Scenario 1	Shumway Hollow and Lucasville-Minford Interchanges will utilize Ramp D as both an on and off ramp.					
	Wick Drain Spacing (feet)					**Estimated Costs**
	Shumway Hollow Road			**Lucasville-Minford Road**		
	Area 1	**Area 2**	**Area 3**	**CR 28 Ramps**	**Mainline**	
Option 1	6	6	5	7	7	
	Paving at the Lucasville-Minford Interchange could not begin until approximately 23 weeks into the third construction season.					***$4,104,577***
Option 2	6	6	5	6	7	
	Paving could begin at the beginning of the third construction season					***$4,147,733***

Scenario 2	At both the Shumway Hollow and Lucasville-Minford Interchanges, Ramps A and D will be paved and opened to traffic.					
	Wick Drain Spacing (feet)					**Estimated Costs**
	Shumway Hollow Road			**Lucasville-Minford Road**		
	Area 1	**Area 2**	**Area 3**	**CR 28 Ramps**	**Mainline**	
Option 1	5	5	5	7	7	
	Paving at the Lucasville-Minford Interchange could not begin until approximately 23 weeks into the third construction season.					***$4,275,931***
Option 2	5	5	5	6	6	
	Paving could begin at the beginning of the third construction season					***$4,383,857***

Scenario 3	Shumway Hollow Interchange Ramps A & D will be paved and opened to traffic. Additional time allowed for consolidation of embankment south of Shumway Hollow Road (TR 234). At Lucasville-Minford Interchange, Ramps A & D will be opened to traffic.					
	Wick Drain Spacing (feet)					Estimated Costs
	Shumway Hollow Road			Lucasville-Minford Road		
	Area 1	Area 2	Area 3	CR 28 Ramps	Mainline	
Option 1	6	6/5	5	7	7	
	Paving at the Lucasville-Minford Interchange could not begin until approximately 23 weeks into the third construction season.					***$4,199,857***
Option 2	6	6/5	5	6	7	
	Paving could begin at the beginning of the third construction season					***$4,243,014***

SCENARIO #1

Scenario 1 – Shumway Hollow and Lucasville-Minford Interchanges will utilize Ramp D as both an on and off ramp.

Option 1: Wick drains are spaced differently between Areas 1 & 2 and Area 3 {see attached, from *Addendum to Report: Shumway Hollow Road (TR 234) Interchange* (DLZ, 2008)}. Total Cost = $4,104,577

- Wick drains at TR 234 Ramp D and along the Mainline Embankment from Sta. 384+00 to Sta. 415+00 (Area 3) spaced at 5 feet.
- Wick drains along Mainline Embankment from Sta. 352+00 to 384+00 and along TR 234 ramps A, B, and C (Areas 1 & 2) spaced at 6 feet.
- All wick drains at the Lucasville-Minford Interchange spaced at 7 feet.
- Complete embankments in 2 construction seasons.
- Reach 90% consolidation of TR234 Ramp D and mainline embankment from Sta. 384+00 to Sta. 415+00 in second construction season.
- Reach 90% consolidation of TR234 Ramps A, B and C, Mainline Embankment Sta. 352+00 to Sta. 384+00, and entire Lucasville-Minford Interchange in third construction season.

Constructability Benefits/Issues with Option 1

- Paving along Ramp D and Mainline Embankment from Sta. 384+00 to Sta. 415+00 could start at beginning of third construction season.
- Paving at the Shumway Hollow Interchange could begin approximately 11 weeks into the third construction season.
- Paving at the Lucasville-Minford Interchange could begin approximately 23 weeks into the third construction season.

Option 2: Wick drains are spaced differently between Areas 1 & 2 and Area 3 at the Shumway Hollow Interchange; and between the ramps and the mainline embankment at the Lucasville-Minford Road Interchange. Total Cost = $4,147,733

- Wick drains along Ramps A, B, C and D at the Lucasville-Minford Interchange spaced at 6 feet.
- Remaining areas at the Lucasville-Minford Interchange including the Mainline Embankment from Sta. 520+00 to Sta. 537+00 to have wick drains spaced at 7 feet.
- Wick drains along Mainline Embankment from Sta 352+00 to 384+00 and along Ramp D at Shumway Hollow Interchange spaced at 5 feet.
- Remaining areas at Shumway Hollow Interchange, including Ramps B, C and D and Mainline Embankment Sta. 352+00 to Sta. 384+00, to have wick drains spaced at 6 feet.
- Complete embankments in 2 construction seasons.
- Reach 90% consolidation of TR 234 Ramp D, Mainline Embankment from Sta. 384+00 to Sta. 415+00, and Lucasville-Minford Ramps A, B, C and D in the second construction season.

- Reach 90% consolidation of Mainline Embankment Sta. 352+00 to Sta. 384+00, Mainline Embankment Sta. 520+00 to Sta. 537+00, and TR234 Ramps A, B, and C in the third construction season.

Constructability Benefits/Issues with Option 2

- Paving to begin from either intersection at beginning of third construction season.

COMPUTATIONS

SCENARIO 1

OPTION 1

Job No.	79784	PID No.	19415

HDR Computation

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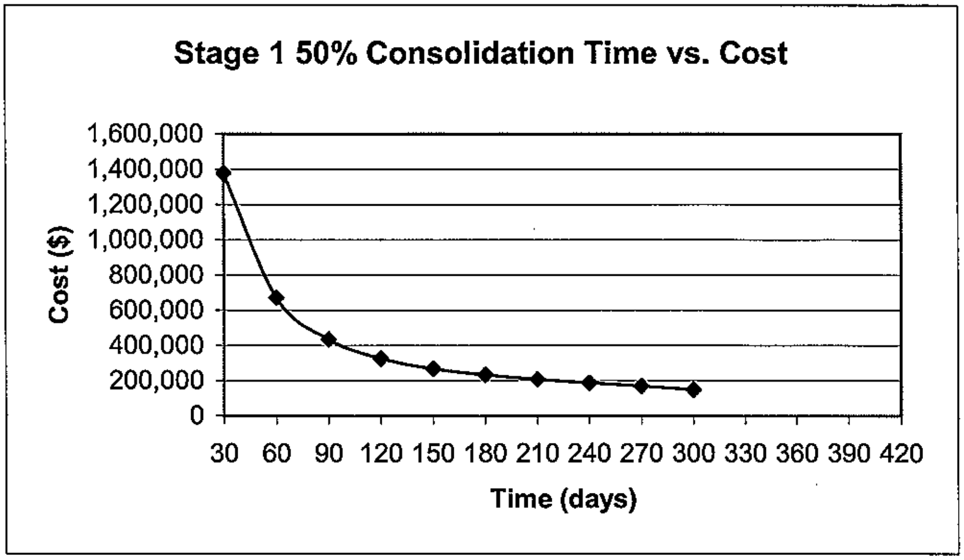
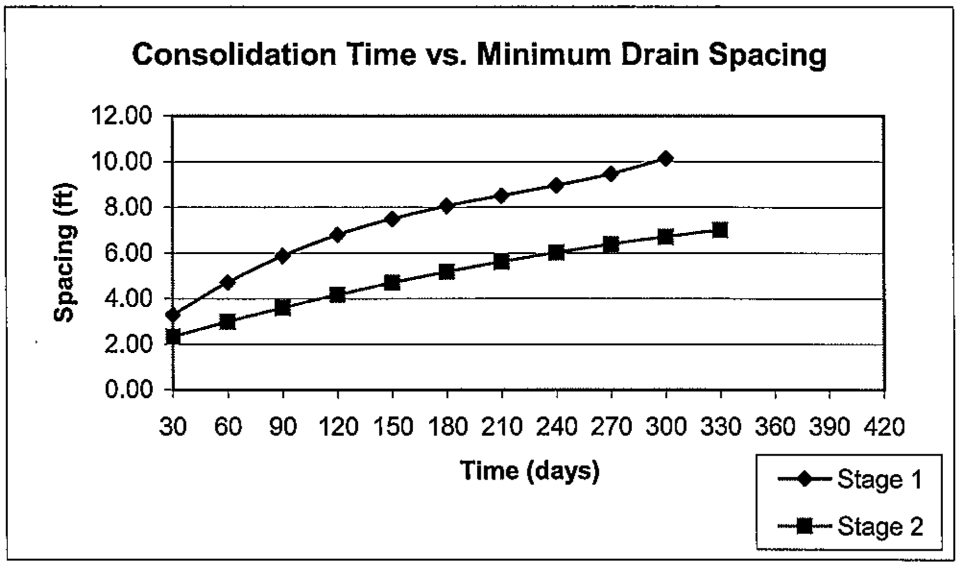
Subject	CR 28 Interchange	Checked	DMV	Date	5/1/2008
Task	Wick Drain Analyses - Idealized Case	Sheet	1	Of	1

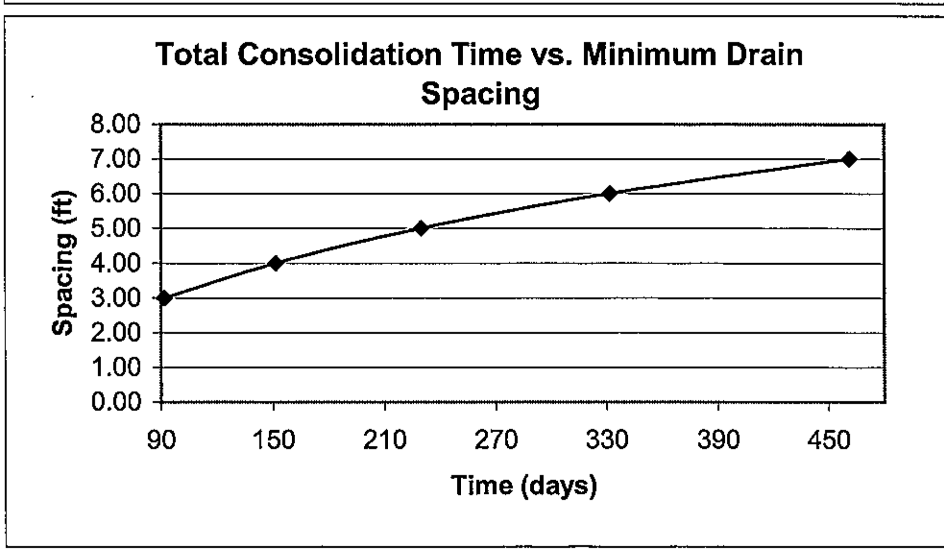
Stage 1 - 50% Consolidation		
Triangular Pattern		
t (days)	Spacing (ft)	Cost ($)
30	3.28	1,378,650
60	4.71	670,829
90	5.87	433,683
120	6.79	325,507
150	7.49	267,358
180	8.05	232,164
210	8.51	208,049
240	8.95	188,074
270	9.46	168,555
300	10.14	147,056



Stage 2 - 90% Consolidation		
Triangular Pattern		
t (days)	Spacing (ft)	Cost ($)
30	2.33	
60	2.99	
90	3.60	
120	4.17	
150	4.70	
180	5.18	
210	5.62	
240	6.02	
270	6.39	
300	6.71	
330	7.01	



Total Time	
Triangular Pattern	
t (days)	Spacing (ft)
92	3.00
151	4.00
230	5.00
332	6.00
461	7.00



Job No.	79784	PID No.	19415

HDR Computation

Project	SCI-823 Portsmouth Bypass	Computed	JSA	Date	4/8/2008
Subject	CR 28 Interchange	Checked	DMV	Date	5/1/2008
Task	Wick Drain Analyses - Idealized Case	Sheet	1	Of	2

References:

1. Federal Highway Administration, "Prefabricated Vertical Drains - A Design and Construction Guidelines Manual." FHWA/RD-86/168, Washington, DC.
2. Department of the Navy, Naval Facilities Engineering Command, "Soil Mechanics." NAVFAC Design Manual 7.1, May 1982, pp. 241-259.
3. Subsurface Exploration Bridge and MSE Retaining Walls SR 823 Over Relocated Shumway Hollow Road SCI-823-0.00, Portsmouth Bypass (DLZ, 2006)
4. SCI-823-6.81, Portsmouth Bypass Project, PID 19415, Addendum to Report: Lucasville-Minford Road (CR 28) (DLZ, 2008)

Assumptions:

1. Terzaghi's one-dimensional consolidation theory applies.
2. Radial drainage theory (as it relates to vertical drains) is a function of time, drain diameter, spacing, coefficient of consolidation, and average degree of desired consolidation.
3. Effect of disturbance related to soil displacement during installation is negligible.
4. Drain has infinite permeability (i.e. no drain resistance).

Input Values:

A =	560,368	sf	Total area at CR 28 Interchange to be drained (DLZ, 2008)
C =	$0.50	cost/lf	Material + Installation Cost
	Single		Vertical Drainage (Single or Double)
	Triangular		Wick Drain Pattern
t =	128	day	available time to achieve desired degree of consolidation U_h
H =	43.5	ft	height of compressible layer
a =	0.33333	ft	width of drain (Assume 4" wide x 1/4" thick)
b =	0.020833	ft	thickness of drain (Assume for 4" wide x 1/4" thick)
c_v =	0.081	ft^2/day	coefficient consolidation for vertical drainage (From Consolidation Tests on B-1 & B-2)
c_h =	0.0972	ft^2/day	coefficient consolidation for horizontal drainage

Note:

-General Case: $c_h = 1.2$ to $1.5*c_v$

-If layering of silt and sand in discontinuous lenses is evident: $c_h = 2$ to $4*c_v$

-For varved clays and other deposits containing embedded and more or less continuous permeable layers: c_h = up to $10*c_v$

Design Equations:

With vertical drains the overall average degree of consolidation, U, is the result of the combined effects of horizontal (radial) and vertical drainage. The combined effect is given by:

$$\overline{U} = 1-(1-\overline{U}_h)(1-\overline{U}_v) \quad \text{(See FHWA eq. 1)}$$

where,

U = overall average degree of consolidation

U_h = average degree of consolidation due to horizontal (or radial) drainage

U_v = average degree of consolidation due to vertical drainage

Check feasibility of 2 way vertical drainage only.

U_h = 0 %

Uv = 50 % t = 4585 days **Need to Consider Other Options.**

$U = U_v$ = 50 %

T_v = 0.19625

Calculate U_v that will occur in design period of t.

t = 128 day

$$T = \frac{tc_v}{H^2}$$

T_v = 0.01

U_v = 0.08

Calculate required U_h

$$\overline{U} = 1-(1-\overline{U}_h)(1-\overline{U}_v) \quad \text{(See FHWA eq. 1)}$$

U_h = 0.45

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HDR Computation

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$$t = \frac{D^2}{8c_h} F(n) \ln\left[\frac{1}{1-\bar{U}_h}\right]$$ (See FHWA eq. 8)

where,

t =	128 day	available time to achieve desired degree of consolidation U_h
$\bar{U}_h$ =	0.45	average degree of consolidation due to horizontal drainage
c_h =	0.0972 ft^2/day	coefficient of consolidation for horizontal drainage
$F(n)$ =	2.806234	drain spacing factor

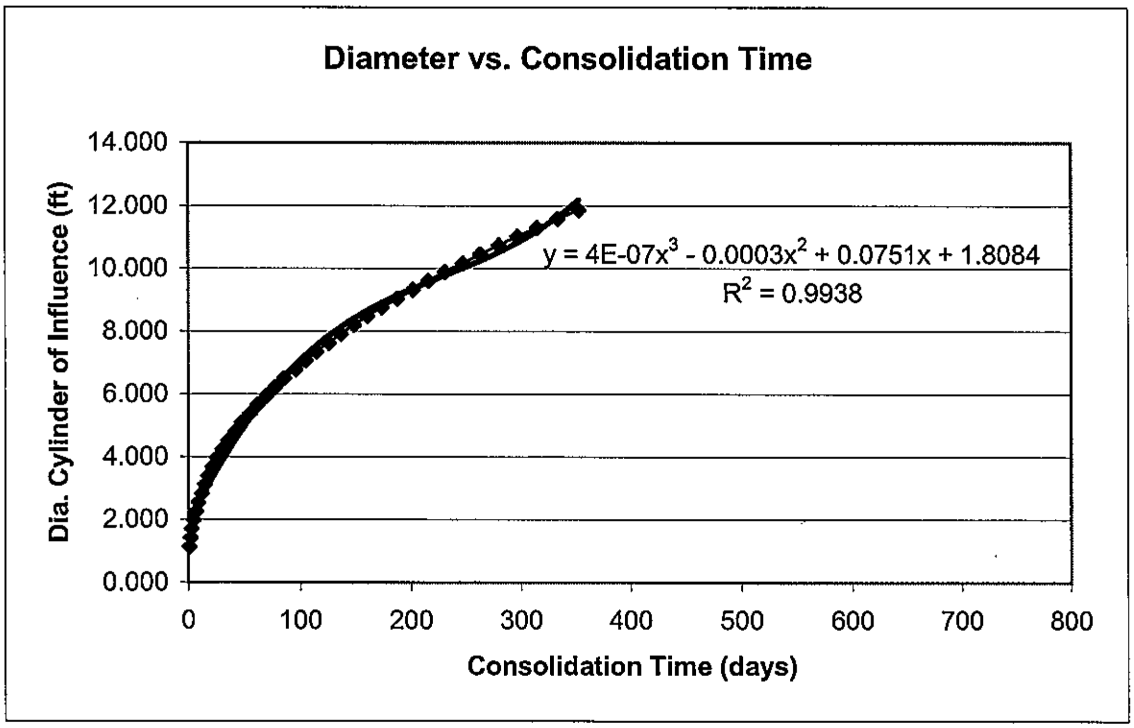
where,

$$F(n) = \ln\left(\frac{D}{d_w}\right) - 0.75$$ (simplified) (See FHWA eq. 3)

d_w = 2(a+b)/π — diameter of an equivalent circular drain (See FHWA eq. 9)

d_w = 0.23 ft

D = 7.902355 ft — required diameter of the cylinder of influence of the drain (drain influence zone) to achieve consolidation within given design period.



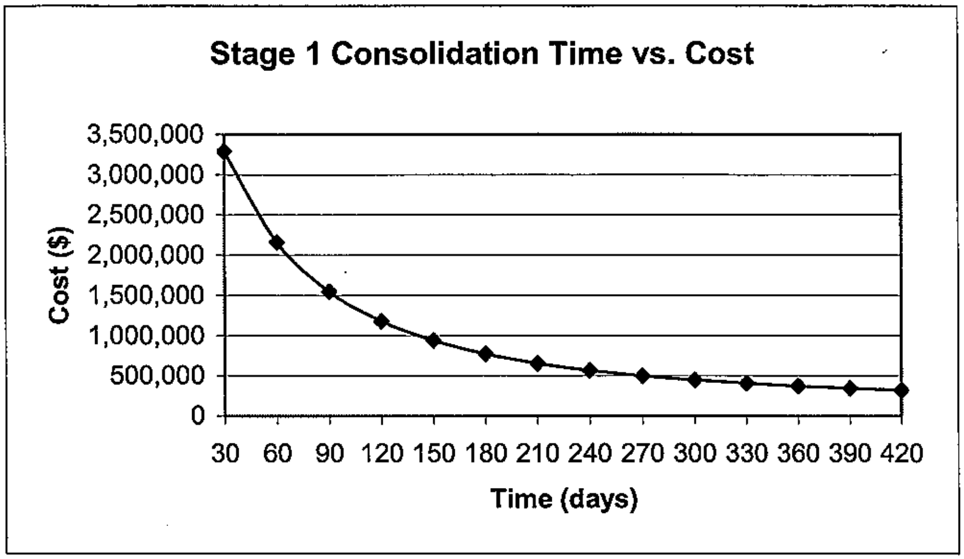
Optimum Drain Spacing based on required diameter of cyliner of influence to achieve primary consolidation within given design period: 6.99 ft

Length Outer Edge of Equilateral Triangle (or square) =	1137.59 ft
Number Drain Spaces Along Outer Edge =	162.67 ea
Total number wick drains =	13476 ea
Total linear feet wick drain =	613158 lf
Estimated total cost =	**$306,579.00**

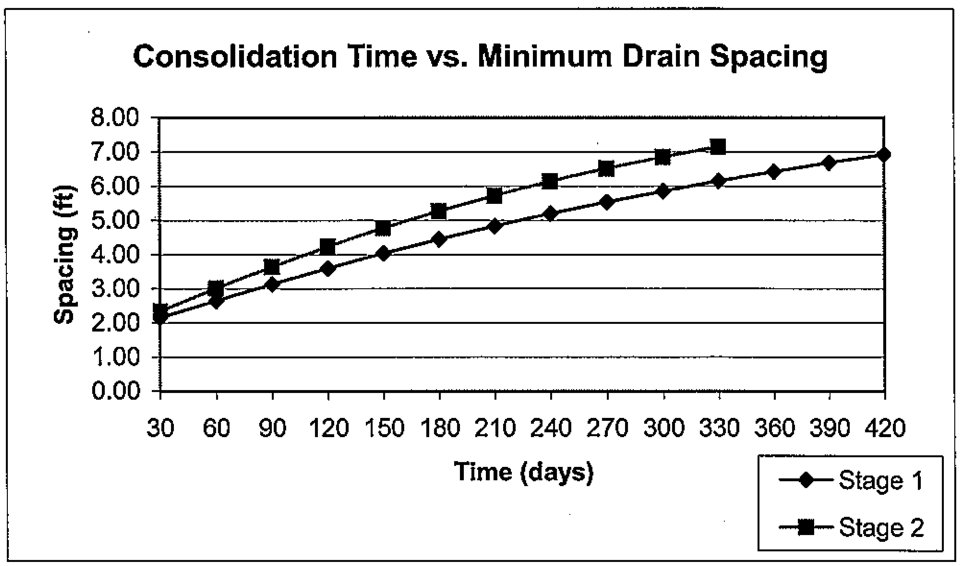
HDR Computation

Project	SCI-823 Portsmouth Bypass	Computed JSA	Date 4/17/2008
Subject	Shumway Hollow Road (TR 234) Interchange: Area #3 (Ramp D Area)	Checked DMV	Date 5/1/2008
Task	Wick Drain Analyses - Idealized Case	Sheet 1	Of 1

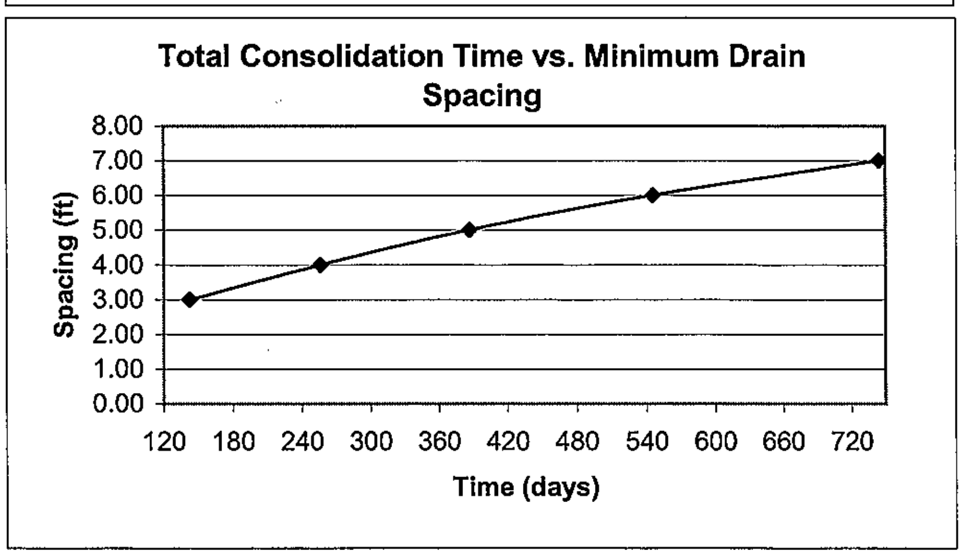
Stage 1		
Triangular Pattern		
t (days)	Spacing (ft)	Cost ($)
30	2.15	3,289,069
60	2.65	2,158,592
90	3.13	1,545,784
120	3.59	1,177,086
150	4.03	937,347
180	4.44	772,303
210	4.83	653,930
240	5.19	565,905
270	5.53	498,775
300	5.85	446,555
330	6.15	404,597
360	6.42	370,900
390	6.68	343,263
420	6.92	320,106



Stage 2		
Triangular Pattern		
t (days)	Spacing (ft)	Cost ($)
30	2.34	
60	3.01	
90	3.64	
120	4.23	
150	4.77	
180	5.27	
210	5.72	
240	6.14	
270	6.51	
300	6.85	
330	7.15	



Total Time	
Triangular Pattern	
t (days)	Spacing (ft)
142	3.00
256	4.00
386	5.00
545	6.00
744	7.00



HDR Computation

Project	SCI-823 Portsmouth Bypass	Computed JSA	Date 4/8/2008
Subject	Shumway Hollow Road (TR 234) Interchange	Checked DMV	Date 5/1/2008
Task	Wick Drain Analyses - Idealized Case	Sheet 1	Of 2

References:

1. Federal Highway Administration, "Prefabricated Vertical Drains - A Design and Construction Guidelines Manual." FHWA/RD-86/168, Washington, DC.
2. Department of the Navy, Naval Facilities Engineering Command, "Soil Mechanics." NAVFAC Design Manual 7.1, May 1982, pp. 241-259.
3. Subsurface Exploration Bridge and MSE Retaining Walls SR 823 Over Relocated Shumway Hollow Road SCI-823-0.00, Portsmouth Bypass (DLZ, 2006)
4. SCI-823-6.81, Portsmouth Bypass Project, PID 19415, Addendum to Report: Shumway Hollow Road (TR 234) (DLZ, 2008)

Assumptions:

1. Terzaghi's one-dimensional consolidation theory applies.
2. Radial drainage theory (as it relates to vertical drains) is a function of time, drain diameter, spacing, coefficient of consolidation, and average degree of desired consolidation.
3. Effect of disturbance related to soil displacement during installation is negligible.
4. Drain has infinite permeability (i.e. no drain resistance).

Input Values:

A =	842,862	sf	Total Area #3 (Ramp D Area) to be drained (DLZ, 2008)
C =	$0.50	cost/lf	Material + Installation Cost
	Single		Vertical Drainage (Single or Double)
	Triangular		Wick Drain Pattern
t =	225	day	available time to achieve desired degree of consolidation U_h
H =	29	ft	height of compressible layer
a =	0.33333	ft	width of drain (Assume 4" wide x 1/4" thick)
b =	0.020833	ft	thickness of drain (Assume for 4" wide x 1/4" thick)
c_v =	0.081	ft^2/day	coefficient consolidation for vertical drainage (From Consolidation Tests on B-1 & B-2)
c_h =	0.0972	ft^2/day	coefficient consolidation for horizontal drainage

Note:

-General Case: c_h = 1.2 to 1.5*c_v

-If layering of silt and sand in discontinuous lenses is evident: c_h = 2 to 4*c_v

-For varved clays and other deposits containing embedded and more or less continuous permeable layers: c_h = up to 10*c_v

Design Equations:

With vertical drains the overall average degree of consolidation, U, is the result of the combined effects of horizontal (radial) and vertical drainage. The combined effect is given by:

$$\overline{U} = 1-(1-\overline{U}_h)(1-\overline{U}_v)$$ (See FHWA eq. 1)

where,

U = overall average degree of consolidation
U_h = average degree of consolidation due to horizontal (or radial) drainage
U_v = average degree of consolidation due to vertical drainage

Check feasibility of 2 way vertical drainage only.

U_h = 0 %
Uv = 90 %
U = U_v = 90 %
T_v = 0.848

t = 8805 days **Need to Consider Other Options.**

Calculate U_v that will occur in design period of t.

t = 225 day

$$T = \frac{tc_v}{H^2}$$

T_v = 0.02
U_v = 0.17

Calculate required U_h

$$\overline{U} = 1-(1-\overline{U}_h)(1-\overline{U}_v)$$ (See FHWA eq. 1)

U_h = 0.88

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HDR Computation

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$$t=\frac{D^2}{8c_h}F(n)\ln\left[\frac{1}{1-\overline{U}_h}\right]$$ (See FHWA eq. 8)

where,

t =	225 day	available time to achieve desired degree of consolidation U_h
$\overline{U}_h$ =	0.88	average degree of consolidation due to horizontal drainage
c_h =	0.0972 ft^2/day	coefficient of consolidation for horizontal drainage
F(n) =	2.473098	drain spacing factor

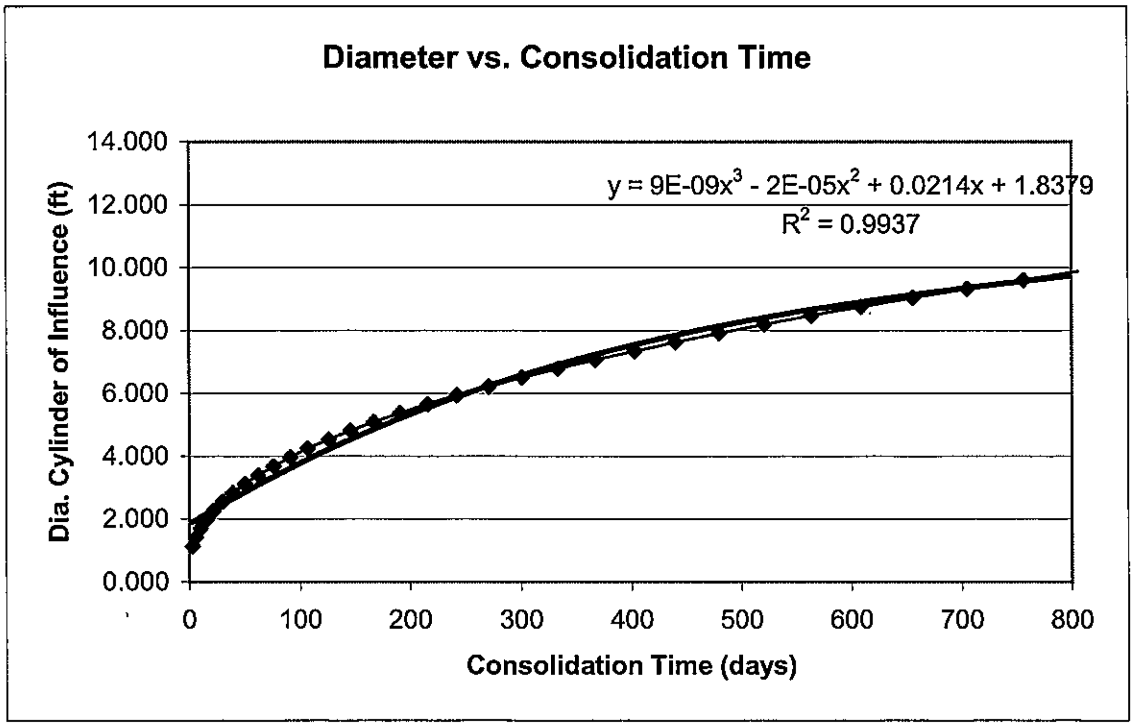
where,

$$F(n)=\ln\left(\frac{D}{d_w}\right)-0.75$$ (simplified) (See FHWA eq. 3)

d_w = 2(a+b)/π — diameter of an equivalent circular drain (See FHWA eq. 9)

d_w = 0.23 ft

D = 5.663406 ft — required diameter of the cylinder of influence of the drain (drain influence zone) to achieve consolidation within given design period.



Optimum Drain Spacing based on required diameter of cyliner of influence to achieve primary consolidation within given design period: **5.01 ft**

Length Outer Edge of Equilateral Triangle (or square) =	1395.17 ft
Number Drain Spaces Along Outer Edge =	278.37 ea
Total number wick drains =	39165 ea
Total linear feet wick drain =	1214115 lf
Estimated total cost =	**$607,057.50**

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HDR Computation

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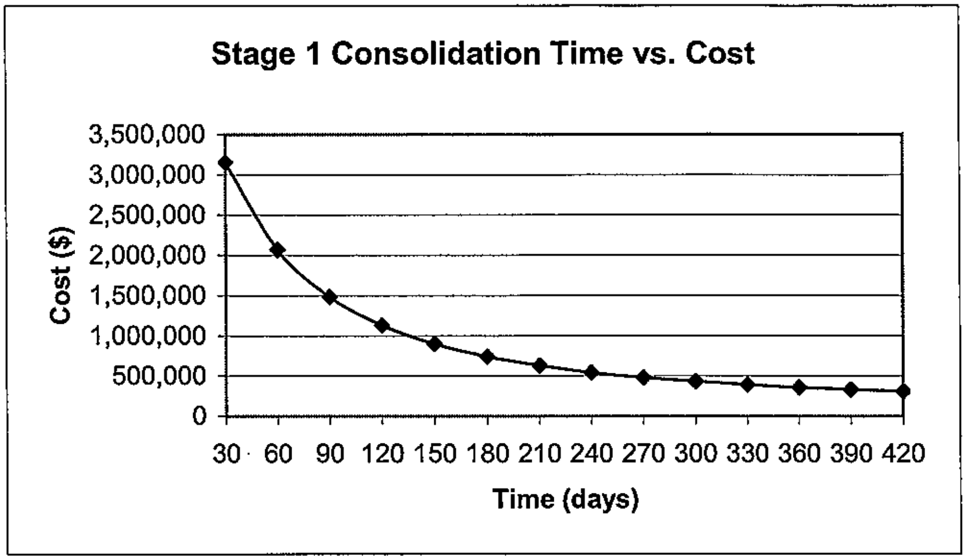
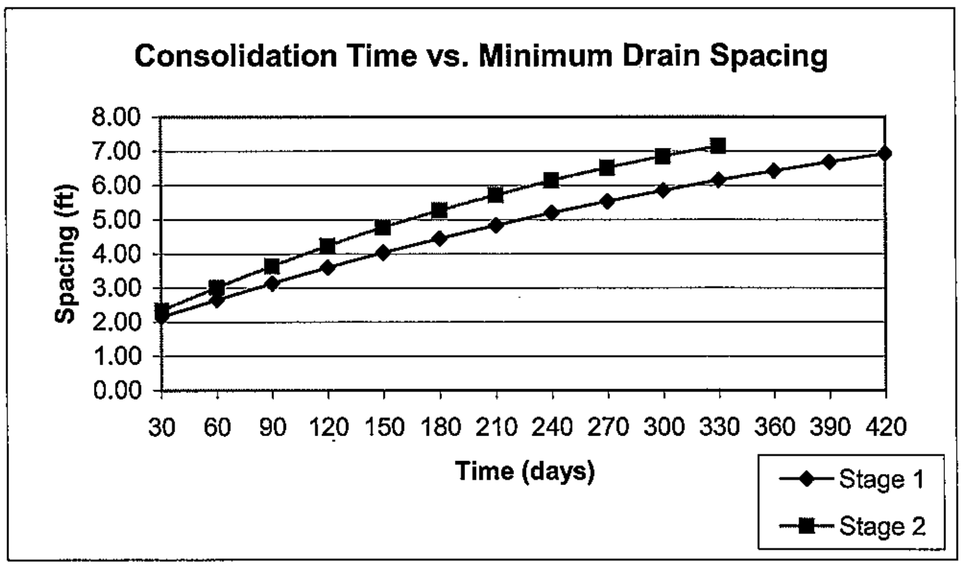
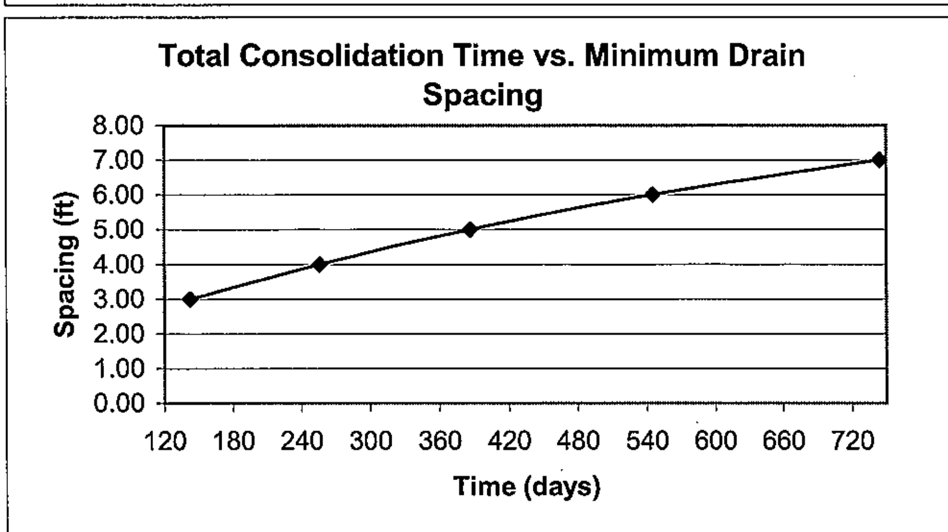
Stage 1		
Triangular Pattern		
t (days)	Spacing (ft)	Cost ($)
30	2.15	3,152,282
60	2.65	2,068,878
90	3.13	1,481,568
120	3.59	1,128,214
150	4.03	898,442
180	4.44	740,265
210	4.83	626,805
240	5.19	542,454
270	5.53	478,113
300	5.85	428,064
330	6.15	387,841
360	6.42	355,555
390	6.68	329,065
420	6.92	306,869



Stage 2		
Triangular Pattern		
t (days)	Spacing (ft)	Cost ($)
30	2.34	
60	3.01	
90	3.64	
120	4.23	
150	4.77	
180	5.27	
210	5.72	
240	6.14	
270	6.51	
300	6.85	
330	7.15	



Total Time	
Triangular Pattern	
t (days)	Spacing (ft)
142	3.00
256	4.00
386	5.00
545	6.00
744	7.00



HDR Computation

Project	SCI-823 Portsmouth Bypass	Computed	JSA	Date	4/8/2008
Subject	Shumway Hollow Road (TR 234) Interchange	Checked	DMV	Date	5/1/2008
Task	Wick Drain Analyses - Idealized Case	Sheet	1	Of	2

References:

1. Federal Highway Administration, "Prefabricated Vertical Drains - A Design and Construction Guidelines Manual." FHWA/RD-86/168, Washington, DC.
2. Department of the Navy, Naval Facilities Engineering Command, "Soil Mechanics." NAVFAC Design Manual 7.1, May 1982, pp. 241-259.
3. Subsurface Exploration Bridge and MSE Retaining Walls SR 823 Over Relocated Shumway Hollow Road SCI-823-0.00, Portsmouth Bypass (DLZ, 2006)
4. SCI-823-6.81, Portsmouth Bypass Project, PID 19415, Addendum to Report: Shumway Hollow Road (TR 234) (DLZ, 2008)

Assumptions:

1. Terzaghi's one-dimensional consolidation theory applies.
2. Radial drainage theory (as it relates to vertical drains) is a function of time, drain diameter, spacing, coefficient of consolidation, and average degree of desired consolidation.
3. Effect of disturbance related to soil displacement during installation is negligible.
4. Drain has infinite permeability (i.e. no drain resistance).

Input Values:

A =	807,730	sf	Total Areas #1 & #2 to be drained (DLZ, 2008)
C =	$0.50	cost/lf	Material + Installation Cost
	Single		Vertical Drainage (Single or Double)
	Triangular		Wick Drain Pattern
t =	315	day	available time to achieve desired degree of consolidation U_h
H =	29	ft	height of compressible layer
a =	0.33333	ft	width of drain (Assume 4" wide x 1/4" thick)
b =	0.020833	ft	thickness of drain (Assume for 4" wide x 1/4" thick)
c_v =	0.081	ft^2/day	coefficient consolidation for vertical drainage (From Consolidation Tests on B-1 & B-2)
c_h =	0.0972	ft^2/day	coefficient consolidation for horizontal drainage

Note:

-General Case: c_h = 1.2 to 1.5*c_v

-If layering of silt and sand in discontinuous lenses is evident: c_h = 2 to 4*c_v

-For varved clays and other deposits containing embedded and more or less continuous permeable layers: c_h = up to 10*c_v

Design Equations:

With vertical drains the overall average degree of consolidation, U, is the result of the combined effects of horizontal (radial) and vertical drainage. The combined effect is given by:

$$\overline{U} = 1-(1-\overline{U}_h)(1-\overline{U}_v)$$ (See FHWA eq. 1)

where,

U = overall average degree of consolidation
U_h = average degree of consolidation due to horizontal (or radial) drainage
U_v = average degree of consolidation due to vertical drainage

Check feasibility of 2 way vertical drainage only.

U_h = 0 %
Uv = 90 %
U = U_v = 90 %
T_v = 0.848

t = 8805 days **Need to Consider Other Options.**

Calculate U_v that will occur in design period of t.

t = 315 day

$$T = \frac{tc_v}{H^2}$$

T_v = 0.03
U_v = 0.20

Calculate required U_h

$$\overline{U} = 1-(1-\overline{U}_h)(1-\overline{U}_v)$$ (See FHWA eq. 1)

U_h = 0.88

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$$t = \frac{D^2}{8c_h} F(n) \ln\left[\frac{1}{1-\overline{U}_h}\right]$$ (See FHWA eq. 8)

where,

t =	315 day	available time to achieve desired degree of consolidation U_h
$\overline{U}_h$ =	0.88	average degree of consolidation due to horizontal drainage
c_h =	0.0972 ft^2/day	coefficient of consolidation for horizontal drainage
$F(n)$ =	2.6532	drain spacing factor

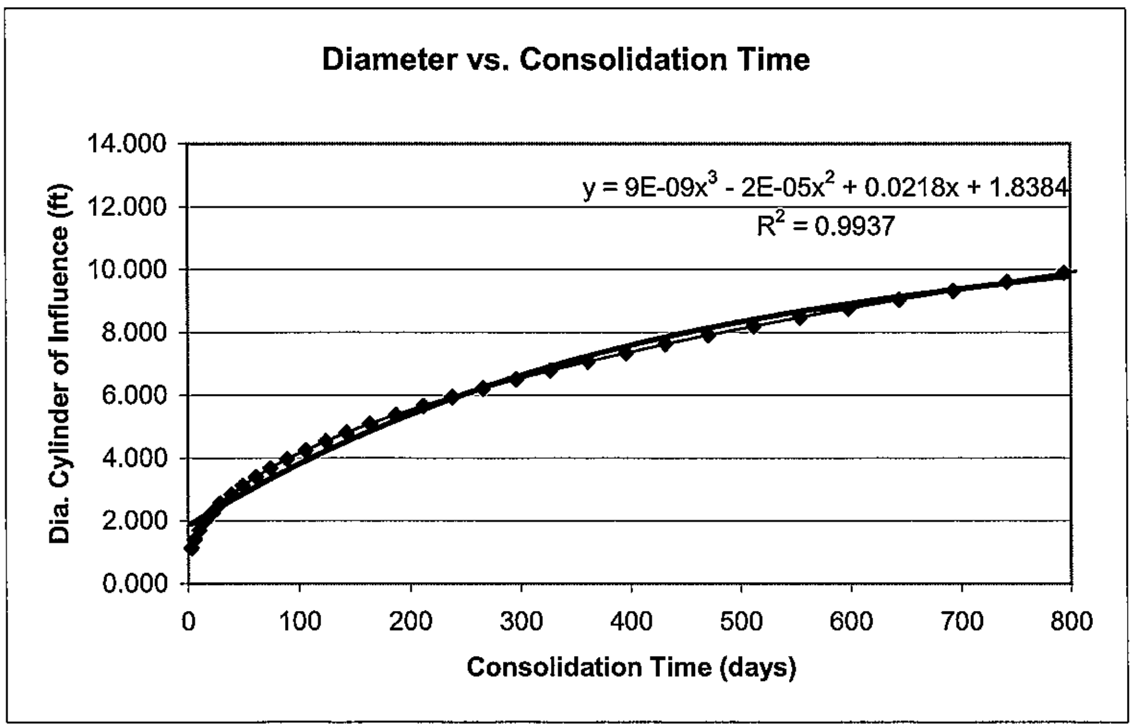
where,

$$F(n) = \ln\left(\frac{D}{d_w}\right) - 0.75$$ (simplified) (See FHWA eq. 3)

d_w = 2(a+b)/π — diameter of an equivalent circular drain (See FHWA eq. 9)

d_w = 0.23 ft

D = 6.781017 ft — required diameter of the cylinder of influence of the drain (drain influence zone) to achieve consolidation within given design period.



Optimum Drain Spacing based on required diameter of cyliner of influence to achieve primary consolidation within given design period: **6.00 ft**

Length Outer Edge of Equilateral Triangle (or square) =	1365.79 ft
Number Drain Spaces Along Outer Edge =	227.60 ea
Total number wick drains =	26243 ea
Total linear feet wick drain =	813533 lf
Estimated total cost =	**$406,766.50**

COMPUTATIONS

SCENARIO 1

OPTION 2

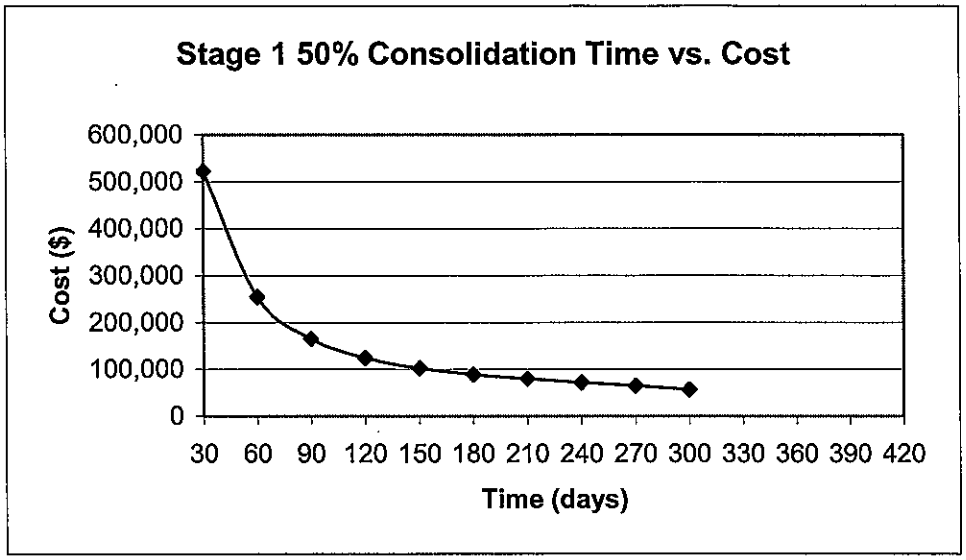
Job No.	79784	PID No.	19415

HDR Computation

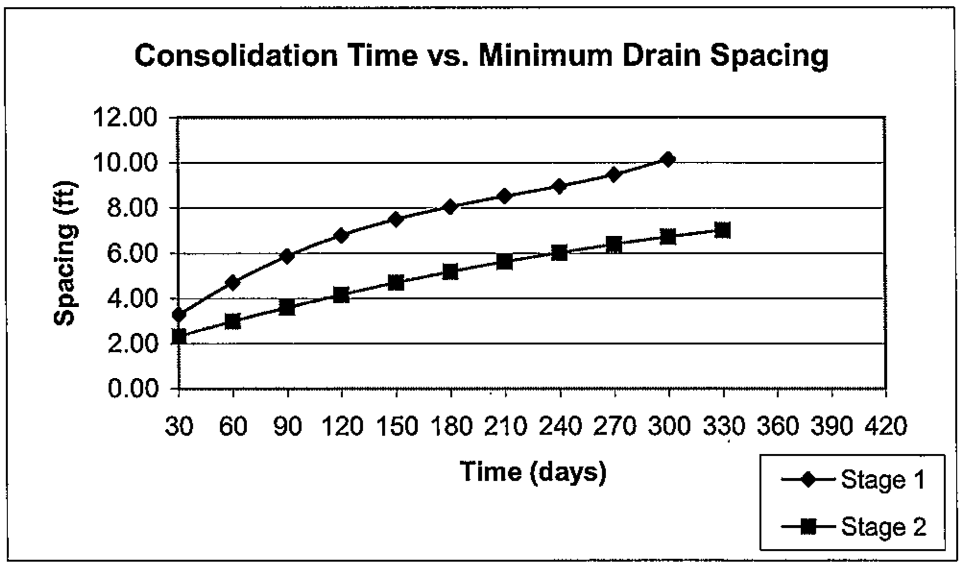
HDR

Project	SCI-823 Portsmouth Bypass	Computed	JSA	Date	4/17/2008
Subject	CR 28 Interchange: Ramps	Checked	DMV	Date	5/1/2008
Task	Wick Drain Analyses - Idealized Case	Sheet	1	Of	1

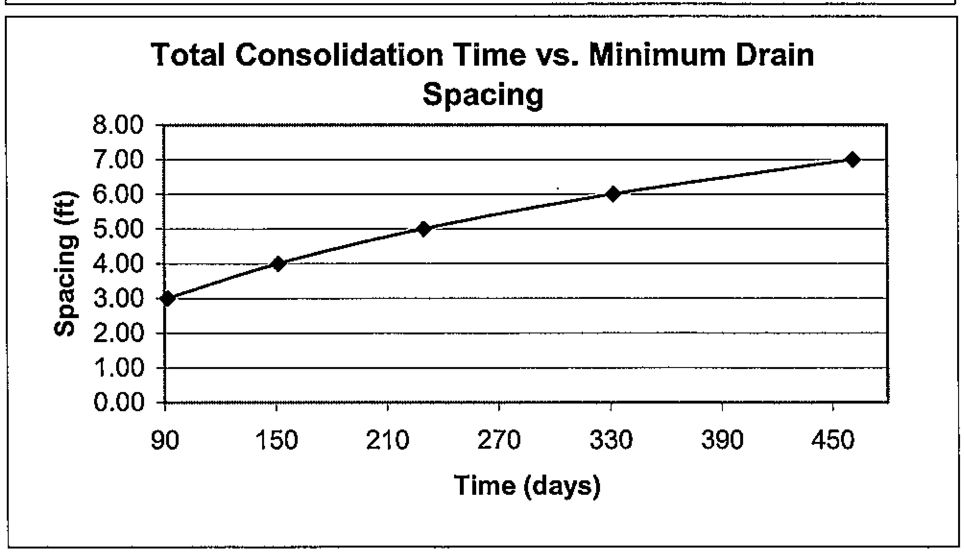
Stage 1 - 50% Consolidation		
Triangular Pattern		
t (days)	Spacing (ft)	Cost ($)
30	3.28	522,067
60	4.71	254,641
90	5.87	164,938
120	6.79	123,965
150	7.49	101,943
180	8.05	88,611
210	8.51	79,466
240	8.95	71,890
270	9.46	64,474
300	10.14	56,306



Stage 2 - 90% Consolidation		
Triangular Pattern		
t (days)	Spacing (ft)	Cost ($)
30	2.33	
60	2.99	
90	3.60	
120	4.17	
150	4.70	
180	5.18	
210	5.62	
240	6.02	
270	6.39	
300	6.71	
330	7.01	



Total Time	
Triangular Pattern	
t (days)	Spacing (ft)
92	3.00
151	4.00
230	5.00
332	6.00
461	7.00



HDR Computation

Project	SCI-823 Portsmouth Bypass	Computed	JSA	Date	4/8/2008
Subject	CR 28 Interchange	Checked	DMV	Date	5/1/2008
Task	Wick Drain Analyses - Idealized Case	Sheet	1	Of	2

References:

1. Federal Highway Administration, "Prefabricated Vertical Drains - A Design and Construction Guidelines Manual." FHWA/RD-86/168, Washington, DC.
2. Department of the Navy, Naval Facilities Engineering Command, "Soil Mechanics." NAVFAC Design Manual 7.1, May 1982, pp. 241-259.
3. Subsurface Exploration Bridge and MSE Retaining Walls SR 823 Over Relocated Shumway Hollow Road SCI-823-0.00, Portsmouth Bypass (DLZ, 2006)
4. SCI-823-6.81, Portsmouth Bypass Project, PID 19415, Addendum to Report: Lucasville-Minford Road (CR 28) (DLZ, 2008)

Assumptions:

1. Terzaghi's one-dimensional consolidation theory applies.
2. Radial drainage theory (as it relates to vertical drains) is a function of time, drain diameter, spacing, coefficient of consolidation, and average degree of desired consolidation.
3. Effect of disturbance related to soil displacement during installation is negligible.
4. Drain has infinite permeability (i.e. no drain resistance).

Input Values:

A =	211,055	sf	Total area along Ramps A, B, C and D at CR 28 Interchange to be drained (DLZ, 2008)
C =	$0.50	cost/lf	Material + Installation Cost
	Single		Vertical Drainage (Single or Double)
	Triangular		Wick Drain Pattern
t =	94	day	available time to achieve desired degree of consolidation U_h
H =	43.5	ft	height of compressible layer
a =	0.33333	ft	width of drain (Assume 4" wide x 1/4" thick)
b =	0.020833	ft	thickness of drain (Assume for 4" wide x 1/4" thick)
c_v =	0.081	ft^2/day	coefficient consolidation for vertical drainage (From Consolidation Tests on B-1 & B-2)
c_h =	0.0972	ft^2/day	coefficient consolidation for horizontal drainage

Note:

-General Case: c_h = 1.2 to 1.5*c_v

-If layering of silt and sand in discontinuous lenses is evident: c_h = 2 to 4*c_v

-For varved clays and other deposits containing embedded and more or less continuous permeable layers: c_h = up to 10*c_v

Design Equations:

With vertical drains the overall average degree of consolidation, U, is the result of the combined effects of horizontal (radial) and vertical drainage. The combined effect is given by:

$$\overline{U} = 1-(1-\overline{U}_h)(1-\overline{U}_v)$$ (See FHWA eq. 1)

where,

U = overall average degree of consolidation

U_h = average degree of consolidation due to horizontal (or radial) drainage

U_v = average degree of consolidation due to vertical drainage

Check feasibility of 2 way vertical drainage only.

U_h = 0 %

Uv = 50 %

U = U_v = 50 %

T_v = 0.19625

t = 4585 days **Need to Consider Other Options.**

Calculate U_v that will occur in design period of t.

t = 94 day

$$T = \frac{tc_v}{H^2}$$

T_v = 0.00

U_v = 0.07

Calculate required U_h

$$\overline{U} = 1-(1-\overline{U}_h)(1-\overline{U}_v)$$ (See FHWA eq. 1)

U_h = 0.46

Job No.	79784	PID No.	19415

HDR Computation

Project	SCI-823 Portsmouth Bypass	Computed	JSA	Date	4/8/2008
Subject	CR 28 Interchange	Checked	DMV	Date	5/1/2008
Task	Wick Drain Analyses - Idealized Case	Sheet	2	Of	2

$$t = \frac{D^2}{8c_h} F(n) \ln\left[\frac{1}{1-\overline{U}_h}\right]$$ (See FHWA eq. 8)

where,

t =	94 day	available time to achieve desired degree of consolidation U_h
$\overline{U}_h$ =	0.46	average degree of consolidation due to horizontal drainage
c_h =	0.0972 ft^2/day	coefficient of consolidation for horizontal drainage
F(n) =	2.654141	drain spacing factor

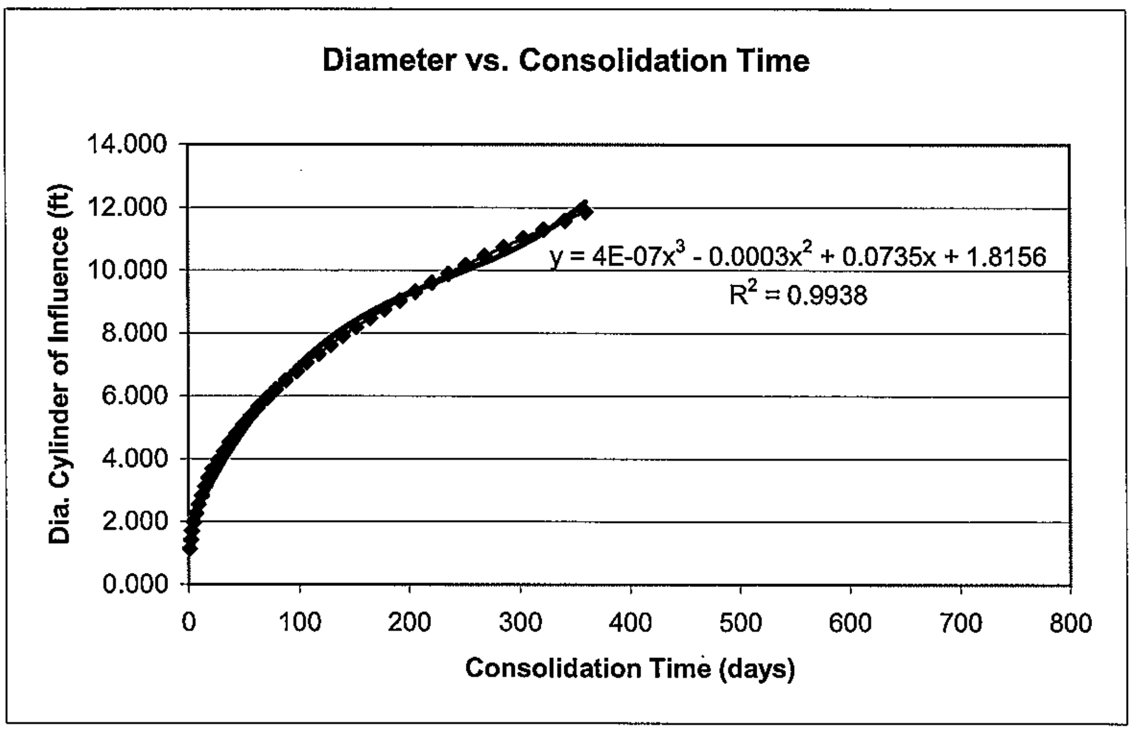
where,

$$F(n) = \ln\left(\frac{D}{d_w}\right) - 0.75$$ (simplified) (See FHWA eq. 3)

$d_w = 2(a+b)/\pi$ diameter of an equivalent circular drain (See FHWA eq. 9)

d_w = 0.23 ft

D = 6.787405 ft required diameter of the cylinder of influence of the drain (drain influence zone) to achieve consolidation within given design period.



Optimum Drain Spacing based on required diameter of cyliner of influence to achieve primary consolidation within given design period: **6.01 ft**

Length Outer Edge of Equilateral Triangle (or square) =	698.15 ft
Number Drain Spaces Along Outer Edge =	116.23 ea
Total number wick drains =	6931 ea
Total linear feet wick drain =	315361 lf
Estimated total cost =	**$157,680.25**

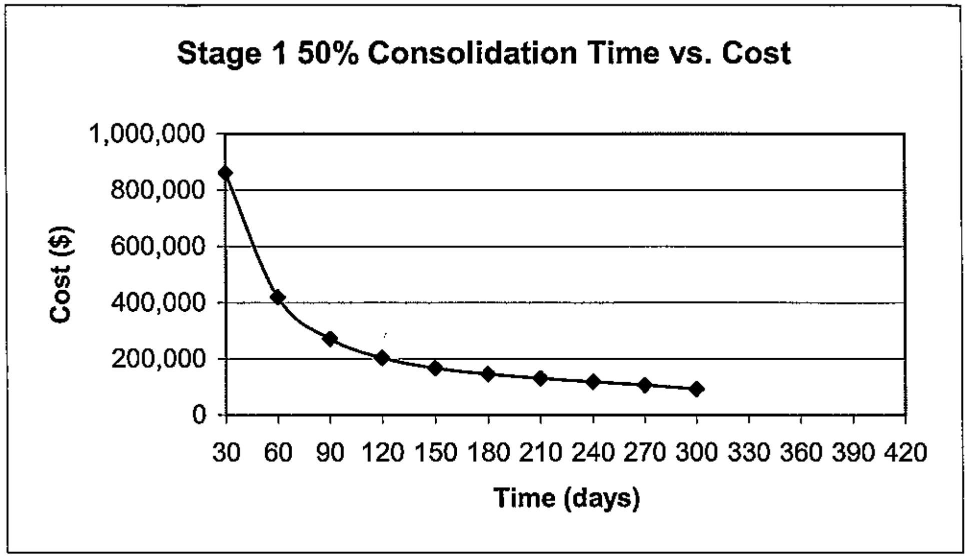
Job No. 79784	PID No. 19415

HDR Computation

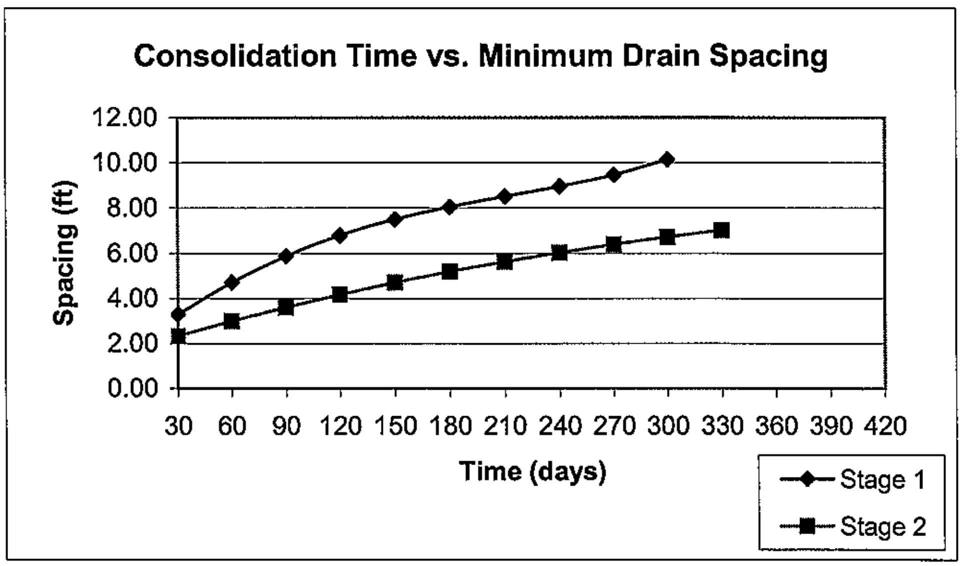
HDR

Project	SCI-823 Portsmouth Bypass	Computed	JSA	Date	4/17/2008
Subject	CR 28 Interchange: Mainline Sta 520+00 to Sta 537+00	Checked	DMV	Date	5/1/2008
Task	Wick Drain Analyses - Idealized Case	Sheet	1	Of	1

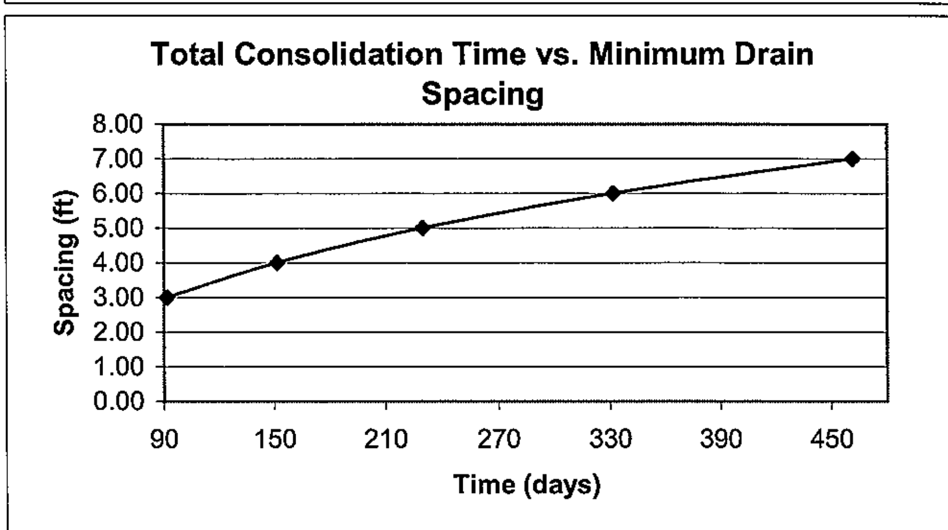
Stage 1 - 50% Consolidation		
Triangular Pattern		
t (days)	Spacing (ft)	Cost ($)
30	3.28	861,383
60	4.71	419,556
90	5.87	271,453
120	6.79	203,863
150	7.49	167,531
180	8.05	145,532
210	8.51	130,471
240	8.95	117,959
270	9.46	105,765
300	10.14	92,320



Stage 2 - 90% Consolidation		
Triangular Pattern		
t (days)	Spacing (ft)	Cost ($)
30	2.33	
60	2.99	
90	3.60	
120	4.17	
150	4.70	
180	5.18	
210	5.62	
240	6.02	
270	6.39	
300	6.71	
330	7.01	



Total Time	
Triangular Pattern	
t (days)	Spacing (ft)
92	3.00
151	4.00
230	5.00
332	6.00
461	7.00



Job No.	79784	PID No.	19415

HDR Computation

Project	SCI-823 Portsmouth Bypass	Computed	JSA	Date	4/8/2008
Subject	CR 28 Interchange	Checked	DMV	Date	5/1/2008
Task	Wick Drain Analyses - Idealized Case	Sheet	1	Of	2

References:

1. Federal Highway Administration, "Prefabricated Vertical Drains - A Design and Construction Guidelines Manual." FHWA/RD-86/168, Washington, DC.
2. Department of the Navy, Naval Facilities Engineering Command, "Soil Mechanics." NAVFAC Design Manual 7.1, May 1982, pp. 241-259.
3. Subsurface Exploration Bridge and MSE Retaining Walls SR 823 Over Relocated Shumway Hollow Road SCI-823-0.00, Portsmouth Bypass (DLZ, 2006)
4. SCI-823-6.81, Portsmouth Bypass Project, PID 19415, Addendum to Report: Lucasville-Minford Road (CR 28) (DLZ, 2008)

Assumptions:

1. Terzaghi's one-dimensional consolidation theory applies.
2. Radial drainage theory (as it relates to vertical drains) is a function of time, drain diameter, spacing, coefficient of consolidation, and average degree of desired consolidation.
3. Effect of disturbance related to soil displacement during installation is negligible.
4. Drain has infinite permeability (i.e. no drain resistance).

Input Values:

A =	349,313	sf	Total area along Mainline Sta 520+00 to Sta 537+00 at CR 28 Interchange to be drained (DLZ, 2008)
C =	$0.50	cost/lf	Material + Installation Cost
	Single		Vertical Drainage (Single or Double)
	Triangular		Wick Drain Pattern
t =	128	day	available time to achieve desired degree of consolidation U_h
H =	43.5	ft	height of compressible layer
a =	0.33333	ft	width of drain (Assume 4" wide x 1/4" thick)
b =	0.020833	ft	thickness of drain (Assume for 4" wide x 1/4" thick)
c_v =	0.081	ft^2/day	coefficient consolidation for vertical drainage (From Consolidation Tests on B-1 & B-2)
c_h =	0.0972	ft^2/day	coefficient consolidation for horizontal drainage

Note:

-General Case: c_h = 1.2 to 1.5*c_v

-If layering of silt and sand in discontinuous lenses is evident: c_h = 2 to 4*c_v

-For varved clays and other deposits containing embedded and more or less continuous permeable layers: c_h = up to 10*c_v

Design Equations:

With vertical drains the overall average degree of consolidation, U, is the result of the combined effects of horizontal (radial) and vertical drainage. The combined effect is given by:

$$\overline{U} = 1 - (1 - \overline{U}_h)(1 - \overline{U}_v)$$ (See FHWA eq. 1)

where,

U = overall average degree of consolidation

U_h = average degree of consolidation due to horizontal (or radial) drainage

U_v = average degree of consolidation due to vertical drainage

Check feasibility of 2 way vertical drainage only.

U_h = 0 %

Uv = 50 %

U = U_v = 50 %

T_v = 0.19625

t = 4585 days **Need to Consider Other Options.**

Calculate U_v that will occur in design period of t.

t = 128 day

$$T = \frac{tc_v}{H^2}$$

T_v = 0.01

U_v = 0.08

Calculate required U_h

$$\overline{U} = 1 - (1 - \overline{U}_h)(1 - \overline{U}_v)$$ (See FHWA eq. 1)

U_h = 0.45

Job No.	79784	PID No.	19415

HDR Computation

Project	SCI-823 Portsmouth Bypass	Computed	JSA	Date	4/8/2008
Subject	CR 28 Interchange	Checked	DMV	Date	5/1/2008
Task	Wick Drain Analyses - Idealized Case	Sheet	2	Of	2

$$t = \frac{D^2}{8c_h} F(n) \ln\left[\frac{1}{1-\bar{U}_h}\right]$$ (See FHWA eq. 8)

where,

$t =$ 128 day — available time to achieve desired degree of consolidation U_h

$\bar{U}_h =$ 0.45 — average degree of consolidation due to horizontal drainage

$c_h =$ 0.0972 ft^2/day — coefficient of consolidation for horizontal drainage

$F(n) =$ 2.806234 — drain spacing factor

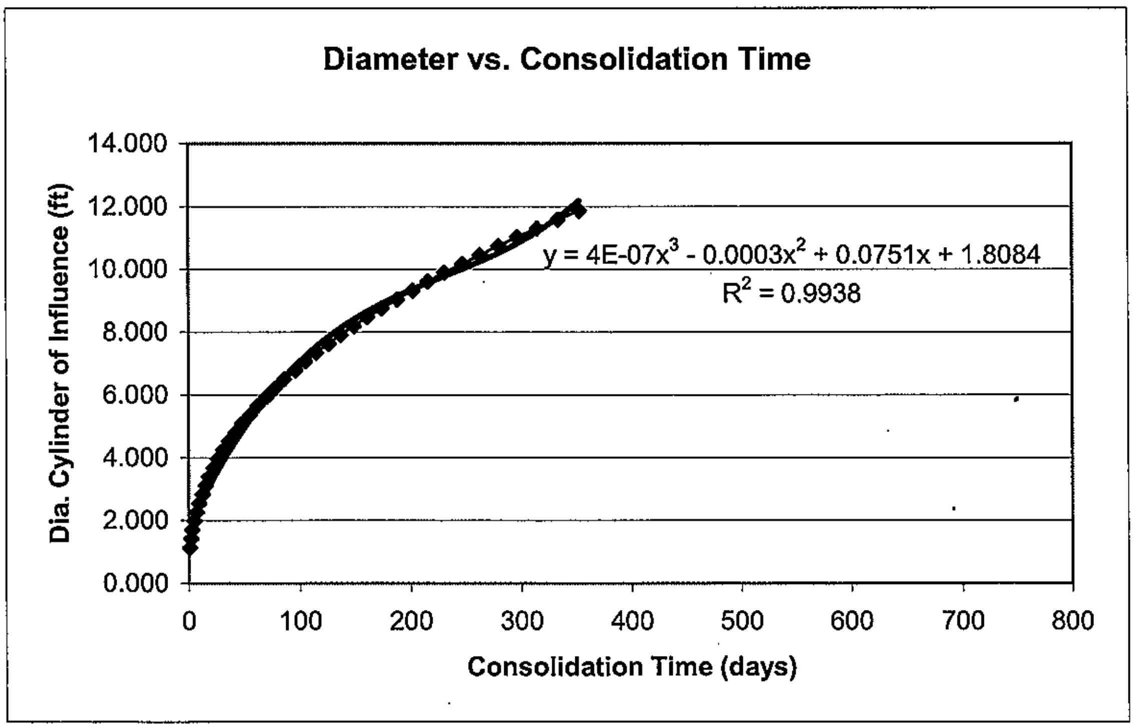
where,

$$F(n) = \ln\left(\frac{D}{d_w}\right) - 0.75$$ (simplified) (See FHWA eq. 3)

$d_w = 2(a+b)/\pi$ — diameter of an equivalent circular drain (See FHWA eq. 9)

$d_w =$ 0.23 ft

$D =$ 7.902355 ft — required diameter of the cylinder of influence of the drain (drain influence zone) to achieve consolidation within given design period.



Optimum Drain Spacing based on required diameter of cyliner of influence to achieve primary consolidation within given design period: 6.99 ft

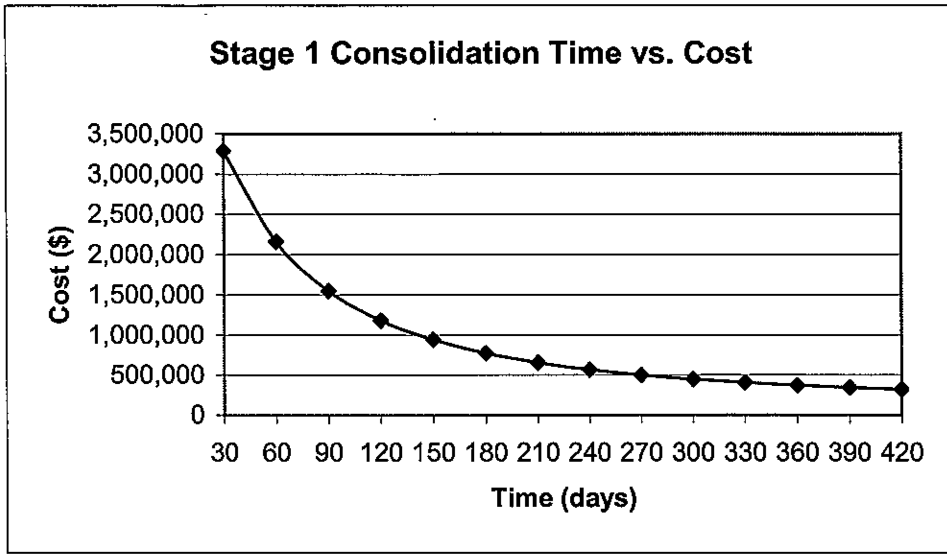
Length Outer Edge of Equilateral Triangle (or square) =	898.17 ft
Number Drain Spaces Along Outer Edge =	128.43 ea
Total number wick drains =	8442 ea
Total linear feet wick drain =	384111 lf
Estimated total cost =	$192,055.50

Job No.	79784	PID No.	19415

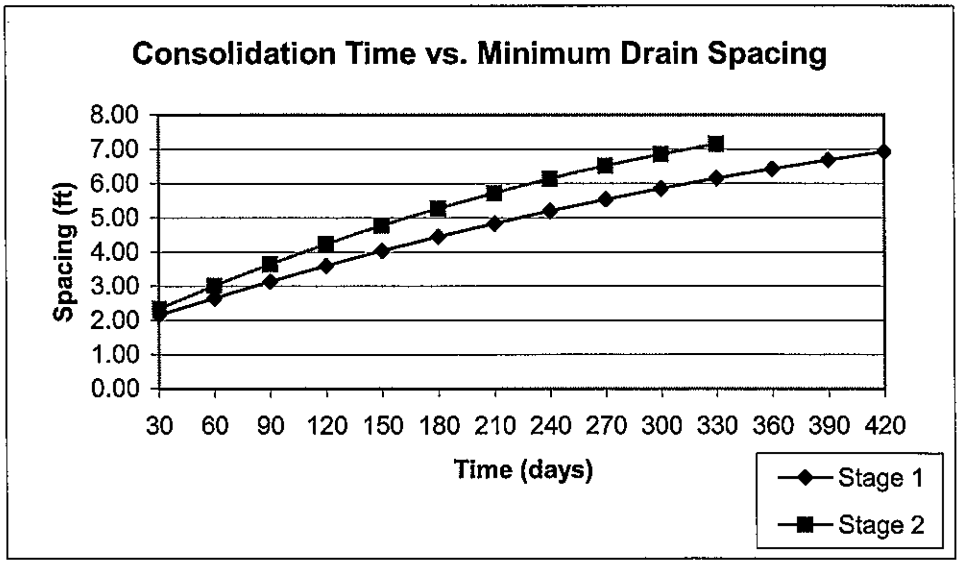
HDR Computation

Project	SCI-823 Portsmouth Bypass	Computed	JSA	Date	4/17/2008
Subject	Shumway Hollow Road (TR 234) Interchange: Area #3 (Ramp D Area)	Checked	DMV	Date	5/1/2008
Task	Wick Drain Analyses - Idealized Case	Sheet	1	Of	1

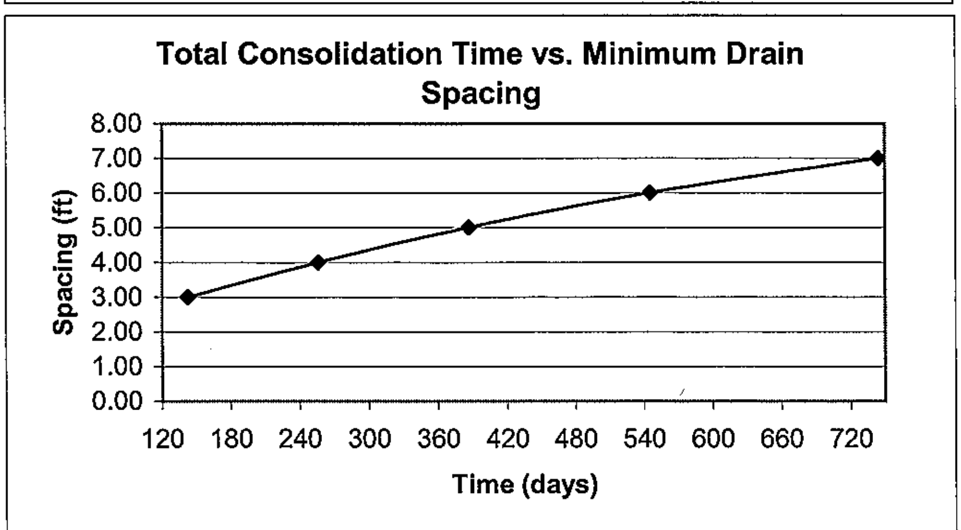
Stage 1		
Triangular Pattern		
t (days)	Spacing (ft)	Cost ($)
30	2.15	3,289,069
60	2.65	2,158,592
90	3.13	1,545,784
120	3.59	1,177,086
150	4.03	937,347
180	4.44	772,303
210	4.83	653,930
240	5.19	565,905
270	5.53	498,775
300	5.85	446,555
330	6.15	404,597
360	6.42	370,900
390	6.68	343,263
420	6.92	320,106



Stage 2		
Triangular Pattern		
t (days)	Spacing (ft)	Cost ($)
30	2.34	
60	3.01	
90	3.64	
120	4.23	
150	4.77	
180	5.27	
210	5.72	
240	6.14	
270	6.51	
300	6.85	
330	7.15	



Total Time	
Triangular Pattern	
t (days)	Spacing (ft)
142	3.00
256	4.00
386	5.00
545	6.00
744	7.00



HDR Computation

Project	SCI-823 Portsmouth Bypass	Computed	JSA	Date	4/8/2008
Subject	Shumway Hollow Road (TR 234) Interchange	Checked	DMV	Date	5/1/2008
Task	Wick Drain Analyses - Idealized Case	Sheet	1	Of	2

References:

1. Federal Highway Administration, "Prefabricated Vertical Drains - A Design and Construction Guidelines Manual." FHWA/RD-86/168, Washington, DC.
2. Department of the Navy, Naval Facilities Engineering Command, "Soil Mechanics." NAVFAC Design Manual 7.1, May 1982, pp. 241-259.
3. Subsurface Exploration Bridge and MSE Retaining Walls SR 823 Over Relocated Shumway Hollow Road SCI-823-0.00, Portsmouth Bypass (DLZ, 2006)
4. SCI-823-6.81, Portsmouth Bypass Project, PID 19415, Addendum to Report: Shumway Hollow Road (TR 234) (DLZ, 2008)

Assumptions:

1. Terzaghi's one-dimensional consolidation theory applies.
2. Radial drainage theory (as it relates to vertical drains) is a function of time, drain diameter, spacing, coefficient of consolidation, and average degree of desired consolidation.
3. Effect of disturbance related to soil displacement during installation is negligible.
4. Drain has infinite permeability (i.e. no drain resistance).

Input Values:

A =	842,862	sf	Total Area #3 (Ramp D Area) to be drained (DLZ, 2008)
C =	$0.50	cost/lf	Material + Installation Cost
	Single		Vertical Drainage (Single or Double)
	Triangular		Wick Drain Pattern
t =	225	day	available time to achieve desired degree of consolidation U_h
H =	29	ft	height of compressible layer
a =	0.33333	ft	width of drain (Assume 4" wide x 1/4" thick)
b =	0.020833	ft	thickness of drain (Assume for 4" wide x 1/4" thick)
c_v =	0.081	ft^2/day	coefficient consolidation for vertical drainage (From Consolidation Tests on B-1 & B-2)
c_h =	0.0972	ft^2/day	coefficient consolidation for horizontal drainage

Note:

-General Case: c_h = 1.2 to 1.5*c_v

-If layering of silt and sand in discontinuous lenses is evident: c_h = 2 to 4*c_v

-For varved clays and other deposits containing embedded and more or less continuous permeable layers: c_h = up to 10*c_v

Design Equations:

With vertical drains the overall average degree of consolidation, U, is the result of the combined effects of horizontal (radial) and vertical drainage. The combined effect is given by:

$$\overline{U} = 1-(1-\overline{U}_h)(1-\overline{U}_v)$$ (See FHWA eq. 1)

where,

U = overall average degree of consolidation
U_h = average degree of consolidation due to horizontal (or radial) drainage
U_v = average degree of consolidation due to vertical drainage

Check feasibility of 2 way vertical drainage only.

U_h = 0 %
Uv = 90 %   t = 8805 days **Need to Consider Other Options.**
$U = U_v$ = 90 %
T_v = 0.848

Calculate U_v that will occur in design period of t.

t = 225 day

$$T = \frac{tc_v}{H^2}$$

T_v = 0.02
U_v = 0.17

Calculate required U_h

$$\overline{U} = 1-(1-\overline{U}_h)(1-\overline{U}_v)$$ (See FHWA eq. 1)

U_h = 0.88

Job No.	79784	PID No.	19415

HDR Computation

Project	SCI-823 Portsmouth Bypass	Computed	JSA	Date	4/8/2008
Subject	Shumway Hollow Road (TR 234) Interchange	Checked	DMV	Date	5/1/2008
Task	Wick Drain Analyses - Idealized Case	Sheet	2	Of	2

$$t = \frac{D^2}{8c_h} F(n) \ln\left[\frac{1}{1-\overline{U}_h}\right]$$ (See FHWA eq. 8)

where,

t =	225 day	available time to achieve desired degree of consolidation U_h
$\overline{U}_h$ =	0.88	average degree of consolidation due to horizontal drainage
c_h =	0.0972 ft^2/day	coefficient of consolidation for horizontal drainage
$F(n)$ =	2.473098	drain spacing factor

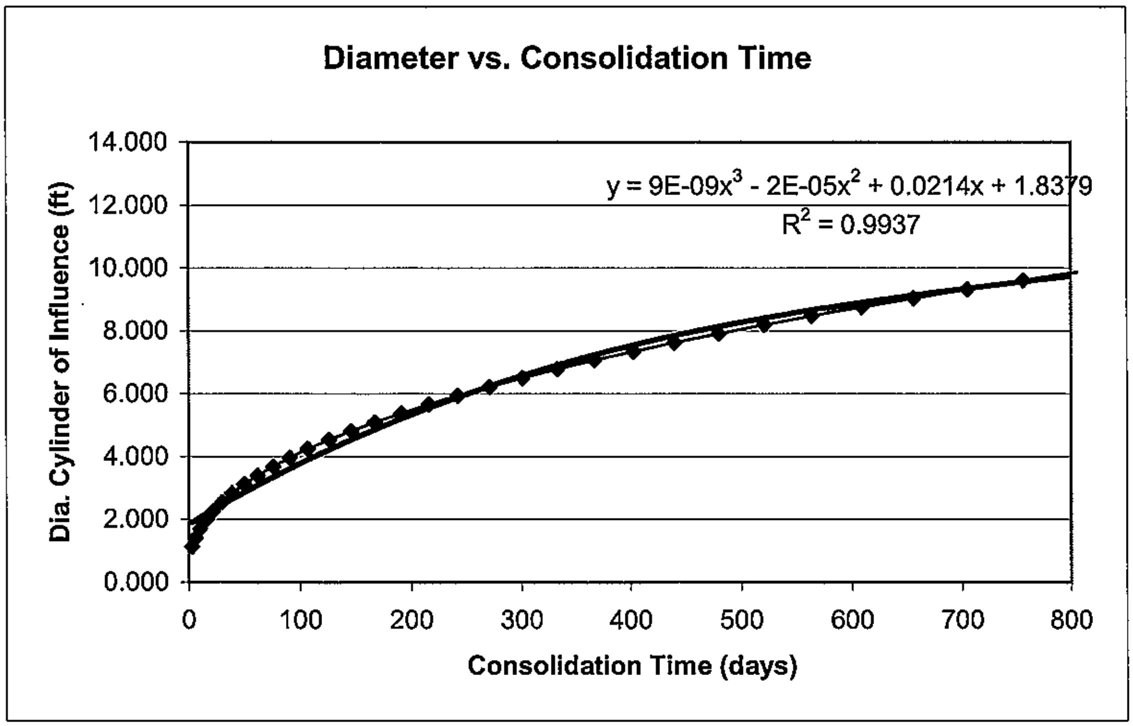
where,

$$F(n) = \ln\left(\frac{D}{d_w}\right) - 0.75$$ (simplified) (See FHWA eq. 3)

d_w = 2(a+b)/π — diameter of an equivalent circular drain (See FHWA eq. 9)

d_w = 0.23 ft

D = 5.663406 ft — required diameter of the cylinder of influence of the drain (drain influence zone) to achieve consolidation within given design period.



Optimum Drain Spacing based on required diameter of cyliner of influence to achieve primary consolidation within given design period: 5.01 ft

Length Outer Edge of Equilateral Triangle (or square) =	1395.17 ft
Number Drain Spaces Along Outer Edge =	278.37 ea
Total number wick drains =	39165 ea
Total linear feet wick drain =	1214115 lf
Estimated total cost =	**$607,057.50**

Job No. 79784 | PID No. 19415

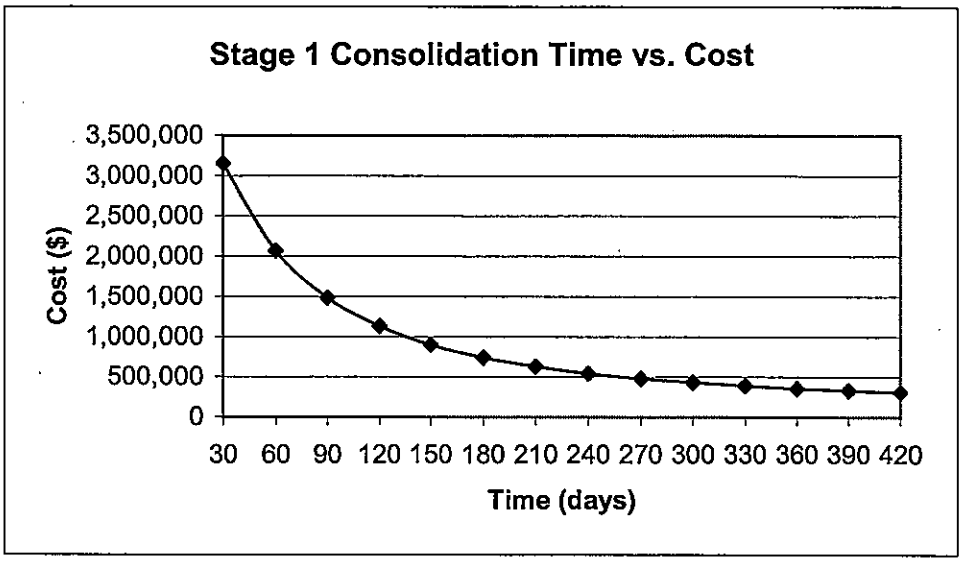
HDR Computation

Project: SCI-823 Portsmouth Bypass | Computed: JSA | Date: 4/17/2008

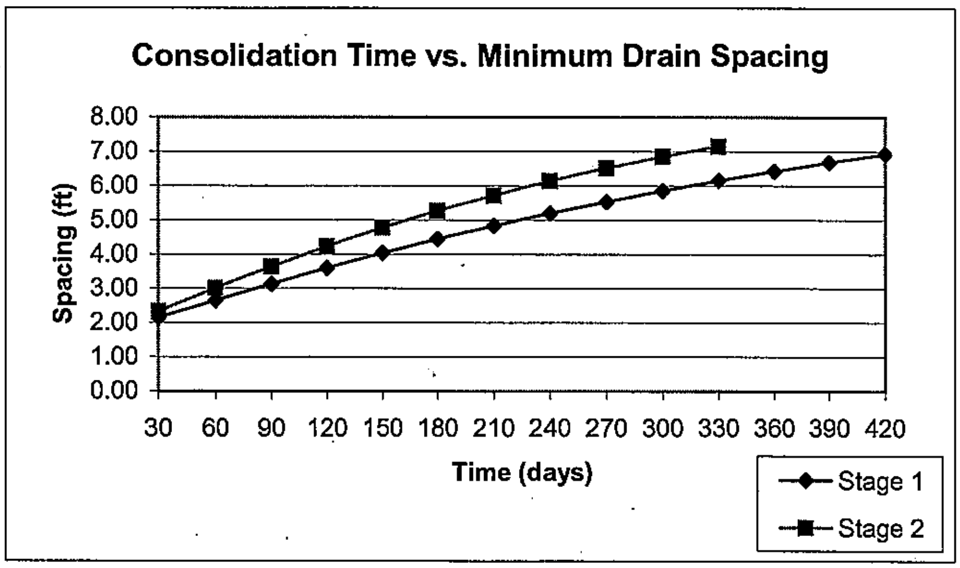
Subject: Shumway Hollow Road (TR 234) Interchange: Areas #1 & #2 | Checked: DMV | Date: 5/1/2008

Task: Wick Drain Analyses - Idealized Case | Sheet 1 | Of 1

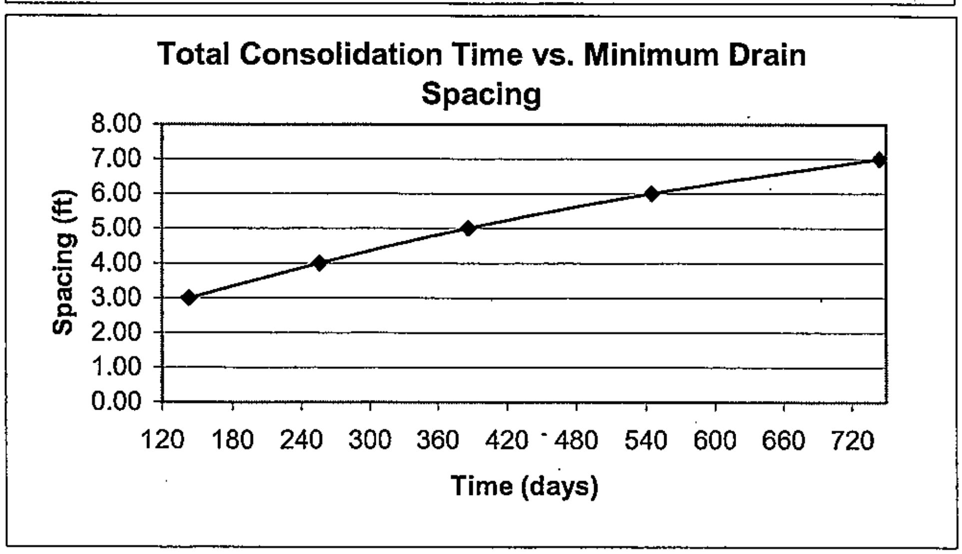
Stage 1		
Triangular Pattern		
t (days)	Spacing (ft)	Cost ($)
30	2.15	3,152,282
60	2.65	2,068,878
90	3.13	1,481,568
120	3.59	1,128,214
150	4.03	898,442
180	4.44	740,265
210	4.83	626,805
240	5.19	542,454
270	5.53	478,113
300	5.85	428,064
330	6.15	387,841
360	6.42	355,555
390	6.68	329,065
420	6.92	306,869



Stage 2		
Triangular Pattern		
t (days)	Spacing (ft)	Cost ($)
30	2.34	
60	3.01	
90	3.64	
120	4.23	
150	4.77	
180	5.27	
210	5.72	
240	6.14	
270	6.51	
300	6.85	
330	7.15	



Total Time	
Triangular Pattern	
t (days)	Spacing (ft)
142	3.00
256	4.00
386	5.00
545	6.00
744	7.00



HDR Computation

Project	SCI-823 Portsmouth Bypass	Computed	JSA	Date	4/8/2008
Subject	Shumway Hollow Road (TR 234) Interchange	Checked	DMV	Date	5/1/2008
Task	Wick Drain Analyses - Idealized Case	Sheet	1	Of	2

References:

1. Federal Highway Administration, "Prefabricated Vertical Drains - A Design and Construction Guidelines Manual." FHWA/RD-86/168, Washington, DC.
2. Department of the Navy, Naval Facilities Engineering Command, "Soil Mechanics." NAVFAC Design Manual 7.1, May 1982, pp. 241-259.
3. Subsurface Exploration Bridge and MSE Retaining Walls SR 823 Over Relocated Shumway Hollow Road SCI-823-0.00, Portsmouth Bypass (DLZ, 2006)
4. SCI-823-6.81, Portsmouth Bypass Project, PID 19415, Addendum to Report: Shumway Hollow Road (TR 234) (DLZ, 2008)

Assumptions:

1. Terzaghi's one-dimensional consolidation theory applies.
2. Radial drainage theory (as it relates to vertical drains) is a function of time, drain diameter, spacing, coefficient of consolidation, and average degree of desired consolidation.
3. Effect of disturbance related to soil displacement during installation is negligible.
4. Drain has infinite permeability (i.e. no drain resistance).

Input Values:

A =	807,730	sf	Total Areas #1 & #2 to be drained (DLZ, 2008)
C =	$0.50	cost/lf	Material + Installation Cost
	Single		Vertical Drainage (Single or Double)
	Triangular		Wick Drain Pattern
t =	315	day	available time to achieve desired degree of consolidation U_h
H =	29	ft	height of compressible layer
a =	0.33333	ft	width of drain (Assume 4" wide x 1/4" thick)
b =	0.020833	ft	thickness of drain (Assume for 4" wide x 1/4" thick)
c_v =	0.081	ft²/day	coefficient consolidation for vertical drainage (From Consolidation Tests on B-1 & B-2)
c_h =	0.0972	ft²/day	coefficient consolidation for horizontal drainage

Note:

-General Case: c_h = 1.2 to 1.5*c_v

-If layering of silt and sand in discontinuous lenses is evident: c_h = 2 to 4*c_v

-For varved clays and other deposits containing embedded and more or less continuous permeable layers: c_h = up to 10*c_v

Design Equations:

With vertical drains the overall average degree of consolidation, U, is the result of the combined effects of horizontal (radial) and vertical drainage. The combined effect is given by:

$$\overline{U} = 1-(1-\overline{U}_h)(1-\overline{U}_v)$$ (See FHWA eq. 1)

where,

U = overall average degree of consolidation

U_h = average degree of consolidation due to horizontal (or radial) drainage

U_v = average degree of consolidation due to vertical drainage

Check feasibility of 2 way vertical drainage only.

U_h = 0 %

Uv = 90 %

U = U_v = 90 %

T_v = 0.848

t = 8805 days **Need to Consider Other Options.**

Calculate U_v that will occur in design period of t.

t = 315 day

$$T = \frac{tc_v}{H^2}$$

T_v = 0.03

U_v = 0.20

Calculate required U_h

$$\overline{U} = 1-(1-\overline{U}_h)(1-\overline{U}_v)$$ (See FHWA eq. 1)

U_h = 0.88

Job No.	79784	PID No.	19415

HDR Computation

Project	SCI-823 Portsmouth Bypass	Computed	JSA	Date	4/8/2008
Subject	Shumway Hollow Road (TR 234) Interchange	Checked	DMV	Date	5/1/2008
Task	Wick Drain Analyses - Idealized Case	Sheet	2	Of	2

$$t = \frac{D^2}{8c_h} F(n) \ln\left[\frac{1}{1-\overline{U}_h}\right]$$ (See FHWA eq. 8)

where,

t =	315 day	available time to achieve desired degree of consolidation U_h
$\overline{U}_h$ =	0.88	average degree of consolidation due to horizontal drainage
c_h =	0.0972 ft^2/day	coefficient of consolidation for horizontal drainage
$F(n)$ =	2.6532	drain spacing factor

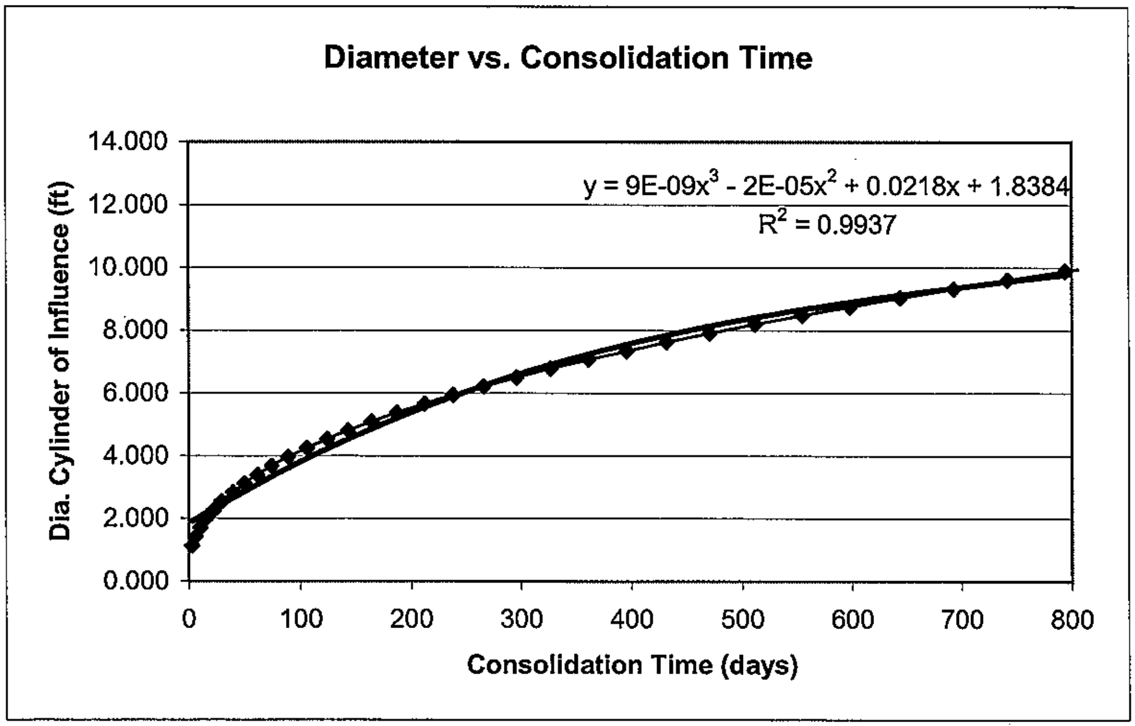
where,

$$F(n) = \ln\left(\frac{D}{d_w}\right) - 0.75$$ (simplified) (See FHWA eq. 3)

d_w = 2(a+b)/π — diameter of an equivalent circular drain (See FHWA eq. 9)

d_w = 0.23 ft

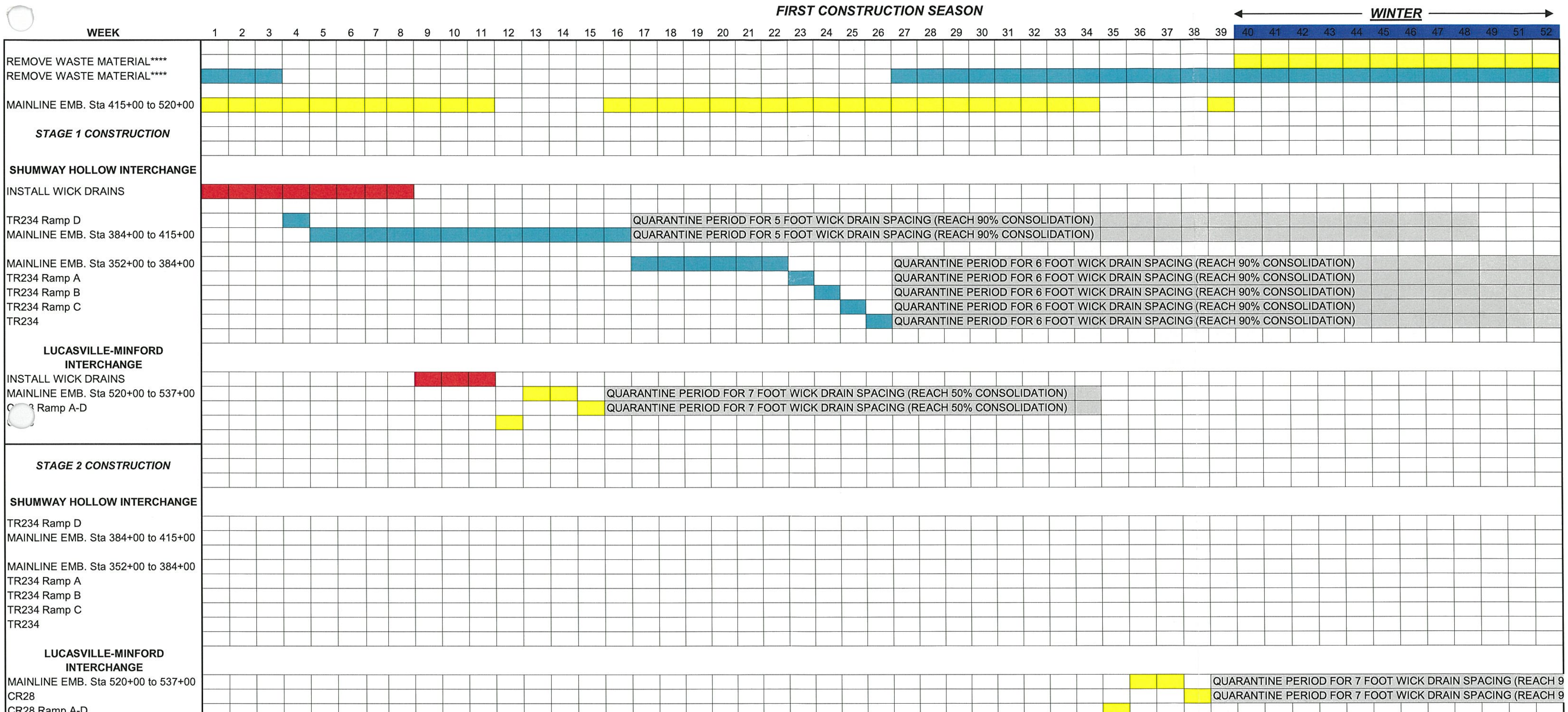
D = 6.781017 ft — required diameter of the cylinder of influence of the drain (drain influence zone) to achieve consolidation within given design period.



Optimum Drain Spacing based on required diameter of cyliner of influence to achieve primary consolidation within given design period: **6.00 ft**

Length Outer Edge of Equilateral Triangle (or square) =	1365.79 ft
Number Drain Spaces Along Outer Edge =	227.60 ea
Total number wick drains =	26243 ea
Total linear feet wick drain =	813533 lf
Estimated total cost =	**$406,766.50**

CONCEPTUALIZED CONSTRUCTION SCHEDULE



NOTES:

1. Schedule based on 10 hour work days and a 5 day week.
2. Productivity rate of 700 CY / HR was used for time estimates based on conversations with contractors.
3. QUANTITIES USED IN ANALYSES:
   - CUT = 5,789,155 CY
   - FILL = 3,316,338 CY
   - WASTE = 3,920,106 CY (BASED ON 15% SWELL)
4. Wick drains at Shumway Hollow Interchange North and South of TR 234 at 5 ft. and 6 ft. spacing, respectively. All wick drains at Lucasville-Minford Interchange at 7 ft. spacing.
5. Assume 6 rigs for installation of wick drains at an istallation rate of 10,000 ft/day per rig.
6. Estimated Total Wick Drain Installation Cost ($0.50/ft Installed) = $306,579 (CR 28) + $607,057 (Shumway Hollow Ramp D Area #3) + $406,766 (Shumway Hollow Remaining Areas #1 & #2) + $2,784,175 (2 ft. sand blanket) = **$ 4,104,577 (Total)**

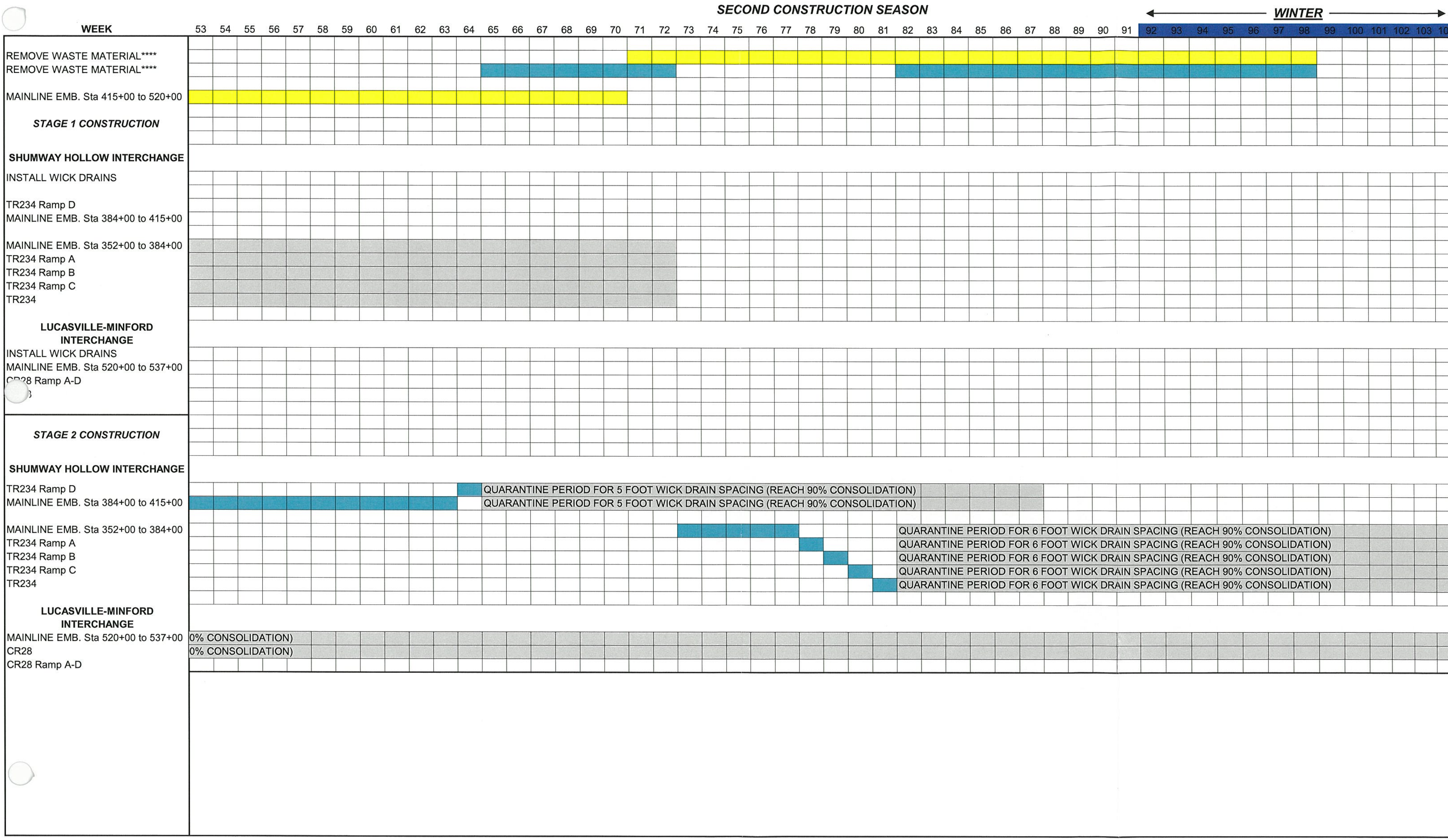
Legend

- Crew Number 1 (2 Excavators)
- Crew Number 2 (2 Excavators)
- Wick Drain Installation
- Quarantine Period

Scenario 1: Option 1

CONCEPTUALIZED CONSTRUCTION SCHEDULE

SHEET 2



CONCEPTUALIZED CONSTRUCTION SCHEDULE

THIRD CONSTRUCTION SEASON (Weeks 105–143) — *WINTER* (Weeks 144–156)

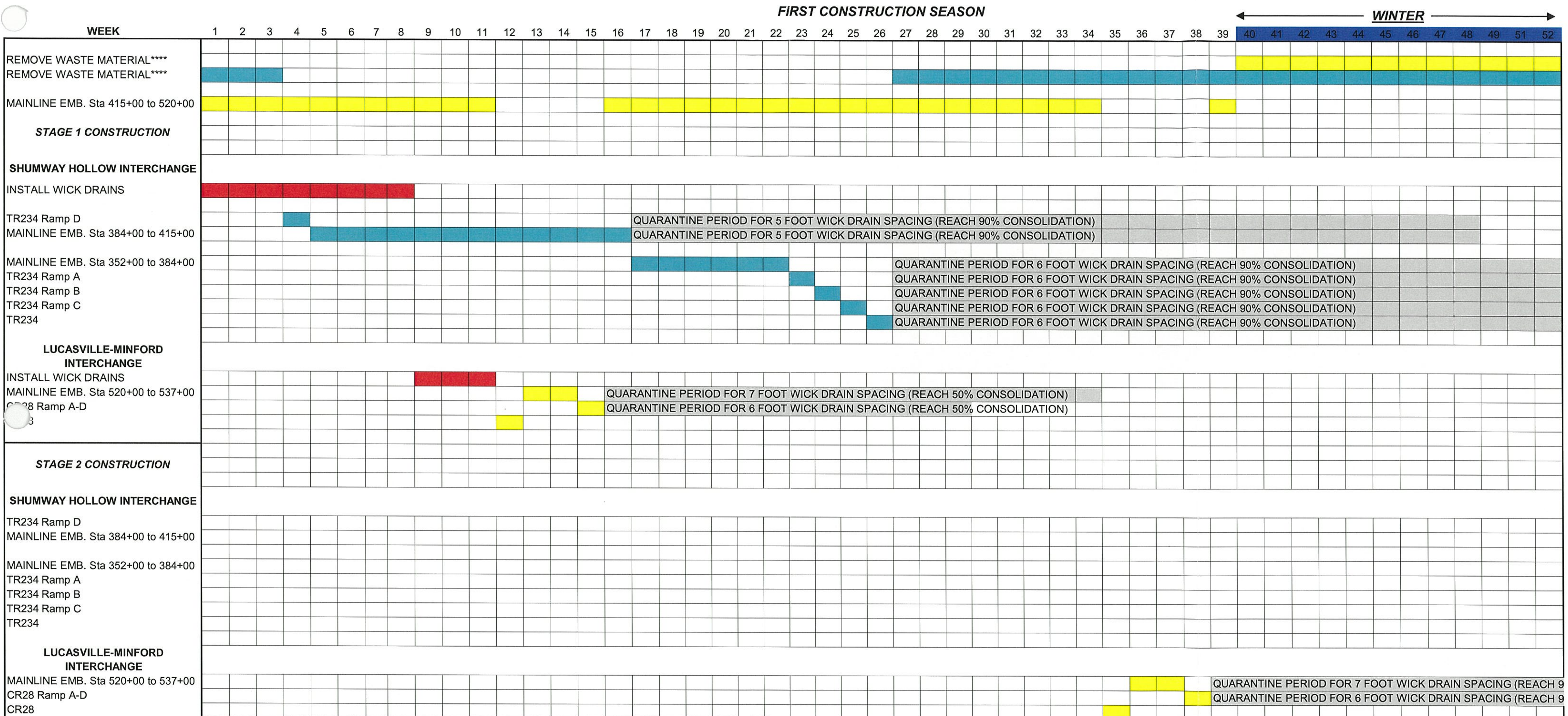
WEEK: 105 106 107 108 109 110 111 112 113 114 115 116 117 118 119 120 121 122 123 124 125 126 127 128 129 130 131 132 133 134 135 136 137 138 139 140 141 142 143 144 145 146 147 148 149 150 151 152 153 154 155 156

WEEK	
REMOVE WASTE MATERIAL****	
REMOVE WASTE MATERIAL****	
MAINLINE EMB. Sta 415+00 to 520+00	
STAGE 1 CONSTRUCTION	
SHUMWAY HOLLOW INTERCHANGE	
INSTALL WICK DRAINS	
TR234 Ramp D	
MAINLINE EMB. Sta 384+00 to 415+00	
MAINLINE EMB. Sta 352+00 to 384+00	
TR234 Ramp A	
TR234 Ramp B	
TR234 Ramp C	
TR234	
LUCASVILLE-MINFORD INTERCHANGE	
INSTALL WICK DRAINS	
MAINLINE EMB. Sta 520+00 to 537+00	
CR28 Ramp A-D	
CR28	
STAGE 2 CONSTRUCTION	
SHUMWAY HOLLOW INTERCHANGE	
TR234 Ramp D	
MAINLINE EMB. Sta 384+00 to 415+00	
MAINLINE EMB. Sta 352+00 to 384+00	105–115
TR234 Ramp A	105–115
TR234 Ramp B	105–115
TR234 Ramp C	105–115
TR234	105–115
LUCASVILLE-MINFORD INTERCHANGE	
MAINLINE EMB. Sta 520+00 to 537+00	105–127
CR28	105–127
CR28 Ramp A-D	

Scenario 1: Option 2

CONCEPTUALIZED CONSTRUCTION SCHEDULE

SHEET 1



NOTES:

1. Schedule based on 10 hour work days and a 5 day week.
2. Productivity rate of 700 CY / HR was used for time estimates based on conversations with contractors.
3. QUANTITIES USED IN ANALYSES:
   - CUT = 5,789,155 CY
   - FILL = 3,316,338 CY
   - WASTE = 3,920,106 CY (BASED ON 15% SWELL)
4. Wick drains at Shumway Hollow Interchange North and South of TR 234 at 5 ft. and 6 ft. spacing, respectively. Wick drains along ramps and mainline embankment at Lucasville-Minford Interchange at 7 ft. and 6 ft. spacing, respectively.
5. Assume 6 rigs for installation of wick drains at an istallation rate of 10,000 ft/day per rig.
6. Estimated Total Wick Drain Installation Cost ($0.50/ft Installed) = $157,680 (CR 28 - 6 ft. spacing) + $192,055 (CR 28 - 7 ft. spacing) + $607,057 (Shumway Hollow Ramp D Area #3) + $406,766 (Shumway Hollow Remaining Area #1 & #2) + $2,784,175 (2 ft. sand blanket) = **$ 4,147,733 (Total)**

Legend

- Crew Number 1 (2 Excavators) — yellow
- Crew Number 2 (2 Excavators) — blue
- Wick Drain Installation — red
- Quarantine Period — gray

Scenario 1: Option 2

CONCEPTUALIZED CONSTRUCTION SCHEDULE

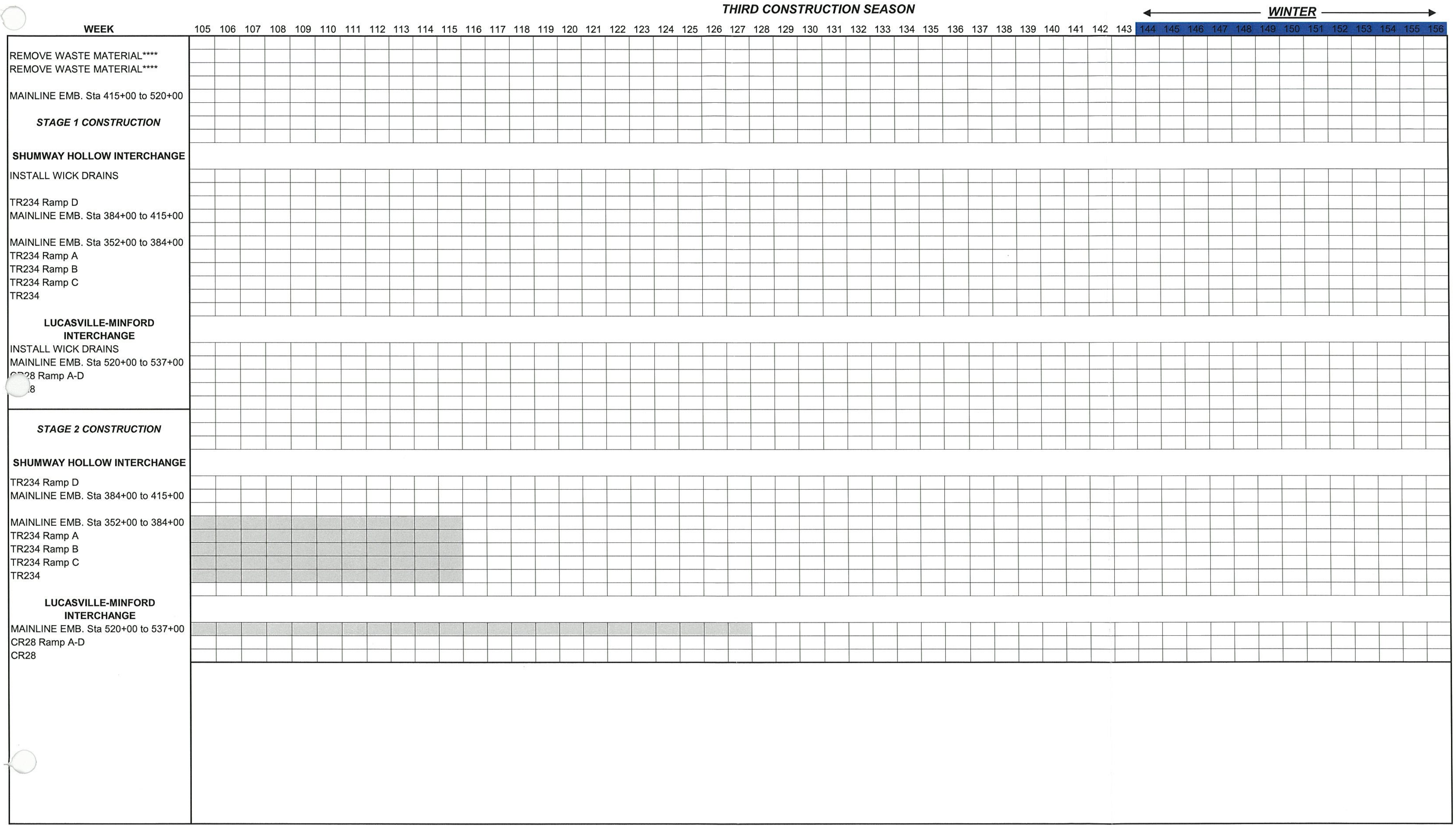
SHEET 2

SECOND CONSTRUCTION SEASON — ← ***WINTER*** → (weeks 92–104)

WEEK: 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 100 101 102 103 104

WEEK	
REMOVE WASTE MATERIAL****	
REMOVE WASTE MATERIAL****	
MAINLINE EMB. Sta 415+00 to 520+00	
STAGE 1 CONSTRUCTION	
SHUMWAY HOLLOW INTERCHANGE	
INSTALL WICK DRAINS	
TR234 Ramp D	
MAINLINE EMB. Sta 384+00 to 415+00	
MAINLINE EMB. Sta 352+00 to 384+00	
TR234 Ramp A	
TR234 Ramp B	
TR234 Ramp C	
TR234	
LUCASVILLE-MINFORD INTERCHANGE	
INSTALL WICK DRAINS	
MAINLINE EMB. Sta 520+00 to 537+00	
[illegible]28 Ramp A-D	
[illegible]8	
STAGE 2 CONSTRUCTION	
SHUMWAY HOLLOW INTERCHANGE	
TR234 Ramp D	QUARANTINE PERIOD FOR 5 FOOT WICK DRAIN SPACING (REACH 90% CONSOLIDATION)
MAINLINE EMB. Sta 384+00 to 415+00	QUARANTINE PERIOD FOR 5 FOOT WICK DRAIN SPACING (REACH 90% CONSOLIDATION)
MAINLINE EMB. Sta 352+00 to 384+00	QUARANTINE PERIOD FOR 6 FOOT WICK DRAIN SPACING (REACH 90% CONSOLIDATION)
TR234 Ramp A	QUARANTINE PERIOD FOR 6 FOOT WICK DRAIN SPACING (REACH 90% CONSOLIDATION)
TR234 Ramp B	QUARANTINE PERIOD FOR 6 FOOT WICK DRAIN SPACING (REACH 90% CONSOLIDATION)
TR234 Ramp C	QUARANTINE PERIOD FOR 6 FOOT WICK DRAIN SPACING (REACH 90% CONSOLIDATION)
TR234	QUARANTINE PERIOD FOR 6 FOOT WICK DRAIN SPACING (REACH 90% CONSOLIDATION)
LUCASVILLE-MINFORD INTERCHANGE	
MAINLINE EMB. Sta 520+00 to 537+00	0% CONSOLIDATION)
CR28 Ramp A-D	0% CONSOLIDATION)
CR28	

CONCEPTUALIZED CONSTRUCTION SCHEDULE



SCENARIO #2

__Scenario 2__ – At both the Shumway Hollow and Lucasville-Minford Interchanges, Ramps A and D will be paved and opened to traffic. The wick drains will be spaced evenly at each interchange.

Option 1: Total Cost = $4,275,931

- Wick drains at Shumway Hollow Interchange as well as the mainline embankment from Sta. 352+00 to Sta. 415+00 spaced at 5 feet.
- All wick drains at 7-foot spacing across the Lucasville-Minford Interchange.
- Complete embankments in 2 construction seasons.
- Reach 90% consolidation of entire Shumway Hollow Interchange including Mainline Embankment Sta. 352+00 to Sta. 415+00 in second construction season.
- Reach 90% consolidation of entire Lucasville-Minford Interchange including Mainline Embankment Sta. 520+00 to Sta. 537+00 in third construction season.

Constructability Benefits/Issues with Option 1

- Paving at Shumway Hollow Interchange could begin at the beginning of the third construction season.
- Paving at the Lucasville-Minford Interchange could begin approximately 23 weeks into the third construction season.

Option 2: Total Cost = $4,383,857

- Wick drains at Shumway Hollow Interchange as well as the mainline embankment from Sta. 352+00 to Sta. 415+00 spaced at 5 feet.
- All wick drains at 6-foot spacing across the Lucasville-Minford Interchange.
- Complete embankments in 2 construction seasons.
- Reach 90% consolidation of all embankments at both interchanges in 2 construction seasons.

Constructability Benefits/Issues with Option 2

- Allow paving to begin from either intersection at beginning of third construction season.

COMPUTATIONS

SCENARIO 2

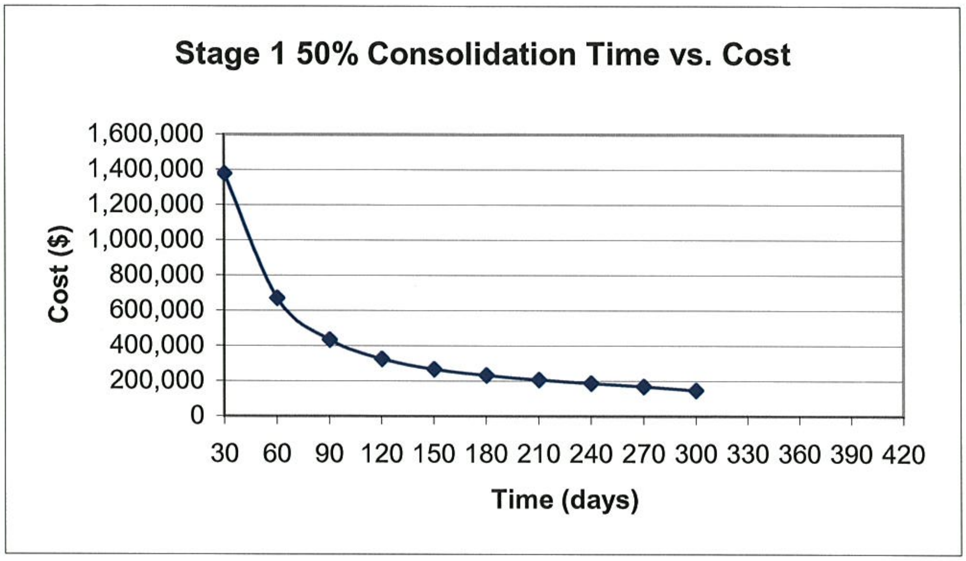
OPTION 1

Job No. 79784	PID No. 19415

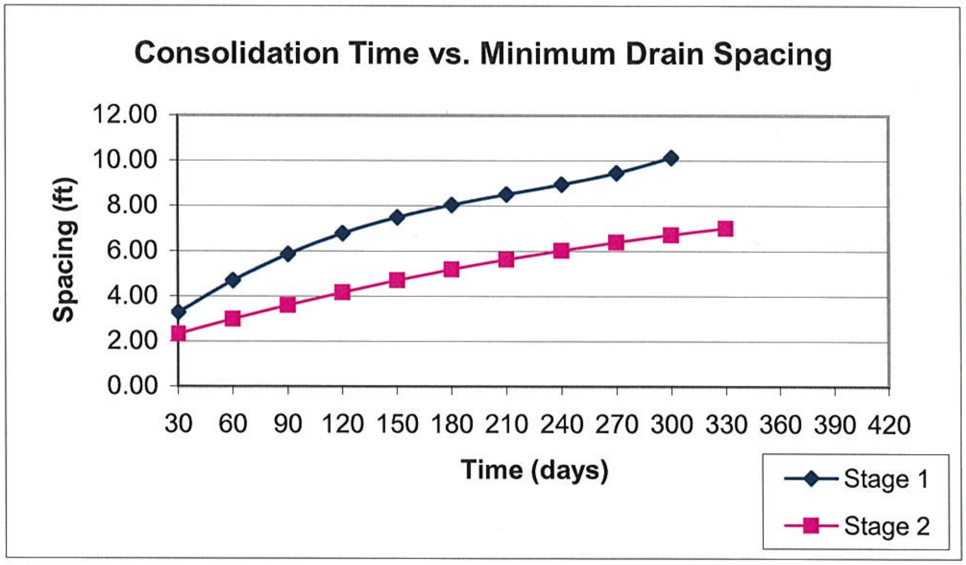
HDR Computation

Project	SCI-823 Portsmouth Bypass	Computed JSA	Date 4/17/2008
Subject	CR 28 Interchange	Checked DMV	Date 5/1/2008
Task	Wick Drain Analyses - Idealized Case	Sheet 1	Of 1

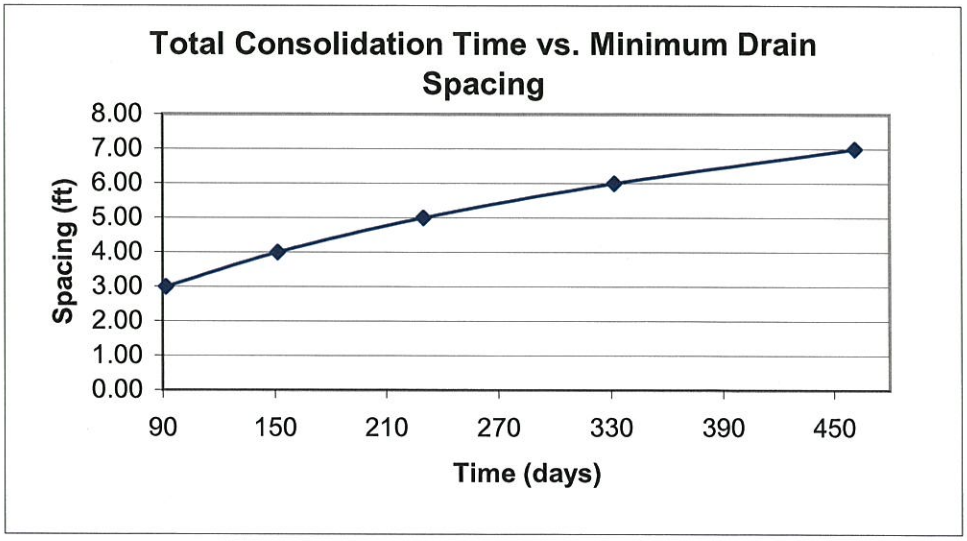
Stage 1 - 50% Consolidation		
Triangular Pattern		
t (days)	Spacing (ft)	Cost ($)
30	3.28	1,378,650
60	4.71	670,829
90	5.87	433,683
120	6.79	325,507
150	7.49	267,358
180	8.05	232,164
210	8.51	208,049
240	8.95	188,074
270	9.46	168,555
300	10.14	147,056



Stage 2 - 90% Consolidation		
Triangular Pattern		
t (days)	Spacing (ft)	Cost ($)
30	2.33	
60	2.99	
90	3.60	
120	4.17	
150	4.70	
180	5.18	
210	5.62	
240	6.02	
270	6.39	
300	6.71	
330	7.01	



Total Time	
Triangular Pattern	
t (days)	Spacing (ft)
92	3.00
151	4.00
230	5.00
332	6.00
461	7.00



Job No.	79784	PID No.	19415

HDR Computation

Project	SCI-823 Portsmouth Bypass	Computed	JSA	Date	4/8/2008
Subject	CR 28 Interchange	Checked	DMV	Date	5/1/2008
Task	Wick Drain Analyses - Idealized Case	Sheet	1	Of	2

References:

1. Federal Highway Administration, "Prefabricated Vertical Drains - A Design and Construction Guidelines Manual." FHWA/RD-86/168, Washington, DC.
2. Department of the Navy, Naval Facilities Engineering Command, "Soil Mechanics." NAVFAC Design Manual 7.1, May 1982, pp. 241-259.
3. Subsurface Exploration Bridge and MSE Retaining Walls SR 823 Over Relocated Shumway Hollow Road SCI-823-0.00, Portsmouth Bypass (DLZ, 2006)
4. SCI-823-6.81, Portsmouth Bypass Project, PID 19415, Addendum to Report: Shumway Hollow Road (TR 234) (DLZ, 2008)

Assumptions:

1. Terzaghi's one-dimensional consolidation theory applies.
2. Radial drainage theory (as it relates to vertical drains) is a function of time, drain diameter, spacing, coefficient of consolidation, and average degree of desired consolidation.
3. Effect of disturbance related to soil displacement during installation is negligible.
4. Drain has infinite permeability (i.e. no drain resistance).

Input Values:

A =	560,368	sf	Total area to be drained (DLZ, 2008)
C =	$0.50	cost/lf	Material + Installation Cost
	Single		Vertical Drainage (Single or Double)
	Triangular		Wick Drain Pattern
t =	128	day	available time to achieve desired degree of consolidation U_h
H =	43.5	ft	height of compressible layer
a =	0.33333	ft	width of drain (Assume 4" wide x 1/4" thick)
b =	0.020833	ft	thickness of drain (Assume for 4" wide x 1/4" thick)
c_v =	0.081	ft^2/day	coefficient consolidation for vertical drainage (From Consolidation Tests on B-1 & B-2)
c_h =	0.0972	ft^2/day	coefficient consolidation for horizontal drainage

Note:

-General Case: c_h = 1.2 to 1.5*c_v

-If layering of silt and sand in discontinuous lenses is evident: c_h = 2 to 4*c_v

-For varved clays and other deposits containing embedded and more or less continuous permeable layers: c_h = up to 10*c_v

Design Equations:

With vertical drains the overall average degree of consolidation, U, is the result of the combined effects of horizontal (radial) and vertical drainage. The combined effect is given by:

$$\overline{U} = 1-(1-\overline{U}_h)(1-\overline{U}_v)$$ (See FHWA eq. 1)

where,

U = overall average degree of consolidation

U_h = average degree of consolidation due to horizontal (or radial) drainage

U_v = average degree of consolidation due to vertical drainage

Check feasibility of 2 way vertical drainage only.

U_h = 0 %

Uv = 50 %　　　t = 4585 days　　　**Need to Consider Other Options.**

$U = U_v$ = 50 %

T_v = 0.19625

Calculate U_v that will occur in design period of t.

t = 128 day

$$T = \frac{tc_v}{H^2}$$

T_v = 0.01

U_v = 0.08

Calculate required U_h

$$\overline{U} = 1-(1-\overline{U}_h)(1-\overline{U}_v)$$ (See FHWA eq. 1)

U_h = 0.45

HDR Computation

Project	SCI-823 Portsmouth Bypass	Computed	JSA	Date	4/8/2008
Subject	CR 28 Interchange	Checked	DMV	Date	5/1/2008
Task	Wick Drain Analyses - Idealized Case	Sheet	2	Of	2

$$t = \frac{D^2}{8c_h} F(n) \ln\left[\frac{1}{1-\bar{U}_h}\right]$$ (See FHWA eq. 8)

where,

t =	128 day	available time to achieve desired degree of consolidation U_h
$\bar{U}_h$ =	0.45	average degree of consolidation due to horizontal drainage
c_h =	0.0972 ft^2/day	coefficient of consolidation for horizontal drainage
F(n) =	2.806234	drain spacing factor

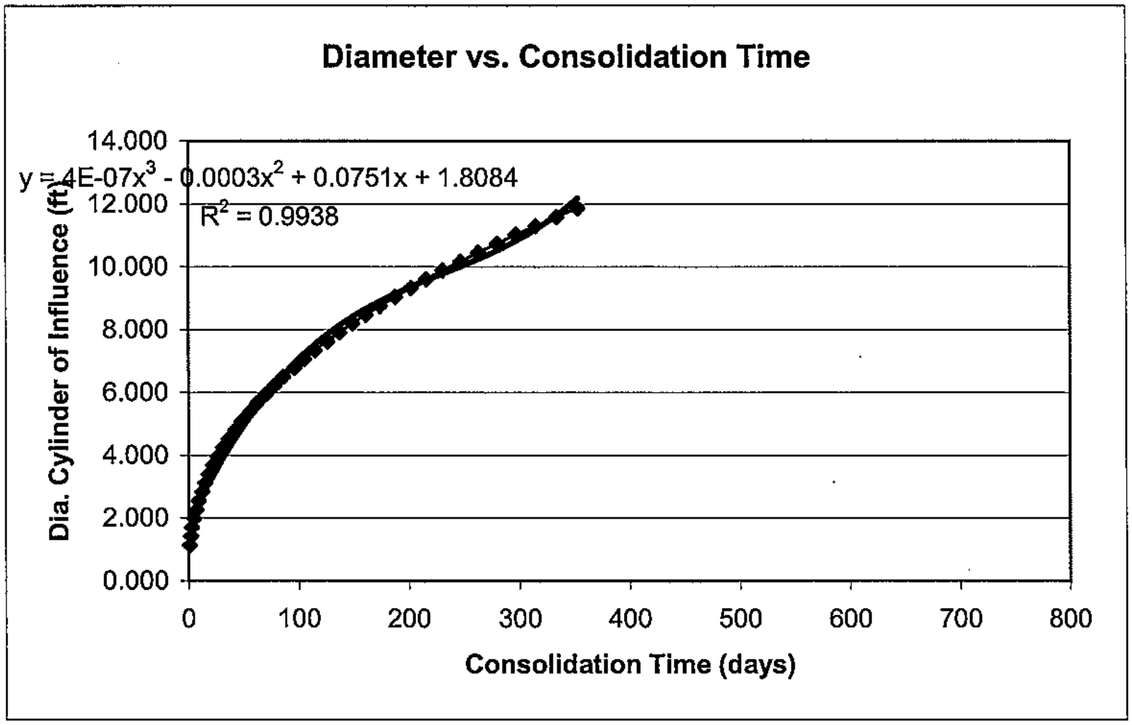
where,

$$F(n) = \ln\left(\frac{D}{d_w}\right) - 0.75$$ (simplified) (See FHWA eq. 3)

d_w = 2(a+b)/π — diameter of an equivalent circular drain (See FHWA eq. 9)

d_w = 0.23 ft

D = 7.902355 ft — required diameter of the cylinder of influence of the drain (drain influence zone) to achieve consolidation within given design period.



Optimum Drain Spacing based on required diameter of cyliner of influence to achieve primary consolidation within given design period: **6.99 ft**

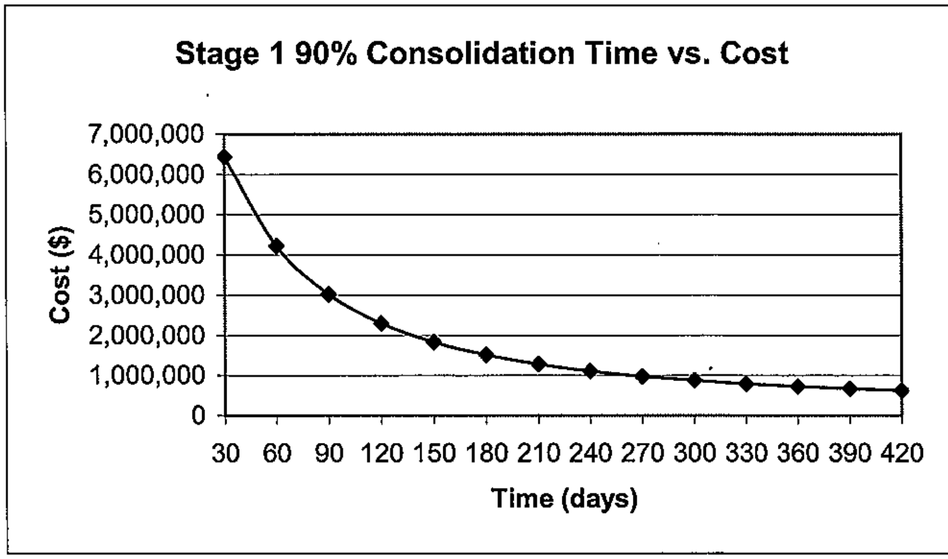
Length Outer Edge of Equilateral Triangle (or square) =	1137.59 ft
Number Drain Spaces Along Outer Edge =	162.67 ea
Total number wick drains =	13476 ea
Total linear feet wick drain =	613158 lf
Estimated total cost =	**$306,579.00**

Job No.	79784	PID No.	19415

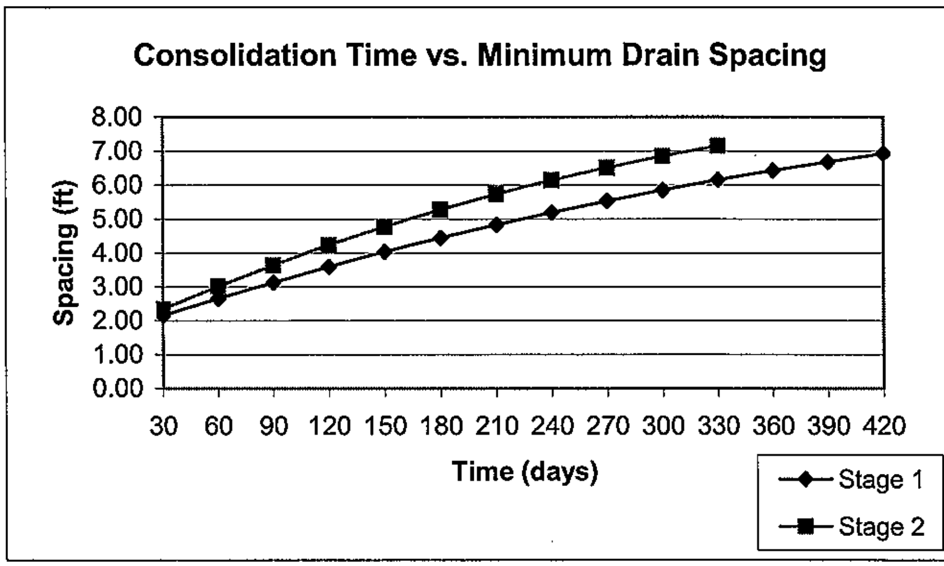
HDR Computation

Project	SCI-823 Portsmouth Bypass	Computed	JSA	Date	4/8/2008
Subject	Shumway Hollow Road (TR 234) Interchange	Checked	DMV	Date	5/1/2008
Task	Wick Drain Analyses - Idealized Case	Sheet	1	Of	1

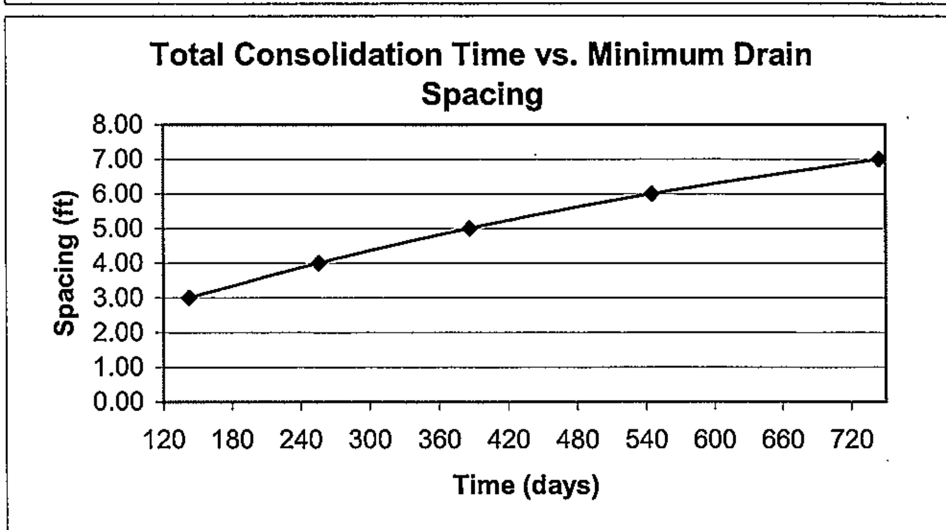
Stage 1		
Triangular Pattern		
t (days)	Spacing (ft)	Cost ($)
30	2.15	6,432,578
60	2.65	4,220,356
90	3.13	3,021,322
120	3.59	2,300,045
150	4.03	1,831,093
180	4.44	1,508,305
210	4.83	1,276,813
240	5.19	1,104,716
270	5.53	973,478
300	5.85	871,379
330	6.15	789,369
360	6.42	723,509
390	6.68	669,492
420	6.92	624,232



Stage 2		
Triangular Pattern		
t (days)	Spacing (ft)	Cost ($)
30	2.34	
60	3.01	
90	3.64	
120	4.23	
150	4.77	
180	5.27	
210	5.72	
240	6.14	
270	6.51	
300	6.85	
330	7.15	



Total Time	
Triangular Pattern	
t (days)	Spacing (ft)
142	3.00
256	4.00
386	5.00
545	6.00
744	7.00



HDR Computation

Project	SCI-823 Portsmouth Bypass	Computed JSA	Date 4/8/2008
Subject	Shumway Hollow Road (TR 234) Interchange	Checked DMV	Date 5/1/2008
Task	Wick Drain Analyses - Idealized Case	Sheet 1	Of 2

References:

1. Federal Highway Administration, "Prefabricated Vertical Drains - A Design and Construction Guidelines Manual." FHWA/RD-86/168, Washington, DC.
2. Department of the Navy, Naval Facilities Engineering Command, "Soil Mechanics." NAVFAC Design Manual 7.1, May 1982, pp. 241-259.
3. Subsurface Exploration Bridge and MSE Retaining Walls SR 823 Over Relocated Shumway Hollow Road SCI-823-0.00, Portsmouth Bypass (DLZ, 2006)
4. SCI-823-6.81, Portsmouth Bypass Project, PID 19415, Addendum to Report: Shumway Hollow Road (TR 234) (DLZ, 2008)

Assumptions:

1. Terzaghi's one-dimensional consolidation theory applies.
2. Radial drainage theory (as it relates to vertical drains) is a function of time, drain diameter, spacing, coefficient of consolidation, and average degree of desired consolidation.
3. Effect of disturbance related to soil displacement during installation is negligible.
4. Drain has infinite permeability (i.e. no drain resistance).

Input Values:

A =	1,650,592	sf	Total area to be drained (DLZ, 2008)
C =	$0.50	cost/lf	Material + Installation Cost
	Single		Vertical Drainage (Single or Double)
	Triangular		Wick Drain Pattern
t =	225	day	available time to achieve desired degree of consolidation U_h
H =	29	ft	height of compressible layer
a =	0.33333	ft	width of drain (Assume 4" wide x 1/4" thick)
b =	0.020833	ft	thickness of drain (Assume for 4" wide x 1/4" thick)
c_v =	0.081	ft²/day	coefficient consolidation for vertical drainage (From Consolidation Tests on B-1 & B-2)
c_h =	0.0972	ft²/day	coefficient consolidation for horizontal drainage

Note:

-General Case: c_h = 1.2 to 1.5*c_v

-If layering of silt and sand in discontinuous lenses is evident: c_h = 2 to 4*c_v

-For varved clays and other deposits containing embedded and more or less continuous permeable layers: c_h = up to 10*c_v

Design Equations:

With vertical drains the overall average degree of consolidation, U, is the result of the combined effects of horizontal (radial) and vertical drainage. The combined effect is given by:

$$\overline{U} = 1-(1-\overline{U}_h)(1-\overline{U}_v)$$ (See FHWA eq. 1)

where,

U = overall average degree of consolidation
U_h = average degree of consolidation due to horizontal (or radial) drainage
U_v = average degree of consolidation due to vertical drainage

Check feasibility of 2 way vertical drainage only.

U_h = 0 %
Uv = 90 %
$U = U_v$ = 90 %
T_v = 0.848

t = 8805 days **Need to Consider Other Options.**

Calculate U_v that will occur in design period of t.

t = 225 day

$$T = \frac{tc_v}{H^2}$$

T_v = 0.02
U_v = 0.17

Calculate required U_h

$$\overline{U} = 1-(1-\overline{U}_h)(1-\overline{U}_v)$$ (See FHWA eq. 1)

U_h = 0.88

Job No.	79784	PID No.	19415

HDR Computation

Project	SCI-823 Portsmouth Bypass	Computed	JSA	Date	4/8/2008
Subject	Shumway Hollow Road (TR 234) Interchange	Checked	DMV	Date	5/1/2008
Task	Wick Drain Analyses - Idealized Case	Sheet	2	Of	2

$$t = \frac{D^2}{8c_h} F(n) \ln\left[\frac{1}{1-\overline{U}_h}\right]$$ (See FHWA eq. 8)

where,

t =	225 day	available time to achieve desired degree of consolidation U_h
$\overline{U}_h$ =	0.88	average degree of consolidation due to horizontal drainage
c_h =	0.0972 ft^2/day	coefficient of consolidation for horizontal drainage
$F(n)$ =	2.473098	drain spacing factor

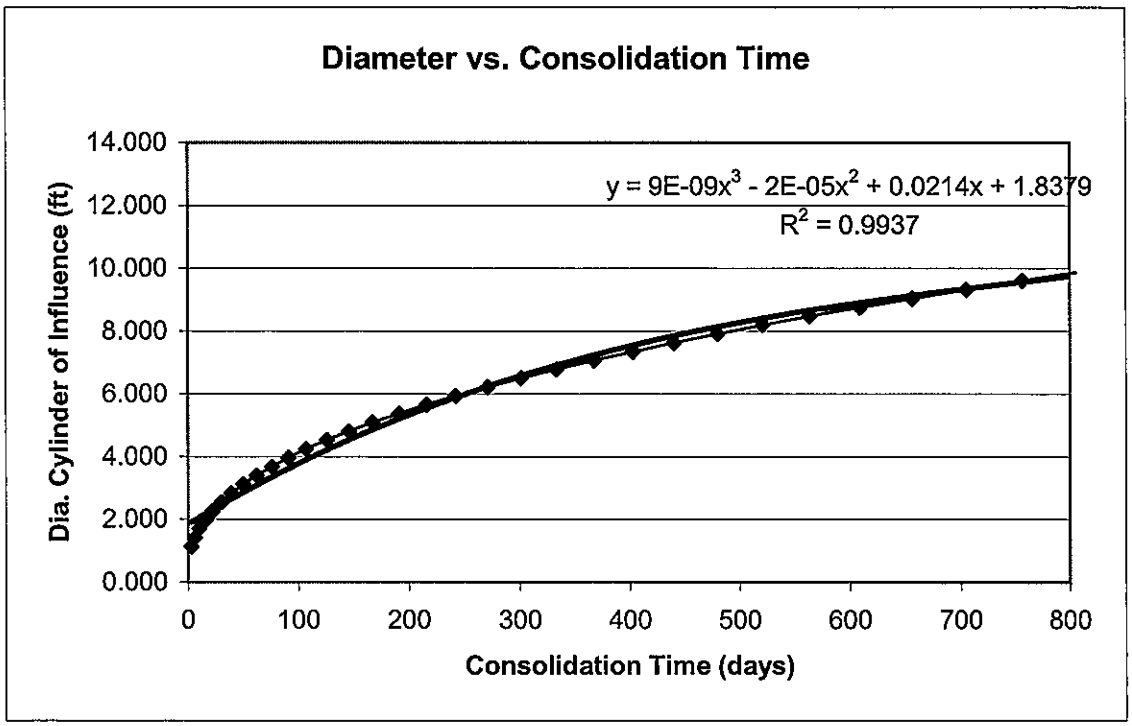
where,

$$F(n) = \ln\left(\frac{D}{d_w}\right) - 0.75$$ (simplified) (See FHWA eq. 3)

d_w = 2(a+b)/π — diameter of an equivalent circular drain (See FHWA eq. 9)

d_w = 0.23 ft

D = 5.663406 ft — required diameter of the cylinder of influence of the drain (drain influence zone) to achieve consolidation within given design period.



Optimum Drain Spacing based on required diameter of cyliner of influence to achieve primary consolidation within given design period: **5.01 ft**

Length Outer Edge of Equilateral Triangle (or square) =	1952.40 ft
Number Drain Spaces Along Outer Edge =	389.56 ea
Total number wick drains =	76463 ea
Total linear feet wick drain =	2370353 lf
Estimated total cost =	**$1,185,176.50**

COMPUTATIONS

SCENARIO 2

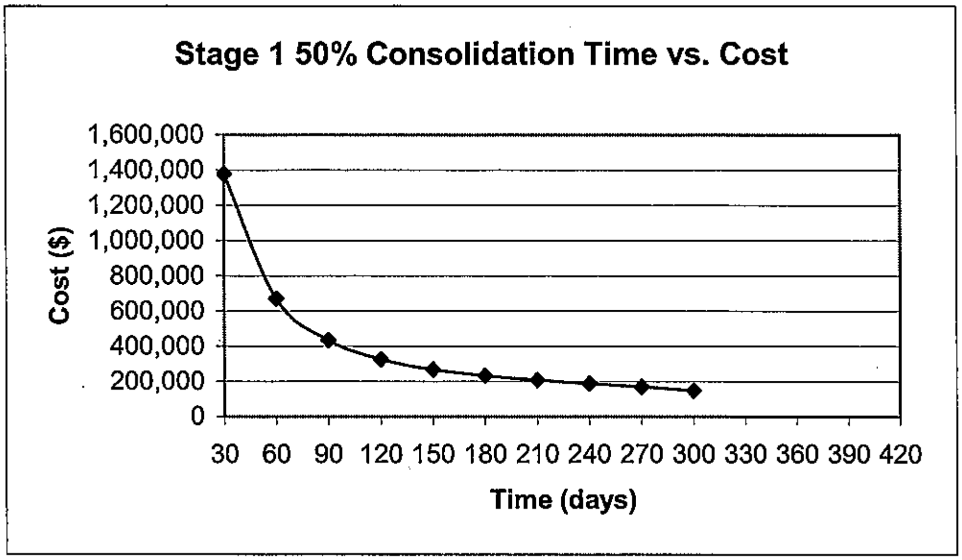
OPTION 2

Job No.	79784	PID No.	19415

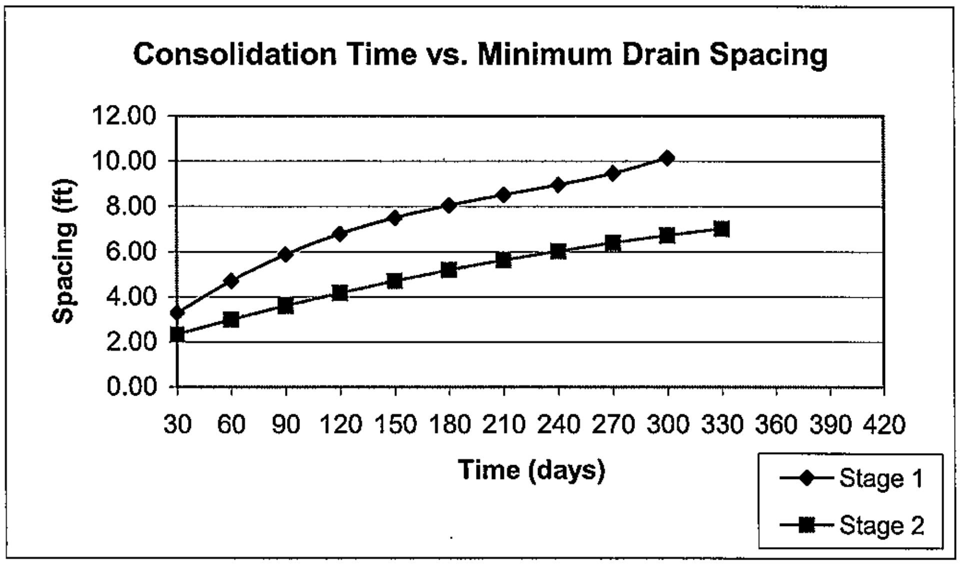
HDR Computation

Project	SCI-823 Portsmouth Bypass	Computed	JSA	Date	4/17/2008
Subject	CR 28 Interchange	Checked	DMV	Date	5/1/2008
Task	Wick Drain Analyses - Idealized Case	Sheet	1	Of	1

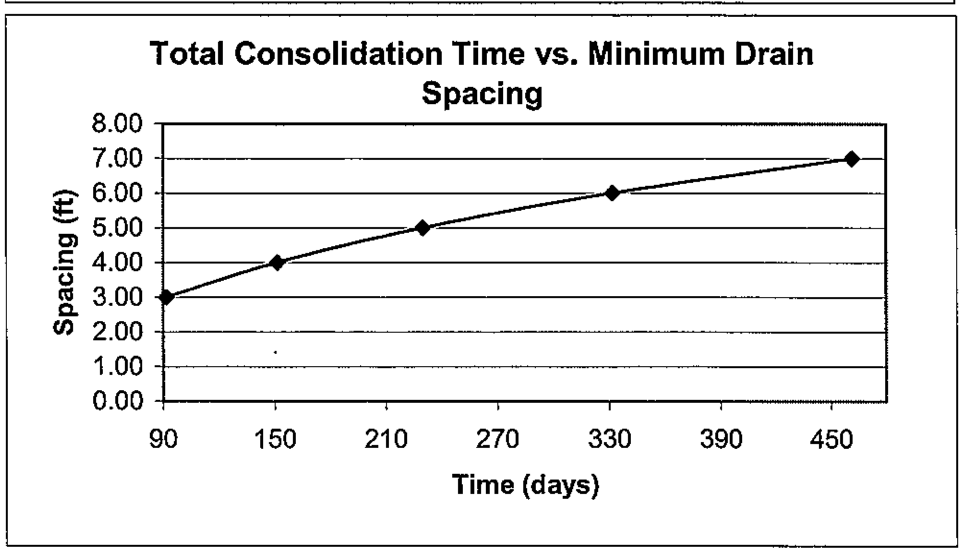
Stage 1 - 50% Consolidation		
Triangular Pattern		
t (days)	Spacing (ft)	Cost ($)
30	3.28	1,378,650
60	4.71	670,829
90	5.87	433,683
120	6.79	325,507
150	7.49	267,358
180	8.05	232,164
210	8.51	208,049
240	8.95	188,074
270	9.46	168,555
300	10.14	147,056



Stage 2 - 90% Consolidation		
Triangular Pattern		
t (days)	Spacing (ft)	Cost ($)
30	2.33	
60	2.99	
90	3.60	
120	4.17	
150	4.70	
180	5.18	
210	5.62	
240	6.02	
270	6.39	
300	6.71	
330	7.01	



Total Time	
Triangular Pattern	
t (days)	Spacing (ft)
92	3.00
151	4.00
230	5.00
332	6.00
461	7.00



HDR Computation

HDR

Project	SCI-823 Portsmouth Bypass	Computed	JSA	Date	4/8/2008
Subject	CR 28 Interchange	Checked	DMV	Date	5/1/2008
Task	Wick Drain Analyses - Idealized Case	Sheet	1	Of	2

References:

1. Federal Highway Administration, "Prefabricated Vertical Drains - A Design and Construction Guidelines Manual." FHWA/RD-86/168, Washington, DC.
2. Department of the Navy, Naval Facilities Engineering Command, "Soil Mechanics." NAVFAC Design Manual 7.1, May 1982, pp. 241-259.
3. Subsurface Exploration Bridge and MSE Retaining Walls SR 823 Over Relocated Shumway Hollow Road SCI-823-0.00, Portsmouth Bypass (DLZ, 2006)
4. SCI-823-6.81, Portsmouth Bypass Project, PID 19415, Addendum to Report: Shumway Hollow Road (TR 234) (DLZ, 2008)

Assumptions:

1. Terzaghi's one-dimensional consolidation theory applies.
2. Radial drainage theory (as it relates to vertical drains) is a function of time, drain diameter, spacing, coefficient of consolidation, and average degree of desired consolidation.
3. Effect of disturbance related to soil displacement during installation is negligible.
4. Drain has infinite permeability (i.e. no drain resistance).

Input Values:

A =	560,368	sf	Total area to be drained (DLZ, 2008)
C =	$0.50	cost/lf	Material + Installation Cost
	Single		Vertical Drainage (Single or Double)
	Triangular		Wick Drain Pattern
t =	94	day	available time to achieve desired degree of consolidation U_h
H =	43.5	ft	height of compressible layer
a =	0.33333	ft	width of drain (Assume 4" wide x 1/4" thick)
b =	0.020833	ft	thickness of drain (Assume for 4" wide x 1/4" thick)
c_v =	0.081	ft^2/day	coefficient consolidation for vertical drainage (From Consolidation Tests on B-1 & B-2)
c_h =	0.0972	ft^2/day	coefficient consolidation for horizontal drainage

Note:

-General Case: c_h = 1.2 to 1.5*c_v

-If layering of silt and sand in discontinuous lenses is evident: c_h = 2 to 4*c_v

-For varved clays and other deposits containing embedded and more or less continuous permeable layers: c_h = up to 10*c_v

Design Equations:

With vertical drains the overall average degree of consolidation, U, is the result of the combined effects of horizontal (radial) and vertical drainage. The combined effect is given by:

$$\overline{U} = 1-(1-\overline{U}_h)(1-\overline{U}_v)$$ (See FHWA eq. 1)

where,

U = overall average degree of consolidation
U_h = average degree of consolidation due to horizontal (or radial) drainage
U_v = average degree of consolidation due to vertical drainage

Check feasibility of 2 way vertical drainage only.

U_h = 0 %
Uv = 50 % t = 4585 days **Need to Consider Other Options.**
U = U_v = 50 %
T_v = 0.19625

Calculate U_v that will occur in design period of t.

t = 94 day

$$T = \frac{tc_v}{H^2}$$

T_v = 0.00
U_v = 0.07

Calculate required U_h

$$\overline{U} = 1-(1-\overline{U}_h)(1-\overline{U}_v)$$ (See FHWA eq. 1)

U_h = 0.46

Job No.	79784	PID No.	19415

HDR Computation

Project	SCI-823 Portsmouth Bypass	Computed	JSA	Date	4/8/2008
Subject	CR 28 Interchange	Checked	DMV	Date	5/1/2008
Task	Wick Drain Analyses - Idealized Case	Sheet	2	Of	2

$$t = \frac{D^2}{8c_h} F(n) \ln\left[\frac{1}{1-\bar{U}_h}\right]$$ (See FHWA eq. 8)

where,

t =	94 day	available time to achieve desired degree of consolidation U_h
$\bar{U}_h$ =	0.46	average degree of consolidation due to horizontal drainage
c_h =	0.0972 ft^2/day	coefficient of consolidation for horizontal drainage
$F(n)$ =	2.654141	drain spacing factor

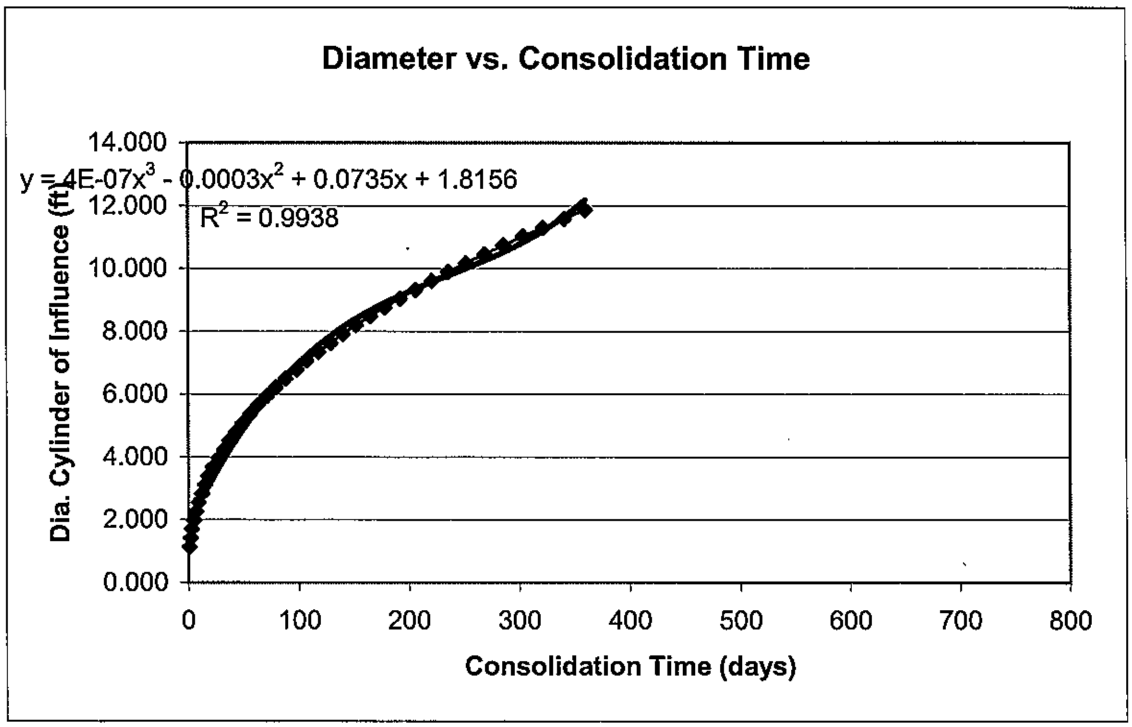
where,

$$F(n) = \ln\left(\frac{D}{d_w}\right) - 0.75$$ (simplified) (See FHWA eq. 3)

d_w = 2(a+b)/π — diameter of an equivalent circular drain (See FHWA eq. 9)

d_w = 0.23 ft

D = 6.787405 ft — required diameter of the cylinder of influence of the drain (drain influence zone) to achieve consolidation within given design period.



Optimum Drain Spacing based on required diameter of cyliner of influence to achieve primary consolidation within given design period: **6.01 ft**

Length Outer Edge of Equilateral Triangle (or square) =	1137.59 ft
Number Drain Spaces Along Outer Edge =	189.39 ea
Total number wick drains =	18220 ea
Total linear feet wick drain =	829010 lf
Estimated total cost =	**$414,505.00**

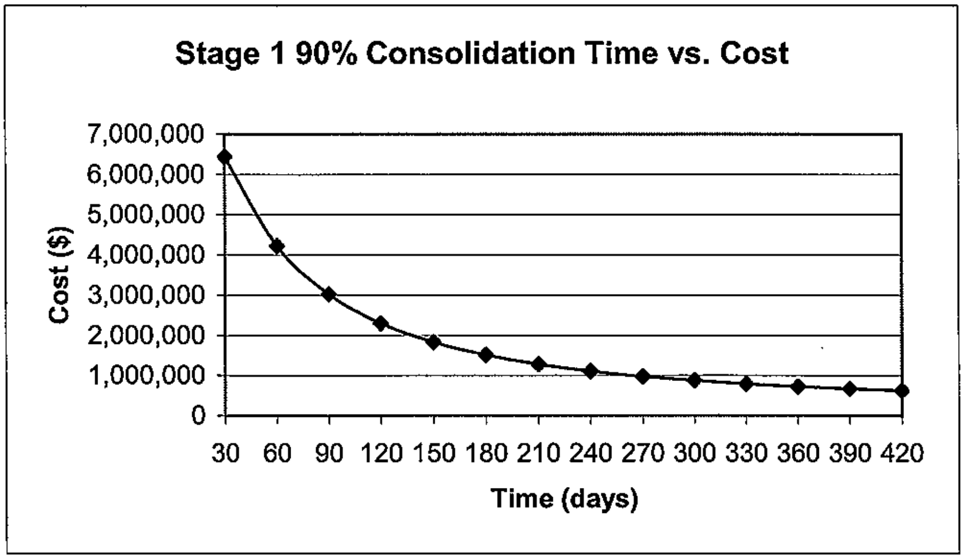
Job No. 79784 | PID No. 19415

HDR Computation

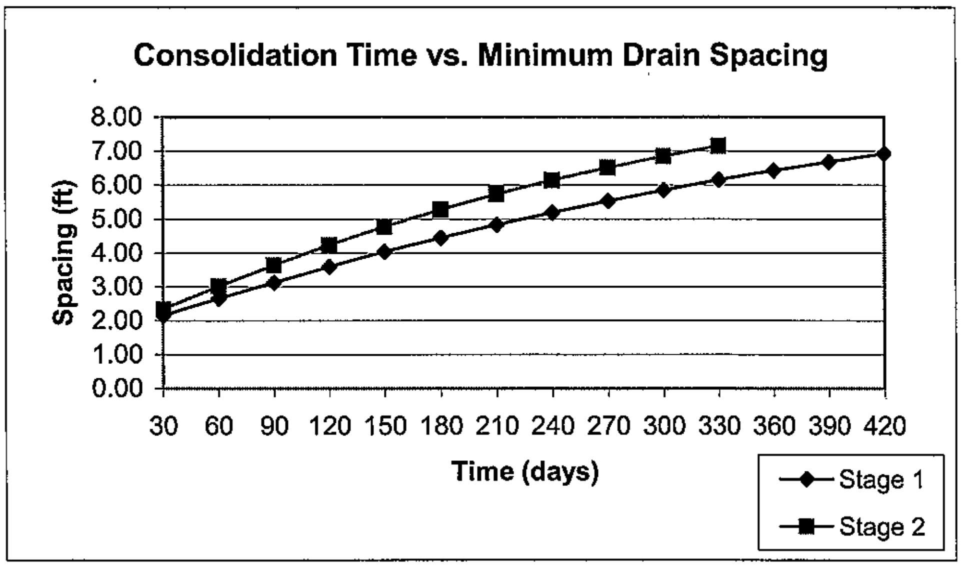
HDR

Project	SCI-823 Portsmouth Bypass	Computed	JSA	Date	4/8/2008
Subject	Shumway Hollow Road (TR 234) Interchange	Checked	DMV	Date	5/1/2008
Task	Wick Drain Analyses - Idealized Case	Sheet	1	Of	1

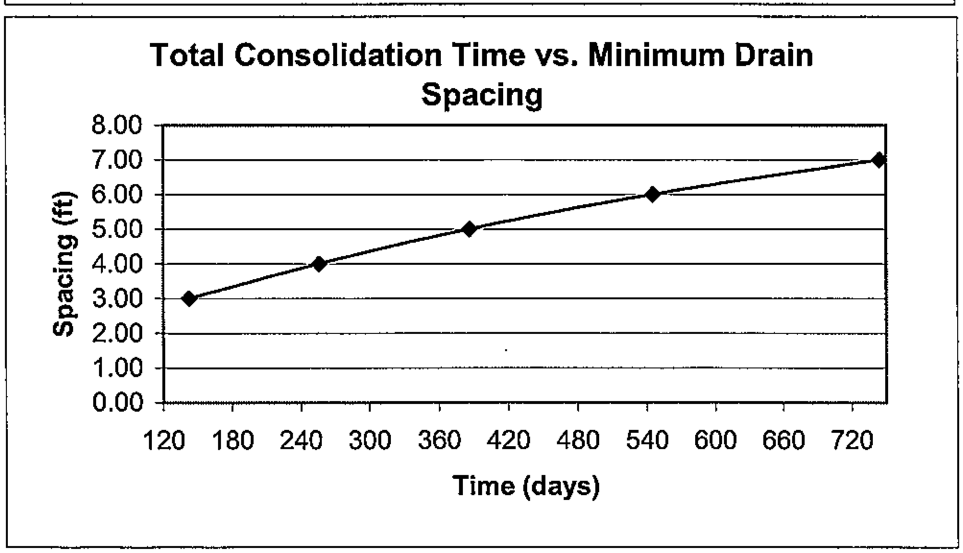
Stage 1		
Triangular Pattern		
t (days)	Spacing (ft)	Cost ($)
30	2.15	6,432,578
60	2.65	4,220,356
90	3.13	3,021,322
120	3.59	2,300,045
150	4.03	1,831,093
180	4.44	1,508,305
210	4.83	1,276,813
240	5.19	1,104,716
270	5.53	973,478
300	5.85	871,379
330	6.15	789,369
360	6.42	723,509
390	6.68	669,492
420	6.92	624,232



Stage 2		
Triangular Pattern		
t (days)	Spacing (ft)	Cost ($)
30	2.34	
60	3.01	
90	3.64	
120	4.23	
150	4.77	
180	5.27	
210	5.72	
240	6.14	
270	6.51	
300	6.85	
330	7.15	



Total Time	
Triangular Pattern	
t (days)	Spacing (ft)
142	3.00
256	4.00
386	5.00
545	6.00
744	7.00



HDR Computation

Project	SCI-823 Portsmouth Bypass	Computed JSA	Date 4/8/2008
Subject	Shumway Hollow Road (TR 234) Interchange	Checked DMV	Date 5/1/2008
Task	Wick Drain Analyses - Idealized Case	Sheet 1	Of 2

References:

1. Federal Highway Administration, "Prefabricated Vertical Drains - A Design and Construction Guidelines Manual." FHWA/RD-86/168, Washington, DC.
2. Department of the Navy, Naval Facilities Engineering Command, "Soil Mechanics." NAVFAC Design Manual 7.1, May 1982, pp. 241-259.
3. Subsurface Exploration Bridge and MSE Retaining Walls SR 823 Over Relocated Shumway Hollow Road SCI-823-0.00, Portsmouth Bypass (DLZ, 2006)
4. SCI-823-6.81, Portsmouth Bypass Project, PID 19415, Addendum to Report: Shumway Hollow Road (TR 234) (DLZ, 2008)

Assumptions:

1. Terzaghi's one-dimensional consolidation theory applies.
2. Radial drainage theory (as it relates to vertical drains) is a function of time, drain diameter, spacing, coefficient of consolidation, and average degree of desired consolidation.
3. Effect of disturbance related to soil displacement during installation is negligible.
4. Drain has infinite permeability (i.e. no drain resistance).

Input Values:

A =	1,650,592	sf	Total area to be drained (DLZ, 2008)
C =	$0.50	cost/lf	Material + Installation Cost
	Single		Vertical Drainage (Single or Double)
	Triangular		Wick Drain Pattern
t =	225	day	available time to achieve desired degree of consolidation U_h
H =	29	ft	height of compressible layer
a =	0.33333	ft	width of drain (Assume 4" wide x 1/4" thick)
b =	0.020833	ft	thickness of drain (Assume for 4" wide x 1/4" thick)
c_v =	0.081	ft^2/day	coefficient consolidation for vertical drainage (From Consolidation Tests on B-1 & B-2)
c_h =	0.0972	ft^2/day	coefficient consolidation for horizontal drainage

Note:

-General Case: c_h = 1.2 to 1.5*c_v

-If layering of silt and sand in discontinuous lenses is evident: c_h = 2 to 4*c_v

-For varved clays and other deposits containing embedded and more or less continuous permeable layers: c_h = up to 10*c_v

Design Equations:

With vertical drains the overall average degree of consolidation, U, is the result of the combined effects of horizontal (radial) and vertical drainage. The combined effect is given by:

$$\overline{U} = 1-(1-\overline{U}_h)(1-\overline{U}_v)$$ (See FHWA eq. 1)

where,

U = overall average degree of consolidation

U_h = average degree of consolidation due to horizontal (or radial) drainage

U_v = average degree of consolidation due to vertical drainage

Check feasibility of 2 way vertical drainage only.

U_h = 0 %

Uv = 90 %

U = U_v = 90 %

T_v = 0.848

t = 8805 days **Need to Consider Other Options.**

Calculate U_v that will occur in design period of t.

t = 225 day

$$T = \frac{tc_v}{H^2}$$

T_v = 0.02

U_v = 0.17

Calculate required U_h

$$\overline{U} = 1-(1-\overline{U}_h)(1-\overline{U}_v)$$ (See FHWA eq. 1)

U_h = 0.88

HDR Computation

Project	SCI-823 Portsmouth Bypass	Computed	JSA	Date	4/8/2008
Subject	Shumway Hollow Road (TR 234) Interchange	Checked	DMV	Date	5/1/2008
Task	Wick Drain Analyses - Idealized Case	Sheet	2	Of	2

$$t = \frac{D^2}{8c_h} F(n) \ln\left[\frac{1}{1-\overline{U}_h}\right]$$ (See FHWA eq. 8)

where,

$t =$ 225 day — available time to achieve desired degree of consolidation U_h

$\overline{U}_h =$ 0.88 — average degree of consolidation due to horizontal drainage

$c_h =$ 0.0972 ft^2/day — coefficient of consolidation for horizontal drainage

$F(n) =$ 2.473098 — drain spacing factor

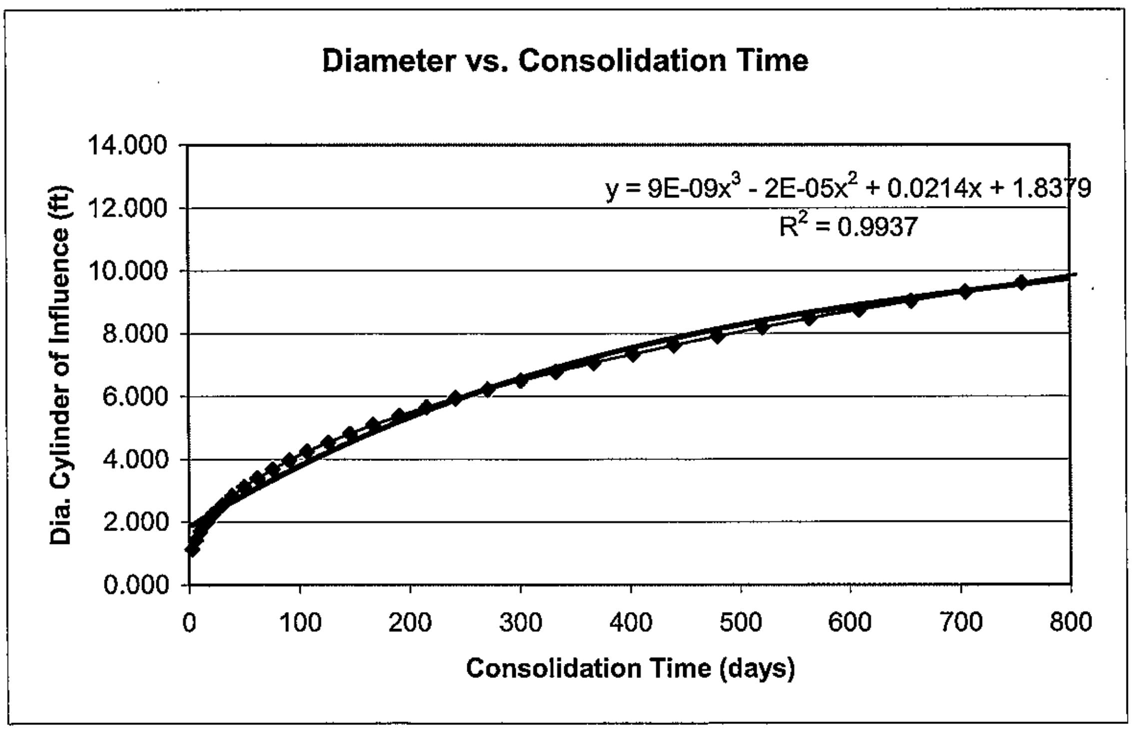
where,

$$F(n) = \ln\left(\frac{D}{d_w}\right) - 0.75$$ (simplified) (See FHWA eq. 3)

$d_w = 2(a+b)/\pi$ — diameter of an equivalent circular drain (See FHWA eq. 9)

$d_w =$ 0.23 ft

$D =$ 5.663406 ft — required diameter of the cylinder of influence of the drain (drain influence zone) to achieve consolidation within given design period.



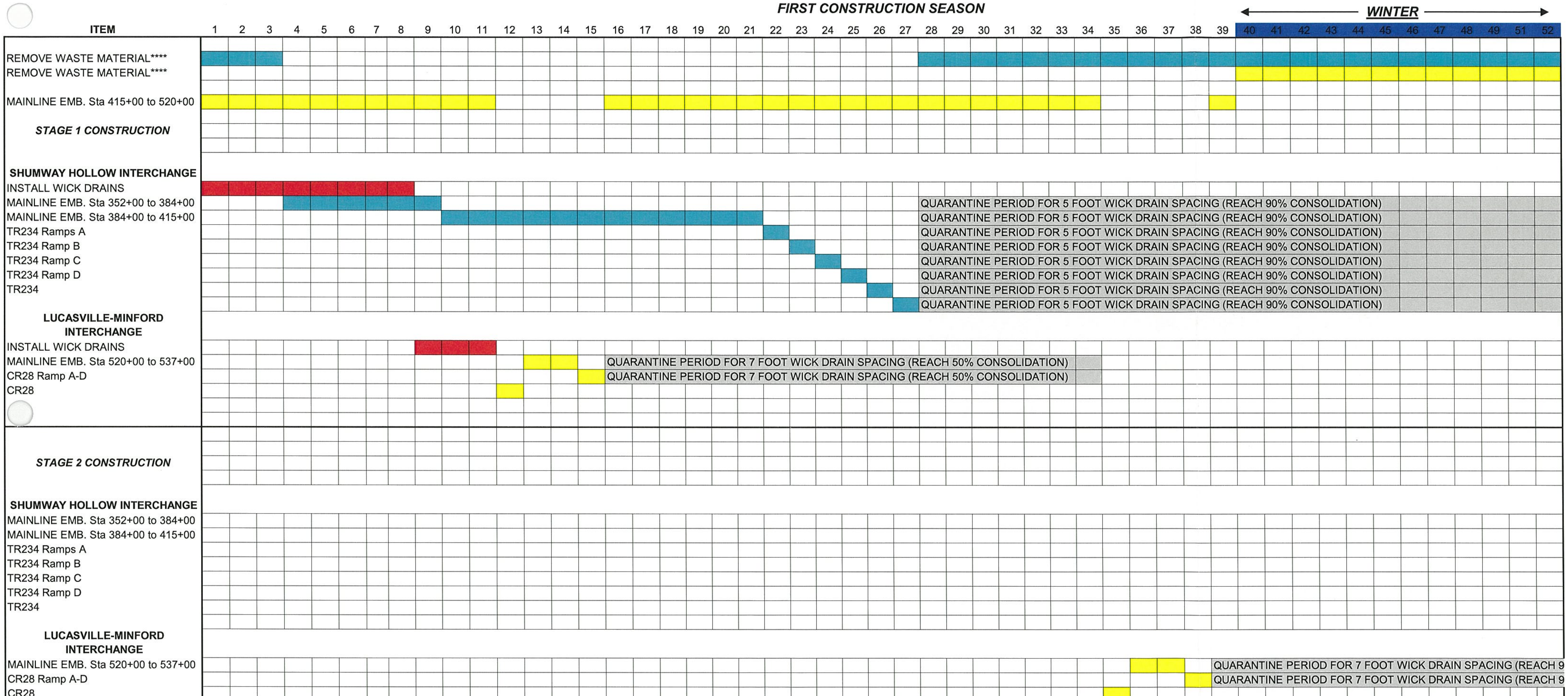
Optimum Drain Spacing based on required diameter of cyliner of influence to achieve primary consolidation within given design period: **5.01 ft**

Length Outer Edge of Equilateral Triangle (or square) =	1952.40	ft
Number Drain Spaces Along Outer Edge =	389.56	ea
Total number wick drains =	76463	ea
Total linear feet wick drain =	2370353	lf
Estimated total cost =	**$1,185,176.50**	

Scenario 2: Option 1

CONCEPTUALIZED CONSTRUCTION SCHEDULE

SHEET 1



NOTES:

1. Schedule based on 10 hour work days and a 5 day week.
2. Productivity rate of 700 CY / HR was used for time estimates based on conversations with contractors.
3. QUANTITIES USED IN ANALYSES:
   - CUT = 5,789,155 CY
   - FILL = 3,316,338 CY
   - WASTE = 3,341,190 CY (BASED ON 15% SWELL)
4. All wick drains at Shumway Hollow Interchange at 5 ft. spacing and all wick drains at Lucasville-Minford Interchange at 7 ft. spacing.
5. Assume 6 rigs for installation of wick drains at an istallation rate of 10,000 ft/day per rig.
6. Estimated Total Wick Drain Installation Cost ($0.50/ft installed) = $306,579 (CR 28) + $1,185,177 (Shumway Hollow) + $2,784,175 (2 ft. Sand Blanket)= **$ 4,275,931 (Total)**

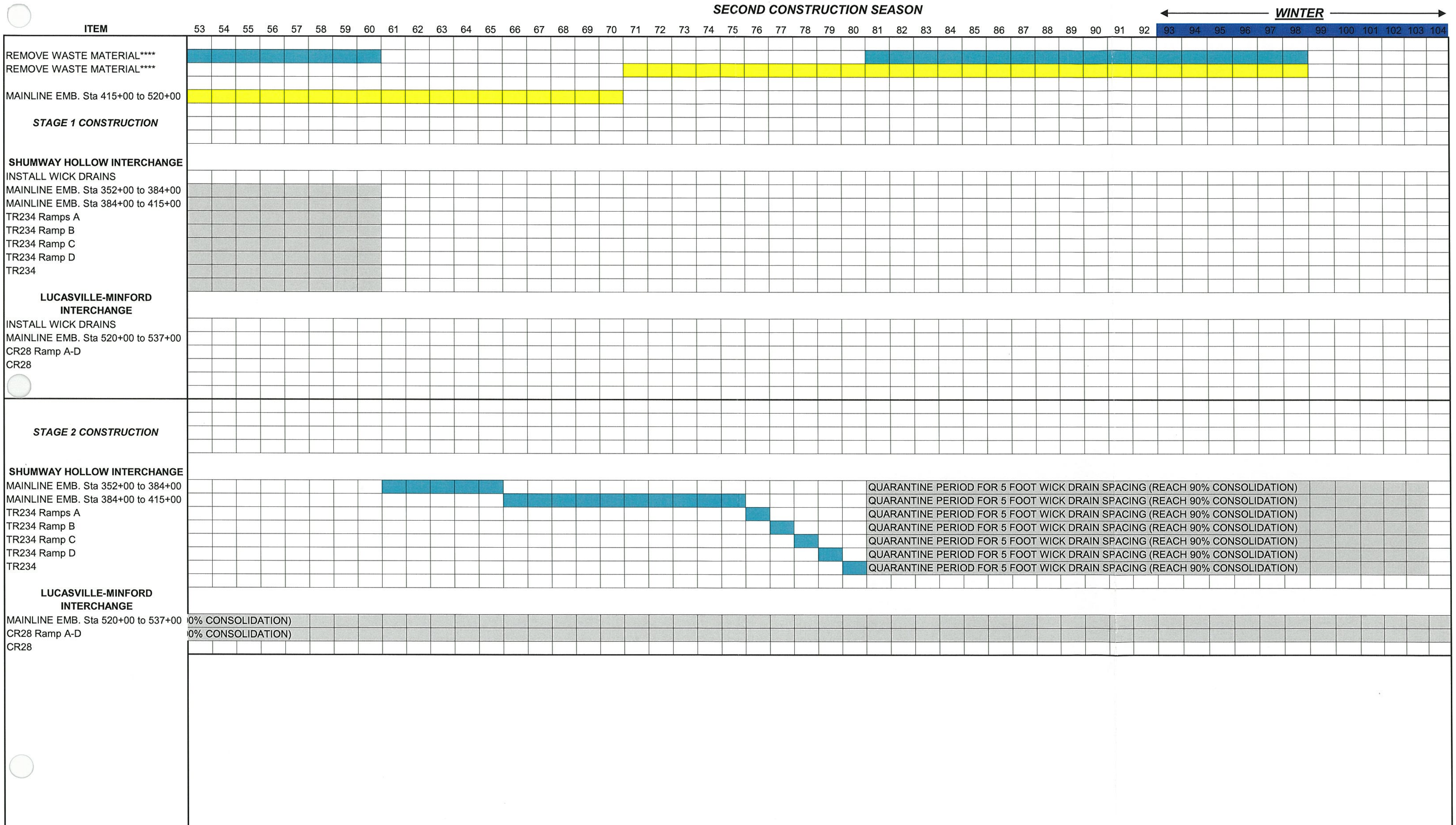
Legend

- Crew Number 1 (2 Excavators)
- Crew Number 2 (2 Excavators)
- Wick Drain Installation
- Quarantine Period

Scenario 2: Option 1

CONCEPTUALIZED CONSTRUCTION SCHEDULE

SHEET 2



Scenario 2: Option 1

CONCEPTUALIZED CONSTRUCTION SCHEDULE

SHEET 3

THIRD CONSTRUCTION SEASON (105–144)

WINTER (145–156)

ITEM	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119	120	121	122	123	124	125	126	127	128	129	130	131	132	133	134	135	136	137	138	139	140	141	142	143	144	145	146	147	148	149	150	151	152	153	154	155	156
REMOVE WASTE MATERIAL****																																																				
REMOVE WASTE MATERIAL****																																																				
MAINLINE EMB. Sta 415+00 to 520+00																																																				
STAGE 1 CONSTRUCTION																																																				
SHUMWAY HOLLOW INTERCHANGE																																																				
INSTALL WICK DRAINS																																																				
MAINLINE EMB. Sta 352+00 to 384+00																																																				
MAINLINE EMB. Sta 384+00 to 415+00																																																				
TR234 Ramps A																																																				
TR234 Ramp B																																																				
TR234 Ramp C																																																				
TR234 Ramp D																																																				
TR234																																																				
LUCASVILLE-MINFORD INTERCHANGE																																																				
INSTALL WICK DRAINS																																																				
MAINLINE EMB. Sta 520+00 to 537+00																																																				
CR28 Ramp A-D																																																				
CR28																																																				
STAGE 2 CONSTRUCTION																																																				
SHUMWAY HOLLOW INTERCHANGE																																																				
MAINLINE EMB. Sta 352+00 to 384+00																																																				
MAINLINE EMB. Sta 384+00 to 415+00																																																				
TR234 Ramps A																																																				
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TR234 Ramp C																																																				
TR234 Ramp D																																																				
TR234																																																				
LUCASVILLE-MINFORD INTERCHANGE																																																				
MAINLINE EMB. Sta 520+00 to 537+00																																																				
CR28 Ramp A-D																																																				
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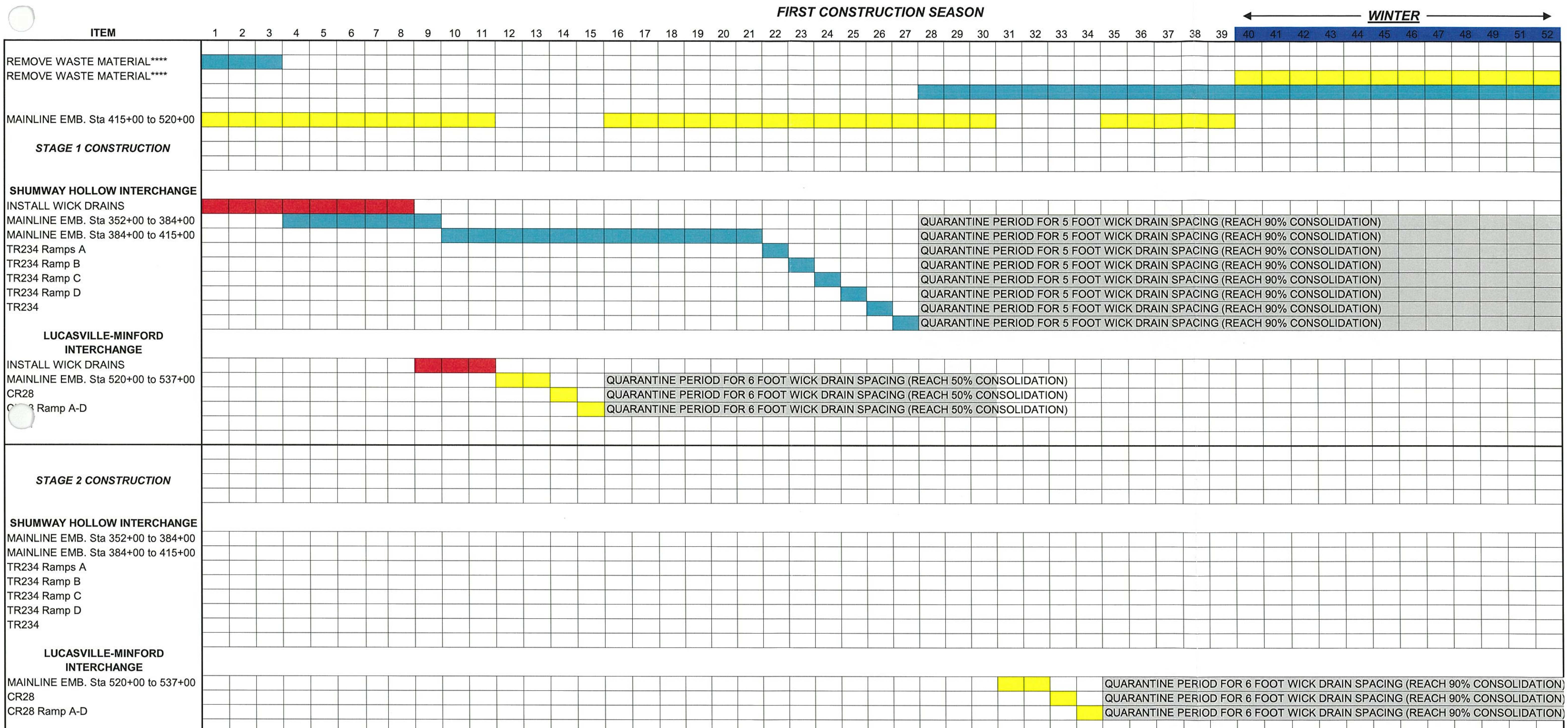
Scenario 2: Option 2

CONCEPTUALIZED CONSTRUCTION SCHEDULE

SHEET 1



NOTES:

1. Schedule based on 10 hour work days and a 5 day week.
2. Productivity rate of 700 CY / HR was used for time estimates based on conversations with contractors.
3. QUANTITIES USED IN ANALYSES:
   - CUT = 5,789,155 CY
   - FILL = 3,316,338 CY
   - WASTE = 3,341,190 CY (BASED ON 15% SWELL)
4. All wick drains at Shumway Hollow Interchange at 5 ft. spacing and all wick drains at Lucasville-Minford Interchange at 6 ft. spacing.
5. Assume 6 rigs for installation of wick drains at an istallation rate of 10,000 ft/day per rig.
6. Estimated Total Wick Drain Installation Cost ($0.50/ft Installed) = $414,505 (CR 28) + $1,185,177 (Shumway Hollow) + $2,784,175 (2 ft. Sand Blanket)= **$ 4,383,857 (Total)**

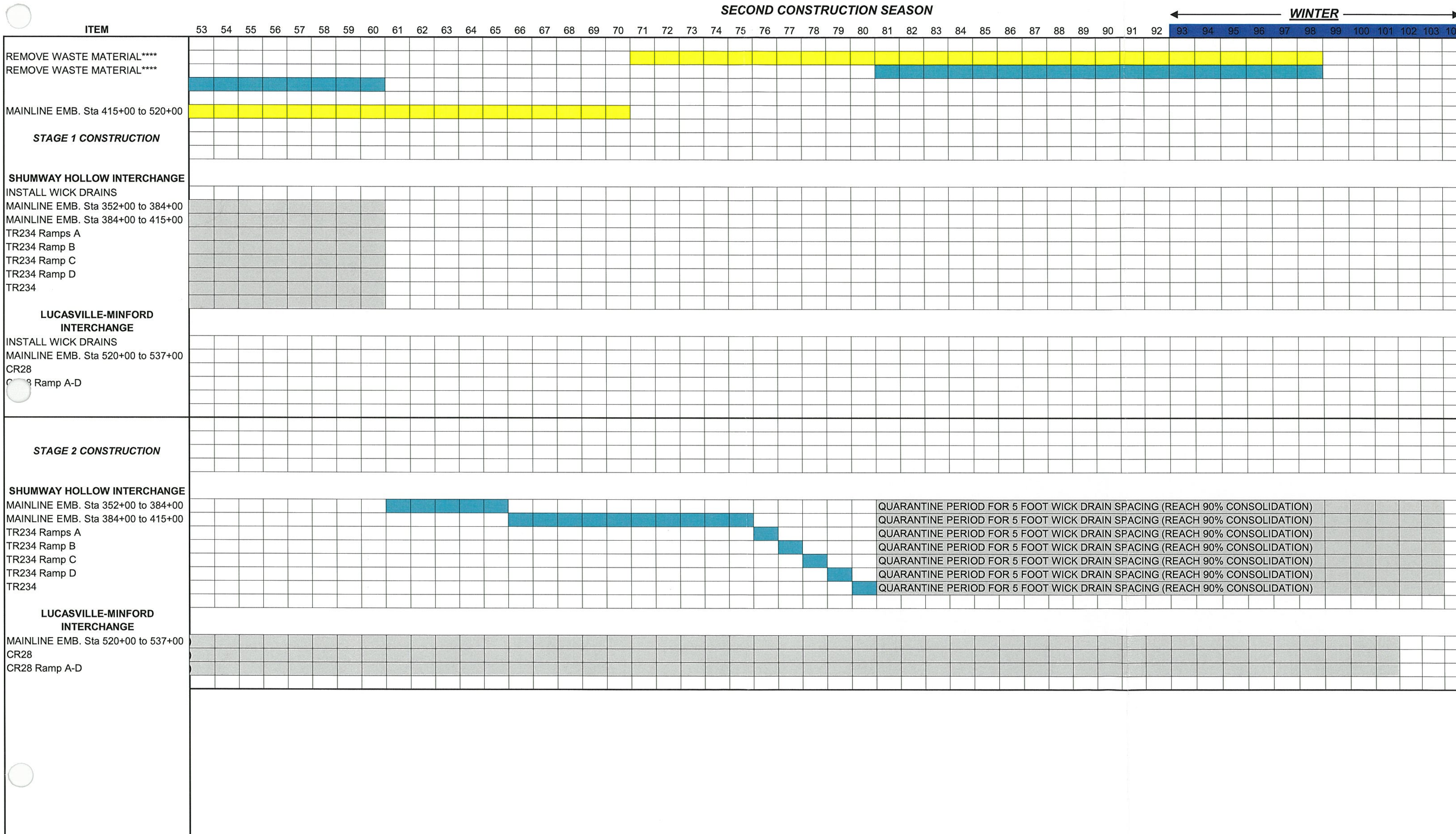
Legend

- Crew Number 1 (2 Excavators)
- Crew Number 2 (2 Excavators)
- Wick Drain Installation
- Quarantine Period

Scenario 2: Option 2

CONCEPTUALIZED CONSTRUCTION SCHEDULE

SHEET 2



SCENARIO
#3

Scenario 3 – Shumway Hollow Interchange Ramps A & D will be paved and opened to traffic. Additional time allowed for consolidation of embankment south of Shumway Hollow Road (TR 234), as this area will not be open to traffic. At Lucasville-Minford Interchange, Ramps A & D will be opened to traffic.

Option 1: Total Cost = $4,199,857

- Wick drains along the mainline embankment from Sta. 384+00 to Sta. 415+00 and at TR 234 Ramps A & D spaced at 5 feet.
- Wick drains along the mainline embankment from Sta. 352+00 to Sta. 384+00 and at TR 234 Ramps B & C spaced at 6 feet.
- Wick drains at 7 foot spacing across the Lucasville-Minford Interchange.
- Complete embankments in 2 construction seasons.
- Reach 90% consolidation of Shumway Hollow Interchange north of TR 234 (i.e. TR 234 Ramps A & D and Mainline Embankment from Sta. 384+00 to Sta. 415+00) in second construction season.
- Reach 90% consolidation of Shumway Hollow Interchange south of TR 234 (i.e. TR 234 Ramps B & C and Mainline Embankment from Sta. 352+00 to 384+00) and the Lucasville-Minford Interchange in third construction season.

Constructability Benefits/Issues with Option 1

- Paving to begin at north end of Shumway Hollow Interchange at beginning of third construction season.
- Paving at south end of Shumway Hollow Interchange could begin approximately 9 weeks into the third construction season.
- Paving at Lucasville-Minford Interchange could begin approximately 23 weeks into third construction season.

Option 2: Total Cost = $4,243,014

- Wick drains at Shumway Hollow Interchange along the Mainline Embankment from Sta. 384+00 to Sta. 415+00 and at TR 234 Ramps A & D spaced at 5 feet.
- Wick drains at Shumway Hollow Interchange along the Mainline Embankment from Sta. 352+00 to Sta. 384+00 and at TR 234 Ramps B & C spaced at 6 feet.
- Wick drains at Lucasville-Minford Interchange along Ramps A, B, C and D spaced at 6 feet.
- Wick drains at Lucasville-Minford Interchange along the mainline Embankment from Sta. 520+00 to Sta. 537+00 spaced at 7 feet.
- Complete construction of all embankments in 2 construction seasons.
- Reach 90% consolidation of North Shumway Hollow Interchange (i.e. TR 234 Ramps A & D and Mainline Embankment from Sta. 384+00 to Sta. 415+00) in second construction season.

- Reach 90% consolidation of South Shumway Hollow Interchange (i.e. TR234 Ramps B & C and Mainline Embankment from Sta. 352+00 to 384+00) in third construction season.
- Reach 90% consolidation of Ramps A, B, C and D at Lucasville-Minford Interchange in second construction season.
- Reach 90% consolidation of Mainline Embankment from Sta. 520+00 to Sta. 537+00 at Lucasville-Minford Interchange in third construction season.

Constructability Benefits/Issues with Option 2

- Paving at the North end of the Shumway Hollow Interchange could begin at the beginning of the third construction season.
- Paving at South end of Shumway Hollow Interchange could begin approximately 9 weeks into the third construction season.
- Paving along ramps A, B, C, and D at the Lucasville-Minford Interchange could begin at the beginning of the third construction season.
- Paving along the mainline at the Lucasville-Minford Interchange could begin approximately 23 weeks inot the third construction season.

COMPUTATIONS

SCENARIO 3

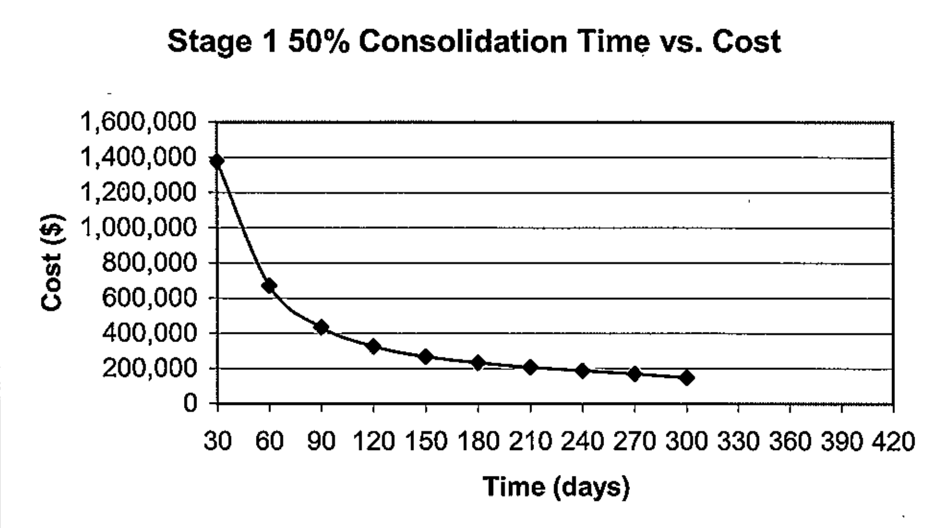
OPTION 1

Job No.	79784	PID No.	19415

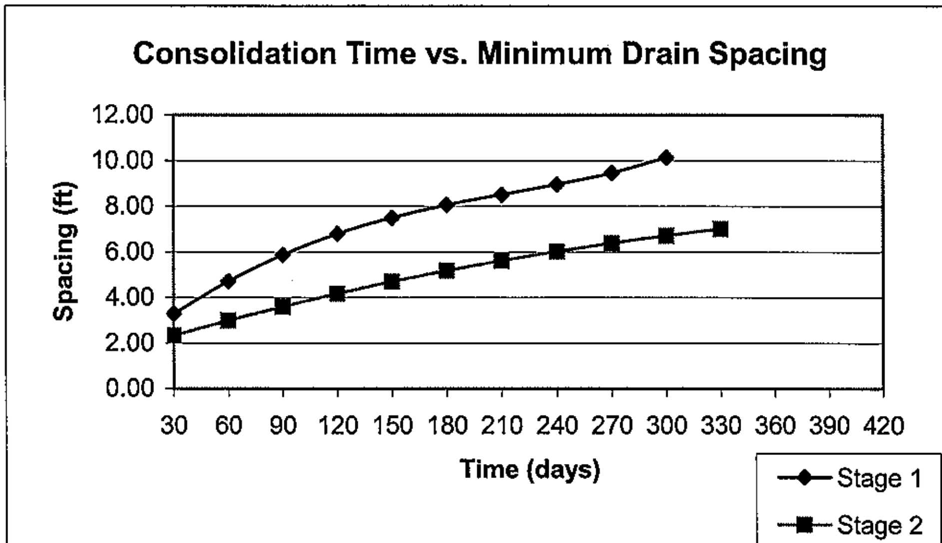
HDR Computation

Project	SCI-823 Portsmouth Bypass	Computed	JSA	Date	4/17/2008
Subject	CR 28 Interchange	Checked	DMV	Date	5/1/2008
Task	Wick Drain Analyses - Idealized Case	Sheet	1	Of	1

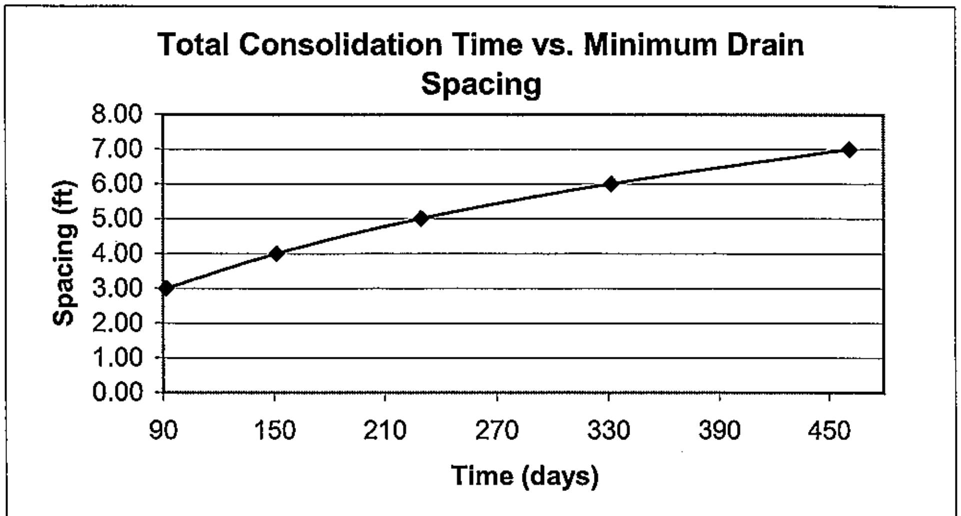
Stage 1 - 50% Consolidation		
Triangular Pattern		
t (days)	Spacing (ft)	Cost ($)
30	3.28	1,378,650
60	4.71	670,829
90	5.87	433,683
120	6.79	325,507
150	7.49	267,358
180	8.05	232,164
210	8.51	208,049
240	8.95	188,074
270	9.46	168,555
300	10.14	147,056



Stage 2 - 90% Consolidation		
Triangular Pattern		
t (days)	Spacing (ft)	Cost ($)
30	2.33	
60	2.99	
90	3.60	
120	4.17	
150	4.70	
180	5.18	
210	5.62	
240	6.02	
270	6.39	
300	6.71	
330	7.01	



Total Time	
Triangular Pattern	
t (days)	Spacing (ft)
92	3.00
151	4.00
230	5.00
332	6.00
461	7.00



HDR Computation

Project	SCI-823 Portsmouth Bypass	Computed	JSA	Date	4/8/2008
Subject	CR 28 Interchange	Checked	DMV	Date	5/1/2008
Task	Wick Drain Analyses - Idealized Case	Sheet	1	Of	2

References:

1. Federal Highway Administration, "Prefabricated Vertical Drains - A Design and Construction Guidelines Manual." FHWA/RD-86/168, Washington, DC.
2. Department of the Navy, Naval Facilities Engineering Command, "Soil Mechanics." NAVFAC Design Manual 7.1, May 1982, pp. 241-259.
3. Subsurface Exploration Bridge and MSE Retaining Walls SR 823 Over Relocated Shumway Hollow Road SCI-823-0.00, Portsmouth Bypass (DLZ, 2006)
4. SCI-823-6.81, Portsmouth Bypass Project, PID 19415, Addendum to Report: Shumway Hollow Road (TR 234) (DLZ, 2008)

Assumptions:

1. Terzaghi's one-dimensional consolidation theory applies.
2. Radial drainage theory (as it relates to vertical drains) is a function of time, drain diameter, spacing, coefficient of consolidation, and average degree of desired consolidation.
3. Effect of disturbance related to soil displacement during installation is negligible.
4. Drain has infinite permeability (i.e. no drain resistance).

Input Values:

A =	560,368	sf	Total ramp area at CR 28 Interchange to be drained (DLZ, 2008)
C =	$0.50	cost/lf	Material + Installation Cost
	Single		Vertical Drainage (Single or Double)
	Triangular		Wick Drain Pattern
t =	128	day	available time to achieve desired degree of consolidation U_h
H =	43.5	ft	height of compressible layer
a =	0.33333	ft	width of drain (Assume 4" wide x 1/4" thick)
b =	0.020833	ft	thickness of drain (Assume for 4" wide x 1/4" thick)
c_v =	0.081	ft^2/day	coefficient consolidation for vertical drainage (From Consolidation Tests on B-1 & B-2)
c_h =	0.0972	ft^2/day	coefficient consolidation for horizontal drainage

Note:

-General Case: c_h = 1.2 to 1.5*c_v

-If layering of silt and sand in discontinuous lenses is evident: c_h = 2 to 4*c_v

-For varved clays and other deposits containing embedded and more or less continuous permeable layers: c_h = up to 10*c_v

Design Equations:

With vertical drains the overall average degree of consolidation, U, is the result of the combined effects of horizontal (radial) and vertical drainage. The combined effect is given by:

$$\overline{U} = 1 - (1 - \overline{U}_h)(1 - \overline{U}_v)$$ (See FHWA eq. 1)

where,

U = overall average degree of consolidation

U_h = average degree of consolidation due to horizontal (or radial) drainage

U_v = average degree of consolidation due to vertical drainage

Check feasibility of 2 way vertical drainage only.

U_h = 0 %

Uv = 50 %

U = U_v = 50 %

T_v = 0.19625

t = 4585 days **Need to Consider Other Options.**

Calculate U_v that will occur in design period of t.

t = 128 day

$$T = \frac{tc_v}{H^2}$$

T_v = 0.01

U_v = 0.08

Calculate required U_h

$$\overline{U} = 1 - (1 - \overline{U}_h)(1 - \overline{U}_v)$$ (See FHWA eq. 1)

U_h = 0.45

HDR Computation

Project	SCI-823 Portsmouth Bypass	Computed	JSA	Date	4/8/2008
Subject	CR 28 Interchange	Checked	DMV	Date	5/1/2008
Task	Wick Drain Analyses - Idealized Case	Sheet	2	Of	2

$$t = \frac{D^2}{8c_h} F(n) \ln\left[\frac{1}{1-\bar{U}_h}\right]$$ (See FHWA eq. 8)

where,

$t =$	128 day	available time to achieve desired degree of consolidation U_h
$\bar{U}_h =$	0.45	average degree of consolidation due to horizontal drainage
$c_h =$	0.0972 ft^2/day	coefficient of consolidation for horizontal drainage
$F(n) =$	2.806234	drain spacing factor

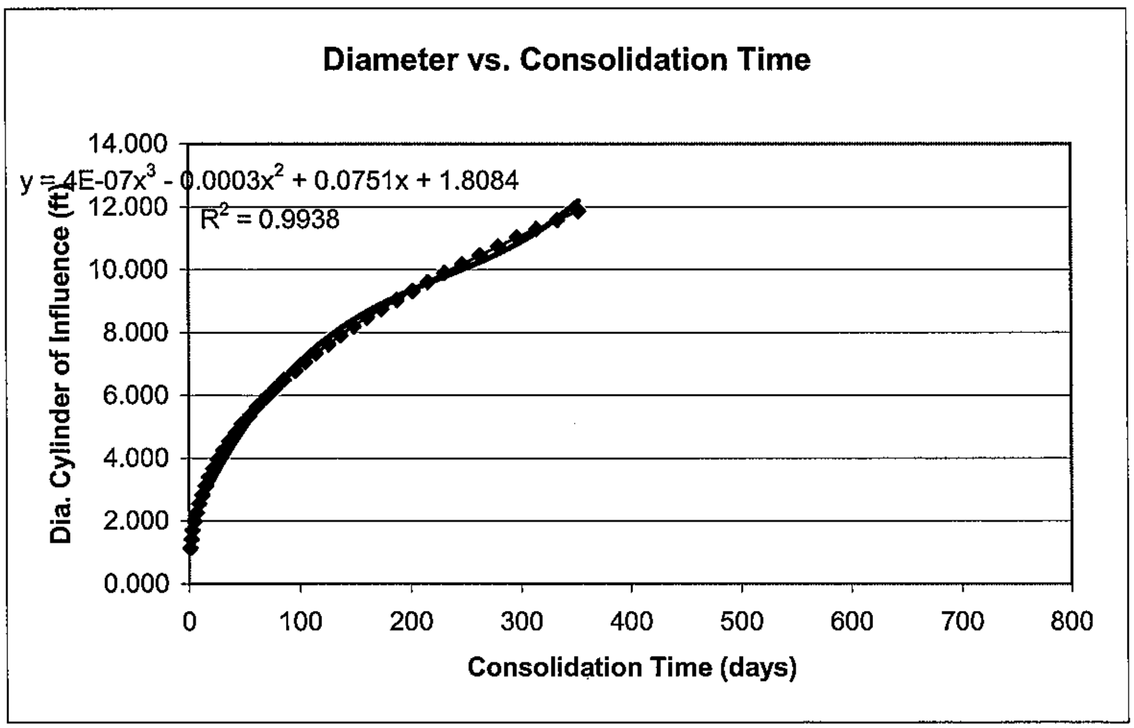
where,

$$F(n) = \ln\left(\frac{D}{d_w}\right) - 0.75$$ (simplified) (See FHWA eq. 3)

$d_w = 2(a+b)/\pi$ diameter of an equivalent circular drain (See FHWA eq. 9)

$d_w =$ 0.23 ft

$D =$ 7.902355 ft required diameter of the cylinder of influence of the drain (drain influence zone) to achieve consolidation within given design period.



Optimum Drain Spacing based on required diameter of cyliner of influence to achieve primary consolidation within given design period: **6.99 ft**

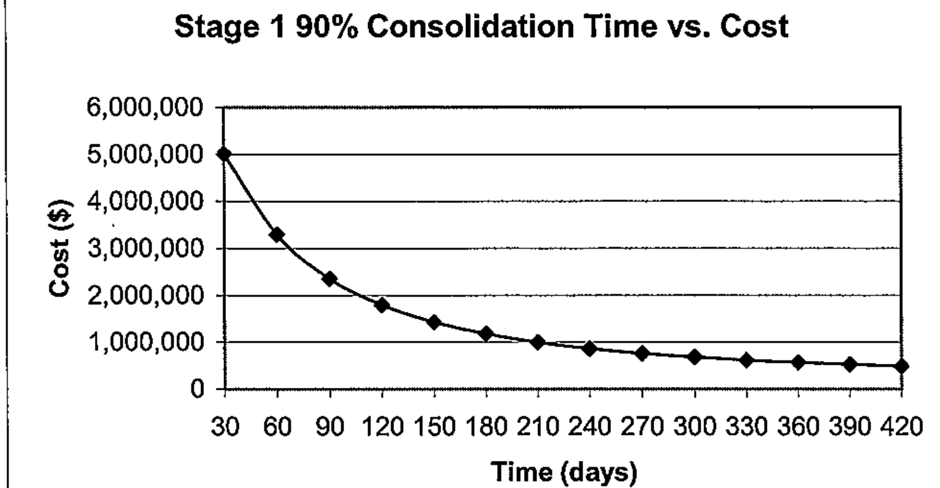
Length Outer Edge of Equilateral Triangle (or square) =	1137.59 ft
Number Drain Spaces Along Outer Edge =	162.67 ea
Total number wick drains =	13476 ea
Total linear feet wick drain =	613158 lf
Estimated total cost =	**$306,579.00**

Job No.	79784	PID No.	19415

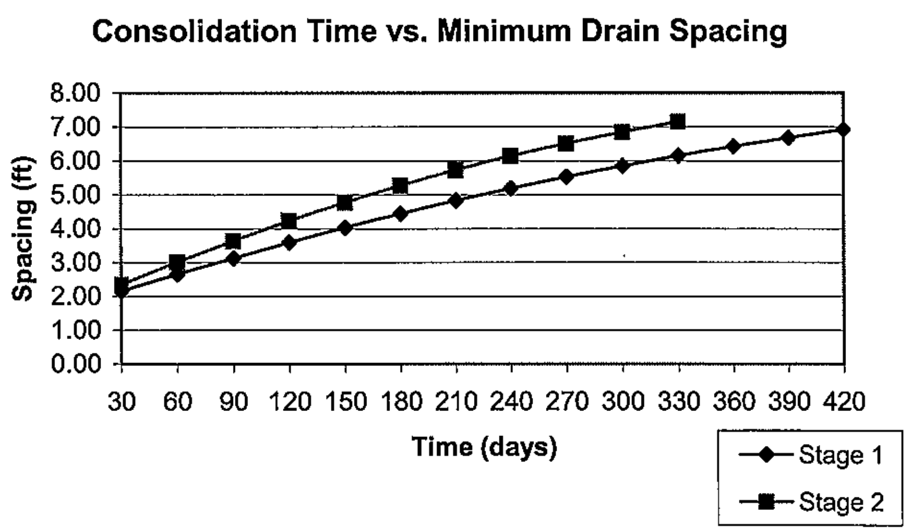
HDR Computation

Project	SCI-823 Portsmouth Bypass	Computed	JSA	Date	4/17/2008
Subject	Shumway Hollow Road (TR 234) Interchange: North Area	Checked	DMV	Date	5/1/2008
Task	Wick Drain Analyses - Idealized Case	Sheet	1	Of	1

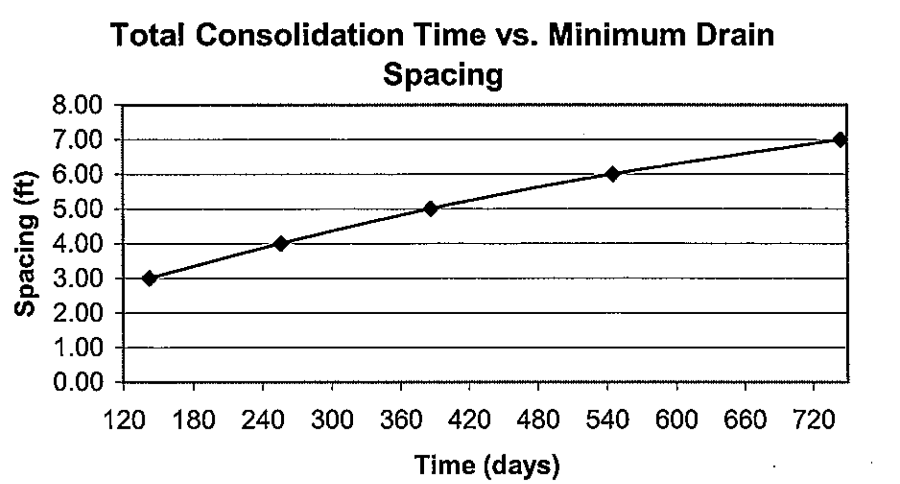
Stage 1		
Triangular Pattern		
t (days)	Spacing (ft)	Cost ($)
30	2.15	5,013,754
60	2.65	3,289,813
90	3.13	2,355,380
120	3.59	1,793,257
150	4.03	1,427,767
180	4.44	1,176,171
210	4.83	995,736
240	5.19	861,583
270	5.53	759,283
300	5.85	679,691
330	6.15	615,769
360	6.42	564,417
390	6.68	522,304
420	6.92	487,010



Stage 2		
Triangular Pattern		
t (days)	Spacing (ft)	Cost ($)
30	2.34	
60	3.01	
90	3.64	
120	4.23	
150	4.77	
180	5.27	
210	5.72	
240	6.14	
270	6.51	
300	6.85	
330	7.15	



Total Time	
Triangular Pattern	
t (days)	Spacing (ft)
142	3.00
256	4.00
386	5.00
545	6.00
744	7.00



HDR Computation

Project	SCI-823 Portsmouth Bypass	Computed	JSA	Date	4/8/2008
Subject	Shumway Hollow Road (TR 234) Interchange: North of TR 234	Checked	DMV	Date	5/1/2008
Task	Wick Drain Analyses - Idealized Case	Sheet	1	Of	2

References:

1. Federal Highway Administration, "Prefabricated Vertical Drains - A Design and Construction Guidelines Manual." FHWA/RD-86/168, Washington, DC.
2. Department of the Navy, Naval Facilities Engineering Command, "Soil Mechanics." NAVFAC Design Manual 7.1, May 1982, pp. 241-259.
3. Subsurface Exploration Bridge and MSE Retaining Walls SR 823 Over Relocated Shumway Hollow Road SCI-823-0.00, Portsmouth Bypass (DLZ, 2006)
4. SCI-823-6.81, Portsmouth Bypass Project, PID 19415, Addendum to Report: Shumway Hollow Road (TR 234) (DLZ, 2008)

Assumptions:

1. Terzaghi's one-dimensional consolidation theory applies.
2. Radial drainage theory (as it relates to vertical drains) is a function of time, drain diameter, spacing, coefficient of consolidation, and average degree of desired consolidation.
3. Effect of disturbance related to soil displacement during installation is negligible.
4. Drain has infinite permeability (i.e. no drain resistance).

Input Values:

A =	1,285,961	sf	Total area North of TR 234 to be drained (Modified from DLZ, 2008)
C =	$0.50	cost/lf	Material + Installation Cost
	Single		Vertical Drainage (Single or Double)
	Triangular		Wick Drain Pattern
t =	225	day	available time to achieve desired degree of consolidation U_h
H =	29	ft	height of compressible layer
a =	0.33333	ft	width of drain (Assume 4" wide x 1/4" thick)
b =	0.020833	ft	thickness of drain (Assume for 4" wide x 1/4" thick)
c_v =	0.081	ft²/day	coefficient consolidation for vertical drainage (From Consolidation Tests on B-1 & B-2)
c_h =	0.0972	ft²/day	coefficient consolidation for horizontal drainage

Note:

-General Case: c_h = 1.2 to 1.5*c_v

-If layering of silt and sand in discontinuous lenses is evident: c_h = 2 to 4*c_v

-For varved clays and other deposits containing embedded and more or less continuous permeable layers: c_h = up to 10*c_v

Design Equations:

With vertical drains the overall average degree of consolidation, U, is the result of the combined effects of horizontal (radial) and vertical drainage. The combined effect is given by:

$$\overline{U} = 1-(1-\overline{U}_h)(1-\overline{U}_v)$$ (See FHWA eq. 1)

where,

U = overall average degree of consolidation

U_h = average degree of consolidation due to horizontal (or radial) drainage

U_v = average degree of consolidation due to vertical drainage

Check feasibility of 2 way vertical drainage only.

U_h = 0 %

Uv = 90 % t = 8805 days **Need to Consider Other Options.**

$U = U_v$ = 90 %

T_v = 0.848

Calculate U_v that will occur in design period of t.

t = 225 day

$$T = \frac{tc_v}{H^2}$$

T_v = 0.02

U_v = 0.17

Calculate required U_h

$$\overline{U} = 1-(1-\overline{U}_h)(1-\overline{U}_v)$$ (See FHWA eq. 1)

U_h = 0.88

HDR Computation

Project	SCI-823 Portsmouth Bypass	Computed JSA	Date 4/8/2008
Subject	Shumway Hollow Road (TR 234) Interchange: North of TR 234	Checked DMV	Date 5/1/2008
Task	Wick Drain Analyses - Idealized Case	Sheet 2	Of 2

$$t = \frac{D^2}{8c_h} F(n) \ln\left[\frac{1}{1-\overline{U}_h}\right]$$ (See FHWA eq. 8)

where,

$t =$	225 day	available time to achieve desired degree of consolidation U_h
$\overline{U}_h =$	0.88	average degree of consolidation due to horizontal drainage
$c_h =$	0.0972 ft^2/day	coefficient of consolidation for horizontal drainage
$F(n) =$	2.473098	drain spacing factor

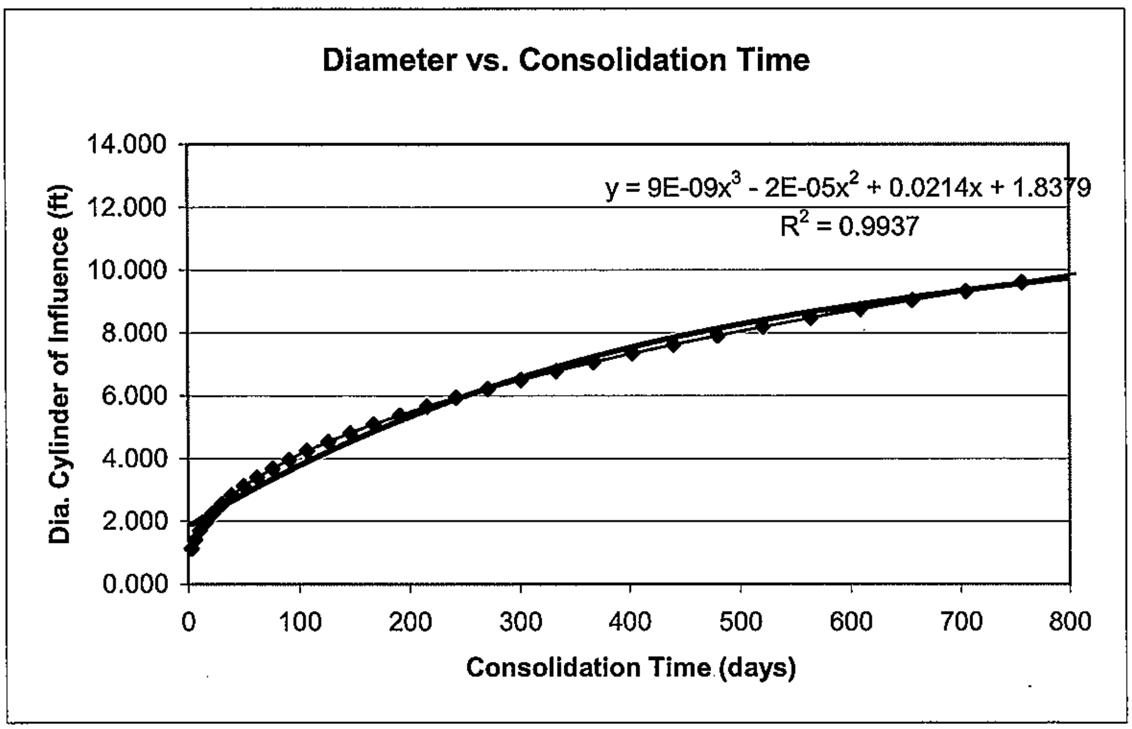
where,

$$F(n) = \ln\left(\frac{D}{d_w}\right) - 0.75$$ (simplified) (See FHWA eq. 3)

$d_w = 2(a+b)/\pi$ diameter of an equivalent circular drain (See FHWA eq. 9)

$d_w =$ 0.23 ft

$D =$ 5.663406 ft required diameter of the cylinder of influence of the drain (drain influence zone) to achieve consolidation within given design period.



Optimum Drain Spacing based on required diameter of cyliner of influence to achieve primary consolidation within given design period: **5.01 ft**

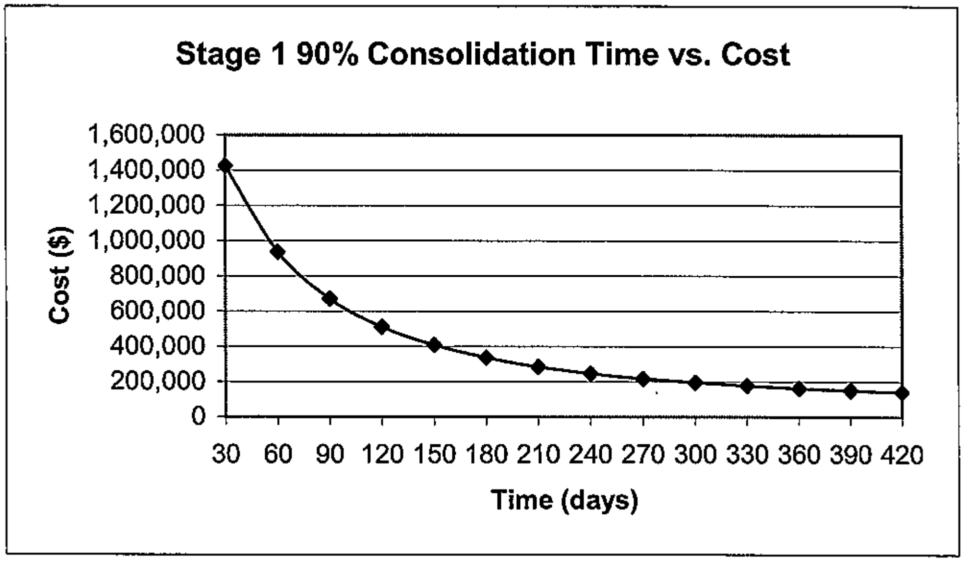
Length Outer Edge of Equilateral Triangle (or square) =	1723.31	ft
Number Drain Spaces Along Outer Edge =	343.85	ea
Total number wick drains =	59632	ea
Total linear feet wick drain =	1848592	lf
Estimated total cost =	**$924,296.00**	

Job No.	79784	PID No.	19415

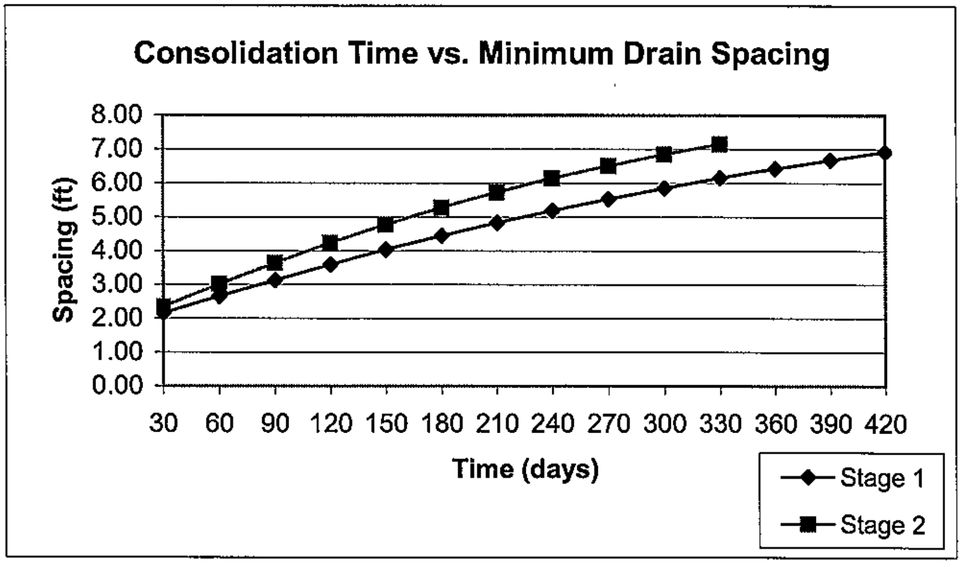
HDR Computation

Project	SCI-823 Portsmouth Bypass	Computed	JSA	Date	4/17/2008
Subject	Shumway Hollow Road (TR 234) Interchange: South Area	Checked	DMV	Date	5/1/2008
Task	Wick Drain Analyses - Idealized Case	Sheet	1	Of	1

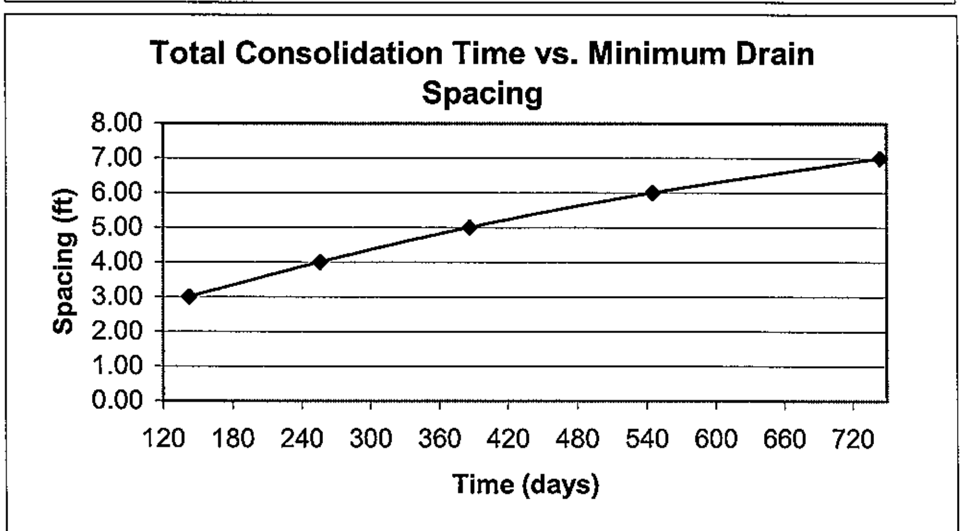
Stage 1		
Triangular Pattern		
t (days)	Spacing (ft)	Cost ($)
30	2.15	1,426,295
60	2.65	936,603
90	3.13	671,057
120	3.59	511,268
150	4.03	407,325
180	4.44	335,761
210	4.83	284,425
240	5.19	246,233
270	5.53	217,109
300	5.85	194,448
330	6.15	176,235
360	6.42	161,603
390	6.68	149,606
420	6.92	139,547



Stage 2		
Triangular Pattern		
t (days)	Spacing (ft)	Cost ($)
30	2.34	
60	3.01	
90	3.64	
120	4.23	
150	4.77	
180	5.27	
210	5.72	
240	6.14	
270	6.51	
300	6.85	
330	7.15	



Total Time	
Triangular Pattern	
t (days)	Spacing (ft)
142	3.00
256	4.00
386	5.00
545	6.00
744	7.00



HDR Computation

Project	SCI-823 Portsmouth Bypass	Computed JSA	Date 4/8/2008
Subject	Shumway Hollow Road (TR 234) Interchange: South of TR 234	Checked DMV	Date 5/1/2008
Task	Wick Drain Analyses - Idealized Case	Sheet 1	Of 2

References:

1. Federal Highway Administration, "Prefabricated Vertical Drains - A Design and Construction Guidelines Manual." FHWA/RD-86/168, Washington, DC.
2. Department of the Navy, Naval Facilities Engineering Command, "Soil Mechanics." NAVFAC Design Manual 7.1, May 1982, pp. 241-259.
3. Subsurface Exploration Bridge and MSE Retaining Walls SR 823 Over Relocated Shumway Hollow Road SCI-823-0.00, Portsmouth Bypass (DLZ, 2006)
4. SCI-823-6.81, Portsmouth Bypass Project, PID 19415, Addendum to Report: Shumway Hollow Road (TR 234) (DLZ, 2008)

Assumptions:

1. Terzaghi's one-dimensional consolidation theory applies.
2. Radial drainage theory (as it relates to vertical drains) is a function of time, drain diameter, spacing, coefficient of consolidation, and average degree of desired consolidation.
3. Effect of disturbance related to soil displacement during installation is negligible.
4. Drain has infinite permeability (i.e. no drain resistance).

Input Values:

A =	364,631	sf	Total area South of TR 234 to be drained (Modified from DLZ, 2008)
C =	$0.50	cost/lf	Material + Installation Cost
	Single		Vertical Drainage (Single or Double)
	Triangular		Wick Drain Pattern
t =	315	day	available time to achieve desired degree of consolidation U_h
H =	29	ft	height of compressible layer
a =	0.33333	ft	width of drain (Assume 4" wide x 1/4" thick)
b =	0.020833	ft	thickness of drain (Assume for 4" wide x 1/4" thick)
c_v =	0.081	ft^2/day	coefficient consolidation for vertical drainage (From Consolidation Tests on B-1 & B-2)
c_h =	0.0972	ft^2/day	coefficient consolidation for horizontal drainage

Note:

-General Case: c_h = 1.2 to 1.5*c_v

-If layering of silt and sand in discontinuous lenses is evident: c_h = 2 to 4*c_v

-For varved clays and other deposits containing embedded and more or less continuous permeable layers: c_h = up to 10*c_v

Design Equations:

With vertical drains the overall average degree of consolidation, U, is the result of the combined effects of horizontal (radial) and vertical drainage. The combined effect is given by:

$$\overline{U} = 1-(1-\overline{U}_h)(1-\overline{U}_v)$$ (See FHWA eq. 1)

where,

U = overall average degree of consolidation

U_h = average degree of consolidation due to horizontal (or radial) drainage

U_v = average degree of consolidation due to vertical drainage

Check feasibility of 2 way vertical drainage only.

U_h = 0 %

Uv = 90 %   t = 8805 days   **Need to Consider Other Options.**

$U = U_v$ = 90 %

T_v = 0.848

Calculate U_v that will occur in design period of t.

t = 315 day

$$T = \frac{tc_v}{H^2}$$

T_v = 0.03

U_v = 0.20

Calculate required U_h

$$\overline{U} = 1-(1-\overline{U}_h)(1-\overline{U}_v)$$ (See FHWA eq. 1)

U_h = 0.88

Job No.	79784	PID No.	19415

HDR Computation

Project	SCI-823 Portsmouth Bypass	Computed	JSA	Date	4/8/2008
Subject	Shumway Hollow Road (TR 234) Interchange: South of TR 234	Checked	DMV	Date	5/1/2008
Task	Wick Drain Analyses - Idealized Case	Sheet	2	Of	2

$$t = \frac{D^2}{8c_h} F(n) \ln\left[\frac{1}{1-\overline{U}_h}\right]$$ (See FHWA eq. 8)

where,

$t =$	315 day	available time to achieve desired degree of consolidation U_h
$\overline{U}_h =$	0.88	average degree of consolidation due to horizontal drainage
$c_h =$	0.0972 ft^2/day	coefficient of consolidation for horizontal drainage
$F(n) =$	2.6532	drain spacing factor

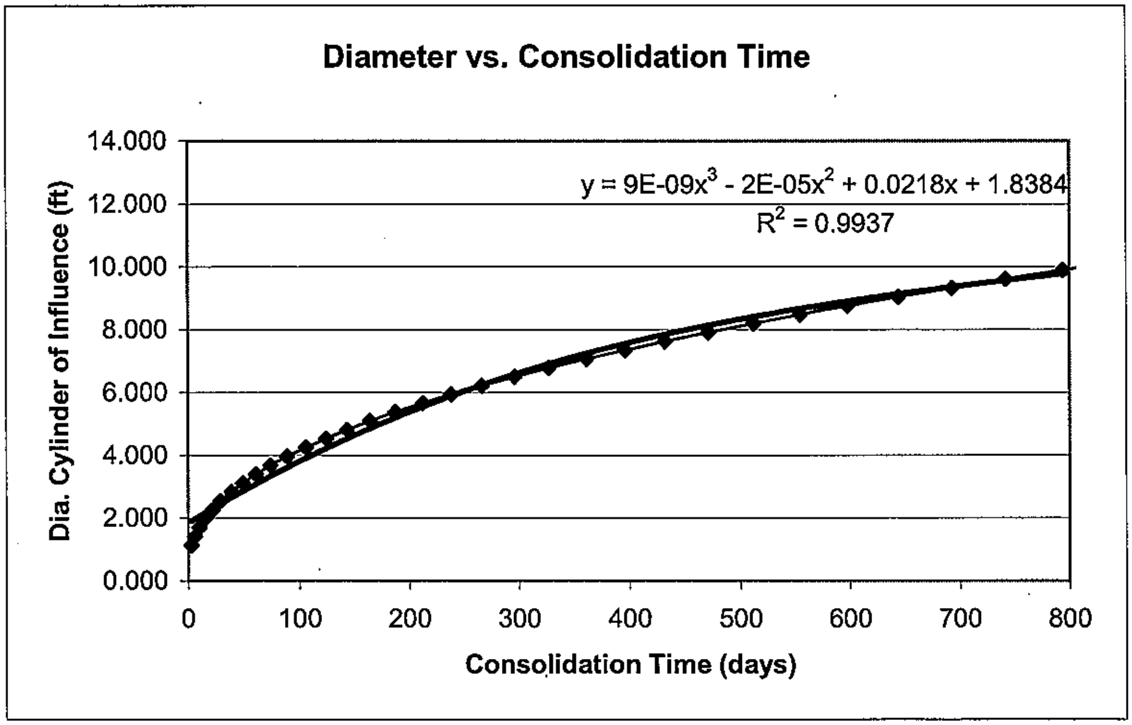
where,

$$F(n) = \ln\left(\frac{D}{d_w}\right) - 0.75$$ (simplified) (See FHWA eq. 3)

$d_w = 2(a+b)/\pi$ diameter of an equivalent circular drain (See FHWA eq. 9)

$d_w =$ 0.23 ft

$D =$ 6.781017 ft required diameter of the cylinder of influence of the drain (drain influence zone) to achieve consolidation within given design period.



Optimum Drain Spacing based on required diameter of cyliner of influence to achieve primary consolidation within given design period: 6.00 ft

Length Outer Edge of Equilateral Triangle (or square) =	917.65 ft
Number Drain Spaces Along Outer Edge =	152.92 ea
Total number wick drains =	11923 ea
Total linear feet wick drain =	369613 lf
Estimated total cost =	**$184,806.50**

COMPUTATIONS

SCENARIO 3

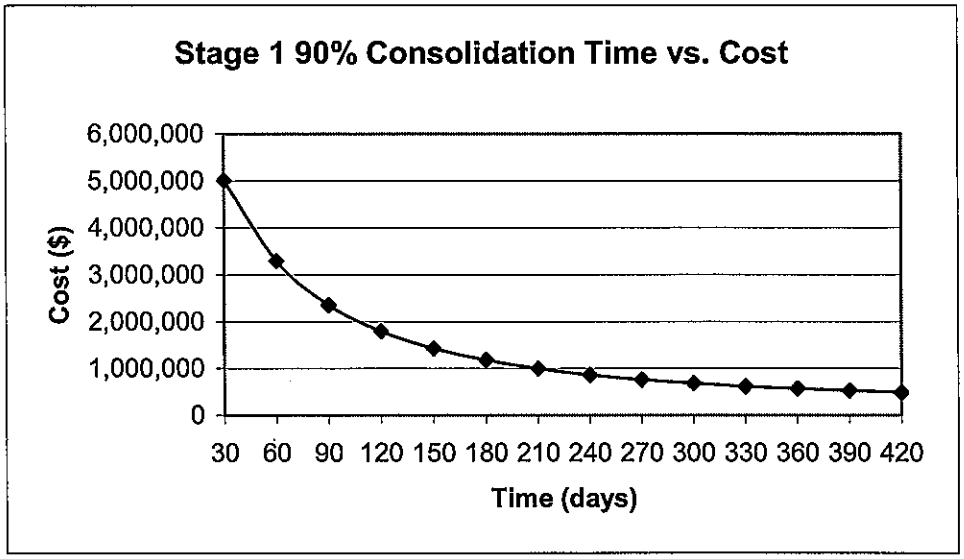
OPTION 2

HDR Computation

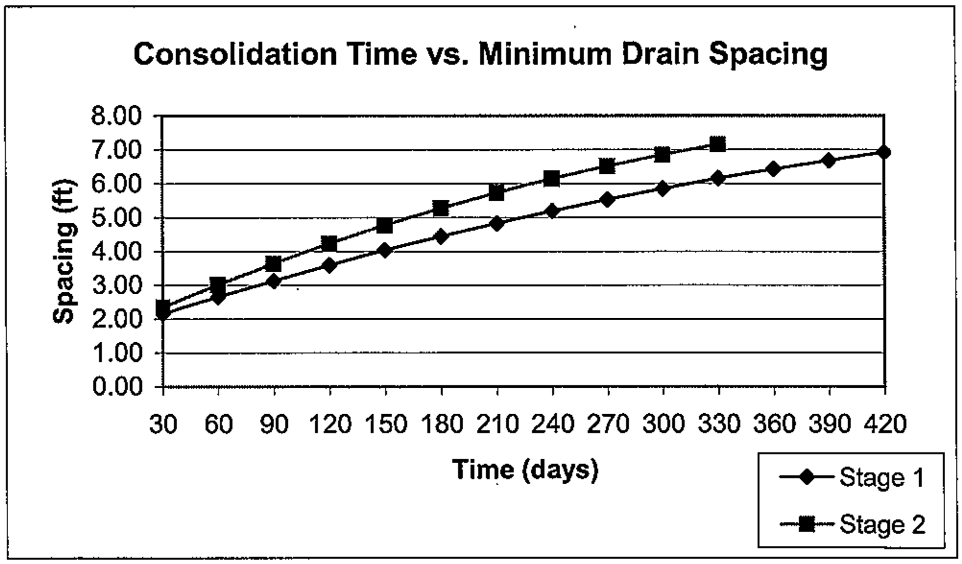
Job No.	79784	PID No.	19415

Project	SCI-823 Portsmouth Bypass	Computed	JSA	Date	4/17/2008
Subject	Shumway Hollow Road (TR 234) Interchange: North of TR 234	Checked	DMV	Date	5/1/2008
Task	Wick Drain Analyses - Idealized Case	Sheet	1	Of	1

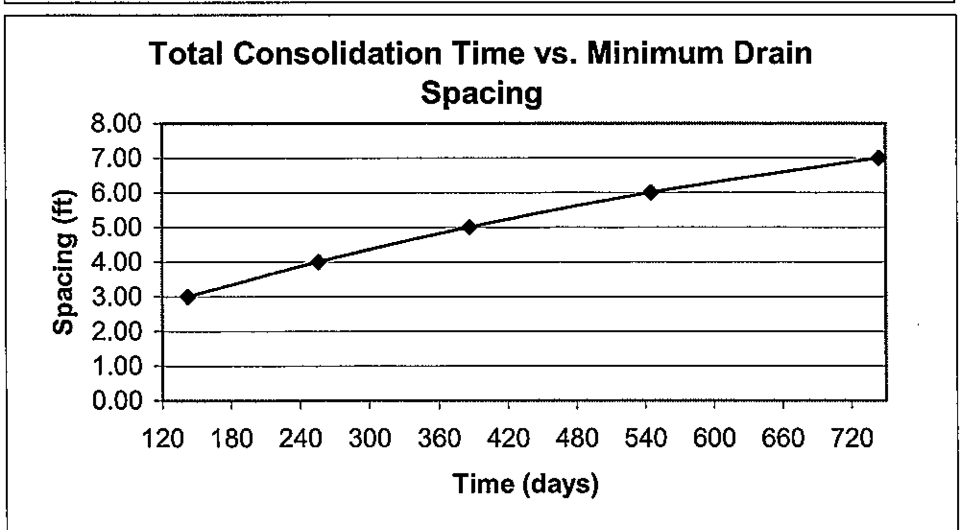
Stage 1		
Triangular Pattern		
t (days)	Spacing (ft)	Cost ($)
30	2.15	5,013,754
60	2.65	3,289,813
90	3.13	2,355,380
120	3.59	1,793,257
150	4.03	1,427,767
180	4.44	1,176,171
210	4.83	995,736
240	5.19	861,583
270	5.53	759,283
300	5.85	679,691
330	6.15	615,769
360	6.42	564,417
390	6.68	522,304
420	6.92	487,010



Stage 2		
Triangular Pattern		
t (days)	Spacing (ft)	Cost ($)
30	2.34	
60	3.01	
90	3.64	
120	4.23	
150	4.77	
180	5.27	
210	5.72	
240	6.14	
270	6.51	
300	6.85	
330	7.15	



Total Time	
Triangular Pattern	
t (days)	Spacing (ft)
142	3.00
256	4.00
386	5.00
545	6.00
744	7.00



HDR Computation

HDR

Project	SCI-823 Portsmouth Bypass	Computed JSA	Date 4/8/2008
Subject	Shumway Hollow Road (TR 234) Interchange: North of TR 234	Checked DMV	Date 5/1/2008
Task	Wick Drain Analyses - Idealized Case	Sheet 1	Of 2

References:

1. Federal Highway Administration, "Prefabricated Vertical Drains - A Design and Construction Guidelines Manual." FHWA/RD-86/168, Washington, DC.
2. Department of the Navy, Naval Facilities Engineering Command, "Soil Mechanics." NAVFAC Design Manual 7.1, May 1982, pp. 241-259.
3. Subsurface Exploration Bridge and MSE Retaining Walls SR 823 Over Relocated Shumway Hollow Road SCI-823-0.00, Portsmouth Bypass (DLZ, 2006)
4. SCI-823-6.81, Portsmouth Bypass Project, PID 19415, Addendum to Report: Shumway Hollow Road (TR 234) (DLZ, 2008)

Assumptions:

1. Terzaghi's one-dimensional consolidation theory applies.
2. Radial drainage theory (as it relates to vertical drains) is a function of time, drain diameter, spacing, coefficient of consolidation, and average degree of desired consolidation.
3. Effect of disturbance related to soil displacement during installation is negligible.
4. Drain has infinite permeability (i.e. no drain resistance).

Input Values:

A =	1,285,961	sf	Total area North of TR 234 to be drained (Modified from DLZ, 2008)
C =	$0.50	cost/lf	Material + Installation Cost
	Single		Vertical Drainage (Single or Double)
	Triangular		Wick Drain Pattern
t =	225	day	available time to achieve desired degree of consolidation U_h
H =	29	ft	height of compressible layer
a =	0.33333	ft	width of drain (Assume 4" wide x 1/4" thick)
b =	0.020833	ft	thickness of drain (Assume for 4" wide x 1/4" thick)
c_v =	0.081	ft^2/day	coefficient consolidation for vertical drainage (From Consolidation Tests on B-1 & B-2)
c_h =	0.0972	ft^2/day	coefficient consolidation for horizontal drainage

Note:

-General Case: c_h = 1.2 to 1.5*c_v

-If layering of silt and sand in discontinuous lenses is evident: c_h = 2 to 4*c_v

-For varved clays and other deposits containing embedded and more or less continuous permeable layers: c_h = up to 10*c_v

Design Equations:

With vertical drains the overall average degree of consolidation, U, is the result of the combined effects of horizontal (radial) and vertical drainage. The combined effect is given by:

$$\overline{U} = 1-(1-\overline{U}_h)(1-\overline{U}_v)$$ (See FHWA eq. 1)

where,

U = overall average degree of consolidation
U_h = average degree of consolidation due to horizontal (or radial) drainage
U_v = average degree of consolidation due to vertical drainage

Check feasibility of 2 way vertical drainage only.

U_h = 0 %
Uv = 90 % t = 8805 days **Need to Consider Other Options.**
$U = U_v$ = 90 %
T_v = 0.848

Calculate U_v that will occur in design period of t.

t = 225 day

$$T = \frac{tc_v}{H^2}$$

T_v = 0.02
U_v = 0.17

Calculate required U_h

$$\overline{U} = 1-(1-\overline{U}_h)(1-\overline{U}_v)$$ (See FHWA eq. 1)

U_h = 0.88

HDR Computation

Project	SCI-823 Portsmouth Bypass	Computed	JSA	Date	4/8/2008
Subject	Shumway Hollow Road (TR 234) Interchange: North of TR 234	Checked	DMV	Date	5/1/2008
Task	Wick Drain Analyses - Idealized Case	Sheet	2	Of	2

$$t=\frac{D^2}{8c_h}F(n)\ln\left[\frac{1}{1-\overline{U}_h}\right]$$ (See FHWA eq. 8)

where,

t =	225 day	available time to achieve desired degree of consolidation U_h
$\overline{U}_h$ =	0.88	average degree of consolidation due to horizontal drainage
c_h =	0.0972 ft^2/day	coefficient of consolidation for horizontal drainage
$F(n)$ =	2.473098	drain spacing factor

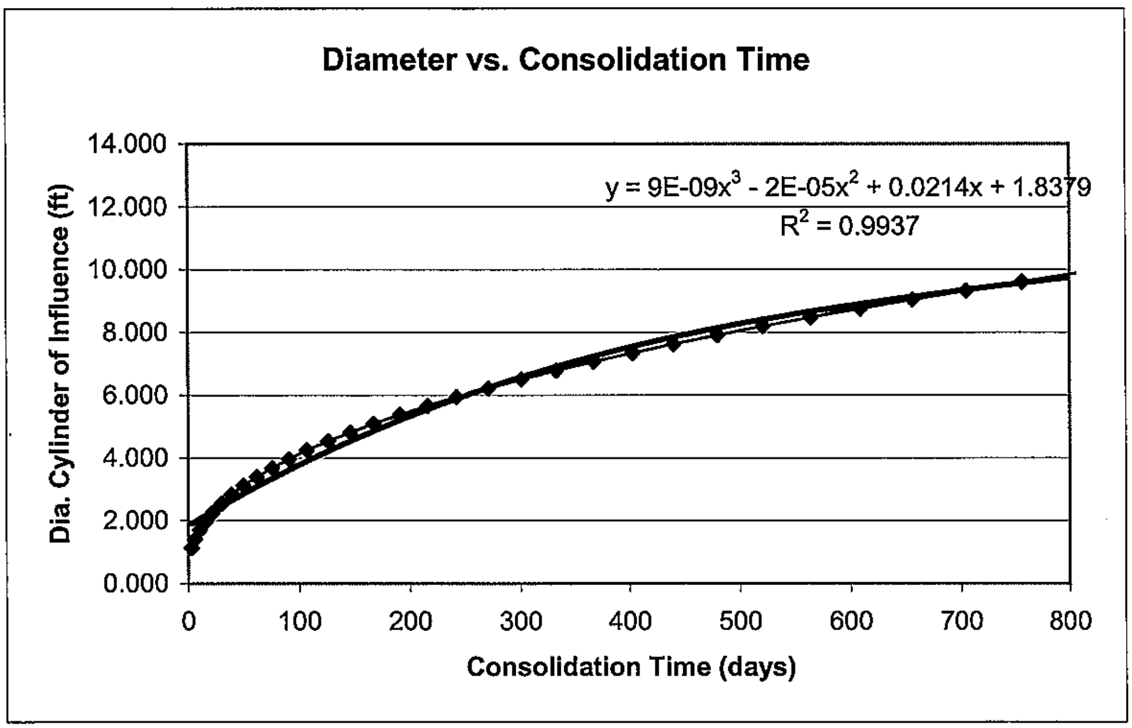
where,

$$F(n)=\ln\left(\frac{D}{d_w}\right)-0.75$$ (simplified) (See FHWA eq. 3)

$d_w = 2(a+b)/\pi$ diameter of an equivalent circular drain (See FHWA eq. 9)

d_w = 0.23 ft

D = 5.663406 ft required diameter of the cylinder of influence of the drain (drain influence zone) to achieve consolidation within given design period.



Optimum Drain Spacing based on required diameter of cyliner of influence to achieve primary consolidation within given design period: **5.01 ft**

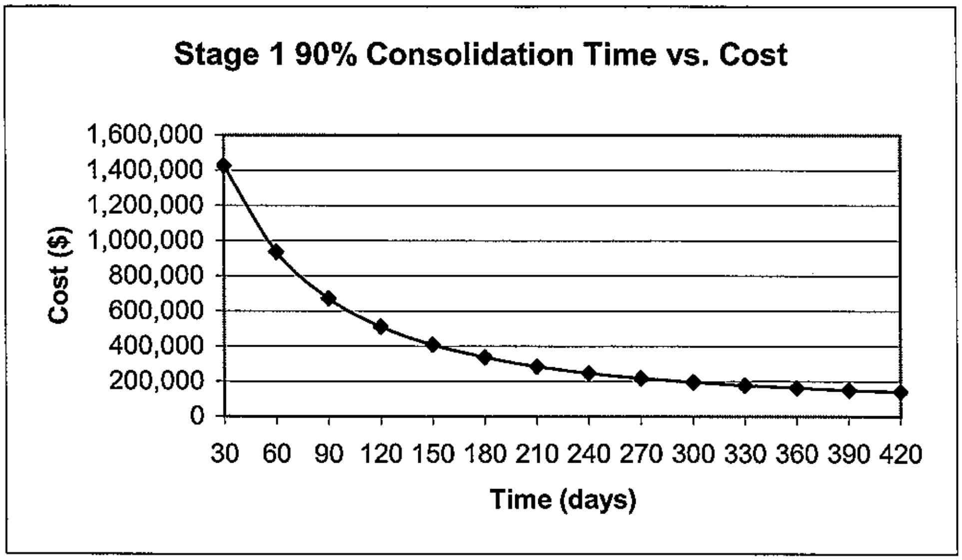
Length Outer Edge of Equilateral Triangle (or square) =	1723.31 ft
Number Drain Spaces Along Outer Edge =	343.85 ea
Total number wick drains =	59632 ea
Total linear feet wick drain =	1848592 lf
Estimated total cost =	**$924,296.00**

Job No.	79784	PID No.	19415

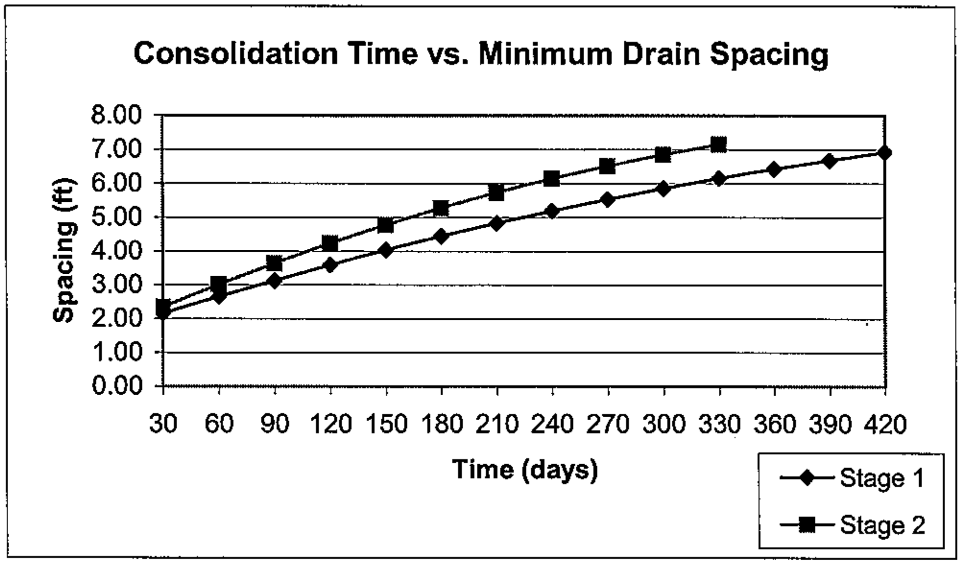
HDR Computation

Project	SCI-823 Portsmouth Bypass	Computed	JSA	Date	4/17/2008
Subject	Shumway Hollow Road (TR 234) Interchange: South of TR 234	Checked	DMV	Date	5/1/2008
Task	Wick Drain Analyses - Idealized Case	Sheet	1	Of	1

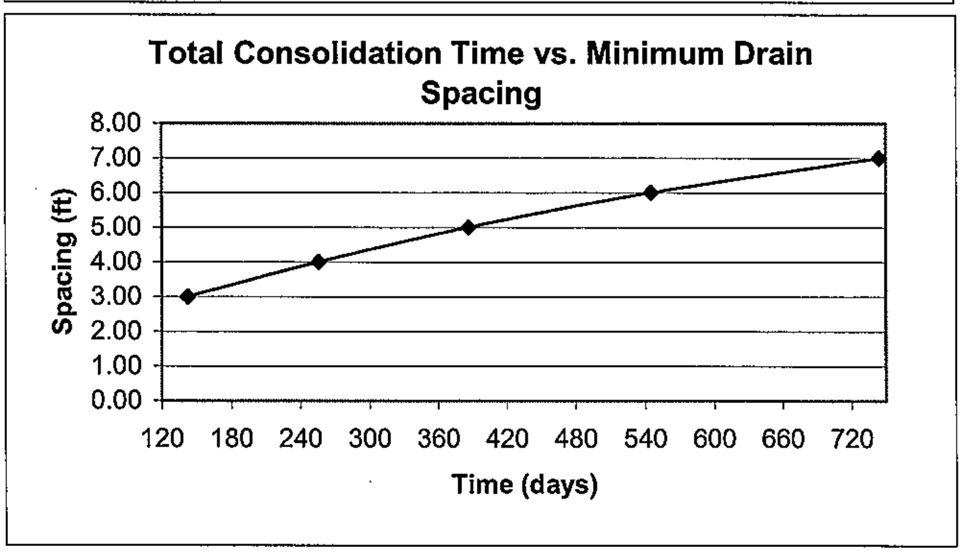
Stage 1		
Triangular Pattern		
t (days)	Spacing (ft)	Cost ($)
30	2.15	1,426,295
60	2.65	936,603
90	3.13	671,057
120	3.59	511,268
150	4.03	407,325
180	4.44	335,761
210	4.83	284,425
240	5.19	246,233
270	5.53	217,109
300	5.85	194,448
330	6.15	176,235
360	6.42	161,603
390	6.68	149,606
420	6.92	139,547



Stage 2		
Triangular Pattern		
t (days)	Spacing (ft)	Cost ($)
30	2.34	
60	3.01	
90	3.64	
120	4.23	
150	4.77	
180	5.27	
210	5.72	
240	6.14	
270	6.51	
300	6.85	
330	7.15	



Total Time	
Triangular Pattern	
t (days)	Spacing (ft)
142	3.00
256	4.00
386	5.00
545	6.00
744	7.00



Job No.	79784	PID No.	19415

HDR Computation

Project	SCI-823 Portsmouth Bypass	Computed	JSA	Date	4/8/2008
Subject	Shumway Hollow Road (TR 234) Interchange: South of TR 234	Checked	DMV	Date	5/1/2008
Task	Wick Drain Analyses - Idealized Case	Sheet	1	Of	2

References:

1. Federal Highway Administration, "Prefabricated Vertical Drains - A Design and Construction Guidelines Manual." FHWA/RD-86/168, Washington, DC.
2. Department of the Navy, Naval Facilities Engineering Command, "Soil Mechanics." NAVFAC Design Manual 7.1, May 1982, pp. 241-259.
3. Subsurface Exploration Bridge and MSE Retaining Walls SR 823 Over Relocated Shumway Hollow Road SCI-823-0.00, Portsmouth Bypass (DLZ, 2006)
4. SCI-823-6.81, Portsmouth Bypass Project, PID 19415, Addendum to Report: Shumway Hollow Road (TR 234) (DLZ, 2008)

Assumptions:

1. Terzaghi's one-dimensional consolidation theory applies.
2. Radial drainage theory (as it relates to vertical drains) is a function of time, drain diameter, spacing, coefficient of consolidation, and average degree of desired consolidation.
3. Effect of disturbance related to soil displacement during installation is negligible.
4. Drain has infinite permeability (i.e. no drain resistance).

Input Values:

A =	364,631	sf	Total area South of TR 234 to be drained (Modified from DLZ, 2008)
C =	$0.50	cost/lf	Material + Installation Cost
	Single		Vertical Drainage (Single or Double)
	Triangular		Wick Drain Pattern
t =	315	day	available time to achieve desired degree of consolidation U_h
H =	29	ft	height of compressible layer
a =	0.33333	ft	width of drain (Assume 4" wide x 1/4" thick)
b =	0.020833	ft	thickness of drain (Assume for 4" wide x 1/4" thick)
c_v =	0.081	ft^2/day	coefficient consolidation for vertical drainage (From Consolidation Tests on B-1 & B-2)
c_h =	0.0972	ft^2/day	coefficient consolidation for horizontal drainage

Note:

-General Case: c_h = 1.2 to 1.5*c_v

-If layering of silt and sand in discontinuous lenses is evident: c_h = 2 to 4*c_v

-For varved clays and other deposits containing embedded and more or less continuous permeable layers: c_h = up to 10*c_v

Design Equations:

With vertical drains the overall average degree of consolidation, U, is the result of the combined effects of horizontal (radial) and vertical drainage. The combined effect is given by:

$$\overline{U} = 1-(1-\overline{U}_h)(1-\overline{U}_v)$$ (See FHWA eq. 1)

where,

U = overall average degree of consolidation

U_h = average degree of consolidation due to horizontal (or radial) drainage

U_v = average degree of consolidation due to vertical drainage

Check feasibility of 2 way vertical drainage only.

U_h = 0 %

Uv = 90 %   t = 8805 days   **Need to Consider Other Options.**

$U = U_v$ = 90 %

T_v = 0.848

Calculate U_v that will occur in design period of t.

t = 315 day

$$T = \frac{tc_v}{H^2}$$

T_v = 0.03

U_v = 0.20

Calculate required U_h

$$\overline{U} = 1-(1-\overline{U}_h)(1-\overline{U}_v)$$ (See FHWA eq. 1)

U_h = 0.88

HDR Computation

Project	SCI-823 Portsmouth Bypass	Computed JSA	Date 4/8/2008
Subject	Shumway Hollow Road (TR 234) Interchange: South of TR 234	Checked DMV	Date 5/1/2008
Task	Wick Drain Analyses - Idealized Case	Sheet 2	Of 2

$$t = \frac{D^2}{8c_h} F(n) \ln\left[\frac{1}{1-\overline{U}_h}\right]$$ (See FHWA eq. 8)

where,

t =	315 day	available time to achieve desired degree of consolidation U_h
$\overline{U}_h$ =	0.88	average degree of consolidation due to horizontal drainage
c_h =	0.0972 ft^2/day	coefficient of consolidation for horizontal drainage
$F(n)$ =	2.6532	drain spacing factor

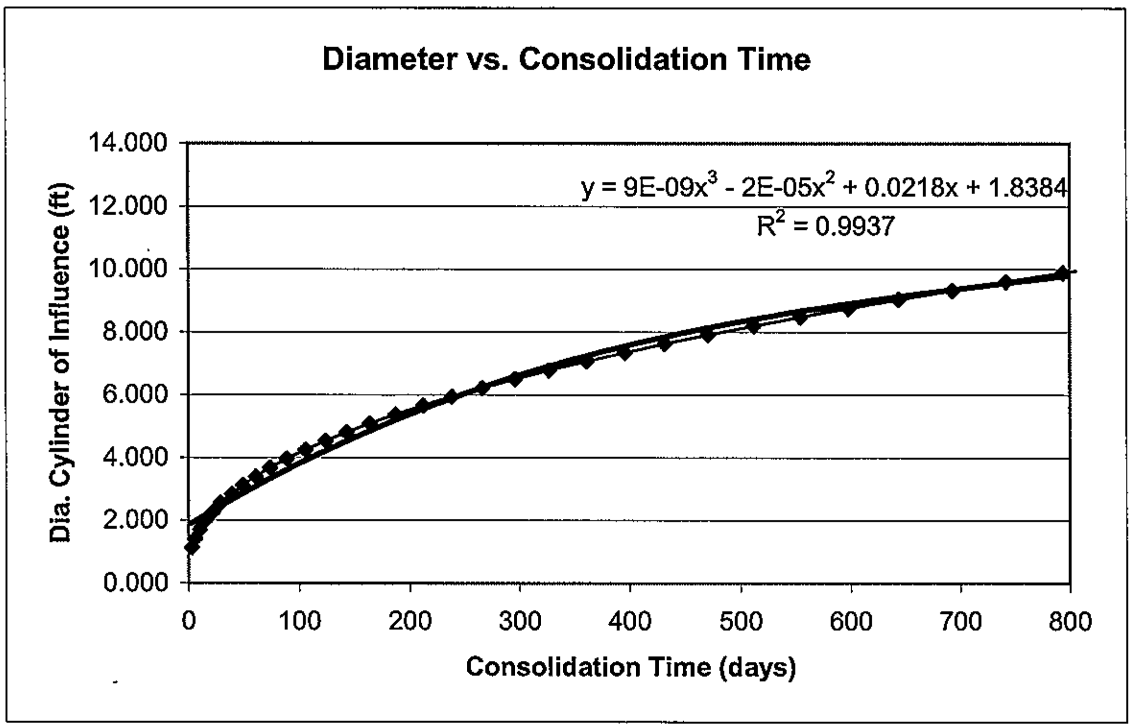
where,

$$F(n) = \ln\left(\frac{D}{d_w}\right) - 0.75$$ (simplified) (See FHWA eq. 3)

d_w = 2(a+b)/π — diameter of an equivalent circular drain (See FHWA eq. 9)

d_w = 0.23 ft

D = 6.781017 ft — required diameter of the cylinder of influence of the drain (drain influence zone) to achieve consolidation within given design period.



Optimum Drain Spacing based on required diameter of cyliner of influence to achieve primary consolidation within given design period: **6.00 ft**

Length Outer Edge of Equilateral Triangle (or square) =	917.65 ft
Number Drain Spaces Along Outer Edge =	152.92 ea
Total number wick drains =	11923 ea
Total linear feet wick drain =	369613 lf
Estimated total cost =	**$184,806.50**

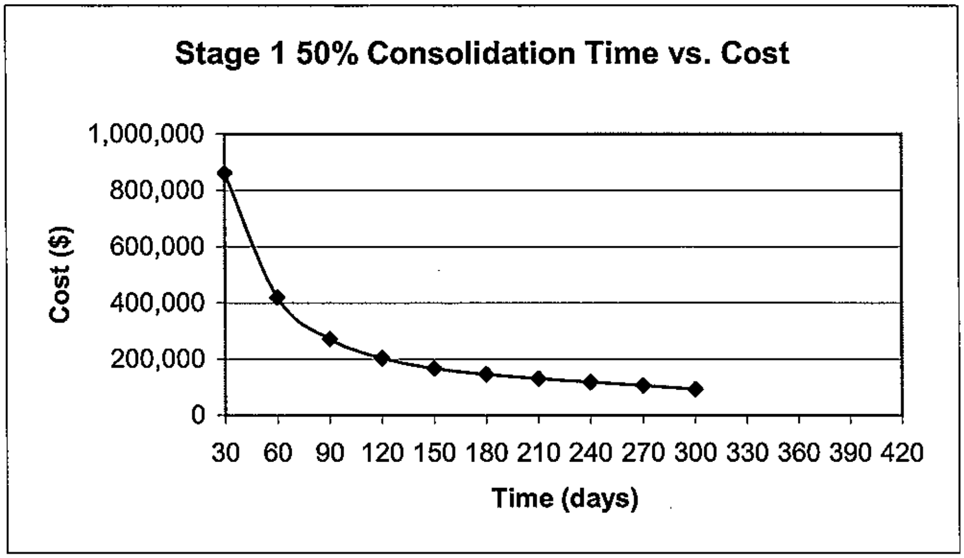
Job No. 79784 | PID No. 19415

HDR Computation

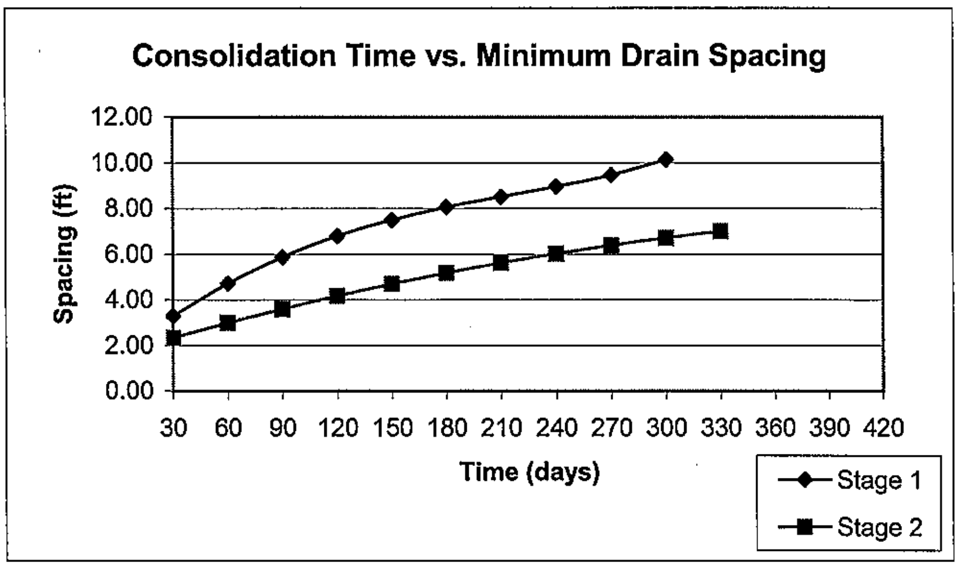
HDR

Project	SCI-823 Portsmouth Bypass	Computed JSA	Date 4/17/2008
Subject	CR 28 Interchange: Mainline Embankment	Checked	Date
Task	Wick Drain Analyses - Idealized Case	Sheet 1	Of 1

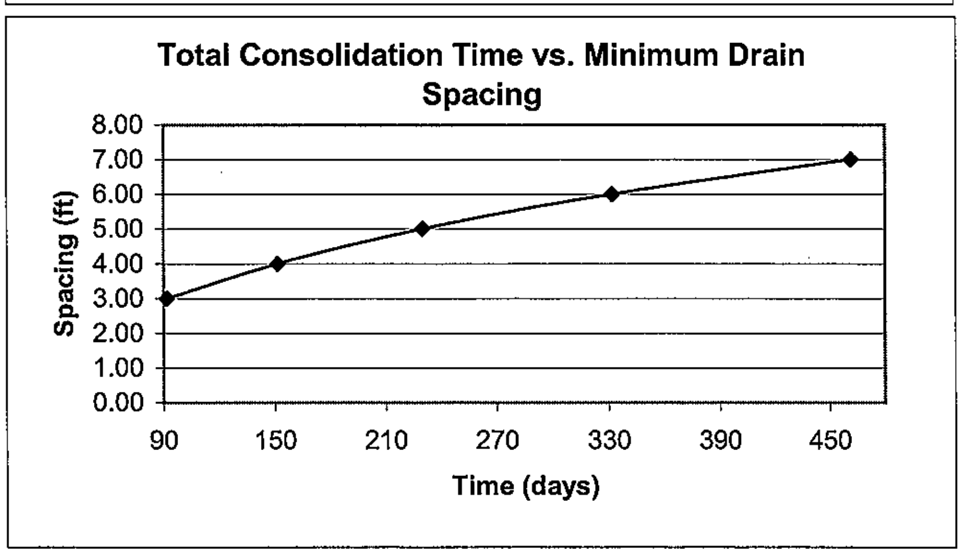
Stage 1 - 50% Consolidation		
Triangular Pattern		
t (days)	Spacing (ft)	Cost ($)
30	3.28	861,383
60	4.71	419,556
90	5.87	271,453
120	6.79	203,863
150	7.49	167,531
180	8.05	145,532
210	8.51	130,471
240	8.95	117,959
270	9.46	105,765
300	10.14	92,320



Stage 2 - 90% Consolidation		
Triangular Pattern		
t (days)	Spacing (ft)	Cost ($)
30	2.33	
60	2.99	
90	3.60	
120	4.17	
150	4.70	
180	5.18	
210	5.62	
240	6.02	
270	6.39	
300	6.71	
330	7.01	



Total Time	
Triangular Pattern	
t (days)	Spacing (ft)
92	3.00
151	4.00
230	5.00
332	6.00
461	7.00



Job No.	79784	PID No.	19415

HDR Computation

Project	SCI-823 Portsmouth Bypass	Computed	JSA	Date	4/8/2008
Subject	CR 28 Interchange: Mainline Embankment	Checked	DMV	Date	5/1/2008
Task	Wick Drain Analyses - Idealized Case	Sheet	1	Of	2

References:

1. Federal Highway Administration, "Prefabricated Vertical Drains - A Design and Construction Guidelines Manual." FHWA/RD-86/168, Washington, DC.
2. Department of the Navy, Naval Facilities Engineering Command, "Soil Mechanics." NAVFAC Design Manual 7.1, May 1982, pp. 241-259.
3. Subsurface Exploration Bridge and MSE Retaining Walls SR 823 Over Relocated Shumway Hollow Road SCI-823-0.00, Portsmouth Bypass (DLZ, 2006)
4. SCI-823-6.81, Portsmouth Bypass Project, PID 19415, Addendum to Report: Shumway Hollow Road (TR 234) (DLZ, 2008)

Assumptions:

1. Terzaghi's one-dimensional consolidation theory applies.
2. Radial drainage theory (as it relates to vertical drains) is a function of time, drain diameter, spacing, coefficient of consolidation, and average degree of desired consolidation.
3. Effect of disturbance related to soil displacement during installation is negligible.
4. Drain has infinite permeability (i.e. no drain resistance).

Input Values:

A =	349,313	sf	Total ramp area at CR 28 Interchange to be drained (DLZ, 2008)
C =	$0.50	cost/lf	Material + Installation Cost
	Single		Vertical Drainage (Single or Double)
	Triangular		Wick Drain Pattern
t =	128	day	available time to achieve desired degree of consolidation U_h
H =	43.5	ft	height of compressible layer
a =	0.33333	ft	width of drain (Assume 4" wide x 1/4" thick)
b =	0.020833	ft	thickness of drain (Assume for 4" wide x 1/4" thick)
c_v =	0.081	ft^2/day	coefficient consolidation for vertical drainage (From Consolidation Tests on B-1 & B-2)
c_h =	0.0972	ft^2/day	coefficient consolidation for horizontal drainage

Note:

-General Case: c_h = 1.2 to 1.5*c_v

-If layering of silt and sand in discontinuous lenses is evident: c_h = 2 to 4*c_v

-For varved clays and other deposits containing embedded and more or less continuous permeable layers: c_h = up to 10*c_v

Design Equations:

With vertical drains the overall average degree of consolidation, U, is the result of the combined effects of horizontal (radial) and vertical drainage. The combined effect is given by:

$$\overline{U} = 1-(1-\overline{U}_h)(1-\overline{U}_v)$$ (See FHWA eq. 1)

where,

U = overall average degree of consolidation

U_h = average degree of consolidation due to horizontal (or radial) drainage

U_v = average degree of consolidation due to vertical drainage

Check feasibility of 2 way vertical drainage only.

U_h =	0	%				
Uv =	50	%	t =	4585	days	**Need to Consider Other Options.**
U = U_v =	50	%				
T_v =	0.19625					

Calculate U_v that will occur in design period of t.

t = 128 day

$$T = \frac{tc_v}{H^2}$$

T_v = 0.01

U_v = 0.08

Calculate required U_h

$$\overline{U} = 1-(1-\overline{U}_h)(1-\overline{U}_v)$$ (See FHWA eq. 1)

U_h = 0.45

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HDR Computation

Project	SCI-823 Portsmouth Bypass	Computed	JSA	Date	4/8/2008
Subject	CR 28 Interchange: Mainline Embankment	Checked	DMV	Date	5/1/2008
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$$t = \frac{D^2}{8c_h} F(n) \ln\left[\frac{1}{1-\overline{U}_h}\right]$$ (See FHWA eq. 8)

where,

t = 128 day — available time to achieve desired degree of consolidation U_h

$\overline{U}_h$ = 0.45 — average degree of consolidation due to horizontal drainage

c_h = 0.0972 ft^2/day — coefficient of consolidation for horizontal drainage

$F(n)$ = 2.806234 — drain spacing factor

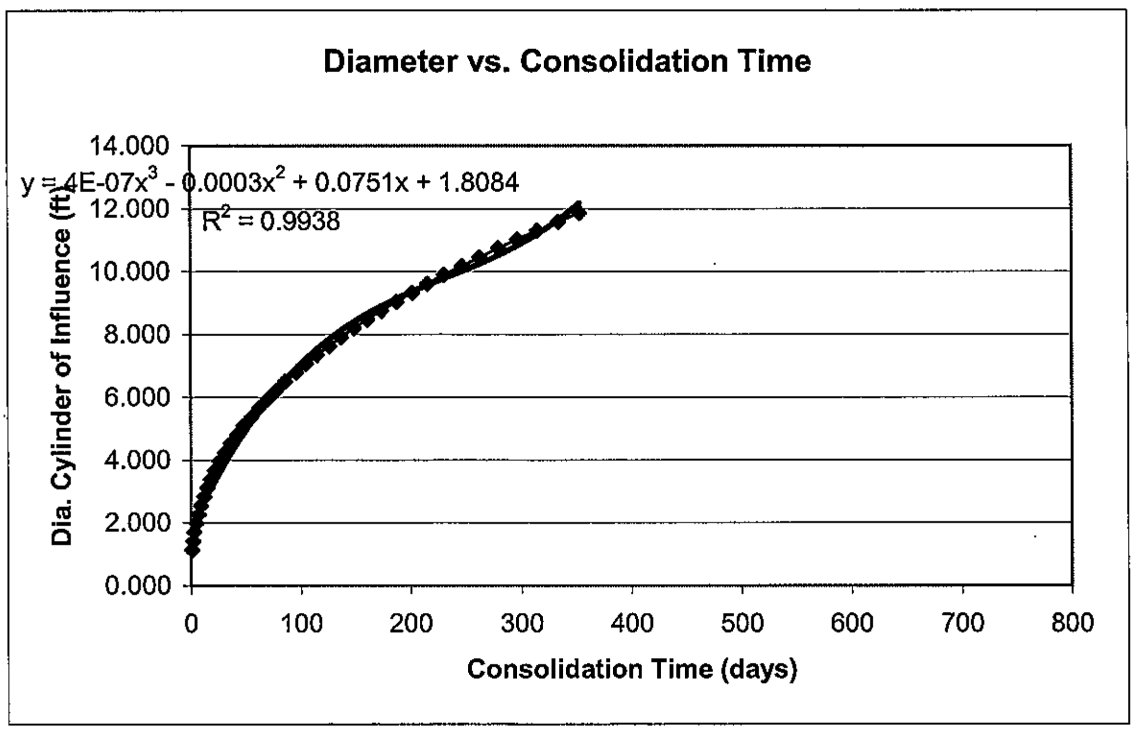
where,

$$F(n) = \ln\left(\frac{D}{d_w}\right) - 0.75$$ (simplified) (See FHWA eq. 3)

d_w = 2(a+b)/π — diameter of an equivalent circular drain (See FHWA eq. 9)

d_w = 0.23 ft

D = 7.902355 ft — required diameter of the cylinder of influence of the drain (drain influence zone) to achieve consolidation within given design period.



Optimum Drain Spacing based on required diameter of cyliner of influence to achieve primary consolidation within given design period: **6.99 ft**

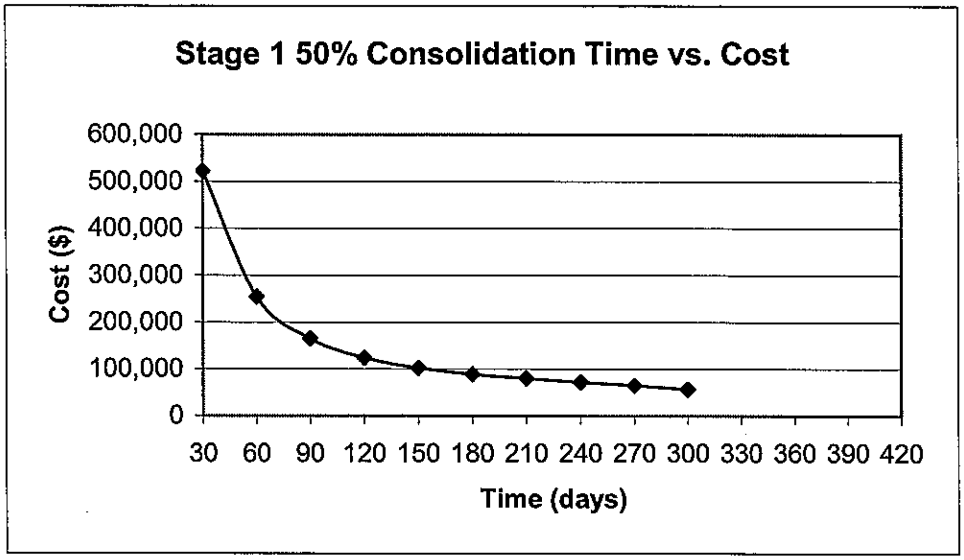
Length Outer Edge of Equilateral Triangle (or square) =	898.17 ft
Number Drain Spaces Along Outer Edge =	128.43 ea
Total number wick drains =	8442 ea
Total linear feet wick drain =	384111 lf
Estimated total cost =	**$192,055.50**

Job No.	79784	PID No.	19415

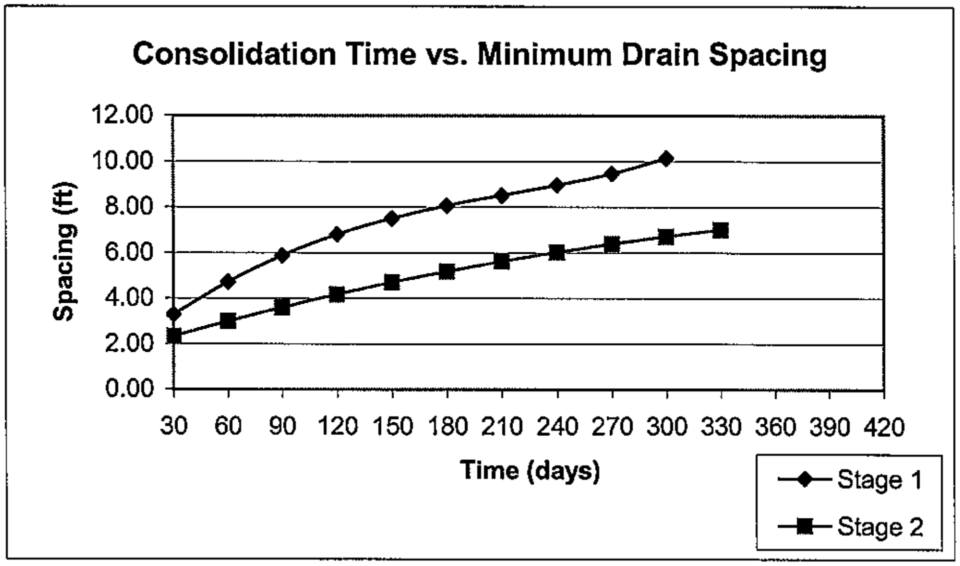
HDR Computation

Project	SCI-823 Portsmouth Bypass	Computed	JSA	Date	4/17/2008
Subject	CR 28 Interchange: Ramps	Checked	DMV	Date	5/1/2008
Task	Wick Drain Analyses - Idealized Case	Sheet	1	Of	1

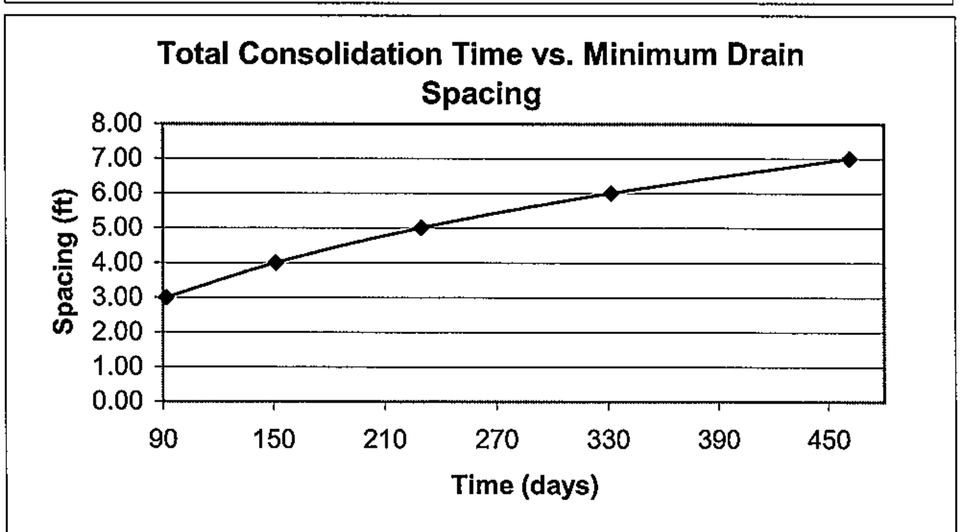
Stage 1 - 50% Consolidation		
Triangular Pattern		
t (days)	Spacing (ft)	Cost ($)
30	3.28	522,067
60	4.71	254,641
90	5.87	164,938
120	6.79	123,965
150	7.49	101,943
180	8.05	88,611
210	8.51	79,466
240	8.95	71,890
270	9.46	64,474
300	10.14	56,306



Stage 2 - 90% Consolidation		
Triangular Pattern		
t (days)	Spacing (ft)	Cost ($)
30	2.33	
60	2.99	
90	3.60	
120	4.17	
150	4.70	
180	5.18	
210	5.62	
240	6.02	
270	6.39	
300	6.71	
330	7.01	



Total Time	
Triangular Pattern	
t (days)	Spacing (ft)
92	3.00
151	4.00
230	5.00
332	6.00
461	7.00



HDR Computation

Project	SCI-823 Portsmouth Bypass	Computed	JSA	Date	4/8/2008
Subject	CR 28 Interchange: Ramps	Checked	DMV	Date	5/1/2008
Task	Wick Drain Analyses - Idealized Case	Sheet	1	Of	2

References:

1. Federal Highway Administration, "Prefabricated Vertical Drains - A Design and Construction Guidelines Manual." FHWA/RD-86/168, Washington, DC.
2. Department of the Navy, Naval Facilities Engineering Command, "Soil Mechanics." NAVFAC Design Manual 7.1, May 1982, pp. 241-259.
3. Subsurface Exploration Bridge and MSE Retaining Walls SR 823 Over Relocated Shumway Hollow Road SCI-823-0.00, Portsmouth Bypass (DLZ, 2006)
4. SCI-823-6.81, Portsmouth Bypass Project, PID 19415, Addendum to Report: Shumway Hollow Road (TR 234) (DLZ, 2008)

Assumptions:

1. Terzaghi's one-dimensional consolidation theory applies.
2. Radial drainage theory (as it relates to vertical drains) is a function of time, drain diameter, spacing, coefficient of consolidation, and average degree of desired consolidation.
3. Effect of disturbance related to soil displacement during installation is negligible.
4. Drain has infinite permeability (i.e. no drain resistance).

Input Values:

A =	211,055	sf	Total ramp area at CR 28 Interchange to be drained (DLZ, 2008)
C =	$0.50	cost/lf	Material + Installation Cost
	Single		Vertical Drainage (Single or Double)
	Triangular		Wick Drain Pattern
t =	94	day	available time to achieve desired degree of consolidation U_h
H =	43.5	ft	height of compressible layer
a =	0.33333	ft	width of drain (Assume 4" wide x 1/4" thick)
b =	0.020833	ft	thickness of drain (Assume for 4" wide x 1/4" thick)
c_v =	0.081	ft²/day	coefficient consolidation for vertical drainage (From Consolidation Tests on B-1 & B-2)
c_h =	0.0972	ft²/day	coefficient consolidation for horizontal drainage

Note:

-General Case: c_h = 1.2 to 1.5*c_v

-If layering of silt and sand in discontinuous lenses is evident: c_h = 2 to 4*c_v

-For varved clays and other deposits containing embedded and more or less continuous permeable layers: c_h = up to 10*c_v

Design Equations:

With vertical drains the overall average degree of consolidation, U, is the result of the combined effects of horizontal (radial) and vertical drainage. The combined effect is given by:

$$\overline{U} = 1-(1-\overline{U}_h)(1-\overline{U}_v)$$ (See FHWA eq. 1)

where,

U = overall average degree of consolidation
U_h = average degree of consolidation due to horizontal (or radial) drainage
U_v = average degree of consolidation due to vertical drainage

Check feasibility of 2 way vertical drainage only.

U_h = 0 %
Uv = 50 %
$U = U_v$ = 50 %
T_v = 0.19625

t = 4585 days **Need to Consider Other Options.**

Calculate U_v that will occur in design period of t.

t = 94 day

$$T = \frac{tc_v}{H^2}$$

T_v = 0.00
U_v = 0.07

Calculate required U_h

$$\overline{U} = 1-(1-\overline{U}_h)(1-\overline{U}_v)$$ (See FHWA eq. 1)

U_h = 0.46

Job No.	79784	PID No.	19415

HDR Computation

Project	SCI-823 Portsmouth Bypass	Computed	JSA	Date	4/8/2008
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Task	Wick Drain Analyses - Idealized Case	Sheet	2	Of	2

$$t = \frac{D^2}{8c_h} F(n) \ln\left[\frac{1}{1-\overline{U}_h}\right]$$ (See FHWA eq. 8)

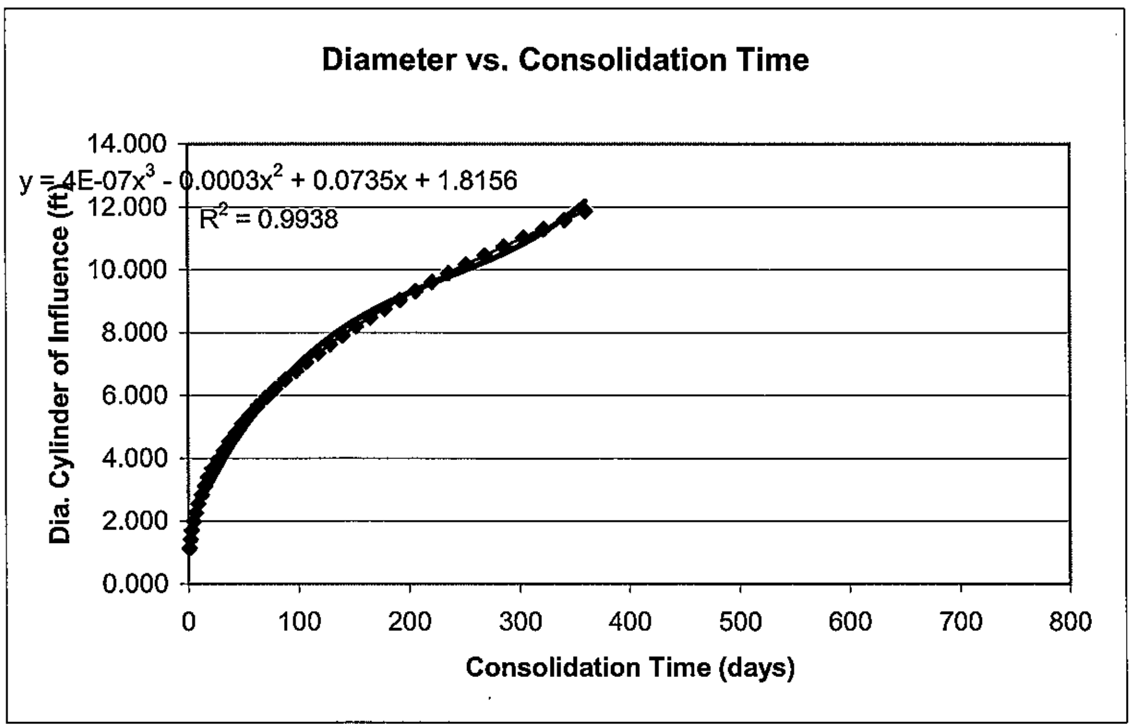
where,

t =	94 day	available time to achieve desired degree of consolidation U_h
$\overline{U}_h$ =	0.46	average degree of consolidation due to horizontal drainage
c_h =	0.0972 ft^2/day	coefficient of consolidation for horizontal drainage
$F(n)$ =	2.654141	drain spacing factor

where,

$$F(n) = \ln\left(\frac{D}{d_w}\right) - 0.75$$ (simplified) (See FHWA eq. 3)

d_w =	$2(a+b)/\pi$	diameter of an equivalent circular drain (See FHWA eq. 9)
d_w =	0.23 ft	
D =	6.787405 ft	required diameter of the cylinder of influence of the drain (drain influence zone) to achieve consolidation within given design period.



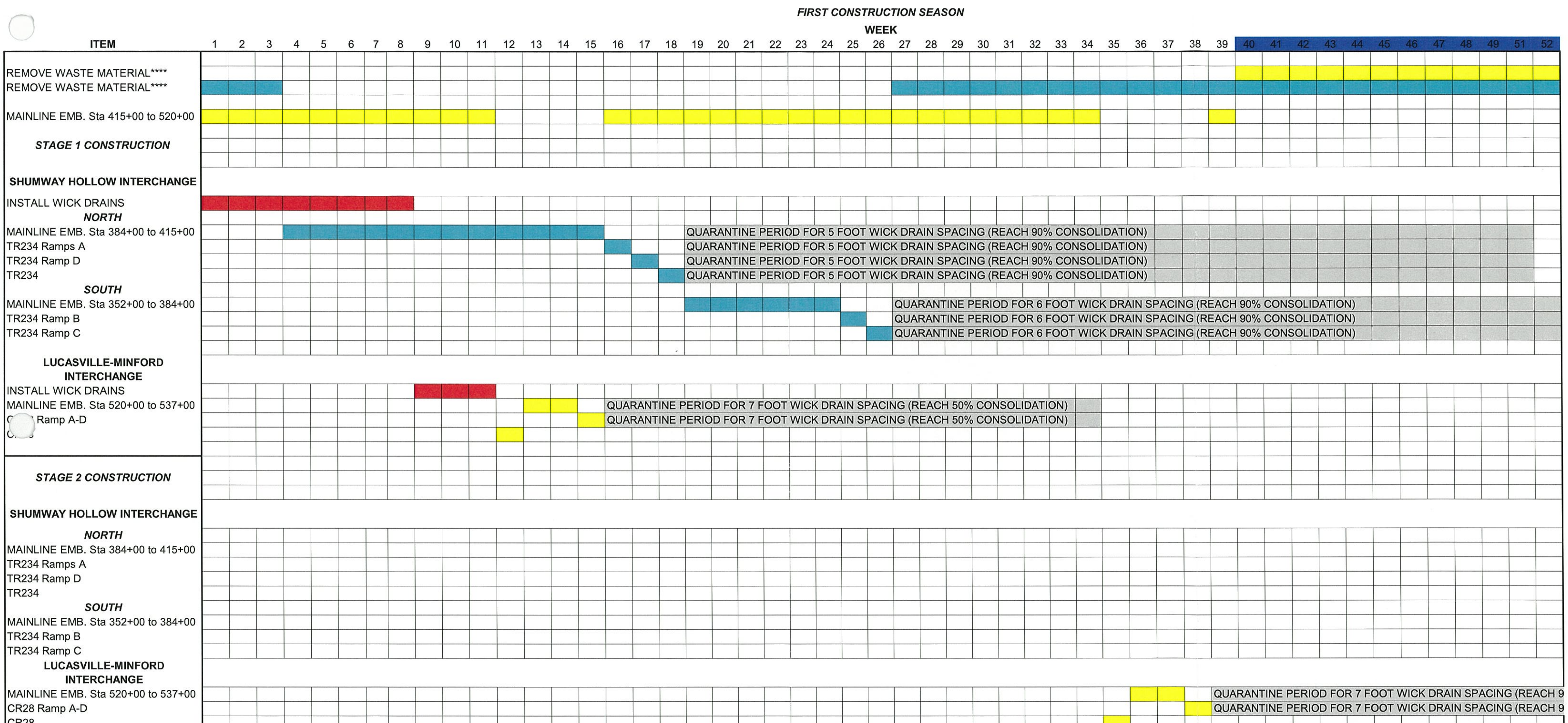
Optimum Drain Spacing based on required diameter of cyliner of influence to achieve primary consolidation within given design period: **6.01 ft**

Length Outer Edge of Equilateral Triangle (or square) =	698.15 ft
Number Drain Spaces Along Outer Edge =	116.23 ea
Total number wick drains =	6931 ea
Total linear feet wick drain =	315361 lf
Estimated total cost =	**$157,680.25**

Scenario 3: Option 1

CONCEPTUALIZED CONSTRUCTION SCHEDULE

SHEET 1



NOTES:

1. Schedule based on 10 hour work days and a 5 day week.
2. Productivity rate of 700 CY / HR was used for time estimates based on conversations with contractors.
3. QUANTITIES USED IN ANALYSES:
   - CUT = 5,789,155 CY
   - FILL = 3,316,338 CY
   - WASTE = 3,341,190 CY (BASED ON 15% SWELL)
4. Wick drains at Shumway Hollow Interchange North and South of TR 234 at 5 ft. and 6 ft. spacing, respectively. All wick drains at Lucasville-Minford Interchange at 7 ft. spacing.
5. Assume 6 rigs for installation of wick drains at an istallation rate of 10,000 ft/day per rig.
6. Estimated Total Wick Drain Installation Cost ($0.50/ft. Installed) = $306,579 (CR 28) + $924,296 (North of TR 234) + $184,807 (South of TR 234) + $2,784,175 (2 ft. sand blanket) =

$ 4,199,857 (Total)

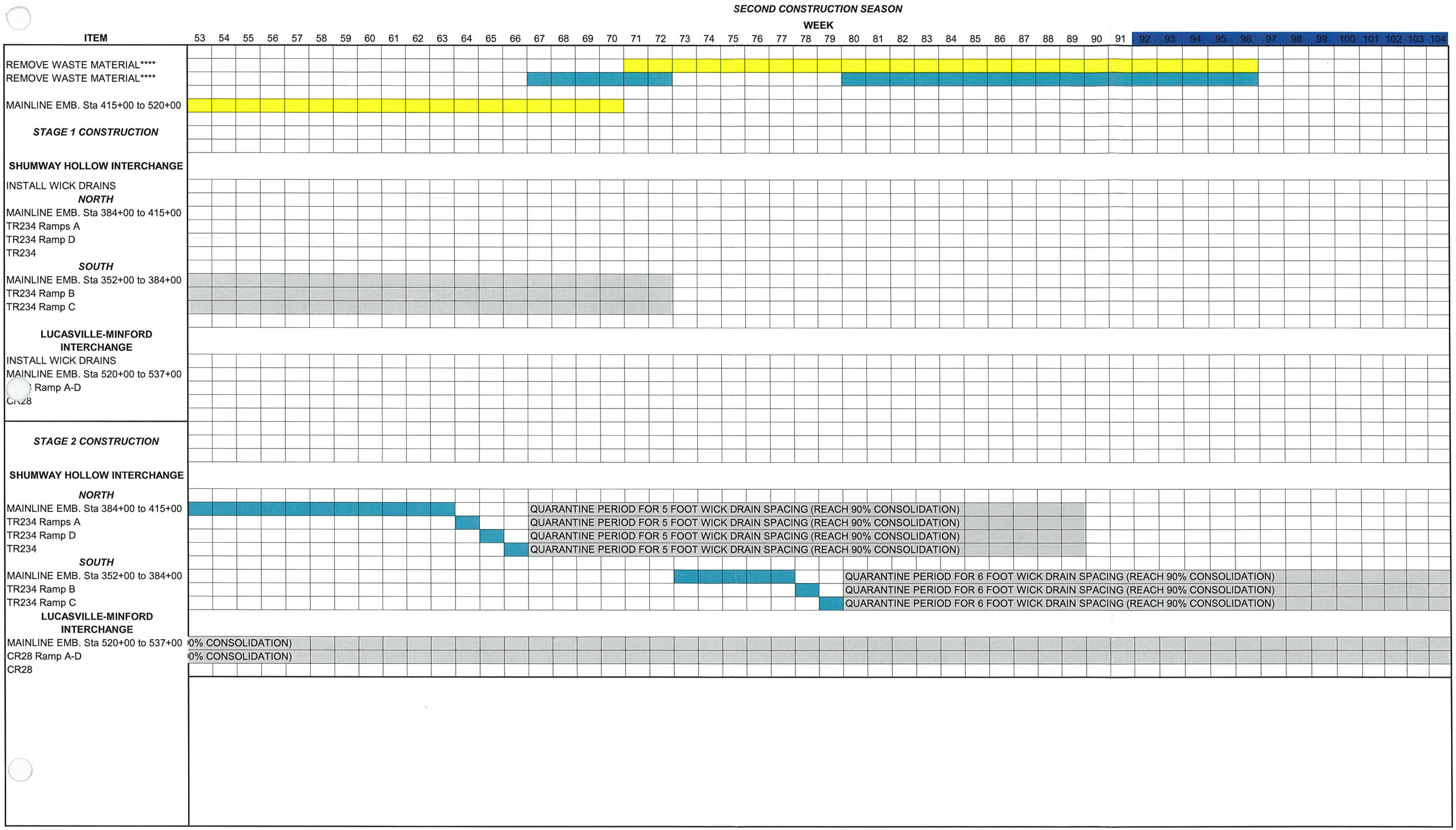
Legend

- Crew Number 1 (2 Excavators)
- Crew Number 2 (2 Excavators)
- Wick Drain Installation
- Quarantine Period

Scenario 3: Option 1

CONCEPTUALIZED CONSTRUCTION SCHEDULE

SHEET 2



Scenario 3: Option 1

CONCEPTUALIZED CONSTRUCTION SCHEDULE

SHEET 3

THIRD CONSTRUCTION SEASON

WEEK

ITEM	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119	120	121	122	123	124	125	126	127	128	129	130	131	132	133	134	135	136	137	138	139	140	141	142	143	144	145	146	147	148	149	150	151	152	153	154	155	156
REMOVE WASTE MATERIAL****																																																				
REMOVE WASTE MATERIAL****																																																				
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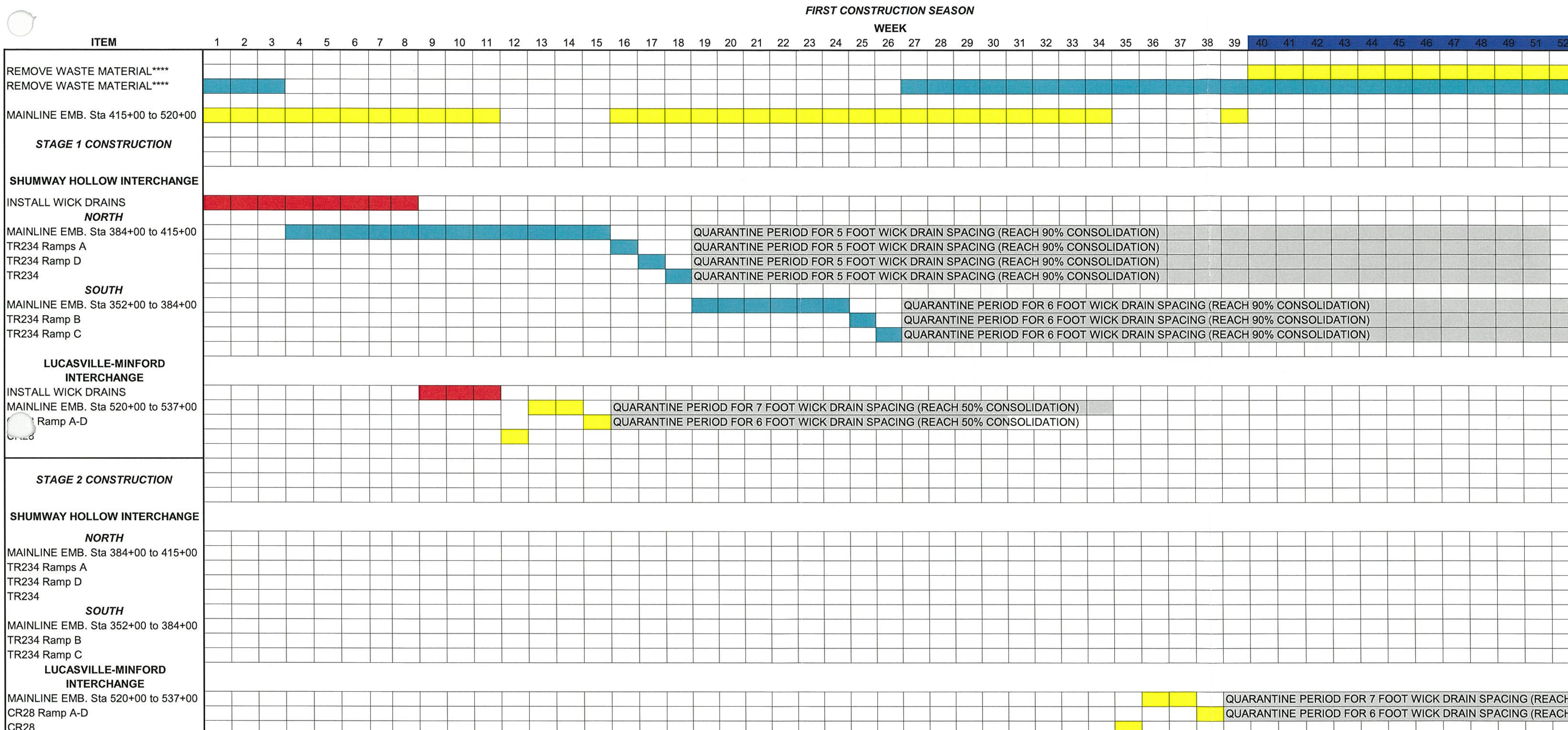
Scenario 3: Option 2

CONCEPTUALIZED CONSTRUCTION SCHEDULE

SHEET 1



NOTES:

1. Schedule based on 10 hour work days and a 5 day week.
2. Productivity rate of 700 CY / HR was used for time estimates based on conversations with contractors.
3. QUANTITIES USED IN ANALYSES:
   - CUT = 5,789,155 CY
   - FILL = 3,316,338 CY
   - WASTE = 3,341,190 CY (BASED ON 15% SWELL)
4. Wick drains at Shumway Hollow Interchange North & South of TR 234 at 5 ft. and 6 ft. spacing, respectively. Wick drains along Ramps A-D at Lucasville-Minford Int. at 6 ft. spacing (rest of area at 7 ft. space).
5. Assume 6 rigs for installation of wick drains at an istallation rate of 10,000 ft/day per rig.
6. Estimated Total Wick Drain Installation Cost ($0.50/ft. Installed) = $157,680 (CR 28 - 6 ft. spacing) + $192,056 (CR 28 - 7 ft. spacing) + $924,296 (North of TR 234) + $184,807 (South of TR 234) + $2,784,175 (2 ft. sand blanket) =

$ 4,243,014 (Total)

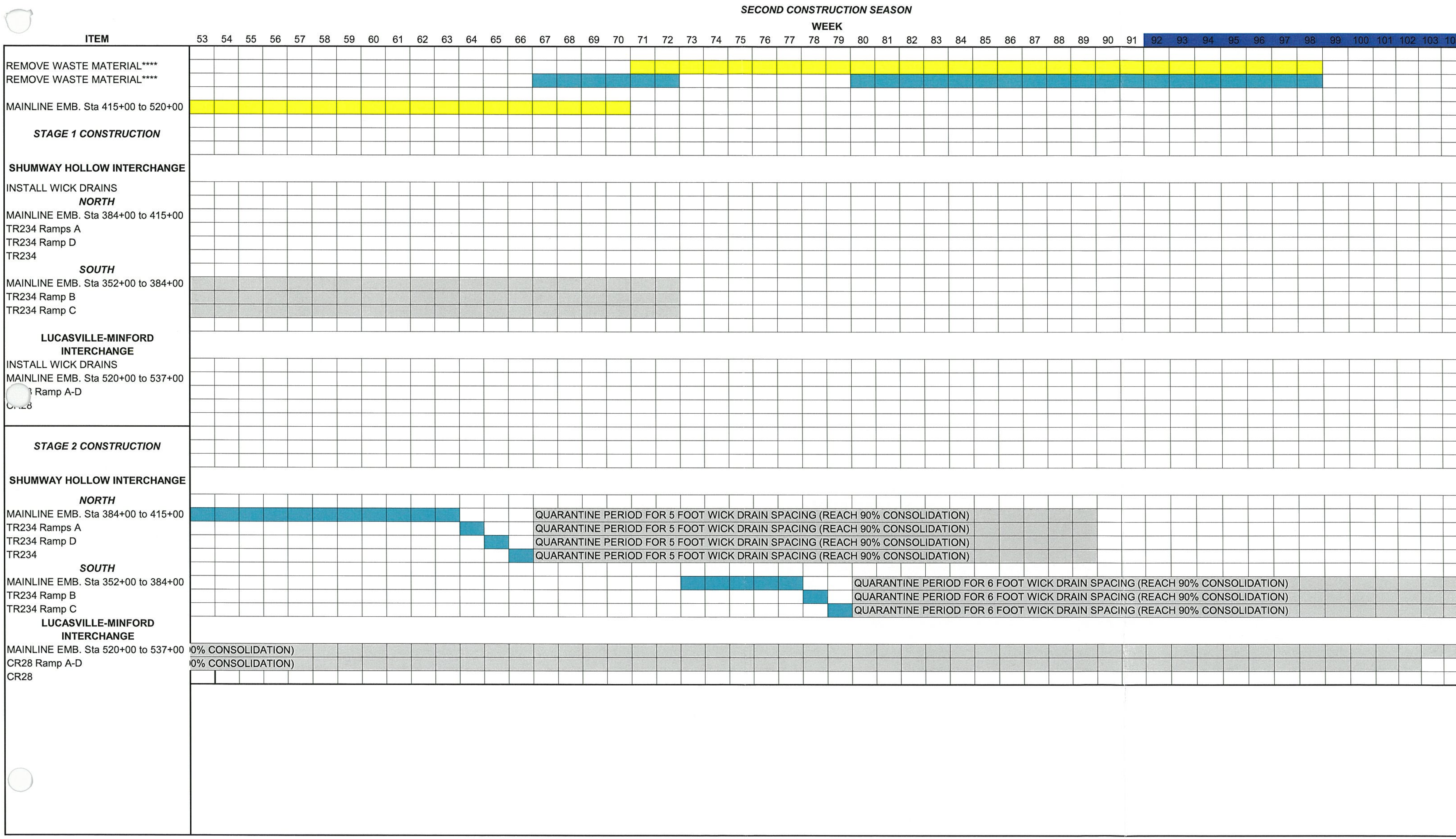
Legend

- Crew Number 1 (2 Excavators)
- Crew Number 2 (2 Excavators)
- Wick Drain Installation
- Quarantine Period

Scenario 3: Option 2

CONCEPTUALIZED CONSTRUCTION SCHEDULE

SHEET 2



CONCEPTUALIZED CONSTRUCTION SCHEDULE

THIRD CONSTRUCTION SEASON

WEEK

ITEM	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119	120	121	122	123	124	125	126	127	128	129	130	131	132	133	134	135	136	137	138	139	140	141	142	143	144	145	146	147	148	149	150	151	152	153	154	155	156
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WICK DRAIN
AREAS/COSTS

__Wick Drain Cost Evaluation:__

- Based on conversations with Mr. Steve Roy (Nilex Construction Group), Mr. Dave Panich (Terrasystems, Inc.), and Mr. Martin Taube (DGI-Menard), the average installed unit cost for wick drains ranges from $0.30/LF to $0.50/LF should no predrilling be required.
- Based on conversations with contractors, unit costs could increase by as much as $2.00/LF if predrilling is required.
- Based upon review of two typical boring logs in the area of the Shumway-Hollow Interchange, Mr. Martin Taube (DGI-Menard) does not anticipate the need for predrilling.
- DLZ does not indicate a need for predrilling in their reports.
- Federal Highway Administration recommends or $0.37/LF to $0.61/LF for large projects (*see Publication No. FHWA-SA-98-086).*
- **Based on information compiled from FHWA, conversations with contractors and engineering judgment an installed unit cost of $0.50/LF is recommended for wick drains.**

__2 ft. Sand Drainage Blanket Cost Evaluation:__

Note: Reduced sand drainage blanket from 3 feet to 2 feet using lower end of DLZ's recommended 2 to 3 feet from their interchange reports. This is a modification from the 3-feet started in their plan sheets provided in their interchange report addendums.

- Based on the estimated wick drain treatment areas defined in *SCI-823-6.81, Portsmouth Bypass Project, PID 19415 – Addendum to Report: Lucasville-Minford Road (CR 28) Interchange* and *SCI-823-6.81, Portsmouth Bypass Project, PID 19415 – Addendum to Report: Shumway Hollow Road (TR 234) Interchange,* the total area to be drained equals 2,210,960 ft^2 (560,368 ft^2 + 1,650,592 ft^2).
- For a 2 ft. drainage blanket, the total volume of sand equals 163,775 CY.
- Using a $9.00/ton quote given by Hanson Aggregates (see attached), and assuming a unit weight of 125 PCF, the material unit cost for sand shipped to the site would be $15.27/CY.
- Based on a conversation with Mr. Bill Launsberry (R.B. Jergens Contractors, Inc.), the material costs represent 90-95% of the installed cost for the sand blanket. Total unit cost ranges from 16.07/CY to $16.97/CY.
- For comparison, the average unit cost for granular embankment from past projects in Kentucky (see attached "KYTC Average Bid Prices 2007") is approximately $18.00/CY installed.
- **Based on information compiled from KYTC, conversations with contractors and vendors, and engineering judgment, a unit cost of $17.00/CY for the sand blanket is recommended.**

HDR | ONE COMPANY *Many Solutions*℠

Telephone Record

Project: SCI-823-6.81; PID 19415	Project No: 45878
Date: 4/25/2008	Subject: Wick Drain Installation Cost & Production Rate
Call to: Mike Greenwald, Hanson Aggregates	Phone No: (937) 587-2671
Call from: Justin Anderson, HDR	Phone No: (513) 984-7500

Discussion, Agreement and/or Action:

Mr. Greenwald stated that the estimated 165,000 CY of sand required for the drainage blanket (at the interchanges) would equate to approximately 280,000 tons and estimated a material cost of $8.75-$9.00 per ton after careful consideration (called me back after thinking over the numbers).

Note: $9.00/TON equates to $15.27/CY (based on 125 pcf used in Mr. Greenwald's calculation, which appears to be a very reasonable number.)

HDR | ONE COMPANY *Many Solutions*℠

Telephone Record

Project:	SCI-823-6.81; PID 19415	Project No:	45878
Date:	4/24/2008	Subject:	Wick Drain Installation Cost & Production Rate
Call to:	Steve Roy, Nilex Construction Group	Phone No:	303-766-2000
Call from:	Justin Anderson, HDR	Phone No:	(513) 984-7500

Discussion, Agreement and/or Action:

Mr. Roy stated that wick drain installation costs generally range between $0.50/LF and $1.00/LF depending on project size. He also mentioned that the cost would likely be lower than the $0.50/LF for a project with a large project like ours (i.e. Portsmouth Bypass Project).

With respect to productivity, a crew usually produces 15,000 ft/day and will work six 10-hour days per week. He said that they usually use 2 crews, but have regularly used 4 crews, and can use more than 4 crews if necessary.

Mobilization is $1,500 per crew.

HDR | ONE COMPANY *Many Solutions*℠

Telephone Record

Project: SCI-823-6.81; PID 19415	Project No: 45878
Date: 4/24/2008	Subject: Wick Drain Installation Cost & Production Rate
Call to: Dave Panich, Terrasystems, Inc.	Phone No: 540-882-4130
Call from: Justin Anderson, HDR	Phone No: (513) 984-7500

Discussion, Agreement and/or Action:

Mr. Panich stated that the cost could vary between $0.30 and $0.40 for a job our size. However, if predrilling were required, it may add as much as $2.00 per foot to the cost.

Estimated productivity rates are 10,000 to 20,000 feet/day/rig based on a 10-hour work day.

HDR | ONE COMPANY *Many Solutions℠*

Telephone Record

Project:	SCI-823-6.81; PID 19415	Project No:	45878
Date:	4/24/2008	Subject:	Wick Drain Installation Cost & Production Rate
Call to:	Martin Taube, DGI-Menard, Inc.	Phone No:	412-257-2750
Call from:	Justin Anderson, HDR	Phone No:	(513) 984-7500

Discussion, Agreement and/or Action:

Mr. Taube stated that it does not appear that predrilling will be required based on the N values from the two sample logs (B-1307 and B-1326) provided. However, as the soils are stiff, adequate borings should be included in the bid set for the wick installer to make an adequate determination of whether or not predrilling is needed. Remember that if predrilling is required it will significantly increase the price of the wick drains. As the design advances, Mr. Taube is available for questions.

Mr. Taube recommends using $20,000 mobilization and $0.45/LF for the wick drain installation if no predrilling is required.

KYTC Average Bid Prices 2007 updated 2/4/08

Overall Rank	Bid Item #	ITEM DESCRIPTION	UNITS	QUANTITY	Average Price	% total dollars	Dollars	# of Occurances
1	02200	ROADWAY EXCAVATION	CUYD	22,574,828	$5.37	7.85	$121,226,826	85
8	02230	EMBANKMENT IN PLACE	CUYD	5,306,618	$6.08	2.09	$32,264,237	50
9	08100	CONCRETE-CLASS A	CUYD	66,294	$467.08	2.01	$30,964,602	113
17	08104	CONCRETE-CLASS AA	CUYD	42,824	$557.21	1.55	$23,861,961	55
36	21554EN	EXCAVATION	CUYD	1,635,601	$5.94	0.63	$9,715,470	7
47	02223	GRANULAR EMBANKMENT	CUYD	388,314	$17.94	0.45	$6,966,353	36
53	21553EN	EMBANKMENT	CUYD	965,548	$5.59	0.35	$5,397,413	7
59	00021	DRAINAGE BLANKET-EMBANKMENT	CUYD	159,609	$30.59	0.32	$4,882,439	3
68	08534	CONCRETE OVERLAY-LATEX	CUYD	2,663	$1,405.44	0.24	$3,742,687	34
141	02555	CONCRETE-CLASS B	CUYD	3337	$414.88	0.09	$1,384,455	19
148	22653EN	ROCK ROADBED	CUYD	50,736	$24.68	0.08	$1,252,164	1
153	22830EN	ROADWAY EXCAVATION SPECIAL UNDERCUT	CUYD	289,111	$4.20	0.08	$1,214,266	2
158	08002	STRUCTURE EXCAV-SOLID ROCK	CUYD	38,631	$30.02	0.08	$1,159,703	55
160	02610	RETAINING WALL-GABION	CUYD	7,980	$141.40	0.07	$1,128,372	6
166	08001	STRUCTURE EXCAVATION-COMMON	CUYD	56,694	$19.23	0.07	$1,090,226	39
173	02220	FLOWABLE FILL	CUYD	11346	91.26	0.07	$1,035,436	23
181	02403	REMOVE CONCRETE MASONRY	CUYD	3,292	$290.86	0.06	$957,511	20
186	02235	BACKFILLING UNDERCUT	CUYD	123,853	$7.07	0.06	$875,641	6
223	20602EC	LIGHTWEIGHT FILL	CUYD	3,563	$192.94	0.04	$687,445	3
228	22831EN	REFILL UNDERCUT	CUYD	216,325	$3.09	0.04	$668,444	1
233	20209EP69	GRANULAR PILE CORE	CUYD	21,076	$29.69	0.04	$625,746	9
238	02690	SAFELOADING	CUYD	3,255	$180.15	0.04	$586,388	38
240	02231	STRUCTURE GRANULAR BACKFILL	CUYD	14,738	$39.15	0.04	$576,993	34
252	06490	CLASS A CONCRETE FOR SIGNS	CUYD	946	555.43	0.03	$525,437	14
374	08526	CONC CLASS M FULL DEPTH PATCH	CUYD	474	$601.24	0.02	$284,988	31
392	22655EN	UNDERCUT/STABILIZATION EXCAVATION	CUYD	174,969	$1.50	0.02	$262,454	1
393	22529EN	PERVIOUS CONCRETE	CUYD	400	$650.00	0.02	$260,000	1
496	02488	CHANNEL LINING CLASS IV	CUYD	19,989	$7.94	0.01	$158,713	7
515	22006EN	CONC CLASS AA-SUPERSTRUCTURE	CUYD	208	$700.00	0.01	$145,600	1
525	02711	SEDIMENTATION BASIN	CUYD	1012	$135.73	0.01	$137,359	2
531	20911ED	HIGH SLUMP 3000 PSI GROUT	CUYD	805	164.29	0.01	$132,253	2
559	20361ES601	CONCRETE PATCHING REPAIR	CUYD	14	8428.57	0.01	$118,000	3
638	03235	EXCAVATION AND BACKFILL	CUYD	2,884	$30.69	0.01	$88,510	5
679	05997	TOPSOIL FURNISHED AND PLACED	CUYD	1,790	$42.61	0	$76,272	3
791	02551	CONCRETE-CLASS A FOR STEPS	CUYD	40	$1,274.83	0	$50,993	5
842	02203	STRUCTURE EXCAV-UNCLASSIFIED	CUYD	1192	$36.51	0	$43,520	5
903	20210EP69	COHESIVE PILE CORE	CUYD	2394	$14.83	0	$35,503	3
907	20897ED	CONC FOR CRADLES-ANCHORS AND ENCASEMENT	CUYD	202	$173.09	0	$34,964	2
933	02712	CLEAN SEDIMENTATION BASIN	CUYD	3,312	$9.77	0	$32,358	3
1229	02219	PIPE UNDERCUT	CUYD	391	$32.90	0	$12,864	1
1355	21952EN	CONCRETE FOR THRUST BLOCKS-ETC	CUYD	76	$117.79	0	$8,952	1
1421	22691EN	RIFFLE STRUCTURE-GABION	CUYD	71	$100.00	0	$7,100	1
1435	21953EN	UNCLASSIFIED EXCAVATION FOR UNDERCUTS	CUYD	300	$22.87	0	$6,861	1
1567	02556	CONCRETE CAP	CUYD	3	$1,283.73	0	$3,851	2
1721	20315ED	CLAY SOIL CAP	CUYD	246	$10.35	0	$2,546	1
1766	20597EC	DITCH EXCAVATION	CUYD	535	$4.00	0	$2,140	1

Job No.	79784	PID No.	19415

HDR Computation

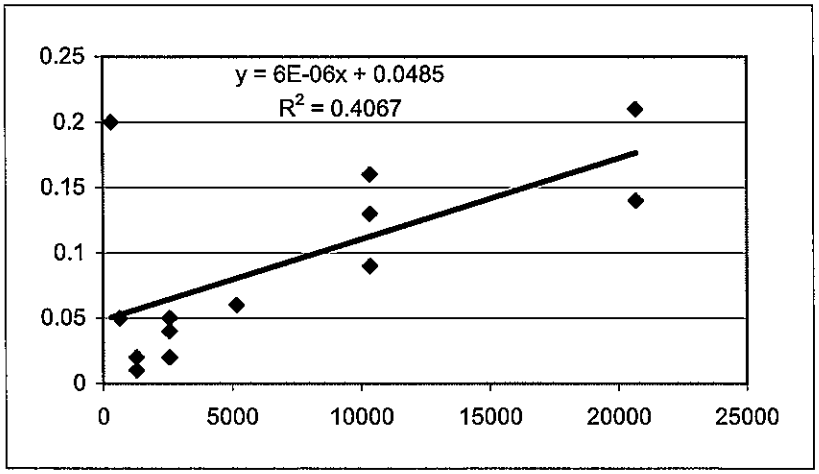
Project	SCI-823 Portsmouth Bypass	Computed	JSA	Date	4/8/2008
Subject	Shumway Hollow Road (TR 234) Interchange: Mainline Embankment	Checked		Date	
Task	Determine Coefficient Consolidation for Vertical Drainage (Cv)	Sheet	1	Of	1

References:

1. SCI-823-6.81, Portsmouth Bypass Project, PID 19415, Addendum to Report: Shumway Hollow Road (TR 234) (DLZ, 2008)

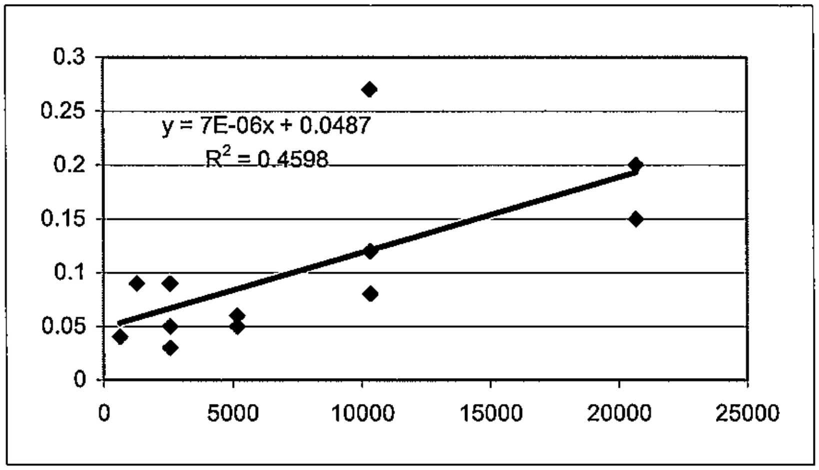
B-1

	Load (psf)	Cv
1	324	0.2
2	646	0.05
3	1292	0.02
4	2584	0.05
5	10336	0.13
6	20672	0.21
7	10336	0.16
8	2584	0.04
9	1292	0.01
10	2584	0.02
11	5168	0.06
12	10336	0.09
13	20672	0.14



B-2

	Load (psf)	Cv
1	324	1.38
2	646	0.04
4	2584	0.09
6	10336	0.12
7	20672	0.2
8	10336	0.27
9	5168	0.05
10	2584	0.03
12	1292	0.09
13	2584	0.05
14	5168	0.06
15	10336	0.08
16	20672	0.15



From Undrained Shear Strength Analysis - Staged Construction SR 823 Mainline Embankment (DLZ, 2008)

H_{comp}	=	29	ft	*Height Compressible Layer*
γ_{soil}	=	120	pcf	*Unit Weight of Compressible Soil*
γ_{fill}	=	125	pcf	*Unit Weight of Fill*
H_1	=	23	ft	*Stage 1 Fill Lift Height*
H_2	=	34	ft	*Stage 2 Fill Lift Height*

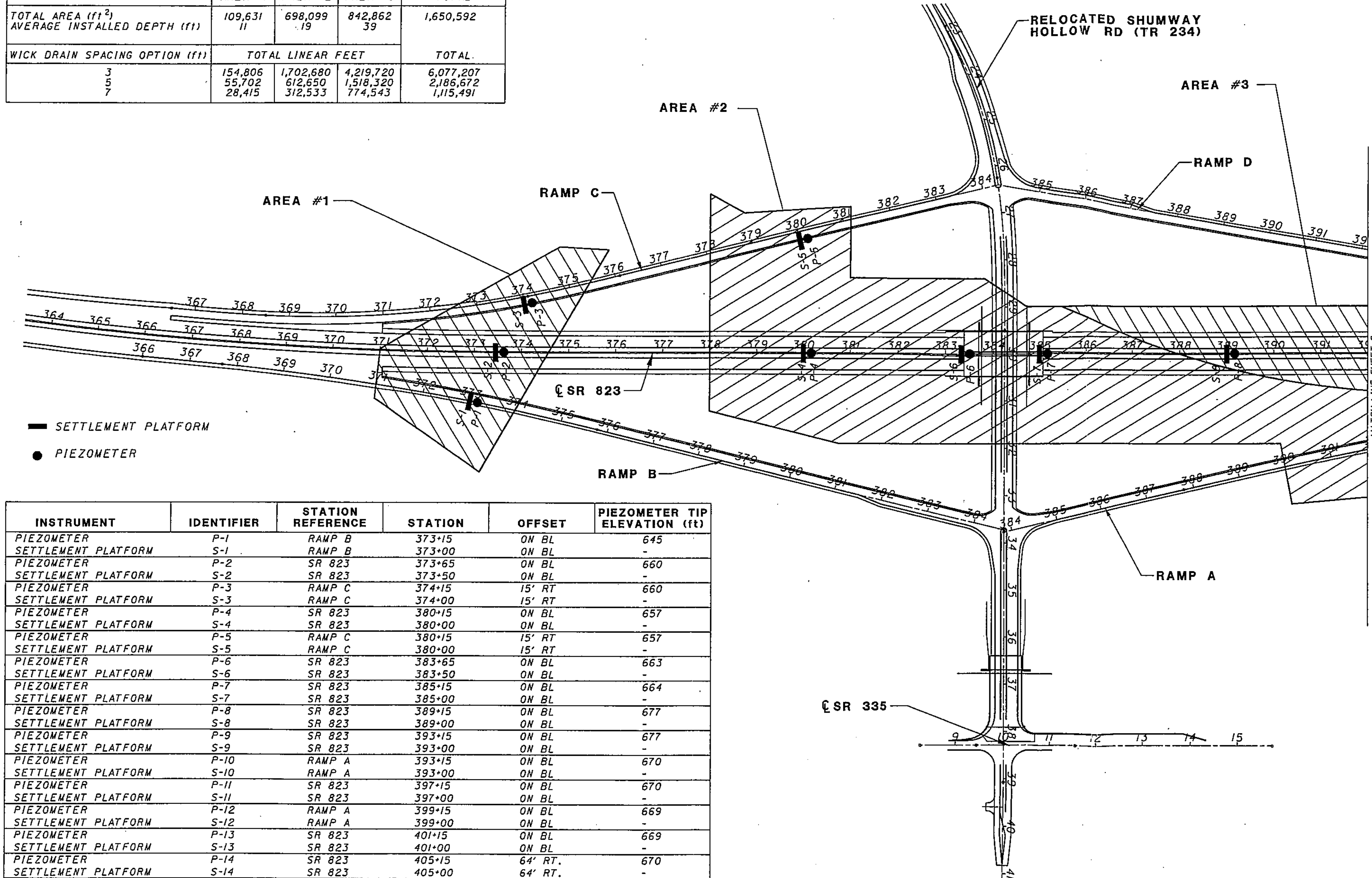
σ_{v0}	=	$\gamma*(H_{comp}/2)$ =	1740	psf	*Initial Stress at Midpoint of Compressible Layer*
σ_{F1}	=	$\sigma_{v0} + H_1*\gamma_{fill}$ =	4615	psf	*Stress at Midpoint of Compressible Layer after placement of Stage 1 Fill.*
σ_{F2}	=	$\sigma_{F1} + H_2*\gamma_{fill}$ =	8865	psf	*Stress at Midpoint of Compressible Layer after placement of Stage 2 Fill.*

Based on Consolidation Testing on B-1 & B-2 and the estimated load due to additional Stage 1 & Stage 2 fill

c_v = 0.081 ft^2/day *after placing Stage 1 Fill*

c_v = 0.111 ft^2/day *after placing Stage 2 Fill*

	TREATMENT AREA			
	AREA #1	AREA #2	AREA #3	TOTAL
TOTAL AREA (ft^2) AVERAGE INSTALLED DEPTH (ft)	109,631 11	698,099 19	842,862 39	1,650,592
WICK DRAIN SPACING OPTION (ft)	TOTAL LINEAR FEET			TOTAL
3	154,806	1,702,680	4,219,720	6,077,207
5	55,702	612,650	1,518,320	2,186,672
7	28,415	312,533	774,543	1,115,491



INSTRUMENT	IDENTIFIER	STATION REFERENCE	STATION	OFFSET	PIEZOMETER TIP ELEVATION (ft)
PIEZOMETER	P-1	RAMP B	373+15	ON BL	645
SETTLEMENT PLATFORM	S-1	RAMP B	373+00	ON BL	-
PIEZOMETER	P-2	SR 823	373+65	ON BL	660
SETTLEMENT PLATFORM	S-2	SR 823	373+50	ON BL	-
PIEZOMETER	P-3	RAMP C	374+15	15' RT	660
SETTLEMENT PLATFORM	S-3	RAMP C	374+00	15' RT	-
PIEZOMETER	P-4	SR 823	380+15	ON BL	657
SETTLEMENT PLATFORM	S-4	SR 823	380+00	ON BL	-
PIEZOMETER	P-5	RAMP C	380+15	15' RT	657
SETTLEMENT PLATFORM	S-5	RAMP C	380+00	15' RT	-
PIEZOMETER	P-6	SR 823	383+65	ON BL	663
SETTLEMENT PLATFORM	S-6	SR 823	383+50	ON BL	-
PIEZOMETER	P-7	SR 823	385+15	ON BL	664
SETTLEMENT PLATFORM	S-7	SR 823	385+00	ON BL	-
PIEZOMETER	P-8	SR 823	389+15	ON BL	677
SETTLEMENT PLATFORM	S-8	SR 823	389+00	ON BL	-
PIEZOMETER	P-9	SR 823	393+15	ON BL	677
SETTLEMENT PLATFORM	S-9	SR 823	393+00	ON BL	-
PIEZOMETER	P-10	RAMP A	393+15	ON BL	670
SETTLEMENT PLATFORM	S-10	RAMP A	393+00	ON BL	-
PIEZOMETER	P-11	SR 823	397+15	ON BL	670
SETTLEMENT PLATFORM	S-11	SR 823	397+00	ON BL	-
PIEZOMETER	P-12	RAMP A	399+15	ON BL	669
SETTLEMENT PLATFORM	S-12	RAMP A	399+00	ON BL	-
PIEZOMETER	P-13	SR 823	401+15	ON BL	669
SETTLEMENT PLATFORM	S-13	SR 823	401+00	ON BL	-
PIEZOMETER	P-14	SR 823	405+15	64' RT.	670
SETTLEMENT PLATFORM	S-14	SR 823	405+00	64' RT.	-
PIEZOMETER	P-15	SR 823	409+15	56' RT.	670
SETTLEMENT PLATFORM	S-15	SR 823	409+00	56' RT.	-
PIEZOMETER	P-16	SR 823	413+15	48' RT.	680
SETTLEMENT PLATFORM	S-16	SR 823	413+00	48' RT.	-

WICK DRAIN AND INSTRUMENTATION PLAN
SHUMWAY HOLLOW RD (TR 234) INTERCHANGE

PID NO. 19415

SCI-823-6.81

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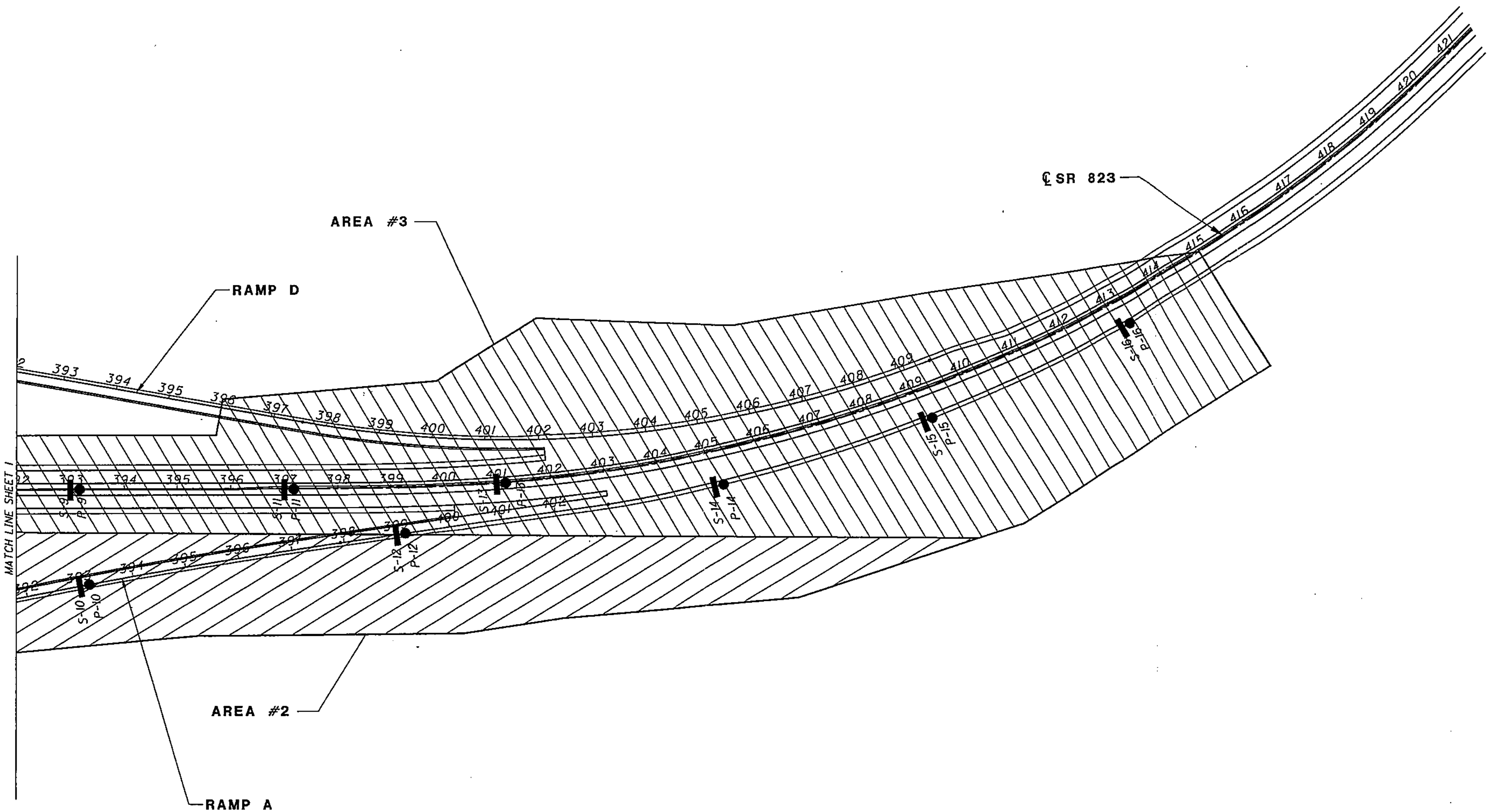

WICK DRAIN AND INSTRUMENTATION PLAN
SHUMWAY HOLLOW RD (TR 234) INTERCHANGE

PID NO. 19415

SCI-823-6.81

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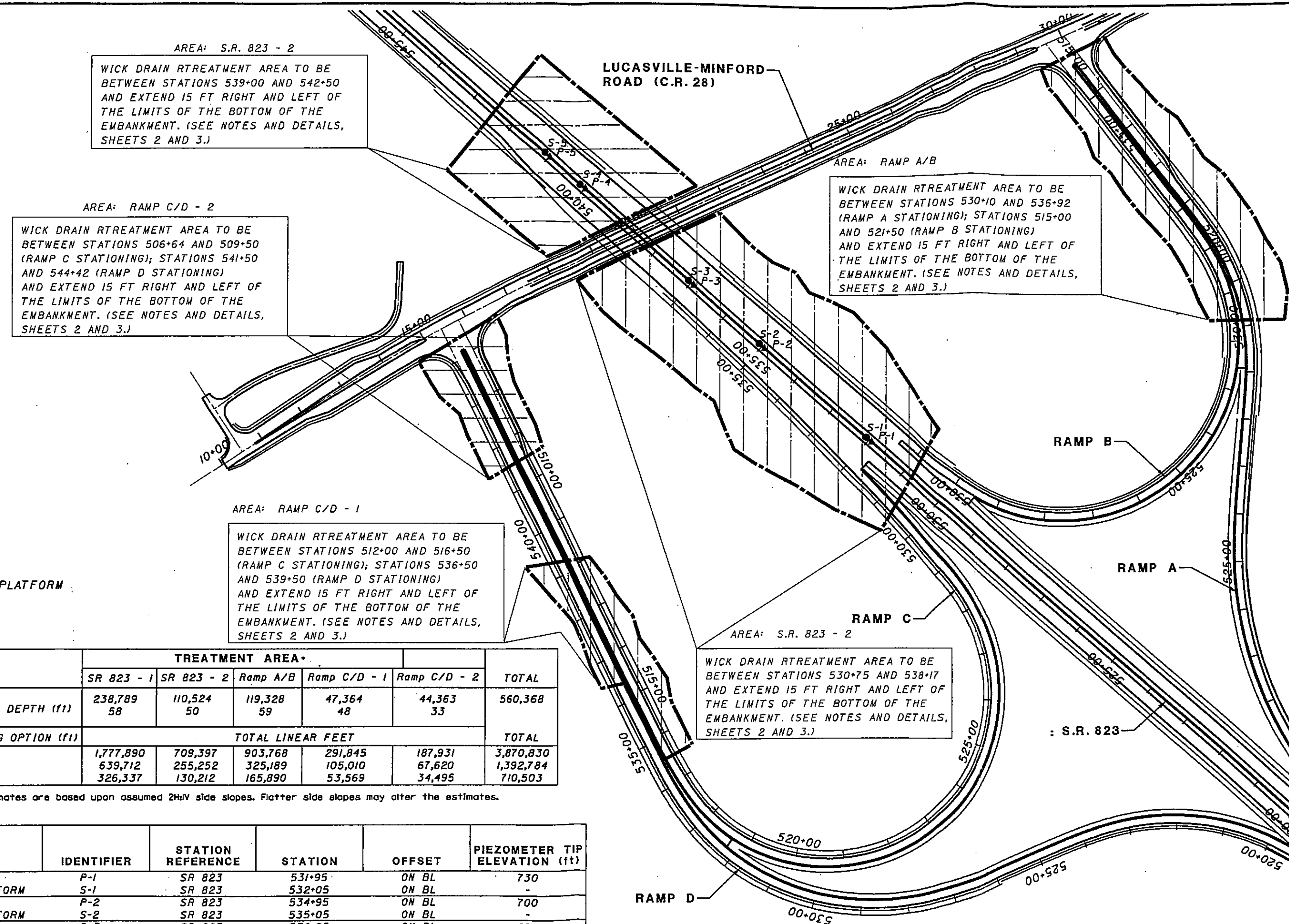
WICK DRAIN AND INSTRUMENTATION PLAN
C.R. 28/SR 823 INTERCHANGE



	TREATMENT AREA+					
	SR 823 - 1	SR 823 - 2	Ramp A/B	Ramp C/D - 1	Ramp C/D - 2	TOTAL
TOTAL AREA (ft^2)	238,789	110,524	119,328	47,364	44,363	560,368
AVERAGE INSTALLED DEPTH (ft)	58	50	59	48	33	
WICK DRAIN SPACING OPTION (ft)	TOTAL LINEAR FEET					TOTAL
3	1,777,890	709,397	903,768	291,845	187,931	3,870,830
5	639,712	255,252	325,189	105,010	67,620	1,392,784
7	326,337	130,212	165,890	53,569	34,495	710,503

+ Treatment area estimates are based upon assumed 2H:1V side slopes. Flatter side slopes may alter the estimates.

INSTRUMENT	IDENTIFIER	STATION REFERENCE	STATION	OFFSET	PIEZOMETER TIP ELEVATION (ft)
PIEZOMETER	P-1	SR 823	531+95	ON BL	730
SETTLEMENT PLATFORM	S-1	SR 823	532+05	ON BL	-
PIEZOMETER	P-2	SR 823	534+95	ON BL	700
SETTLEMENT PLATFORM	S-2	SR 823	535+05	ON BL	-
PIEZOMETER	P-3	SR 823	536+95	ON BL	694
SETTLEMENT PLATFORM	S-3	SR 823	537+05	ON BL	-
PIEZOMETER	P-4	SR 823	540+00	ON BL	700
SETTLEMENT PLATFORM	S-4	SR 823	540+10	ON BL	-
PIEZOMETER	P-5	SR 823	541+00	ON BL	725
SETTLEMENT PLATFORM	S-5	SR 823	541+10	ON BL	-

PID NO. 19415

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