



August 11, 2025

Project US-EI-5539.3867

Sandra Miller
Seattle Housing Authority
101 Elliott Avenue West, Suite 100, PO Box 79015
Seattle, Washington 98119

sent via email: Sandra.Miller@seattlehousing.org

Subject: Geotechnical Engineering Supplement No. 1 – Temporary Dewatering Settlement Evaluation
Jackson Park Village
14738 30th Avenue NE
Seattle, Washington

Dear Ms. Miller,

WSP USA Inc. (WSP) is submitting this supplemental letter to accompany our Geotechnical Engineering Report Rev. 1, dated August 4, 2025, to provide additional, specific geotechnical analysis of the potential impacts of temporary dewatering. A temporary dewatering plan has been designed to facilitate the construction of the stormwater detention vault, the Littlebrook Creek bypass culvert, and the basement parking below Building A. The recommendations presented herein, along with the attached figures, are intended to supplement our geotechnical engineering recommendations by addressing considerations related to temporary dewatering and potential settlement impacts on adjacent structures.

ANALYSIS OF ADJACENT STRUCTURES

Based on the temporary dewatering design prepared by Richard Martin Groundwater LLC (Richard Martin), dated August 6, 2025 (attached), the estimated groundwater drawdown will extend outside the boundaries of the project site. WSP has reviewed the dewatering layout provided in Attachment 1 and identified three key locations to assess potential impacts on adjacent structures. Through a request for information from SDCI, WSP determined the foundation types of the surrounding buildings, as summarized below and in Table 1.

- The first key location is an 8" Cast Iron Water Main owned by Seattle Public Utilities trending along the approximate centerline of 30th Ave NE. Based on the Boundary and Topographic Survey for the Seattle Housing Authority for Jackson Park House and Village dated 6/4/18, the pipe elevation is at 220.7 ft.
- The second key location is the Jackson Park Apartments located at 14378 30th Ave NE 98125 and owned by the Seattle Housing Authority. As-built plans dated 11/1/1971, provided by SHA show the building is supported on driven timber piles driven to a minimum capacity of 40 tons.
- The final key location is a 2-story apartment building located at 14331 32nd Ave NE, owned by 3030 Lake City LLC. Based on information from Chapman Warren with the City of Seattle who responded to our Request for information on 7/15/2025, the building appeared to be constructed on spread footings.



Table 1: Settlement Points Considered

Point	Latitude, Longitude	Structure Description	Foundation Type
Point 1	47.733139, -122.296538	8" Cast Iron Water Main	Soil supported pipe
Point 2	47.733459, -122.295931	5 Story Apartment Building	Timber Piles
Point 3	47.733051, -122.295150	2 Story Apartment Building	Spread Footings

Soil profiles at the evaluated locations were interpreted based on nearby geotechnical investigations and are presented in Attachments B and C. In general, the soil profiles consisted of granular fill soils, over an estimated 5-foot-thick layer of either peat or clay, over dense silty sand.

SETTLEMENT CALCULATIONS AND POTENTIAL IMPACTS

Temporary lowering the groundwater table by dewatering activities typically leads to an increase in effective stress within the soil. This occurs because, when the water level drops, the soil loses its buoyancy and instead bears its full saturated weight. For loose or soft soil this results in settlement. For settlement analysis, WSP assumed that dewatered Peat and Clay layers would undergo primary consolidation, as detailed in Attachment B. The calculated primary consolidation was added to the immediate settlement estimates of the granular soils which were calculated with the Hough method, as outlined in Attachment C.

Allowable settlement beneath the cast iron water main was determined in accordance with the Seattle Public Utilities "Settlement Monitoring Requirements for Cast Iron Water Mains." For adjacent buildings, an allowable settlement threshold of 1 inch was assumed as per typically accepted engineering standards. The results of these calculations are summarized in Table 2 below.

Table 2: Settlement

Points	Calculated Settlement	Allowable Settlement
Point 1	0.36" (beneath the pipe)	1.2"
Point 2	0.94"	1"
Point 3	0.71"	1"

Differential settlement was evaluated by analyzing opposing corners of each building. The results of this assessment are summarized in Table 3. Allowable differential settlement is assumed to be 0.5" as per typical engineering standards.

Table 3: Differential Settlement

Points	Calculated Differential Settlement	Allowable Differential Settlement
Points 2A and 2B	0.0"	0.5"
Points 3A and 3B	0.15"	0.5"

CONCLUSIONS AND RECOMMENDATIONS

According to the results of our settlement analyses, the settlement induced by temporary dewatering is estimated to be less than 1 inch for nearby structures. As stated previously, a 1-inch threshold is generally regarded as the point beyond which negative impacts may occur. Furthermore, the Richard Martin report recommends implementing drawdown mitigation measures to decrease anticipated groundwater drawdown, thereby further reducing expected settlement. A 24-hour pump test is also advised to refine the current groundwater model, which was developed using conservative assumptions. We concur with the recommendations within the



Richard Martin report, and, by incorporating these recommendations, there will be a minimal risk of detrimental impacts to the adjacent property and structures.

CLOSURE

If you have any questions or need additional information, please do not hesitate to call.

Sincerely,

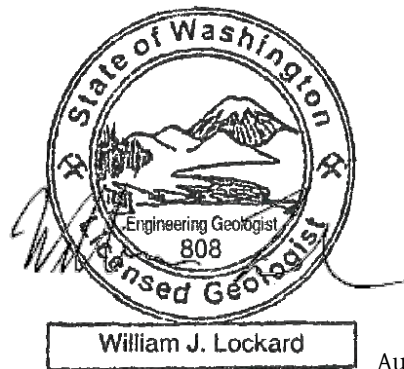
WSP USA Inc.

Kayla Campbell
Associate Consultant, Geotechnical Engineering



August 11, 2025

Todd D. Wentworth, P.E., L.G.
Principal Geotechnical Engineer



August 11, 2025

William J. Lockard, L.E.G.
Senior Geologist

KC/TDW/WJL:al

[https://wsponlinenam.sharepoint.com/sites/us-sha-wo005-jackson/shared documents/project files/e_deliverables/warning - this library for admins only/003/jackson park village supplemental 1.docx](https://wsponlinenam.sharepoint.com/sites/us-sha-wo005-jackson/shared%20documents/project%20files/e_deliverables/warning%20this%20library%20for%20admins%20only/003/jackson%20park%20village%20supplemental%201.docx)

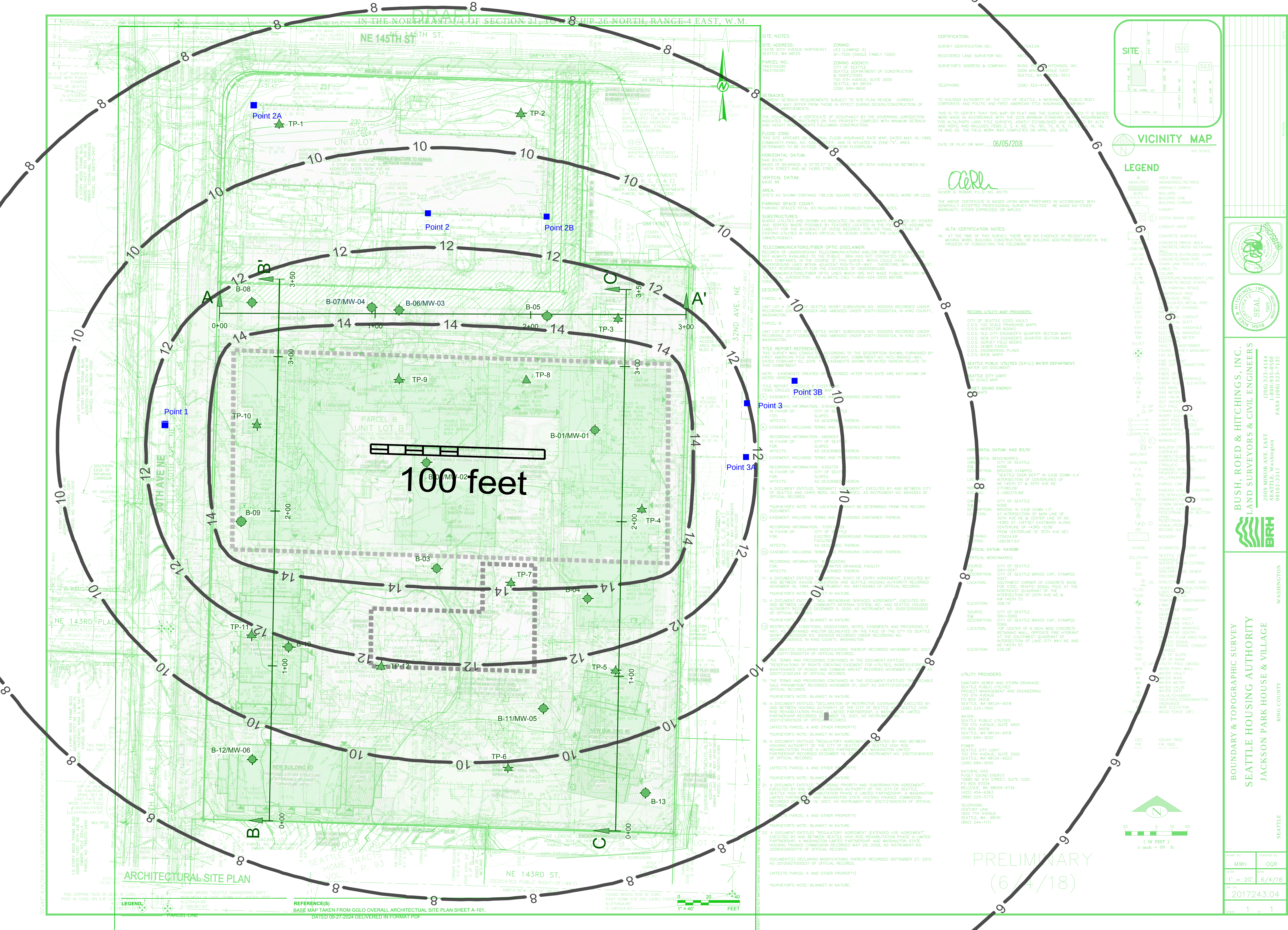
Attachments: Attachment A – Richard Martin Groundwater LLC Dewatering Plan
Attachment B – Settlement Calculations

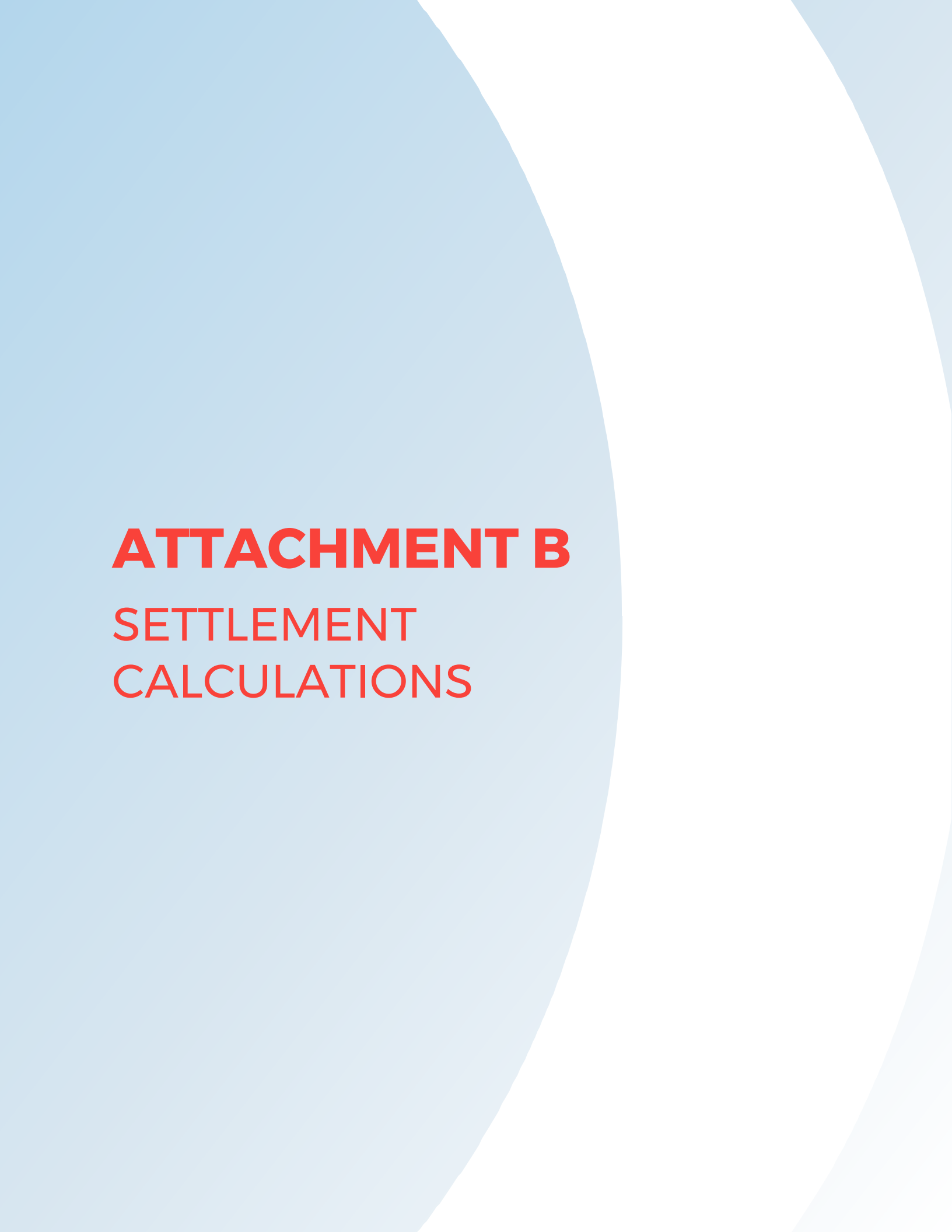
REFERENCES

- American Association of State Highway and Transportation Officials (AASHTO). *AASHTO LRFD Bridge Design Specifications, 9th Edition*. Washington, D.C.: AASHTO, 2020. ISBN: 978-1-56051-738-2. Pub Code: LRFDBDS-9.
- Holtz, R.D., Kovacs, W.D., & Sheahan, T.C. (2011). *An Introduction to Geotechnical Engineering* (2nd ed.). Upper Saddle River, NJ: Pearson Education. ISBN: 9780132496346
- Kimmerling, R.E. (2002). *Geotechnical Engineering Circular No. 6: Shallow Foundations*. FHWA-SA-02-054. U.S. Department of Transportation, Federal Highway Administration, Office of Bridge Technology, Washington, D.C. Prepared by PanGEO, Inc., Seattle, WA.
- National Council of Examiners for Engineering and Surveying (NCEES). *PE Mechanical Reference Handbook*, Version 1.8. NCEES, 2019.
- Springer, F. (1972). *Architectural and Structural Plans for 10-Unit Apartment House at 14331 32nd Ave NE, Seattle*. Job No. 3-1-3-72. Prepared for Mr. Perry Martin. Seattle Department of Buildings, Microfilmed at 24X.

ATTACHMENT A

**RICHARD MARTIN
GROUNDWATER LLC
DEWATERING PLAN**





ATTACHMENT B

SETTLEMENT CALCULATIONS

Project	Jackson Park	Created By:	KKC
Project No.	US-EI-5539.3867-US-SHA Jackson Park Village	Date:	6/2/2025
Subject	Hough Settlement Calculations due to dewatering	Reviewed by:	TDW
		Date:	8/1/2025

Method: Hough (1959)

Point 1			
Description:	Sanitary sewer line in NE 30th Sreet		
	Elevation	Depth below Ground Surface	
Top of Ground	231 ft	0 ft	
Pipe	220.7 ft	10.3 ft	
Current Water Level	225 ft	6 ft	
Drawdown Water Level	212.5 ft	18.5 ft	
	Bottom of Soil Layer Elevation	Bottom of Soil Depth	Unit Weight
Medium dense, well graded silty Sand	211 ft	20 ft	130
Medium stiff lean Clay	206 ft	25 ft	120
Medium dense Sand w/ some gravel	205 ft	26 ft	130
Very stiff sandy Silt	-	-	130

Soil Type Per Hough (1959) based off figure 10.6.2.4.2b-1:

- Well graded fine to medium silty sand, $0.009 \cdot N_{60}^2 + 1.3134 \cdot N_{60} + 28.052$
- Clean well graded fine to coarse sand, $0.0002 \cdot N_{60}^3 - 0.01 \cdot N_{60}^2 + 2.1694 \cdot N_{60} + 27.145$
- Well graded silty sand and gravel, $0.0335 \cdot N_{60}^2 + 0.8276 \cdot N_{60} + 42.86$
- Inorganic Silt, $0.0022 \cdot N_{60}^2 + 1.208 \cdot N_{60} + 17.206$

Input Parameters:

C _E	1.33
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AASHTO LRFD 9th Edition					Based off figure 10.6.2.4.2b-1					SPT Corrections					Based off figure 10.6.2.4.2b-1	Equ. 10.6.2.4.2b-2	Equ. 10.6.2.4.2b-2
Depth (ft)	Elevation	Sublayer Thickness (ft)	Mid-point Depth (ft)	Mid-point Elevation (ft)	Soil Type	N (blows per foot)	Unit Weight (pcf)	Initial σ_v' (ksf)	After Dewatering σ_v' (ksf)	N ₆₀ (blows per foot)	C _n	N ₁₆₀ (blows per foot)	$\Delta \sigma_v'$ (ksf)	H _c (ft)	C'	ΔH (ft)	ΔH (inch)
2.5	226.5	5	2.5	226.5	3	11	130	0.33	0.33	14.6	1.61	23.5	0.00	5	80.9	0.00	0.00
5	224	2.5	6.25	222.75	3	6	130	0.75	1.14	8.0	1.33	10.6	0.39	2.5	55.4	0.01	0.10
7.5	221.5	2.5	8.75	220.25	3	9	130	1.34	2.28	12.0	1.14	13.6	0.93	2.5	60.3	0.01	0.11
10	219	5	12.5	216.5	3	5	130	2.19	3.90	6.7	0.97	6.5	1.71	5	49.6	0.03	0.30
15	214	5	17.5	211.5	3	4	130	3.37	6.18	5.3	0.83	4.4	2.80	5	47.2	0.03	0.33
20	209	5	22.5	206.5	4	7	120	4.67	7.47	9.3	0.72	6.7	2.80	0	25.4	0.00	0.00
25	204	5	27.5	201.5	4	20	120	6.26	9.06	26.6	0.62	16.5	2.80	5	37.7	0.00	0.00
30	199	0	0	0	3	44	130	6.26	9.06	58.5	0.62	36.3	2.80	0	117.1	0.00	0.00

Experiences primary consolidation

From Ground Surface to 30 feet deep

Total Settlement = 0.85 inch
(FHWA GEC#6) 2/3 Correction = 0.57 inch
with primary consolidation settlement **0.71** inch

Beneath Pipe to 30 feet deep

Total Settlement = 0.33 inch
(FHWA GEC#6) 2/3 Correction = 0.22 inch
with primary consolidation settlement **0.36** inch

Project	Jackson Park	Created By:	KKC
Project No.	US-EI-5539.3867-US-SHA Jackson Park Village	Date:	6/2/2025
Subject	Hough Settlement Calculations due to dewatering	Reviewed by:	TDW
		Updated:	8/1/2025

Method: Hough (1959)

Point 2			
Description:	Jackson Village apartments. On timber piles.		
	Elevation	Depth below Ground Surface	
Top of Ground	227 ft	0 ft	
Current Water Level	225 ft	2 ft	
Drawdown Water Level	214.75 ft	12.25 ft	
	Bottom of Soil Layer Elevation	Bottom of Soil Depth	Unit Weight
Medium dense silty Sand (Fill)	223 ft	4 ft	130
Peat	217 ft	10 ft	80
Loose to medium dense silty Sand	212 ft	15 ft	125
Dense, gray silty, gravelly Sand	-	-	130

Input Parameters:

C _E	1.33
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Soil Type Per Hough (1959):

- 1 Well graded fine to medium silty sand, $0.009 \cdot N_{160}^2 + 1.3134 \cdot N_{160} + 28.052$
- 2 Clean well graded fine to coarse sand, $0.0002 \cdot N_{160}^3 - 0.01 \cdot N_{160}^2 + 2.1694 \cdot N_{160} + 27.145$
- 3 Well graded silty sand and gravel, $0.0335 \cdot N_{160}^2 + 0.8276 \cdot N_{160} + 42.86$
- 4 Inorganic Silt, $0.0022 \cdot N_{160}^2 + 1.208 \cdot N_{160} + 17.206$

AASHTO LRFD 9th Edition					Based off figure 10.6.2.4.2b-1					SPT Corrections					figure 10.6.2.4.2b-1	Equ. 10.6.2.4.2b-2	Equ. 10.6.2.4.2b-2
Depth (ft)	Elevation	Sublayer Thickness (ft)	Mid-point Depth (ft)	Mid-point Elevation (ft)	Soil Type	N (bpf)	γ (pcf)	Initial σ_v' (ksf)	After Dewatering σ_v' (ksf)	N ₆₀ (bpf)	C _n	N ₁₆₀ (bpf)	$\Delta \sigma_v'$ (ksf)	H _c (ft)	C _r	ΔH (ft)	ΔH (inch)
4	225	4.5	2.5	226.5	3	20	130	0.17	0.33	26.6	1.83	48.6	0.16	4.5	162.3	0.01	0.09
5	224	2.5	6.25	222.75	4	4	130	0.59	1.14	5.3	1.41	7.5	0.55	2.5	26.4	0.03	0.32
7.5	221.5	2.5	8.75	220.25	3	4	80	0.75	1.84	5.3	1.33	7.1	1.09	2.5	50.4	0.00	0.00
10	219	5	12.5	216.5	3	8	80	0.97	2.84	10.6	1.24	13.2	1.87	5	59.7	0.00	0.00
15	214	5	17.5	211.5	3	8	80	1.28	3.15	10.6	1.15	12.3	1.87	5	58.0	0.00	0.00
20	209	5	22.5	206.5	3	30	130	2.80	4.67	39.9	0.89	35.5	1.87	5	114.4	0.01	0.12
25	204	5	27.5	201.5	3	30	130	4.66	6.53	39.9	0.72	28.7	1.87	5	94.1	0.01	0.09
30	199	0	0	0	3	30	130	4.66	6.53	39.9	0.72	28.7	1.87	0	94.1	0.00	0.00

Experiences primary consolidation

Total Settlement = 0.63 inch
(FHWA GEC#6 2/3 Correction = 0.42 inch
with primary consolidation settlement 0.94 inch

Project	Jackson Park	Created By:	KKC
Project No.	US-EI-5539.3867-US-SHA Jackson Park Village	Date:	6/2/2025
Subject	Hough Settlement Calculations due to dewatering	Reviewed by:	TDW
		Updated:	8/1/2025

Method: Hough (1959)

Point 3			
Description:	2 Story Apartment Building to the east		
	Elevation	Depth below Ground Surface	
Top of Ground	227 ft	0 ft	
Current Water Level	225 ft	2 ft	
Drawdown Water Level	214 ft	13 ft	
	Bottom of Soil Layer Elevation	Bottom of Soil Depth	Unit Weight
Fill	224 ft	3 ft	130
Peat	219 ft	8 ft	80
Medium dense silty Sand	215 ft	12 ft	130
Very dense silty Sand w/gravel	-	-	135

Soil Type Per Hough (1959):

- 1 Well graded fine to medium silty sand, $0.009 \cdot N_{160}^2 + 1.3134 \cdot N_{160} + 28.052$
- 2 Clean well graded fine to coarse sand, $0.0002 \cdot N_{160}^3 - 0.01 \cdot N_{160}^2 + 2.1694 \cdot N_{160} + 27.145$
- 3 Well graded silty sand and gravel, $0.0335 \cdot N_{160}^2 + 0.8276 \cdot N_{160} + 42.86$
- 4 Inorganic Silt, $0.0022 \cdot N_{160}^2 + 1.208 \cdot N_{160} + 17.206$

Input Parameters:

C _E	1.33
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AASHTO LRFD 9th Edition					Based off figure 10.6.2.4.2b-1					SPT Corrections					figure 10.6.2.4.2b-1	Equ. 10.6.2.4.2b-2	Equ. 10.6.2.4.2b-2
Depth (ft)	Elevation	Sublayer Thickness (ft)	Mid-point Depth (ft)	Mid-point Elevation (ft)	Soil Type	N (bpf)	γ (pcf)	Initial σ _v ' (ksf)	After Dewatering σ _v ' (ksf)	N ₆₀ (bpf)	C _n	N ₁₆₀ (bpf)	Δσ _v ' (ksf)	H _c (ft)	C'	ΔH (ft)	ΔH (inch)
2.5	226.5	5	2.5	226.5	3	27	130	0.33	0.33	35.9	1.61	57.8	0.00	5	202.6	0.00	0.00
5	224	2.5	6.25	222.75	4	20	80	0.44	0.83	26.6	1.51	40.2	0.39	2.5	69.3	0.01	0.12
7.5	221.5	2.5	8.75	220.25	3	14	80	0.59	1.53	18.6	1.41	26.2	0.93	2.5	87.7	0.00	0.00
10	219	5	12.5	216.5	3	2	130	1.44	3.15	2.7	1.11	3.0	1.71	5	45.6	0.00	0.00
15	214	5	17.5	211.5	3	3	130	2.62	4.33	4.0	0.91	3.6	1.71	5	46.3	0.02	0.28
20	209	5	22.5	206.5	3	25	130	4.14	5.86	33.3	0.76	25.2	1.71	5	85.0	0.01	0.11
25	204	5	27.5	201.5	3	21	130	6.01	7.72	27.9	0.63	17.7	1.71	5	68.0	0.01	0.10
30	199	0	0	0	3	11	130	6.01	7.72	14.6	0.63	9.3	1.71	0	53.4	0.00	0.00

Experiences primary consolidation

Total Settlement = 0.61 inch
(FHWA GEC#6) 2/3 Correction = 0.40 inch
with primary consolidation settlement 0.71 inch

Project	Jackson Park	Created By:	KKC
Project No.	US-EI-5539.3867-US-SHA Jackson Park Village	Date:	6/2/2025
Subject	Hough Settlement Calculations due to dewatering	Reviewed by:	TDW
		Updated:	8/1/2025

Method: Hough (1959)

Point 2A			
Description:	Jackson Village apartments. On timber piles.		
	Elevation	Depth below Ground Surface	
Top of Ground	227 ft	0 ft	
Current Water Level	225 ft	2 ft	
Drawdown Water Level	216.5 ft	10.5 ft	
	Bottom of Soil Layer Elevation	Bottom of Soil Depth	Unit Weight
Medium dense silty Sand (Fill)	223 ft	4 ft	130
Peat	217 ft	10 ft	80
Loose to medium dense silty Sand	212 ft	15 ft	125
Dense, gray silty, gravelly Sand	-	-	130

Input Parameters:

C _E	1.33
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AASHTO LRFD 9th Edition					Based off figure 10.6.2.4.2b-1					SPT Corrections					figure 10.6.2.4.2b-1	Equ. 10.6.2.4.2b-2	Equ. 10.6.2.4.2b-2
Depth (ft)	Elevation	Sublayer Thickness (ft)	Mid-point Depth (ft)	Mid-point Elevation (ft)	Soil Type	N (bpf)	γ (pcf)	Initial σ _v ' (ksf)	After Dewatering σ _v ' (ksf)	N ₆₀ (bpf)	C _n	N ₁₆₀ (bpf)	Δσ _v ' (ksf)	H _c (ft)	C _r	ΔH (ft)	ΔH (inch)
4	225	4.5	2.5	226.5	3	20	130	0.17	0.33	26.6	1.83	48.6	0.16	4.5	162.3	0.01	0.09
5	224	2.5	6.25	222.75	4	4	130	0.59	1.14	5.3	1.41	7.5	0.55	2.5	26.4	0.03	0.32
7.5	221.5	2.5	8.75	220.25	3	4	80	0.75	1.84	5.3	1.33	7.1	1.09	2.5	50.4	0.00	0.00
10	219	5	12.5	216.5	3	8	80	0.97	2.84	10.6	1.24	13.2	1.87	5	59.7	0.00	0.00
15	214	5	17.5	211.5	3	8	80	1.28	3.15	10.6	1.15	12.3	1.87	5	58.0	0.00	0.00
20	209	5	22.5	206.5	3	30	130	2.80	4.67	39.9	0.89	35.5	1.87	5	114.4	0.01	0.12
25	204	5	27.5	201.5	3	30	130	4.66	6.53	39.9	0.72	28.7	1.87	5	94.1	0.01	0.09
30	199	0	0	0	3	30	130	4.66	6.53	39.9	0.72	28.7	1.87	0	94.1	0.00	0.00

Experiences primary consolidation

Total Settlement = 0.63 inch
(FHWA GEC#6 2/3 Correction = 0.42 inch
with primary consolidation settlement 0.94 inch

Project	Jackson Park	Created By:	KKC
Project No.	US-EI-5539.3867-US-SHA Jackson Park Village	Date:	6/2/2025
Subject	Hough Settlement Calculations due to dewatering	Reviewed by:	TDW
		Updated:	8/1/2025

Method: Hough (1959)

Point 2B			
Description:	Jackson Village apartments. On timber piles.		
	Elevation	Depth below Ground Surface	
Top of Ground	227 ft	0 ft	
Current Water Level	225 ft	2 ft	
Drawdown Water Level	214 ft	13 ft	
	Bottom of Soil Layer Elevation	Bottom of Soil Depth	Unit Weight
Medium dense silty Sand (Fill)	223 ft	4 ft	130
Peat	217 ft	10 ft	80
Loose to medium dense silty Sand	212 ft	15 ft	125
Dense, gray silty, gravelly Sand	-	-	130

Soil Type Per Hough (1959):

- 1 Well graded fine to medium silty sand, $0.009 \cdot N_{60}^2 + 1.3134 \cdot N_{60} + 28.052$
- 2 Clean well graded fine to coarse sand, $0.0002 \cdot N_{60}^3 - 0.01 \cdot N_{60}^2 + 2.1694 \cdot N_{60} + 27.145$
- 3 Well graded silty sand and gravel, $0.0335 \cdot N_{60}^2 + 0.8276 \cdot N_{60} + 42.86$
- 4 Inorganic Silt, $0.0022 \cdot N_{60}^2 + 1.208 \cdot N_{60} + 17.206$

Input Parameters:	
C_E	1.33

AASHTO LRFD 9th Edition					Based off figure 10.6.2.4.2b-1					SPT Corrections					figure 10.6.2.4.2b-1	Equ. 10.6.2.4.2b-2	Equ. 10.6.2.4.2b-2
Depth (ft)	Elevation	Sublayer Thickness (ft)	Mid-point Depth (ft)	Mid-point Elevation (ft)	Soil Type	N (bpf)	γ (pcf)	Initial σ'_v (ksf)	After Dewatering σ'_v (ksf)	N_{60} (bpf)	C_n	N_{160} (bpf)	$\Delta \sigma'_v$ (ksf)	H_c (ft)	C'	ΔH (ft)	ΔH (inch)
4	225	4.5	2.5	226.5	3	20	130	0.17	0.33	26.6	1.83	48.6	0.16	4.5	162.3	0.01	0.09
5	224	2.5	6.25	222.75	4	4	130	0.59	1.14	5.3	1.41	7.5	0.55	2.5	26.4	0.03	0.32
7.5	221.5	2.5	8.75	220.25	3	4	80	0.75	1.84	5.3	1.33	7.1	1.09	2.5	50.4	0.00	0.00
10	219	5	12.5	216.5	3	8	80	0.97	2.84	10.6	1.24	13.2	1.87	5	59.7	0.00	0.00
15	214	5	17.5	211.5	3	8	80	1.28	3.15	10.6	1.15	12.3	1.87	5	58.0	0.00	0.00
20	209	5	22.5	206.5	3	30	130	2.80	4.67	39.9	0.89	35.5	1.87	5	114.4	0.01	0.12
25	204	5	27.5	201.5	3	30	130	4.66	6.53	39.9	0.72	28.7	1.87	5	94.1	0.01	0.09
30	199	0	0	0	3	30	130	4.66	6.53	39.9	0.72	28.7	1.87	0	94.1	0.00	0.00

Experiences primary consolidation

Total Settlement = 0.63 inch
(FHWA GEC#6) 2/3 Correction = 0.42 inch
with primary consolidation settlement 0.94 inch
Building Differential Point 2A -2B 0.00

Project	Jackson Park	Created By:	KKC
Project No.	US-EI-5539.3867-US-SHA Jackson Park Village	Date:	6/2/2025
Subject	Hough Settlement Calculations due to dewatering	Reviewed by:	TDW
		Updated:	8/1/2025

Method: Hough (1959)

Point 3A			
Description:	2 Story Apartment Building to the east		
	Elevation	Depth below Ground Surface	
Top of Ground	227 ft	0 ft	
Current Water Level	225 ft	2 ft	
Drawdown Water Level	213 ft	14 ft	
	Bottom of Soil Layer Elevation	Bottom of Soil Depth	Unit Weight
Fill	224 ft	3 ft	130
Peat	219 ft	8 ft	80
Medium dense silty Sand	215 ft	12 ft	130
Very dense silty Sand w/gravel	-	-	135

Soil Type Per Hough (1959):

- 1
- Well graded fine to medium silty sand, $0.009 \cdot N_{160}^2 + 1.3134 \cdot N_{160} + 28.052$
- 2
- Clean well graded fine to coarse sand, $0.0002 \cdot N_{160}^3 - 0.01 \cdot N_{160}^2 + 2.1694 \cdot N_{160} + 27.145$
- 3
- Well graded silty sand and gravel, $0.0335 \cdot N_{160}^2 + 0.8276 \cdot N_{160} + 42.86$
- 4
- Inorganic Silt, $0.0022 \cdot N_{160}^2 + 1.208 \cdot N_{160} + 17.206$

Input Parameters:

C _E	1.33
----------------	------

AASHTO LRFD 9th Edition					Based off figure 10.6.2.4.2b-1					SPT Corrections					figure 10.6.2.4.2b-1	Equ. 10.6.2.4.2b-2	Equ. 10.6.2.4.2b-2
Depth (ft)	Elevation	Sublayer Thickness (ft)	Mid-point Depth (ft)	Mid-point Elevation (ft)	Soil Type	N (bpf)	γ (pcf)	Initial σ _v ' (ksf)	After Dewatering σ _v ' (ksf)	N ₆₀ (bpf)	C _n	N ₁₆₀ (bpf)	Δσ _v ' (ksf)	H _c (ft)	C*	ΔH (ft)	ΔH (inch)
2.5	226.5	5	2.5	226.5	3	27	130	0.33	0.33	35.9	1.61	57.8	0.00	5	202.6	0.00	0.00
5	224	2.5	6.25	222.75	4	20	80	0.44	0.83	26.6	1.51	40.2	0.39	2.5	69.3	0.01	0.12
7.5	221.5	2.5	8.75	220.25	3	14	80	0.59	1.53	18.6	1.41	26.2	0.93	2.5	87.7	0.00	0.00
10	219	5	12.5	216.5	3	2	130	1.44	3.15	2.7	1.11	3.0	1.71	5	45.6	0.00	0.00
15	214	5	17.5	211.5	3	3	130	2.62	5.43	4.0	0.91	3.6	2.80	5	46.3	0.03	0.41
20	209	5	22.5	206.5	3	25	130	4.14	6.95	33.3	0.76	25.2	2.80	5	85.0	0.01	0.16
25	204	5	27.5	201.5	3	21	130	6.01	8.81	27.9	0.63	17.7	2.80	5	68.0	0.01	0.15
30	199	0	0	0	3	11	130	6.01	8.81	14.6	0.63	9.3	2.80	0	53.4	0.00	0.00

Total Settlement =

0.83 inch

(FHWA GEC#6) 2/3 Correction =

0.56 inch

with primary consolidation settlement

0.87 inch

Experiences primary consolidation

Project	Jackson Park	Created By:	KKC
Project No.	US-EI-5539.3867-US-SHA Jackson Park Village	Date:	6/2/2025
Subject	Hough Settlement Calculations due to dewatering	Reviewed by:	TDW
		Updated:	8/1/2025

Method: Hough (1959)

Point 3B			
Description:	2 Story Apartment Building to the east		
	Elevation	Depth below Ground Surface	
Top of Ground	227 ft	0 ft	
Current Water Level	225 ft	2 ft	
Drawdown Water Level	214 ft	13 ft	
	Bottom of Soil Layer Elevation	Bottom of Soil Depth	Unit Weight
Fill	224 ft	3 ft	130
Peat	219 ft	8 ft	80
Medium dense silty Sand	215 ft	12 ft	130
Very dense silty Sand w/gravel	-	-	135

Input Parameters:

C _E	1.33
----------------	------

AASHTO LRFD 9th Edition					Based off figure 10.6.2.4.2b-1					SPT Corrections					figure 10.6.2.4.2b-1	Equ. 10.6.2.4.2b-2	Equ. 10.6.2.4.2b-2
Depth (ft)	Elevation	Sublayer Thickness (ft)	Mid-point Depth (ft)	Mid-point Elevation (ft)	Soil Type	N (bpf)	γ (pcf)	Initial σ _v ' (ksf)	After Dewatering σ _v ' (ksf)	N ₆₀ (bpf)	C _n	N ₁₆₀ (bpf)	Δσ _v ' (ksf)	H _c (ft)	C'	ΔH (ft)	ΔH (inch)
2.5	226.5	5	2.5	226.5	3	27	130	0.33	0.33	35.9	1.61	57.8	0.00	5	202.6	0.00	0.00
5	224	2.5	6.25	222.75	4	20	80	0.44	0.83	26.6	1.51	40.2	0.39	2.5	69.3	0.01	0.12
7.5	221.5	2.5	8.75	220.25	3	14	80	0.59	1.53	18.6	1.41	26.2	0.93	2.5	87.7	0.00	0.00
10	219	5	12.5	216.5	3	2	130	1.44	3.15	2.7	1.11	3.0	1.71	5	45.6	0.00	0.00
15	214	5	17.5	211.5	3	3	130	2.62	4.33	4.0	0.91	3.6	1.71	5	46.3	0.02	0.28
20	209	5	22.5	206.5	3	25	130	4.14	5.86	33.3	0.76	25.2	1.71	5	85.0	0.01	0.11
25	204	5	27.5	201.5	3	21	130	6.01	7.72	27.9	0.63	17.7	1.71	5	68.0	0.01	0.10
30	199	0	0	0	3	11	130	6.01	7.72	14.6	0.63	9.3	1.71	0	53.4	0.00	0.00

Experiences primary consolidation

Total Settlement = 0.61 inch
(FHWA GEC#6) 2/3 Correction = 0.40 inch
with primary consolidation settlement 0.71 inch
Building Differential Point 3A - 3B -0.152773205 inch

References:

10.6.2.4.2b—Hough Method

Estimation of spread footing settlement on cohesionless soils by the empirical Hough method shall be determined using Eqs. 10.6.2.4.2b-1 and 10.6.2.4.2b-2. SPT blow counts shall be corrected as specified in Article 10.4.6.2.4 for depth, i.e. overburden stress, and SPT hammer efficiency, before correlating the SPT blow counts to the bearing capacity index, C' .

$$S_f = \sum_{i=1}^n \Delta M_i \quad (10.6.2.4.2b-1)$$

in which:

$$\Delta M_i = M_i \frac{1}{C'} \log \left(\frac{q' + \Delta q}{q'} \right) \quad (10.6.2.4.2b-2)$$

where:

- n = number of soil layers within zone of stress influence of the footing
- ΔM = elastic settlement of layer i (in)
- M = initial height of layer i (ft)
- C' = bearing capacity index from Figure 10.6.2.4.2b-1 (kips)
- q' = initial vertical effective stress at the midpoint of layer i (ksf)
- Δq = increase in vertical stress at the midpoint of layer i (ksf)

10.6.2.4.2c

The Hough method was developed for normally consolidated cohesionless soils.

The Hough method has several advantages over other methods used to estimate settlement in cohesionless and deposits, including express consideration of soil layering and the zone of stress influence beneath a footing of finite size.

The subsurface soil profile should be subdivided into layers based on stratigraphy to a depth of about three times the footing width. The maximum layer thickness should be about 10.0 ft.

While Hough (1919) did not specifically state that the SPT N -values should be corrected for hammer energy in addition to overburden pressure, due to the vintage of the original work, hammers that typically have an efficiency of approximately 60 percent were in general used to develop the empirical correlations contained in the method. If using SPT hammers with efficiencies that differ significantly from this 60 percent value, the N -values should also be corrected for hammer energy, in effect requiring that N_{60} be used (Santani and Nematzai, 2006).

Studies conducted by Gifford et al. (1937) and Santani and Nematzai (2006) indicate that Hough's procedure may be more conservative, but with less prediction variability, than the Schmertmann Method. However, this difference is mostly taken into account through the load factor, γ_{10} , since it has been calibrated using reliability theory (Kolucki et al. 2015) (Santani and Kolucki, 2018) (Santani and Allen (2018).

SECTION 10: FOUNDATIONS

10-49

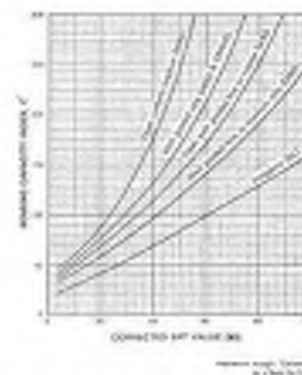


Figure 10.6.2.4.2b-1—Bearing Capacity Index versus Corrected SPT (Hough, 1919, as modified in Santani and Nematzai, 2006)

The Hough method is applicable to cohesionless soil deposits. The "Inorganic SPT" curve should generally not be applied to soils that exhibit plasticity because N -values on such soils are unreliable (Santani and Nematzai, 2006). The settlement characteristics of cohesive soils that exhibit plasticity should be investigated using undisturbed samples and laboratory consolidation tests as prescribed in Article 10.6.2.4.3.

- The Hough method was found to over-predict settlement by an average factor of about 1.8 for the five footings (the standard deviation, $s_{\ln}$, was 0.53). In no case, however, did the Hough method under-predict the observed settlement.

Project	Jackson Park	Created By:	KKC
Project No.	US-EI-5539-3867-US-SHA Jackson Park Village	Date:	6/2/2025
Subject	Settlement Calculations due to dewatering	Reviewed by:	TOW
		Updated:	8/1/2025

Settlement due to Dewatering Point 1

Point 1				Uses FHWA NHI-06-088	
Description:	Sanitary sewer line in NE 30th Street				
	Elevation	Depth below Ground Surface			
Top of Ground	231 ft	0 ft			
Pipe	220.7 ft	10.3 ft			
Previous Water Level	225 ft	6 ft			
Drawdown Water Level	212.5 ft	18.5 ft			
	Bottom of Soil Layer Elevation	Bottom of Soil Depth	Unit Weight	Estimated e_u	
Medium dense, well graded silty SAND	211 ft	20 ft	130	0.6	
Medium stiff lean CLAY	206 ft	25 ft	120	1.64	
Medium dense SAND w/ some gravel	205 ft	26 ft	130	0.4	
Very stiff sandy SILT	-	-	130	0.4	

										Per Layer		Sum		Sum beneath pipe (in)
Elevations	USCS	Unit Weight	Estimated e_u ¹	Cc	Cr	H _u (feet)	p _o ²	p _k		S _c (feet)	S _c (in)	S _c (feet)	S _c (in)	
231 SM	130	0.6	0.099			0	0	0		0.00	0.00	0.00	0.00	
230 SM	130	0.6	0.099			1	130	130		0.00	0.00	0.00	0.00	
229 SM	110	0.6	0.099			1	240	240		0.00	0.00	0.00	0.00	
228 SM	110	0.6	0.099			1	350	350		0.00	0.00	0.00	0.00	
227 SM	110	0.6	0.099			1	460	460		0.00	0.00	0.00	0.00	
226 SM	125	0.6	0.099			1	585	585		0.00	0.00	0.00	0.00	
225 SM	125	0.6	0.099			1	710	710		0.00	0.00	0.00	0.00	
224 SM	125	0.6	0.099			1	772.6	835		0.00	0.00	0.00	0.00	
223 SM	125	0.6	0.099			1	835.2	960		0.00	0.00	0.00	0.00	
222 SM	125	0.6	0.099			1	897.8	1085		0.00	0.00	0.00	0.00	
221 SM	125	0.6	0.099			1	960.4	1210		0.00	0.00	0.00	0.00	
220 SM	125	0.6	0.099			1	1023	1335		0.00	0.00	0.00	0.00	0.00
219 SM	125	0.6	0.099			1	1085.6	1460		0.00	0.00	0.00	0.00	0.00
218 SM	125	0.6	0.099			1	1148.2	1585		0.00	0.00	0.00	0.00	0.00
217 SM	125	0.6	0.099			1	1210.8	1710		0.00	0.00	0.00	0.00	0.00
216 SM	125	0.6	0.099			1	1273.4	1835		0.00	0.00	0.00	0.00	0.00
215 SM	125	0.6	0.099			1	1336	1960		0.00	0.00	0.00	0.00	0.00
214 SM	125	0.6	0.099			1	1398.6	2085		0.00	0.00	0.00	0.00	0.00
213 SM	125	0.6	0.099			1	1461.2	2210		0.00	0.00	0.00	0.00	0.00
212 SM	125	0.6	0.099			1	1523.8	2335.2		0.00	0.00	0.00	0.00	0.00
211 SM	125	0.6	0.099			1	1586.4	2460.4		0.00	0.00	0.00	0.00	0.00
210 CL	125	1.64	0.411	0.0411		1	1649	2585.6	0.03	0.00	0.03	0.00	0.03	0.03
209 CL	125	1.64	0.411	0.0411		1	1711.6	2710.8	0.03	0.00	0.03	0.00	0.03	0.06
208 CL	125	1.64	0.411	0.0411		1	1774.2	2835.8	0.03	0.01	0.03	0.01	0.09	0.09
207 CL	125	1.64	0.411	0.0411		1	1836.8	2960.8	0.03	0.01	0.03	0.01	0.12	0.12
206 CL	125	1.64	0.411	0.0411		1	1899.4	3085.8	0.03	0.01	0.03	0.01	0.14	0.14
205 SP	125	0.4	0.039			1	1962	3210.8	0.01	0.00	0.01	0.01	0.14	0.14

- 1) Estimated using medium stiff density and relative density of 40% and table 5-4.
- 2) Preconsolidation pressures and groundwater based off of dewatering during pipe installation.

Holts and Kovacs

When C_c is assumed to be 5% to 10% of C_r . Typical values of C_c range from 0.01 to 0.03 (Lemnards, 1976). The lower values are for clays of lower plasticity and low OCR. Values of C_c outside the range of 0.01 to 0.03 should be considered questionable.

Table 5-4
Typical particle size, uniformity coefficient, void ratio and unit weight (from Kulhavy and Herson, 1980)

Soil Type	Approximate Particle Size, mm			Uniformity Coefficient	Void Ratio		Normalized Unit Weight			
							Dry		Saturated	
	D_{10}	D_{30}	D_{60}		min	max	min	max	min	max
Uniform granular soil										
Equal spheres (theoretical)	0.075	0.25	0.85	2.0	0.62	0.71	1.40	1.50	1.40	1.50
Standard Ottawa sand	0.075	0.25	0.85	2.0	0.60	0.70	1.40	1.50	1.40	1.50
Clean, well-sorted sand	0.075	0.25	0.85	2.0	0.60	0.70	1.40	1.50	1.40	1.50
Uniform, well-sorted, silty	0.075	0.25	0.85	2.0	0.60	0.70	1.40	1.50	1.40	1.50
Well-graded granular soil										
Clean sand	0.075	0.25	0.85	5.0	0.60	0.70	1.40	1.50	1.40	1.50
Clean, fine to coarse sand	0.075	0.25	0.85	5.0	0.60	0.70	1.40	1.50	1.40	1.50
Medium sand	0.075	0.25	0.85	5.0	0.60	0.70	1.40	1.50	1.40	1.50
Silty sand and gravel	0.075	0.25	0.85	5.0	0.60	0.70	1.40	1.50	1.40	1.50
Silty to sandy clay	0.075	0.25	0.85	10 to 20	0.60	0.70	0.90	1.00	0.90	1.00
Gap-graded silty clay with gravel or larger	0.075	0.25	0.85	10 to 20	0.60	0.70	0.90	1.00	0.90	1.00
Well-graded gravel, sand, silt and clay	0.075	0.25	0.85	20 to 100	0.60	0.70	0.90	1.00	0.90	1.00
Clay (75 to 100% < 0.075 mm)	0.075	0.25	0.85	2.0	0.60	0.70	1.40	1.50	1.40	1.50
Consolidated clay (more than 30% < 0.075 mm)	0.075	0.25	0.85	2.0	0.60	0.70	1.40	1.50	1.40	1.50
Organic soil	0.075	0.25	0.85	2.0	0.60	0.70	1.40	1.50	1.40	1.50
Organic clay (50 to 100% < 0.075 mm)	0.075	0.25	0.85	2.0	0.60	0.70	1.40	1.50	1.40	1.50

Note: D_{10} = 60 < 0.075 mm (No. 200 sieve); D_{30} = 25 < 0.075 mm (No. 60 sieve); D_{60} = 10 < 0.075 mm (No. 20 sieve).

Table 5-5
Correlations for C_c (modified after Holtz and Kovacs, 1981)

Correlation	Soil
$C_c = 0.14(e_u - 0.002)^{0.5}$	All Clays
$C_c = 0.002(140 - LL)^{0.5}$	Lean silty clay
$C_c = 0.002(140 - LL)^{0.5}$	Clay of medium to slight overconsolidation
$C_c = 0.002(140 - LL)^{0.5}$	Organic soils, Peat
$C_c = 0.002(140 - LL)^{0.5}$	Low plasticity clays

¹ e_u = void ratio; ² LL = Plasticity Index; ³ LL = Liquid Limit; ⁴ % = percentage
 * Calculated values of C_c should be used where measured values are not available (see Table 3-12 in Chapter 3). ⁵ e_u = natural void ratio.

FHWA Circular #6

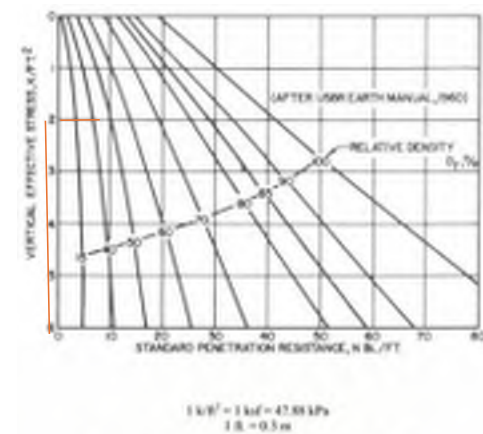


Figure 4-1: Correlation Between Relative Density and SPT Resistance (NAVFAC, 1986a, after Gibbs & Holtz)

Project	Jackson Park	Created By:	KKC
Project No.	US-EI-5539.3867-US-SHA Jackson Park Village	Date:	6/2/2025
Subject	Settlement Calculations due to dewatering	Reviewed by:	TDW
		Updated:	8/1/2025

Settlement due to Dewatering Point 2

Point 2				Uses FHWA NHI-06-088	
Description:	Jackson Village apartments. On timber piles.				
	Elevation	Depth below Ground Surface			
Top of Ground	227 ft	0 ft			
Current Water Level	225 ft	2 ft			
Drawdown Water Level	214.75 ft	12.25 ft			
	Bottom of Soil Layer Elevation	Bottom of Soil Depth		Unit Weight	Estimated e_s
Medium dense silty SAND (FILL)	223 ft	4 ft		130	0.7
Peat	217 ft	10 ft		80	1
Loose to MD silty SAND	212 ft	15 ft		125	0.7
Dense, gray silty, gravelly SAND	-	-		130	0.4

Elevations	USCS	Unit Weight	Estimated e_s^1	Wn^2	C_c	H_u (feet)	p_0	p_r	Per Layer		Sum	
									S_u (feet)	S_u (in)	S_u (feet)	S_u (in)
227 SM		130	0.7	1	0.129	0	0	0	0.00	0.00	0.00	0.00
226 SM		130	0.7	1	0.129	1	130	130	0.00	0.00	0.00	0.00
225 SM		130	0.7	1	0.129	1	260	260	0.00	0.00	0.00	0.00
224 SM		130	0.7	1	0.129	1	327.6	390	0.00	0.00	0.00	0.00
223 SM		130	0.7	1	0.129	1	395.2	520	0.00	0.00	0.00	0.00
222 PEAT		80	2.755	1	0.115	1	412.8	600	0.00	0.06	0.00	0.06
221 PEAT		80	2.755	1	0.115	1	430.4	680	0.01	0.07	0.01	0.13
220 PEAT		80	2.755	1	0.115	1	448	760	0.01	0.08	0.02	0.22
219 PEAT		80	2.755	1	0.115	1	465.6	840	0.01	0.09	0.03	0.31
218 PEAT		80	2.755	1	0.115	1	483.2	920	0.01	0.10	0.03	0.41
217 PEAT		80	2.755	1	0.115	1	500.8	1000	0.01	0.11	0.04	0.52
216 SM		125	0.4	1	0.039	1	563.4	1125	0.00	0.00	0.04	0.52
215 SM		125	0.4	1	0.039	1	626	1250	0.00	0.00	0.04	0.52
214 SM		125	0.4	1	0.039	1	688.6	1312.6	0.00	0.00	0.04	0.52
213 SM		125	0.4	1	0.039	1	751.2	1375.2	0.00	0.00	0.04	0.52
212 SM		125	0.4	1	0.039	1	813.8	1437.8	0.00	0.00	0.04	0.52
211 SM		125	0.4	1	0.039	1	876.4	1500.4	0.00	0.00	0.04	0.52
210 SM		125	0.4	1	0.039	1	939	1563	0.00	0.00	0.04	0.52
209 SM		125	0.4	1	0.039	1	1001.6	1625.6	0.00	0.00	0.04	0.52
208 SM		125	0.4	1	0.039	1	1064.2	1688.2	0.00	0.00	0.04	0.52
207 SM		125	0.4	1	0.039	1	1126.8	1750.8	0.00	0.00	0.04	0.52
206 SM		125	0.4	1	0.039	1	1189.4	1813.4	0.00	0.00	0.04	0.52
205 SM		125	0.4	1	0.039	1	1252	1876	0.00	0.00	0.04	0.52
204 SM		125	0.4	1	0.039	1	1314.6	1938.6	0.00	0.00	0.04	0.52
203 SM		125	0.4	1	0.039	1	1377.2	2001.2	0.00	0.00	0.04	0.52
202 SM		125	0.4	1	0.039	1	1439.8	2063.8	0.00	0.00	0.04	0.52
201 SM		125	0.4	1	0.039	1	1502.4	2126.4	0.00	0.00	0.04	0.52
200 SM		125	0.4	1	0.039	1	1565	2189	0.00	0.00	0.04	0.52
199 SM		125	0.4	1	0.039	1	1627.6	2251.6	0.00	0.00	0.04	0.52
198 SM		125	0.4	1	0.039	1	1690.2	2314.2	0.00	0.00	0.04	0.52
197 SM		125	0.4	1	0.039	1	1752.8	2376.8	0.00	0.00	0.04	0.52
196 SM		125	0.4	1	0.039	1	1815.4	2439.4	0.00	0.00	0.04	0.52

- 1) Estimated using medium stiff density and relative density of 40% and table 5-4.
2) Assumes material is saturated.

Table 5-4
Typical particle sizes, uniformity coefficients, void ratios and unit weights (from Kaftany and Mayas, 2009)

Soil Type	Approximate Particle Size, mm			Uniformity Coefficient	Void Ratio		Normalised Unit Weight			
							Dry		Saturated	
	D_{10}	u_c	w	w/D_{10}	w_c	w_s	$T_{50}/\%$	$T_{90}/\%$	$T_{50}/\%$	$T_{90}/\%$
Uniform granitic soil										
Equal spheres (reference)	0.075	0.425	0.85	1.0	0.67	0.71	-	-	-	-
Standard Ottawa sand	0.30	0.59	0.85	1.1	0.60	0.70	1.47	3.75	1.49	2.30
Clay, uniform sand	-	-	-	1.2 to 2.0	1.90	0.40	1.83	3.89	1.35	2.38
Uniform, nonplastic silt	0.075	0.060	0.051	1.2 to 2.0	1.10	0.40	1.28	3.89	1.80	2.38
Well-graded granitic soil										
Silty sand	1.0	0.060	0.07	5 to 10	0.90	0.90	1.89	2.04	1.43	2.29
Clayey, fine to coarse sand	2.0	0.07	0.09	4 to 8	0.93	0.70	1.88	2.21	1.88	2.23
Microscopic sand	-	-	-	-	1.20	0.40	1.27	3.92	1.28	2.23
Silty sand and gravel	100	0.060	0.07	15 to 100	0.83	0.64	1.69	2.84	1.40	2.40
Silty or sandy clay	2.0	0.060	0.083	10 to 30	1.00	0.73	0.96	2.18	1.00	2.80
Gap-graded silty clay with gravel or larger	250	0.060	-	-	1.00	0.70	1.37	2.24	1.84	2.42
Well-graded gravel, sand, silt, and clay	750	0.060	0.061	15 to 1,000	0.70	0.14	1.40	2.17	2.00	2.30
Clay (10 to 50% < 0.002)	0.075	0.50	0.081	-	1.40	0.90	0.80	3.79	1.11	2.13
Colloidal clay (over 50% < 0.002)	0.075	1.00	-	-	12.00	0.60	0.21	2.70	1.14	2.47
Organic soils										
Organic clay (10 to 50% < 0.002)	-	-	-	-	1.00	0.73	0.64	1.79	1.00	2.80
Organic clay (50 to 100% < 0.002)	-	-	-	-	1.40	0.70	0.40	1.40	1.50	2.40

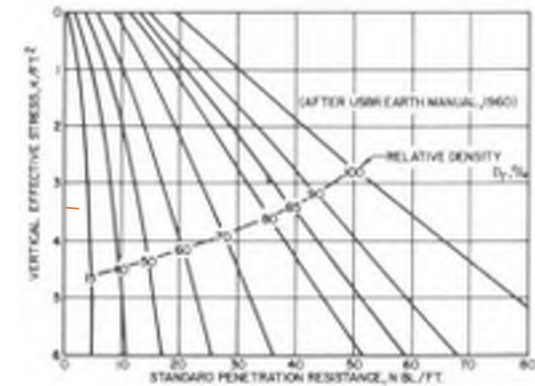
Note: $w_c = 62.4 \text{ pcf}$ (9.81 kN/m³); $w_s = 126 \text{ pcf}$ (19.6 kN/m³); $w = 126 \text{ pcf}$ (19.6 kN/m³).

Table 5-5
Correlations for C_u (modified after Holtz and Kovacs, 1982)

Correlation	Soil
$C_u = 0.154 e_s = 0.0017^{(1)}$	All Clays
$C_u = 0.5 G_u / (p_0 - 100)^{(2)}$	Inorganic, silty, clay
$C_u = 0.36 (w_s - 0.2)^{(3)}$	Clay of medium to slight sensitivity ($S_u < 4$, $LL < 100$) ⁽⁴⁾
$C_u = 0.009 (LL - 10)^{(5)}$	Organic soils, Peat
$C_u = 0.75 (p_s - 0.50)$	Low plasticity clays

⁽¹⁾ e_s = natural void ratio; ⁽²⁾ G_u = Plasticity Index; ⁽³⁾ LL = Liquid Limit; ⁽⁴⁾ S_u = sensitivity
⁽⁵⁾ Unchecked undrained shear strength/Recommended undrained shear strength (see Table 5-12 in Chapter 5). ⁽⁶⁾ w_s = natural water content

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$$1 \text{ k/ft}^2 = 1 \text{ ksf} = 47.88 \text{ kPa}$$

$$1 \text{ ft} = 0.3 \text{ m}$$

Figure 4-1: Correlation Between Relative Density and SPT Resistance (NAVFAC, 1986a, after Gibbs & Holtz)

Project	Jackson Park	Created By:	KKC
Project No.	US-EI-5539.3867-US-SHA Jackson Park Village	Date:	6/2/2025
Subject	Settlement Calculations due to dewatering	Reviewed by:	TDW
		Updated:	8/1/2025

Settlement due to Dewatering Point 3

Point 3				Uses FHWA NHI-06-088			
Description:	2 Story Apartment Building to the east						
	Elevation	Depth below Ground Surface					
Top of Ground	227 ft	0 ft					
Current Water Level	225 ft	2 ft					
Drawdown Water Level	214 ft	13 ft					
	Bottom of Soil Layer Elevation	Bottom of Soil Depth		Unit Weight	Estimated e_o		
Fill	224 ft	3 ft		130	0.4		
Peat	219 ft	8 ft		80	1		
MD silty SAND	215 ft	12 ft		130	0.4		
VD silty sand w/gravel	-	-		135			

Elevations	USCS	Unit Weight	Estimated e_o^1	Wn^2	C_c	H_o (feet)	p_o	p_r	Per Layer		Sum	
									S_v (feet)	S_v (in)	S_v (feet)	S_v (in)
227 SM		130	0.4	1	0.09085	0	0	0	0.00	0.00	0	0
226 SM		130	0.4	1	0.09085	1	130	130	0.00	0.00	0	0.00
225 SM		130	0.4	1	0.09085	1	260	260	0.00	0.00	0.00	0.00
224 SM		130	0.4	1	0.09085	1	327.6	390	0.00	0.00	0.00	0.00
223 PEAT		80	2.755	1	0.09085	1	345.2	470	0.00	0.04	0.00	0.04
222 PEAT		80	2.755	1	0.09085	1	362.8	550	0.00	0.05	0.01	0.09
221 PEAT		80	2.755	1	0.09085	1	380.4	630	0.01	0.06	0.01	0.15
220 PEAT		80	2.755	1	0.09085	1	398	710	0.01	0.07	0.02	0.23
219 PEAT		80	2.755	1	0.09085	1	415.6	790	0.01	0.08	0.03	0.31
218 SM		130	0.4	1	0.09085	1	483.2	920	0.00	0.00	0.03	0.31
217 SM		130	0.4	1	0.09085	1	550.8	1050	0.00	0.00	0.03	0.31
216 SM		130	0.4	1	0.09085	1	618.4	1180	0.00	0.00	0.03	0.31
215 SM		130	0.4	1	0.09085	1	686	1310	0.00	0.00	0.03	0.31
214 SM		130	0.4	1	0.09085	1	753.6	1440	0.00	0.00	0.03	0.31
213 SM		130	0.4	1	0.09085	1	821.2	1570.6	0.00	0.00	0.03	0.31
212 SM		130	0.4	1	0.09085	1	888.8	1575.2	0.00	0.00	0.03	0.31
211 SM		130	0.4	1	0.09085	1	956.4	1642.8	0.00	0.00	0.03	0.31
210 SM		130	0.4	1	0.09085	1	1024	1710.4	0.00	0.00	0.03	0.31
209 SM		130	0.4	1	0.09085	1	1091.6	1778	0.00	0.00	0.03	0.31
208 SM		130	0.4	1	0.09085	1	1159.2	1845.6	0.00	0.00	0.03	0.31
207 SM		130	0.4	1	0.09085	1	1226.8	1913.2	0.00	0.00	0.03	0.31
206 SM		130	0.4	1	0.09085	1	1294.4	1980.8	0.00	0.00	0.03	0.31
205 SM		130	0.4	1	0.09085	1	1362	2048.4	0.00	0.00	0.03	0.31
204 SM		130	0.4	1	0.09085	1	1429.6	2116	0.00	0.00	0.03	0.31
203 SM		130	0.4	1	0.09085	1	1497.2	2183.6	0.00	0.00	0.03	0.31
202 SM		130	0.4	1	0.09085	1	1564.8	2251.2	0.00	0.00	0.03	0.31

- 1) Estimated using medium stiff density and relative density of 40% and table 5-4.
2) Assumes material is saturated.

Table 5-4
Typical particle sizes, uniformity coefficients, void ratios and unit weights (from Kulhavy and Mann, 1990)

Soil Type	Approximate Particle Size, mm			Uniformity Coefficient	Void Ratio		Normal Unit Weights				
							Dry		Saturated		
	D_{10}	d_{50}	d_{60}		e_{min}	e_{max}	$\gamma_{d(100)}$	$\gamma_{d(50)}$	$\gamma_{sat(100)}$	$\gamma_{sat(50)}$	
Uniformly graded soil											
Equal spheres (theoretical)	0.075	0.075	0.075	1.0	0.55	0.95	-	-	-	-	
Smoothed Ottawa sand	0.075	0.075	0.075	1.1	0.60	0.94	1.47	1.78	1.40	2.19	
Coarse, uniform sand	0.075	0.075	0.075	1.2 to 2.0	0.60	0.90	1.33	1.69	1.35	2.18	
Uniform, angular silt	0.075	0.060	0.060	1.2 to 2.0	1.00	0.60	1.28	1.69	1.36	2.18	
Well-graded granular soil											
Silty sand	0.075	0.060	0.060	1 to 10	0.90	0.50	1.30	1.74	1.40	2.25	
Coarse, fine to coarse sand	0.075	0.060	0.060	1 to 8	0.85	0.50	1.36	1.72	1.40	2.27	
Medium sand	0.075	0.060	0.060	1 to 8	0.70	0.40	1.22	1.62	1.29	2.21	
Silty sand and gravel	0.075	0.060	0.060	11 to 200	0.85	0.54	1.43	1.74	1.41	2.46	
Silt or sandy clay	0.075	0.060	0.060	11 to 200	1.00	0.55	0.99	1.28	1.00	2.46	
Gap-graded silty clay with gravel or larger	0.075	0.060	0.060	25 to 1,000	0.80	0.50	1.35	1.64	1.44	2.42	
Well-graded gravel, sand, silt, and clay	0.075	0.060	0.060	25 to 1,000	0.70	0.53	1.40	1.77	1.40	2.50	
Clay (60 to 100% $\leq \gamma_{sat}$)	0.075	0.060	0.060	-	2.40	0.58	0.80	1.39	1.53	2.13	
Colloidal clay (more than 50% $\leq \gamma_{sat}$)	0.075	0.060	0.060	-	12.00	0.60	0.21	0.78	1.04	2.05	
Organic silt	0.075	0.060	0.060	-	1.00	0.75	0.64	1.28	1.00	2.10	
Organic clay (40 to 60% $\leq \gamma_{sat}$)	0.075	0.060	0.060	-	1.40	0.70	0.48	1.00	1.00	2.00	

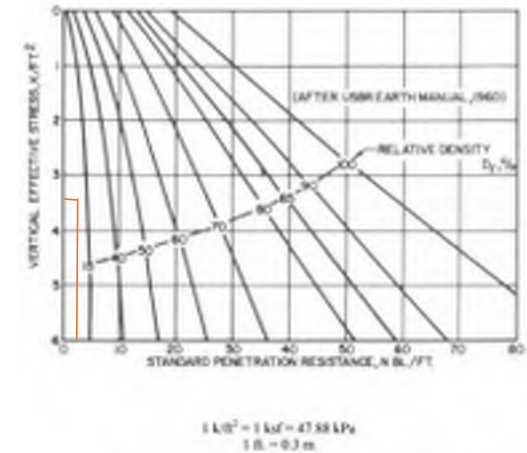
Note: $\gamma_{d(100)}$ = dry unit weight at 100% relative humidity; $\gamma_{d(50)}$ = dry unit weight at 50% relative humidity; $\gamma_{sat(100)}$ = saturated unit weight at 100% relative humidity; $\gamma_{sat(50)}$ = saturated unit weight at 50% relative humidity.

Table 5-5
Correlations for C_c (modified after Holtz and Kovacs, 1982)

Correlation	Soil
$C_c = 0.158 e_o - 0.0057 e_o^2$	All Clays
$C_c = 0.16 (PI - 200)^{0.17}$	
$C_c = 0.30 (e_o - 0.2)^2$	Inorganic, silty, clayey
$C_c = 0.009 (LL - 10)^{0.18}$	Clay of medium to slight sensitivity ($U_c < 4$, $LL < 100$)
$C_c = 0.111 e_o^{0.75}$	Organic Silt, Peat
$C_c = 0.75 (e_o - 0.50)$	Low plasticity clays

¹⁷ e_o = natural void ratio; ¹⁸ PI = Plasticity Index; ¹⁹ LL = Liquid Limit; ²⁰ U_c = sensitivity
²¹ C_c = Compression index; ²² e_o = natural void ratio

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Project	Jackson Park	Created By:	KKC
Project No.	US-EI-5539.3867-US-SHA Jackson Park Village	Date:	6/2/2025
Subject	Settlement Calculations due to dewatering	Reviewed by:	TDW
		Updated:	8/1/2025

Settlement due to Dewatering Point 2

Point 2A					Uses FHWA NHI-06-088	
Description:	Jackson Village apartments. On timber piles.					
	Elevation	Depth below Ground Surface				
Top of Ground	227 ft	0 ft				
Current Water Level	225 ft	2 ft				
Drawdown Water Level	216.5 ft	10.5 ft				
	Bottom of Soil Layer Elevation	Bottom of Soil Depth			Unit Weight	Estimated e_p
Medium dense silty SAND (FILL)	223 ft	4 ft			130	0.7
Peat	217 ft	10 ft			80	1
Loose to MD silty SAND	212 ft	15 ft			125	0.7
Dense, gray silty, gravelly SAND	-	-			130	0.4

Elevations	USCS	Unit Weight	Estimated e_p^1	W_n^2	C_c	H_u (feet)	p_o	p_i	Per Layer		Sum	
									S_u (feet)	S_u (in)	S_u (feet)	S_u (in)
227 SM		130	0.7	1	0.129	0	0	0	0.00	0.00	0.00	0.00
226 SM		130	0.7	1	0.129	1	130	130	0.00	0.00	0.00	0.00
225 SM		130	0.7	1	0.129	1	260	260	0.00	0.00	0.00	0.00
224 SM		130	0.7	1	0.129	1	327.6	390	0.00	0.00	0.00	0.00
223 SM		130	0.7	1	0.129	1	395.2	520	0.00	0.00	0.00	0.00
222 PEAT		80	2.755	1	0.115	1	412.8	600	0.00	0.06	0.00	0.06
221 PEAT		80	2.755	1	0.115	1	430.4	680	0.01	0.07	0.01	0.13
220 PEAT		80	2.755	1	0.115	1	448	760	0.01	0.08	0.02	0.22
219 PEAT		80	2.755	1	0.115	1	465.6	840	0.01	0.09	0.03	0.31
218 PEAT		80	2.755	1	0.115	1	483.2	920	0.01	0.10	0.03	0.41
217 PEAT		80	2.755	1	0.115	1	500.8	1000	0.01	0.11	0.04	0.52
216 SM		125	0.4	1	0.039	1	563.4	1062.6	0.00	0.00	0.04	0.52
215 SM		125	0.4	1	0.039	1	626	1125.2	0.00	0.00	0.04	0.52
214 SM		125	0.4	1	0.039	1	688.6	1187.8	0.00	0.00	0.04	0.52
213 SM		125	0.4	1	0.039	1	751.2	1250.4	0.00	0.00	0.04	0.52
212 SM		125	0.4	1	0.039	1	813.8	1313	0.00	0.00	0.04	0.52
211 SM		125	0.4	1	0.039	1	876.4	1375.6	0.00	0.00	0.04	0.52
210 SM		125	0.4	1	0.039	1	939	1438.2	0.00	0.00	0.04	0.52
209 SM		125	0.4	1	0.039	1	1001.6	1500.8	0.00	0.00	0.04	0.52
208 SM		125	0.4	1	0.039	1	1064.2	1563.4	0.00	0.00	0.04	0.52
207 SM		125	0.4	1	0.039	1	1126.8	1626	0.00	0.00	0.04	0.52
206 SM		125	0.4	1	0.039	1	1189.4	1688.6	0.00	0.00	0.04	0.52
205 SM		125	0.4	1	0.039	1	1252	1751.2	0.00	0.00	0.04	0.52
204 SM		125	0.4	1	0.039	1	1314.6	1813.8	0.00	0.00	0.04	0.52
203 SM		125	0.4	1	0.039	1	1377.2	1876.4	0.00	0.00	0.04	0.52
202 SM		125	0.4	1	0.039	1	1439.8	1939	0.00	0.00	0.04	0.52
201 SM		125	0.4	1	0.039	1	1502.4	2001.6	0.00	0.00	0.04	0.52
200 SM		125	0.4	1	0.039	1	1565	2064.2	0.00	0.00	0.04	0.52
199 SM		125	0.4	1	0.039	1	1627.6	2126.8	0.00	0.00	0.04	0.52
198 SM		125	0.4	1	0.039	1	1690.2	2189.4	0.00	0.00	0.04	0.52
197 SM		125	0.4	1	0.039	1	1752.8	2252	0.00	0.00	0.04	0.52
196 SM		125	0.4	1	0.039	1	1815.4	2314.6	0.00	0.00	0.04	0.52

1) Assumes material is saturated.

Table 5-6
Typical particle sizes, uniformity coefficients, void ratios and unit weights (from Kulhavy and Mayne, 1990)

Soil Type	Approximate Particle Size, mm			Uniformity Coefficient	Void Ratio		Normal Unit Weight			
							Dry		Saturated	
	D_{10}	d_{50}	d_{60}		e_{min}	e_{max}	$\gamma_{d, min}$	$\gamma_{d, max}$	$\gamma_{sat, min}$	$\gamma_{sat, max}$
Uniform granular soil	D_{10}	d_{50}	d_{60}	1.0	0.65	0.95				
Typical, cohesionless (fluvio-glacial)	0.075	0.425	0.85	2.0	0.60	0.90	1.47	1.74	1.48	2.10
Well-sorted, clean sand	0.075	0.425	0.85	1.25	0.55	0.85	1.50	1.80	1.50	2.10
Clean, medium sand	0.075	0.425	0.85	1.25	0.55	0.85	1.50	1.80	1.50	2.10
Uniform, medium sand	0.075	0.425	0.85	1.25	0.55	0.85	1.50	1.80	1.50	2.10
Well-sorted, medium sand	0.075	0.425	0.85	1.25	0.55	0.85	1.50	1.80	1.50	2.10
Uniform, coarse sand	0.075	0.425	0.85	1.25	0.55	0.85	1.50	1.80	1.50	2.10
Well-sorted, coarse sand	0.075	0.425	0.85	1.25	0.55	0.85	1.50	1.80	1.50	2.10
Uniform, fine sand	0.075	0.425	0.85	1.25	0.55	0.85	1.50	1.80	1.50	2.10
Well-sorted, fine sand	0.075	0.425	0.85	1.25	0.55	0.85	1.50	1.80	1.50	2.10
Uniform, very fine sand	0.075	0.425	0.85	1.25	0.55	0.85	1.50	1.80	1.50	2.10
Well-sorted, very fine sand	0.075	0.425	0.85	1.25	0.55	0.85	1.50	1.80	1.50	2.10
Uniform, silt	0.075	0.425	0.85	1.25	0.55	0.85	1.50	1.80	1.50	2.10
Well-sorted, silt	0.075	0.425	0.85	1.25	0.55	0.85	1.50	1.80	1.50	2.10
Uniform, clay	0.075	0.425	0.85	1.25	0.55	0.85	1.50	1.80	1.50	2.10
Well-sorted, clay	0.075	0.425	0.85	1.25	0.55	0.85	1.50	1.80	1.50	2.10

Note: $\gamma_{d, min} = 62 \text{ kN/m}^3$ (120 lb/ft^3); $\gamma_{d, max} = 110 \text{ kN/m}^3$ (220 lb/ft^3); $\gamma_{sat, min} = 120 \text{ kN/m}^3$ (240 lb/ft^3); $\gamma_{sat, max} = 200 \text{ kN/m}^3$ (400 lb/ft^3).

Table 5-8
Correlation for C_u (modified after Holtz and Kavvas, 1992)

Correlation	Soil
$C_u = 0.154 e_p - 0.00077$	All Clays
$C_u = 0.154 (e_p - 0.00077)$	Inorganic, silty, silty clay
$C_u = 0.154 (e_p - 0.00077)$	Clay of medium to slight sensitivity ($\psi_s = 4 \text{ LL} - 100$)
$C_u = 0.113 e_p^{0.77}$	Organic Soils, Peat
$C_u = 0.75 (e_p - 0.145)$	Low plasticity clays

⁽¹⁾ e_p = natural void ratio, ⁽²⁾ PI = Plasticity Index, ⁽³⁾ LL = Liquid Limit, ⁽⁴⁾ ψ_s = sensitivity
 *Unsubscripted subscripted shear strength/Unsubscripted shear strength (see Table 3.17 in Chapter 3) e_p = natural water content

FHWA Circular #6

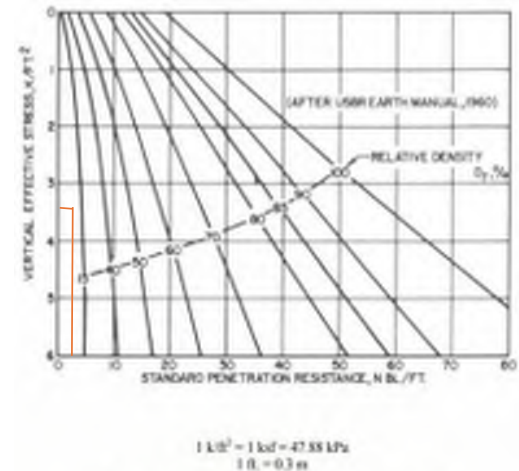


Figure 4-1: Correlation Between Relative Density and SPT Resistance (NAVFAC, 1986a, after Gibbs & Holtz)

Project	Jackson Park	Created By:	KKC
Project No.	US-EI-5539.3867-US-SHA Jackson Park Village	Date:	6/2/2025
Subject	Settlement Calculations due to dewatering	Reviewed by:	TDW
		Updated:	8/1/2025

Settlement due to Dewatering Point 2

Point 2B				Uses FHWA NHI-06-088	
Description:	Jackson Village apartments. On timber piles.				
	Elevation		Depth below Ground Surface		
Top of Ground	227 ft		0 ft		
Current Water Level	225 ft		2 ft		
Drawdown Water Level	214 ft		13 ft		
	Bottom of Soil Layer Elevation		Bottom of Soil Depth	Unit Weight	Estimated e _o
Medium dense silty SAND (FILL)	223 ft		4 ft	130	0.7
Peat	217 ft		10 ft	80	1
Loose to MD silty SAND	212 ft		15 ft	125	0.7
Dense, gray silty, gravelly SAND	-		-	130	0.4

										Per Layer		Sum		
Elevations	USCS	Unit Weight	Estimated e_p ¹	Wn ²	Cc	H _u (feet)	p ₀	p _i		S _u (feet)	S _u (in)	S _u (feet)	S _u (in)	
227 SM	130	0.7	1	0.129	0	0	0	0		0.00	0.00	0.00	0.00	
226 SM	130	0.7	1	0.129	1	130	130	130		0.00	0.00	0.00	0.00	
225 SM	130	0.7	1	0.129	1	260	260	260		0.00	0.00	0.00	0.00	
224 SM	130	0.7	1	0.129	1	327.6	390	390		0.00	0.00	0.00	0.00	
223 SM	130	0.7	1	0.129	1	395.2	520	520		0.00	0.00	0.00	0.00	
222 PEAT	80	2.755	1	0.115	1	412.8	600	600		0.00	0.06	0.00	0.06	
221 PEAT	80	2.755	1	0.115	1	430.4	680	680		0.01	0.07	0.01	0.13	
220 PEAT	80	2.755	1	0.115	1	448	760	760		0.01	0.08	0.02	0.22	
219 PEAT	80	2.755	1	0.115	1	465.6	840	840		0.01	0.09	0.03	0.31	
218 PEAT	80	2.755	1	0.115	1	483.2	920	920		0.01	0.10	0.03	0.41	
217 PEAT	80	2.755	1	0.115	1	500.8	1000	1000		0.01	0.11	0.04	0.52	
216 SM	125	0.4	1	0.039	1	563.4	1125	1125		0.00	0.00	0.04	0.52	
215 SM	125	0.4	1	0.039	1	626	1250	1250		0.00	0.00	0.04	0.52	
214 SM	125	0.4	1	0.039	1	688.6	1375	1375		0.00	0.00	0.04	0.52	
213 SM	125	0.4	1	0.039	1	751.2	1437.6	1437.6		0.00	0.00	0.04	0.52	
212 SM	125	0.4	1	0.039	1	813.8	1500.2	1500.2		0.00	0.00	0.04	0.52	
211 SM	125	0.4	1	0.039	1	876.4	1562.8	1562.8		0.00	0.00	0.04	0.52	
210 SM	125	0.4	1	0.039	1	939	1625.4	1625.4		0.00	0.00	0.04	0.52	
209 SM	125	0.4	1	0.039	1	1001.6	1688	1688		0.00	0.00	0.04	0.52	
208 SM	125	0.4	1	0.039	1	1064.2	1750.6	1750.6		0.00	0.00	0.04	0.52	
207 SM	125	0.4	1	0.039	1	1126.8	1813.2	1813.2		0.00	0.00	0.04	0.52	
206 SM	125	0.4	1	0.039	1	1189.4	1875.8	1875.8		0.00	0.00	0.04	0.52	
205 SM	125	0.4	1	0.039	1	1252	1938.4	1938.4		0.00	0.00	0.04	0.52	
204 SM	125	0.4	1	0.039	1	1314.6	2001	2001		0.00	0.00	0.04	0.52	
203 SM	125	0.4	1	0.039	1	1377.2	2063.6	2063.6		0.00	0.00	0.04	0.52	
202 SM	125	0.4	1	0.039	1	1439.8	2126.2	2126.2		0.00	0.00	0.04	0.52	
201 SM	125	0.4	1	0.039	1	1502.4	2188.8	2188.8		0.00	0.00	0.04	0.52	
200 SM	125	0.4	1	0.039	1	1565	2251.4	2251.4		0.00	0.00	0.04	0.52	
199 SM	125	0.4	1	0.039	1	1627.6	2314	2314		0.00	0.00	0.04	0.52	
198 SM	125	0.4	1	0.039	1	1690.2	2376.6	2376.6		0.00	0.00	0.04	0.52	
197 SM	125	0.4	1	0.039	1	1752.8	2439.2	2439.2		0.00	0.00	0.04	0.52	
196 SM	125	0.4	1	0.039	1	1815.4	2501.8	2501.8		0.00	0.00	0.04	0.52	

1) Assumes material is saturated.

Table 5-4

Typical particle sizes, uniformity coefficients, void ratios and unit weights (from Kaftany and Mayne, 1990)

Soil Type	Approximate Particle Size, mm			Uniformity Coefficient	Void Ratio		Normalized Unit Weight				
							Dry		Saturated		
	D ₁₀	d ₅₀	d ₆₀		e _{min}	e _{max}	γ _d /γ _s	γ _d /γ _s	γ _s /γ _w	γ _s /γ _w	
Uniform granular soil											
Equal grains (homotaxial)	D ₁₀	D ₅₀	D ₆₀	1.0	0.65	0.75					
Standard (homotaxial)	0.04	0.10	0.4	1.1	0.60	0.70	1.47	1.48	1.48	2.20	
Clean, uniform sand	-	-	1.2 to 2.0	1.00	0.60	1.35	1.89	1.89	1.89	2.18	
Uniform, microporous silt	0.01	0.05	0.05	1.2 to 2.0	1.35	0.60	1.28	1.89	1.89	2.18	
Weak graded granular soil											
Silty sand	2.8	0.075	0.425	5 to 10	0.60	0.70	1.48	1.48	1.48	2.20	
Clean, fine to coarse sand	2.8	0.075	0.425	4 to 6	0.65	0.75	1.36	1.36	1.36	2.17	
Medium dense sand	100	0.060	0.425	15 to 300	0.65	0.70	1.47	1.47	1.47	2.21	
Silty sand and gravel	2.8	0.075	0.425	10 to 30	1.80	0.75	0.96	2.34	1.80	2.34	
Silty or sandy clay	2.8	0.075	0.425	10 to 30	1.80	0.75	0.96	2.34	1.80	2.34	
Gap-graded silty clay with gravel or larger	250	0.060	-	-	1.80	0.75	1.33	2.34	1.80	2.34	
Weak graded gravel, sand, silt, and clay	250	0.060	0.425	25 to 1000	0.70	0.75	1.89	2.37	2.00	2.30	
Clay (50 to 70% < 0.075 mm)	0.01	0.075	0.425	-	2.40	0.58	0.89	1.79	1.15	2.13	
Colloidal clay (more 70% < 0.075 mm)	0.01	0.01	-	-	12.00	0.60	0.75	1.79	1.14	2.05	
Organic clay	-	-	-	-	3.00	0.15	0.60	1.79	1.14	2.05	
Organic clay (40 to 50% < 0.075 mm)	-	-	-	-	5.40	0.70	0.60	1.80	1.10	2.00	

Note: γ_d = 62.4 pcf (9.81 kN/m³); γ_s = 128 pcf (19.2 kN/m³); γ_w = 62.4 pcf (9.81 kN/m³); A_v = 10⁻³ mm; A_v = 10⁻³ mm

Table 5-5
Correlation for C_u (modified after Holtz and Kavaz, 1992)

Correlation	Soil
C _u = 0.154 e _p - 0.000077	All Clays
C _u = 0.154 e _p - 0.000077	Inorganic, silty, silty clay
C _u = 0.30 (e _p - 0.25)	Clay of medium to slight sensitivity (e _p = 4 LL - 100) ¹⁰
C _u = 0.008 (LL - 10) ¹¹	Organic Soils, Peat
C _u = 0.75 (e _p - 0.14)	Low plasticity clays

¹⁰ e_p = natural void ratio; ¹¹ PL = Plasticity Index; ¹² LL = Liquid Limit; ¹³ S_u = sensitivity
 *Unsubscripted subscripted shear strength/Unsubscripted subscripted shear strength (see Table 3.17 in Chapter 3); ¹⁴ e_p = natural water content

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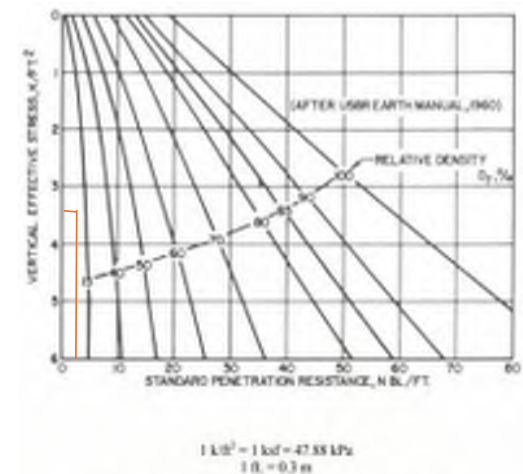


Figure 4-1: Correlation Between Relative Density and SPT Resistance (NAVFAC, 1986a, after Gibbs & Holtz)

Project	Jackson Park	Created By:	KKC
Project No.	US-EI-5539.3867-US-SHA Jackson Park Village	Date:	6/2/2025
Subject	Settlement Calculations due to dewatering	Reviewed by:	TDW
		Updated:	8/1/2025

Settlement due to Dewatering Point 3

Point 3A				Uses FHWA NHI-06-088		
Description:	2 Story Apartment Building to the east					
	Elevation	Depth below Ground Surface				
Top of Ground	227 ft	0 ft				
Current Water Level	225 ft	2 ft				
Drawdown Water Level	213 ft	14 ft				
	Bottom of Soil Layer Elevation	Bottom of Soil Depth		Unit Weight	Estimated e_s	
Fill	224 ft	3 ft		130	0.4	
Peat	219 ft	8 ft		80	1	
MD silty SAND	215 ft	12 ft		130	0.4	
VD silty Sand w/gravel	-	-		135		

Elevations	USCS	Unit Weight	Estimated e_s^1	Wn^2	C_c	H_s (feet)	P_o	P_t	Per Layer		Sum	
									S_v (feet)	S_v (in)	S_v (feet)	S_v (in)
227	SM	130	0.4	1	0.09085	0	0	0	0.00	0.00	0	0
226	SM	130	0.4	1	0.09085	1	130	130	0.00	0.00	0	0
225	SM	130	0.4	1	0.09085	1	260	260	0.00	0.00	0.00	0.00
224	SM	130	0.4	1	0.09085	1	327.6	390	0.00	0.00	0.00	0.00
223	PEAT	80	2.755	1	0.09085	1	345.2	470	0.00	0.04	0.00	0.04
222	PEAT	80	2.755	1	0.09085	1	362.8	550	0.00	0.05	0.01	0.09
221	PEAT	80	2.755	1	0.09085	1	380.4	630	0.01	0.06	0.01	0.15
220	PEAT	80	2.755	1	0.09085	1	398	710	0.01	0.07	0.02	0.23
219	PEAT	80	2.755	1	0.09085	1	415.6	790	0.01	0.08	0.03	0.31
218	SM	130	0.4	1	0.09085	1	483.2	920	0.00	0.00	0.03	0.31
217	SM	130	0.4	1	0.09085	1	550.8	1050	0.00	0.00	0.03	0.31
216	SM	130	0.4	1	0.09085	1	618.4	1180	0.00	0.00	0.03	0.31
215	SM	130	0.4	1	0.09085	1	686	1310	0.00	0.00	0.03	0.31
214	SM	130	0.4	1	0.09085	1	753.6	1440	0.00	0.00	0.03	0.31
213	SM	130	0.4	1	0.09085	1	821.2	1570	0.00	0.00	0.03	0.31
212	SM	130	0.4	1	0.09085	1	888.8	1637.6	0.00	0.00	0.03	0.31
211	SM	130	0.4	1	0.09085	1	956.4	1705.2	0.00	0.00	0.03	0.31
210	SM	130	0.4	1	0.09085	1	1024	1772.8	0.00	0.00	0.03	0.31
209	SM	130	0.4	1	0.09085	1	1091.6	1840.4	0.00	0.00	0.03	0.31
208	SM	130	0.4	1	0.09085	1	1159.2	1908	0.00	0.00	0.03	0.31
207	SM	130	0.4	1	0.09085	1	1226.8	1975.6	0.00	0.00	0.03	0.31
206	SM	130	0.4	1	0.09085	1	1294.4	2043.2	0.00	0.00	0.03	0.31
205	SM	130	0.4	1	0.09085	1	1362	2110.8	0.00	0.00	0.03	0.31
204	SM	130	0.4	1	0.09085	1	1429.6	2178.4	0.00	0.00	0.03	0.31
203	SM	130	0.4	1	0.09085	1	1497.2	2246	0.00	0.00	0.03	0.31
202	SM	130	0.4	1	0.09085	1	1564.8	2313.6	0.00	0.00	0.03	0.31

- 1) Estimated using medium stiff density and relative density of 40% and table 5-4.
2) Assumes material is saturated.

Table 5-4
Typical particle sizes, uniformity coefficients, void ratios and unit weights (from Kulhavy and Meyer, 1990)

Soil Type	Approximate Particle Size, mm			Uniformity Coefficient	Void Ratio		Normalized Unit Weight				
							Dry		Saturated		
	D_{10}	d_{50}	d_{60}		e_{min}	e_{max}	γ_{dmin}/γ_w	γ_{dmax}/γ_w	γ_{smin}/γ_w	γ_{smax}/γ_w	
Uniform granular soil											
Sands, silts (Determined)											
Standard Ottawa sand	0.075	0.25	0.85	2.6	0.58	0.95	0.49	0.87	1.70	2.09	
Clean, uniform sand	-	-	-	1.2 to 2.0	0.60	0.80	0.53	0.89	1.95	2.08	
Uniform, non-plastic silt	0.002	0.003	0.012	1.2 to 2.0	1.30	0.80	1.28	1.05	1.90	2.03	
Well-graded granular soil											
Silty sand	0.075	0.085	0.25	1 to 10	0.60	0.90	0.50	0.86	1.41	2.15	
Clean, fine to coarse sand	0.075	0.25	0.85	0 to 6	0.55	0.90	0.52	0.98	2.22	2.38	
Medium sand	-	-	-	-	0.50	0.80	0.52	0.95	2.28	2.43	
Silty sand and gravel	0.002	0.003	0.02	10 to 300	0.65	0.94	0.43	0.84	1.66	2.44	
Silty or sandy clay	0.075	0.085	0.010	10 to 30	1.00	0.52	0.98	1.04	1.00	2.08	
Gap-graded silty clay with gravel as larger	0.075	0.085	0.010	10 to 30	1.00	0.52	0.98	1.04	1.00	2.08	
Well-graded gravel, sand, silt and clay	0.075	0.085	0.002	20 to 1,000	0.70	0.91	0.60	0.97	2.00	2.50	
Clay (30 to 50% $< 2\mu$ size)	0.002	0.075	0.001	-	2.40	0.50	0.80	0.79	1.71	2.05	
Colloidal clay (more 50% $< 2\mu$ size)	0.001	0.001	-	-	12.00	0.60	0.73	0.70	1.14	2.03	
Organic soil											
Organic clay (30 to 50% $< 2\mu$ size)	-	-	-	-	0.40	0.70	0.40	0.60	1.50	2.00	

Note: $e_{min} = 42 \pm 2$ per (2) 80 (50) μ ; $\rho = 10^3$ mm; Δ - Aspiration = 10' mm

Table 5-5
Correlations for C_u (modified after Holtz and Kovacs, 1980)

Correlation	Soil
$C_u = 0.158 e_s + 0.310^{(1)}$	All Clays
$C_u = 0.158 e_s + 100^{(2)}$	Inorganic, silty clay
$C_u = 0.158 e_s + 0.2^{(3)}$	Clay of medium to slight sensitivity
$C_u = 0.009 (LL - 50)^{(4)}$	$(e_s < 4 \text{ LL} < 60\%)^{(5)}$
$C_u = 0.1113 w_p^{(6)}$	Organic soils, Peat
$C_u = 0.71 (w_p - 0.50)$	Low plasticity clays

⁽¹⁾ e_s = actual void ratio. ⁽²⁾ PE = Plasticity Index. ⁽³⁾ LL = Liquid Limit. ⁽⁴⁾ S_u = sensitivity. ⁽⁵⁾ Indicated undrained shear strength (estimated undrained shear strength (see Table 3-12 in Chapter 3). ⁽⁶⁾ w_p = natural water content

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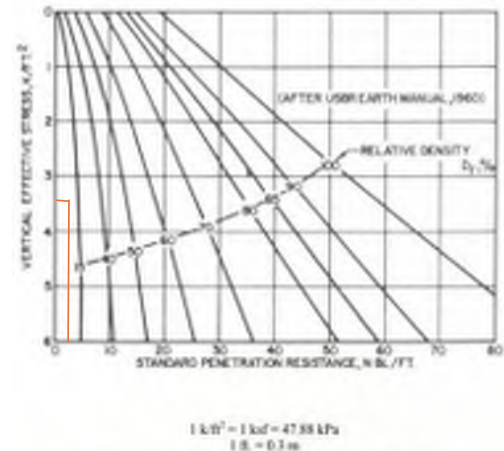


Figure 4-1: Correlation Between Relative Density and SPT Resistance (NAVJAC, 1956a, after Gibbs & Holtz)

Project	Jackson Park	Created By:	KKC
Project No.	US-EI-5539.3867-US-SHA Jackson Park Village	Date:	6/2/2025
Subject	Settlement Calculations due to dewatering	Reviewed by:	TDW
		Updated:	8/1/2025

Settlement due to Dewatering Point 3

Point 3B				Uses FHWA NHI-06-088		
Description:	2 Story Apartment Building to the east					
	Elevation	Depth below Ground Surface				
Top of Ground	227 ft	0 ft				
Current Water Level	225 ft	2 ft				
Drawdown Water Level	214 ft	13 ft				
	Bottom of Soil Layer Elevation	Bottom of Soil Depth		Unit Weight	Estimated e_v	
Fill	224 ft	3 ft		130	0.4	
Peat	219 ft	8 ft		80	1	
MD silty SAND	215 ft	12 ft		130	0.4	
VD silty Sand w/gravel	-	-		135		

Elevations	USCS	Unit Weight	Estimated e_v^1	Wn^2	C_c	H_v (feet)	p_o	p_t	Per Layer		Sum	
									S_v (feet)	S_v (in)	S_v (feet)	S_v (in)
227 SM	SM	130	0.4	1	0.09085	0	0	0	0.00	0.00	0	0
226 SM	SM	130	0.4	1	0.09085	1	130	130	0.00	0.00	0	0
225 SM	SM	130	0.4	1	0.09085	1	260	260	0.00	0.00	0.00	0.00
224 SM	SM	130	0.4	1	0.09085	1	327.6	390	0.00	0.00	0.00	0.00
223 PEAT	PEAT	80	2.755	1	0.09085	1	345.2	470	0.00	0.04	0.00	0.04
222 PEAT	PEAT	80	2.755	1	0.09085	1	362.8	550	0.00	0.05	0.01	0.09
221 PEAT	PEAT	80	2.755	1	0.09085	1	380.4	630	0.01	0.06	0.01	0.15
220 PEAT	PEAT	80	2.755	1	0.09085	1	398	710	0.01	0.07	0.02	0.23
219 PEAT	PEAT	80	2.755	1	0.09085	1	415.6	790	0.01	0.08	0.03	0.31
218 SM	SM	130	0.4	1	0.09085	1	483.2	920	0.00	0.00	0.03	0.31
217 SM	SM	130	0.4	1	0.09085	1	550.8	1050	0.00	0.00	0.03	0.31
216 SM	SM	130	0.4	1	0.09085	1	618.4	1180	0.00	0.00	0.03	0.31
215 SM	SM	130	0.4	1	0.09085	1	686	1310	0.00	0.00	0.03	0.31
214 SM	SM	130	0.4	1	0.09085	1	753.6	1440	0.00	0.00	0.03	0.31
213 SM	SM	130	0.4	1	0.09085	1	821.2	1507.6	0.00	0.00	0.03	0.31
212 SM	SM	130	0.4	1	0.09085	1	888.8	1575.2	0.00	0.00	0.03	0.31
211 SM	SM	130	0.4	1	0.09085	1	956.4	1642.8	0.00	0.00	0.03	0.31
210 SM	SM	130	0.4	1	0.09085	1	1024	1710.4	0.00	0.00	0.03	0.31
209 SM	SM	130	0.4	1	0.09085	1	1091.6	1778	0.00	0.00	0.03	0.31
208 SM	SM	130	0.4	1	0.09085	1	1159.2	1845.6	0.00	0.00	0.03	0.31
207 SM	SM	130	0.4	1	0.09085	1	1226.8	1913.2	0.00	0.00	0.03	0.31
206 SM	SM	130	0.4	1	0.09085	1	1294.4	1980.8	0.00	0.00	0.03	0.31
205 SM	SM	130	0.4	1	0.09085	1	1362	2048.4	0.00	0.00	0.03	0.31
204 SM	SM	130	0.4	1	0.09085	1	1429.6	2116	0.00	0.00	0.03	0.31
203 SM	SM	130	0.4	1	0.09085	1	1497.2	2183.6	0.00	0.00	0.03	0.31
202 SM	SM	130	0.4	1	0.09085	1	1564.8	2251.2	0.00	0.00	0.03	0.31

- 1) Estimated using medium stiff density and realtive density of 40% and table 5-4.
- 2) Assumes material is saturated.

Table 5-4
Typical particle sizes, uniformity coefficients, void ratios and unit weights (from Kulhavy and Mayas, 1990)

Soil Type	Approximate Particle Size, mm			Uniformity Coefficient	Void Ratio		Normalized Unit Weight				
							Dry		Saturated		
	D_{10}	d_5	d_1		e_{min}	e_{max}	$\rho_{d(100)}\%$	$\rho_{d(100)}\%$	$\rho_{sat(100)}\%$	$\rho_{sat(100)}\%$	
Uniform granular soil											
Swell, open (loose)				1.0	0.95	0.95					
Standard Ottawa sand	0.075	0.425	0.85	1.1	0.60	0.70	1.47	1.76	1.69	2.18	
Clean, uniform sand				1.25	0.60	0.70	1.47	1.76	1.69	2.18	
Uniform, non-gravel soil	0.075	0.85	0.425	1.25	0.60	0.70	1.47	1.76	1.69	2.18	
Well-graded granular soil											
Silty sand	0.075	0.85	0.425	1.25	0.60	0.70	1.47	1.76	1.69	2.18	
Clean, fine to coarse sand	0.075	0.85	0.425	1.25	0.60	0.70	1.47	1.76	1.69	2.18	
Medium sand				1.25	0.60	0.70	1.47	1.76	1.69	2.18	
Silty sand and gravel	0.075	0.85	0.425	1.25	0.60	0.70	1.47	1.76	1.69	2.18	
Silty or sandy clay	0.075	0.85	0.425	1.25	0.60	0.70	1.47	1.76	1.69	2.18	
Gap-graded silty clay with gravel or larger	0.075	0.85	0.425	1.25	0.60	0.70	1.47	1.76	1.69	2.18	
Well-graded gravel, sand, silt, and clay	0.075	0.85	0.425	1.25	0.60	0.70	1.47	1.76	1.69	2.18	
Clay (50 to 100% < 0.075 mm)	0.075	0.85	0.425	1.25	0.60	0.70	1.47	1.76	1.69	2.18	
Colloidal clay (over 100% < 0.075 mm)	0.075	0.85	0.425	1.25	0.60	0.70	1.47	1.76	1.69	2.18	
Organic soil											
Organic clay (50 to 100% < 0.075 mm)											
Organic clay (over 100% < 0.075 mm)											

Note: $d_1 = 4.75$ mm (No. 10 sieve), $d_5 = 4.75$ mm (No. 10 sieve), $d_{10} = 4.75$ mm (No. 10 sieve)

Table 5-5
Correlations for C_u (modified after Bity and Kovacs, 1982)

Correlation	Soil
$C_u = 0.124 e_v + 0.0117^{(1)}$	All Clays
$C_u = 0.56 (p_t - 0.2)^{(2)}$	Inorganic, silty, clayey
$C_u = 0.389 (LL - 10)^{(3)}$	Clay of medium to slight sensitivity
$C_u = 0.1113 w_p^{(4)}$	Organic Soils, Peat
$C_u = 0.75 (p_t - 0.58)$	Low plasticity clays

⁽¹⁾ e_v = actual void ratio; ⁽²⁾ p_t = Plasticity Index; ⁽³⁾ LL = Liquid Limit; ⁽⁴⁾ w_p = water content
⁽⁵⁾ Calculated undrained shear strength Remolded undrained shear strength (see Table 3-32 in Chapter 3); ⁽⁶⁾ w_p = natural water content

FHWA Circular #6

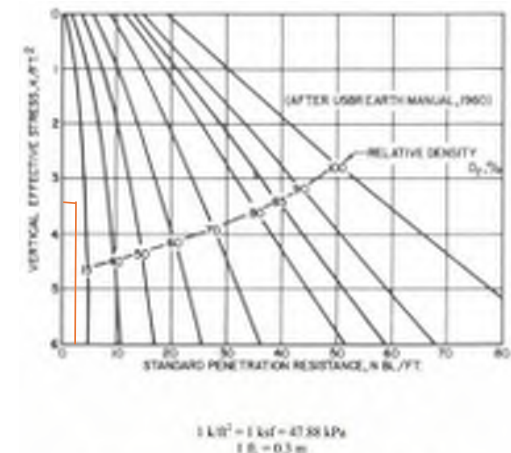


Figure 4-1: Correlation Between Relative Density and SPT Resistance (NAVFAC, 1986a, after Gibbs & Holtz)

		Date:	
		Reviewed by:	
Project	Jackson Park	Created By:	KKC
Project No.	US-EI-5539.3867-US-SHA Jackson Park Village	Date:	6/2/2025
Subject	Settlement Calculations due to dewatering	Reviewed by:	
		Updated:	

Uses FHWA NHI-06-088

$$S_c = \sum_{i=1}^n \frac{C_c}{1 + e_{oi}} H_{ci} \log_{10} \left(\frac{p_f}{p_o} \right)$$

$$S_c = \sum_{i=1}^n C_{ci} H_{ci} \log_{10} \left(\frac{p_f}{p_o} \right)$$

$$C_{ci} = \frac{C_c}{1 + e_{oi}}$$

Equation variables are defined in the following section.

C_c = compression index

C_{ci} = modified compression index

C_r = recompression index

C_{ri} = modified recompression index

e_o = initial void ratio

H_{ci} = thickness of compressible layer

p_o = initial overburden pressure (= p_z for normally consolidated soils)

p_c = preconsolidation pressure

p_f = final overburden pressure = $p_o + \Delta p$

S_c = consolidation settlement

Δp = increase in effective stress

Table 5-4
Typical particle sizes, uniformity coefficients, void ratios and unit weights (from Kulhawy and Mayne, 1990)

Soil Type	Approximate Particle Size, mm			Uniformity Coefficient	Void Ratio		Normalized Unit Weight			
							Dry		Saturated	
	D_{10}	d_{50}	d_{60}		e_{min}	e_{max}	γ_{d0}/γ_s	γ_{dmax}/γ_s	γ_{s0}/γ_s	γ_{smax}/γ_s
Uniform granular soil										
Equal spheres (theoretical)	-	D	D	1.0	0.92 ^a	0.35	-	-	-	-
Standard Ottawa sand	0.075	0.59	0.67	1.1	0.80	0.50	1.47	1.76	1.49	2.10
Clean, uniform sand	-	-	-	1.2 to 2.0	1.00	0.40	1.33	1.89	1.35	2.18
Uniform, inorganic silt	0.05	0.005	0.002	1.2 to 2.0	1.10	0.40	1.28	1.89	1.30	2.18
Well-graded granular soil										
Silty sand	2.0	0.005	0.02	5 to 10	0.90	0.30	1.39	2.04	1.41	2.28
Clean, fine to coarse sand	2.0	0.05	0.09	4 to 6	0.95	0.20	1.36	2.21	1.38	2.37
Microcoarse sand	-	-	-	-	1.20	0.40	1.22	1.92	1.23	2.23
Silty sand and gravel	100	0.005	0.02	15 to 100	0.85	0.14	1.43	2.34	1.44	2.48
Silty or sandy clay	2.0	0.005	0.003	10 to 30	1.00	0.25	0.96	2.16	1.00	2.36
Gap-graded silty clay with gravel or larger	250	0.005	-	-	1.00	0.20	1.35	2.34	1.34	2.42
Well-graded gravel, sand, silt, and clay	250	0.005	0.002	25 to 1,000	0.70	0.13	1.60	2.37	2.00	2.50
Clay (30 to 50% < 2 μ size)	0.05	0.5 μ	0.005	-	2.40	0.50	0.80	1.79	1.32	2.13
Colloidal clay (over 50% < 2 μ size)	0.05	10 μ	-	-	12.00	0.60	0.23	1.70	1.14	2.05
Organic silt	-	-	-	-	3.00	0.55	0.64	1.76	1.39	2.10
Organic clay (30 to 50% < 2 μ size)	-	-	-	-	5.40	0.70	0.48	1.60	1.30	2.00

Note: $\gamma_s = 62.4$ pcf (9.81 kN/m³); $\mu = 10^{-6}$ mm; λ = Angstrom = 10^{-10} mm

Note: γ_s = 62.4 pcf (9.80 kN/m³); μ = 10⁻⁶ mm; Λ - Angstrom = 10⁻¹⁰ mm

5.4.6.1 Compression Index, C_c

Over 70 different equations have been published for correlating C_c with the index properties of clays. Table 5-5 lists some of the more useful correlations. Figure 5-9 shows correlations between natural water content and C_c for fine-grained soils, peats and shales. Note that the coordinates in Figure 5-9 are both logarithmic so that values of C_c can vary by as much as a factor of 5 with respect to the average trend line in these empirical correlations. Values of C_c obtained from Table 5-5 or Figure 5-9 should not be used for final design.

Table 5-5
Correlations for C_c (modified after Holtz and Kovacs, 1981)

Correlation	Soil
$C_c = 0.156 e_o + 0.0107^{(1)}$	All Clays
$C_c = 0.56 (PI - 0.00)^{(2)}$	
$C_c = 0.30 (e_o - 0.27)$	Inorganic, silt, silty clay
$C_c = 0.009 (LL - 10)^{(3)}$	Clay of medium to slight sensitivity ($S_u < 4$, $LL < 100$) ⁽⁴⁾
$C_c = 0.0115 w_p^{(5)}$	Organic Soils, Peat
$C_c = 0.75 (e_o - 0.50)$	Low plasticity clays

⁽¹⁾ e_o = initial void ratio, ⁽²⁾ PI = Plasticity Index, ⁽³⁾ LL = Liquid Limit, ⁽⁴⁾ S_u = sensitivity = Undisturbed undrained shear strength / Remolded undrained shear strength (see Table 3-12 in Chapter 3), ⁽⁵⁾ w_p = natural water content