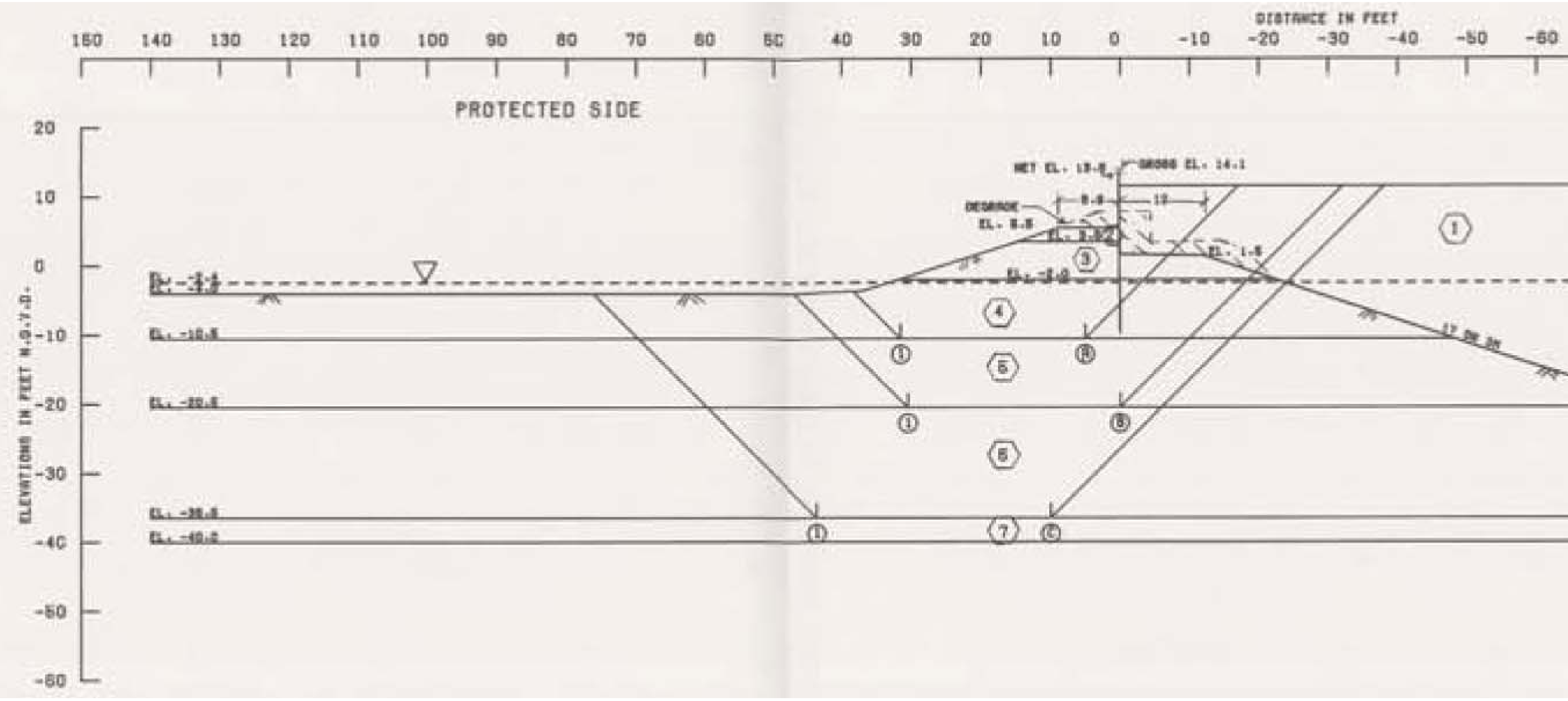
W. L. = 11.5 NGVD

No crack

Method of planes F = 1.30

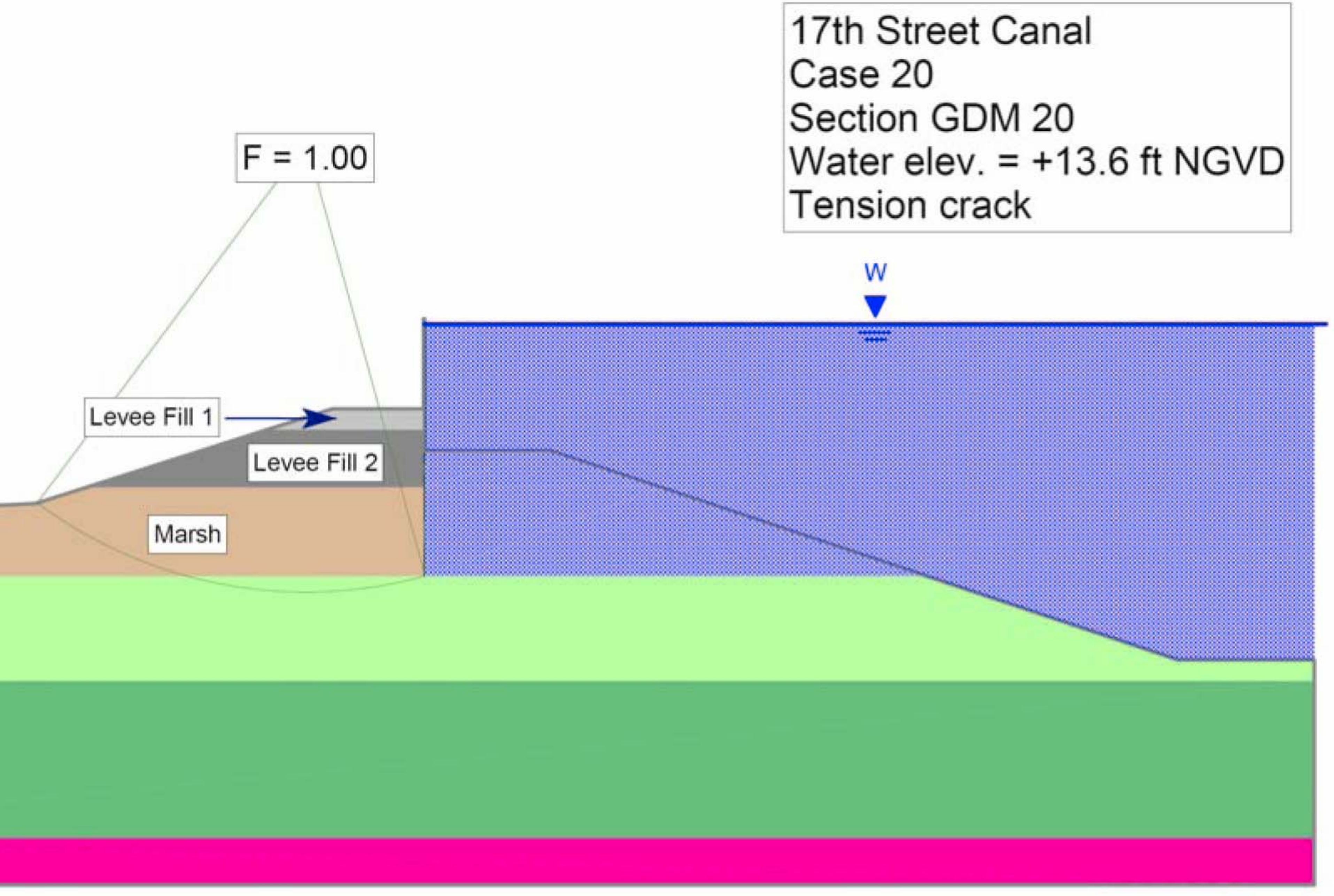


Design cross section for breach area
W. L. = 11.5 NGVD
No crack
Spencer's method F = 1.45



- The Method of Planes is a slightly conservative force equilibrium method.

Design cross section and strength



Factors of safety for adjacent areas

- With clay strength increased by 20%, the factor of safety increased by 13% (from 0.99 to 1.13)
- With peat strength increased by 20%, the factor of safety increased by 5% (from 0.99 to 1.04)
- Clay strength 20% higher north of breach, 30% higher south of breach

Probabilities of failure

- Simplified method based on Taylor Series
- Varied only peat strength and clay strength
- Probability of failure related to F and COV of F

Probabilities of failure for COV_F = 30%

Area	WL	F_{MLV}	p_f
Breach	11.5 ft	0.99	57%
Adjacent	11.5 ft	1.15	37%
Breach	8.5 ft	1.21	31%
Adjacent	8.5 ft	1.45	13%

Summary

- The peat is not the weak link
- The peat is stronger than the clay beneath the peat
- The strength of the clay increases markedly with depth

Summary

- Strengths are lower beneath levee slope and beyond toe than beneath crest
- GDM 20 strengths were the same beneath the levee slope and beyond the toe as beneath the crest
- Strengths are about 20% higher to the south of the breach and 30% higher to the north

Summary

- Factors of safety decrease as water level increases
- Factors of safety are about 25% lower for the cracked condition than for uncracked condition
- Development of a crack on the canal side of the wall is an important factor in the mechanism of failure

Summary

- The Method of Planes is a conservative method of analysis – factors of safety calculated using this method are about 10% lower than factors of safety calculated using Spencer's method

Summary

- Water levels = 11.3 ft to 12.3 ft required for F = 1.00
- These water levels are higher than the eyewitness water level at time of failure
- Differences may be due to:
  - Wave effects
  - IPET shear strengths higher than actual
  - Circular slip surfaces give factors of safety that are higher by about 3%, and water levels for F = 1.0 that are about 1.2 ft higher than noncircular surfaces

Summary

- Factors of safety are about 15% higher for adjacent areas than for the breach area
- For water level = 11.5 ft, probabilities of failure are 57% for the breach area, and 31% for adjacent areas