

To: Jed Friesen, PREDL Systems.
 From: Alonso Vidal, P.E. Bowman Consulting
 Date: August 9, 2018
 Subject: 3ASC Phase 1 Submittal 27 Predl PVC Riser Test Manhole response – Buoyancy

Background

In response to the request to for buoyancy calculation we reviewed and confirmed APOC buoyancy calculations.

Content/Review

From EPOC Engineering

<i>Project</i>	<i>APOC Engineering Ltd.</i>
<i>Designed by</i>	<i>Tel. 7782329364</i>
<i>Date</i>	<i>Sheet of Pages</i>

Buoyancy Effect Consideration to AASHTO Standard and American Concrete Association

Buoyancy Force $B = 9.8 * 3.14 * (1.524^2) / 4 * 3.454 = 61 \text{Kn}$

It is conservatively assumed that groundwater level exists at the top of manhole structure.

Sliding Resistance $R = K_a * (U_{soil} - U_{water}) * H * H / 2 * f * 3.14 * 1.524$

$R = 0.5 * (1600 - 1000) * 3.454 * 3.454 / 2 * 0.3 * 3.14 * 1.524 = 25.18 \text{kn}$

Total counter weight $W = 10000 / 2.2 * 9.8 / 1000 = 44.55 \text{kn}$

Assume that soil unit weight of 100lbs/ft³, friction coefficient of 0.3, $K_a = 0.5$

$R + W = 44.55 + 25.18 = 69.72 \text{Kn} > 61 \text{Kn}$,

Safety factor = $1.14 < 1.5$,

So adding a extended base of 6" with 8" thickness

Additional soil weight $W_{ext} = 3.14 * 1.524 * 0.152 * 3.454 * 1600 * 9.8 / 1000 = 39.4 \text{kn}$

$R + W + W_{ext} = 114.27 \text{kn}$

Safety facto = $114.27 / 61 = 1.87 > 1.5$ **OK!**

Figure 1 APOC Engineering - Buoyancy Calculations

The calculations in Figure 1 were reviewed and confirmed to be accurate following the criteria referenced by Dibble as: “Anti-flotation calculations assuming water table at rim elevation. Manufacturer shall include all other assumptions for the calculations.”

Additionally, refer to the design calculations for ASTM F1759-97(2004) Standard Practice for Design of High-Density Polyethylene (HDPE) Manholes for Subsurface Applications I in response 10 and on the Appendix or in the attachment of the original submittal where the buoyancy safety index is indicated as OK also.

Conclusions

Buoyancy calculation where performed and reviewed as accurate.

PVC Material Information

PVC Pipe ID	60.000	inch
Wall Thickness	1.208	inch
I of Wall	0.147	Inch ⁴ /in

Soil Information

Water Density	62.4	lbs/cu.f
Counter weight Soil Density	80	lbs/cu.f
soil dry density	120.000	lbs/cu.f
soil sat. density	135.000	lbs/cu.f
soil intet.friction angle	30.000	
friction coefficient	0.400	psi,E'
Soil Modulus	1000.000	
active Earth pres. Coe.	0.333	

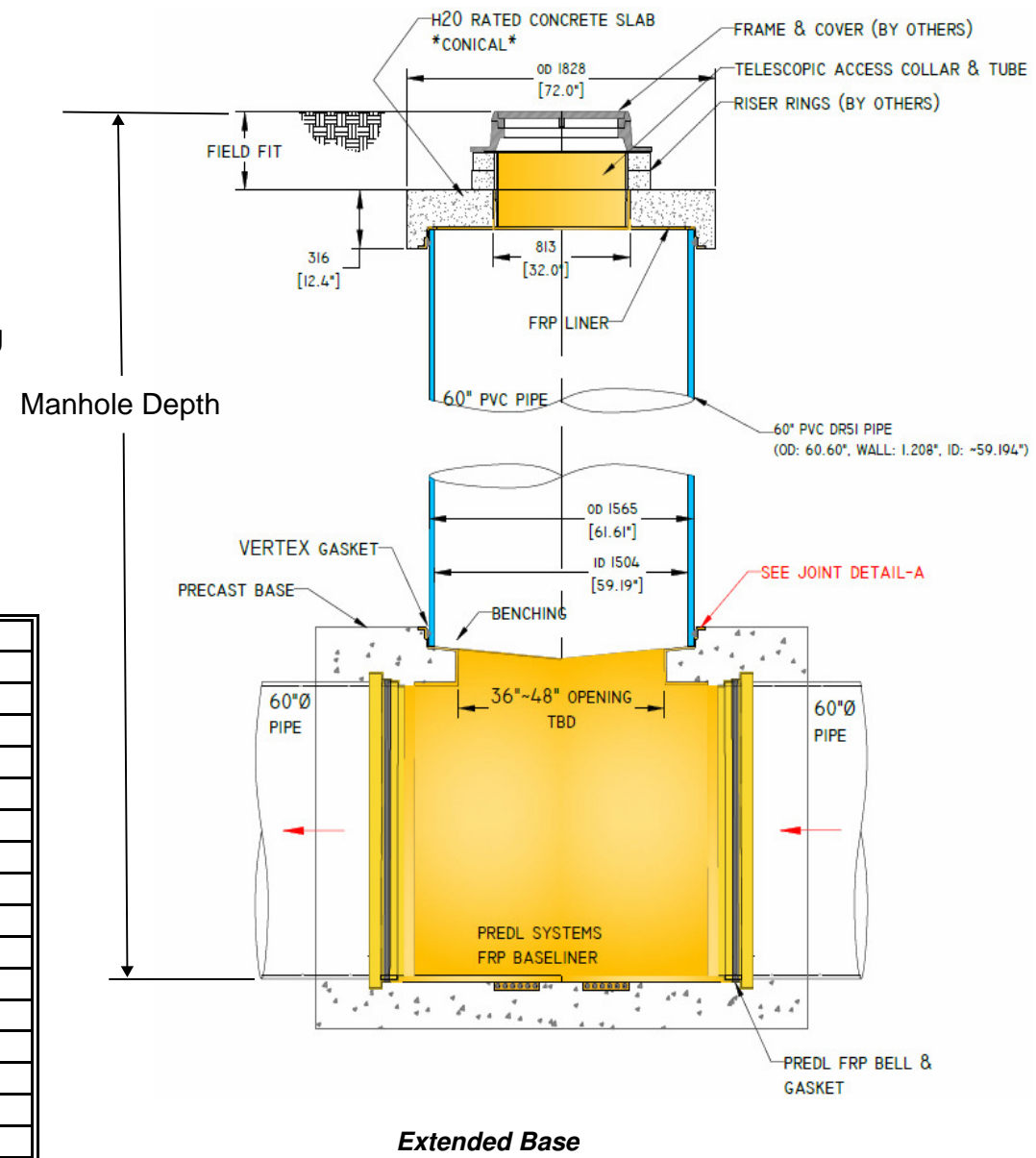
Buoyancy Effect Check

Counter Weights considered in the calculation:

1. Backfill soil weight on top of the lid
2. Self-weight of base and lid
3. Soil carried by the extened base or anti-floatation Ring
4. PVC self-weight
5. Down Drag Force by soils

Calculation Sheet

Manhole Depth	PVC Length	D.D.Shear Stress	D.D. Force	Buoyancy Force	Bouyancy Effect Safety factor
ft	ft	lbf/sf	lbs	lbs	<i>Extended Base</i>
9.00	1.00	81.68	1334.61	11026.99	4.13
10.00	2.00	92.57	3025.11	12252.21	3.87
11.00	3.00	103.46	5071.51	13477.43	3.69
12.00	4.00	114.35	7473.80	14702.65	3.57
13.00	5.00	125.24	10231.99	15927.87	3.49
14.00	6.00	136.13	13346.08	17153.10	3.44
15.00	7.00	147.02	16816.06	18378.32	3.41
16.00	8.00	157.91	20641.94	19603.54	3.41
17.00	9.00	168.80	24823.71	20828.76	3.42
18.00	10.00	179.69	29361.37	22053.98	3.45
19.00	11.00	190.58	34254.94	23279.20	3.49
20.00	12.00	201.47	39504.39	24504.42	3.54
21.00	13.00	212.36	45109.75	25729.64	3.60
22.00	14.00	223.25	51071.00	26954.86	3.67
23.00	15.00	234.14	57388.14	28180.09	3.75
24.00	16.00	245.03	64061.18	29405.31	3.83
25.00	17.00	255.92	71090.12	30630.53	3.91
26.00	18.00	266.81	78474.95	31855.75	4.00
27.00	19.00	277.70	86215.67	33080.97	4.10
28.00	20.00	288.59	94312.29	34306.19	4.19
29.00	21.00	299.48	102764.81	35531.41	4.30
30.00	22.00	310.37	111573.22	36756.63	4.40



D.D.FORCE: Down Drag Force

Counter weight Extened base =	35000	lbs
Counter weight (lid) =	2500	lbs
PVC Riser Weight (per foot length)=	155	lbs/ft

PVC Material Information

PVC Pipe ID	60.000	inch
Wall Thickness	1.208	inch
I of Wall	0.147	Inch ⁴ /in

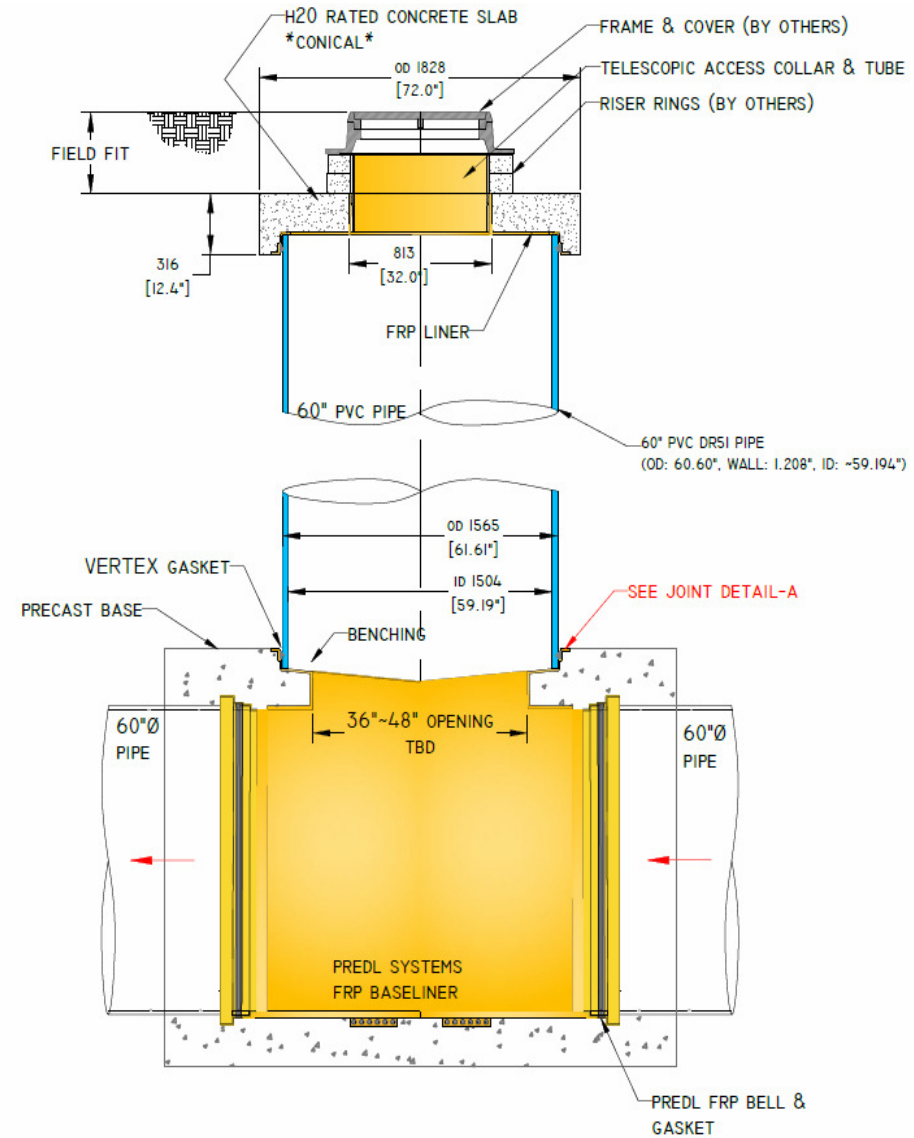
Buoyancy Effect Check

Soil Information

Water Density	62.4	lbs/cu.f
Counter weight Soil Density	80	lbs/cu.f
soil dry density	120.000	lbs/cu.f
soil sat. density	135.000	lbs/cu.f
soil intet.friction angle	30.000	
friction coefficient	0.400	psi,E'
Soil Modulus	1000.000	
active Earth pres. Coe.	0.333	

Counter Weights considered in the calculation:

1. Backfill soil weight on top of the lid
2. Self-weight of base and lid
3. Soil carried by the extened base or anti-floatation Ring
4. PVC self-weight
5. Down Drag Force by soils



Calculation Sheet

Manhole Depth	PVC Length	D.D.Shear Stress	D.D. Force	Buoyancy Force	Bouyancy Effect	Safety factor
ft	ft	lbf/sf	lbs	lbs		Base
9.00	1.00	81.68	1334.61	11026.99		2.95
10.00	2.00	92.57	3025.11	12252.21		2.81
11.00	3.00	103.46	5071.51	13477.43		2.73
12.00	4.00	114.35	7473.80	14702.65		2.69
13.00	5.00	125.24	10231.99	15927.87		2.67
14.00	6.00	136.13	13346.08	17153.10		2.68
15.00	7.00	147.02	16816.06	18378.32		2.70
16.00	8.00	157.91	20641.94	19603.54		2.74
17.00	9.00	168.80	24823.71	20828.76		2.80
18.00	10.00	179.69	29361.37	22053.98		2.86
19.00	11.00	190.58	34254.94	23279.20		2.93
20.00	12.00	201.47	39504.39	24504.42		3.01
21.00	13.00	212.36	45109.75	25729.64		3.10
22.00	14.00	223.25	51071.00	26954.86		3.19
23.00	15.00	234.14	57388.14	28180.09		3.28
24.00	16.00	245.03	64061.18	29405.31		3.38
25.00	17.00	255.92	71090.12	30630.53		3.49
26.00	18.00	266.81	78474.95	31855.75		3.59
27.00	19.00	277.70	86215.67	33080.97		3.70
28.00	20.00	288.59	94312.29	34306.19		3.82
29.00	21.00	299.48	102764.81	35531.41		3.93
30.00	22.00	310.37	111573.22	36756.63		4.05

D.D.FORCE: Down Drag Force

Counter weight Extened base =	22000	lbs
Counter weight (lid) =	2500	lbs
PVC Riser Weight (per foot length)=	155	lbs/ft

PVC Material Information

PVC Pipe ID	60.000	inch
Wall Thickness	1.208	inch
I of Wall	0.147	Inch ⁴ /in

Soil Information

Water Desity	62.4	lbs/cu.f
Counter weight Soil Desity	80	lbs/cu.f
soil dry density	120.000	lbs/cu.f
soil sat. density	135.000	lbs/cu.f
soil intet.friction angle	30.000	
friction coefficient	0.400	psi,E'
Soil Modulus	1000.000	
active Earth pres. Coe.	0.333	

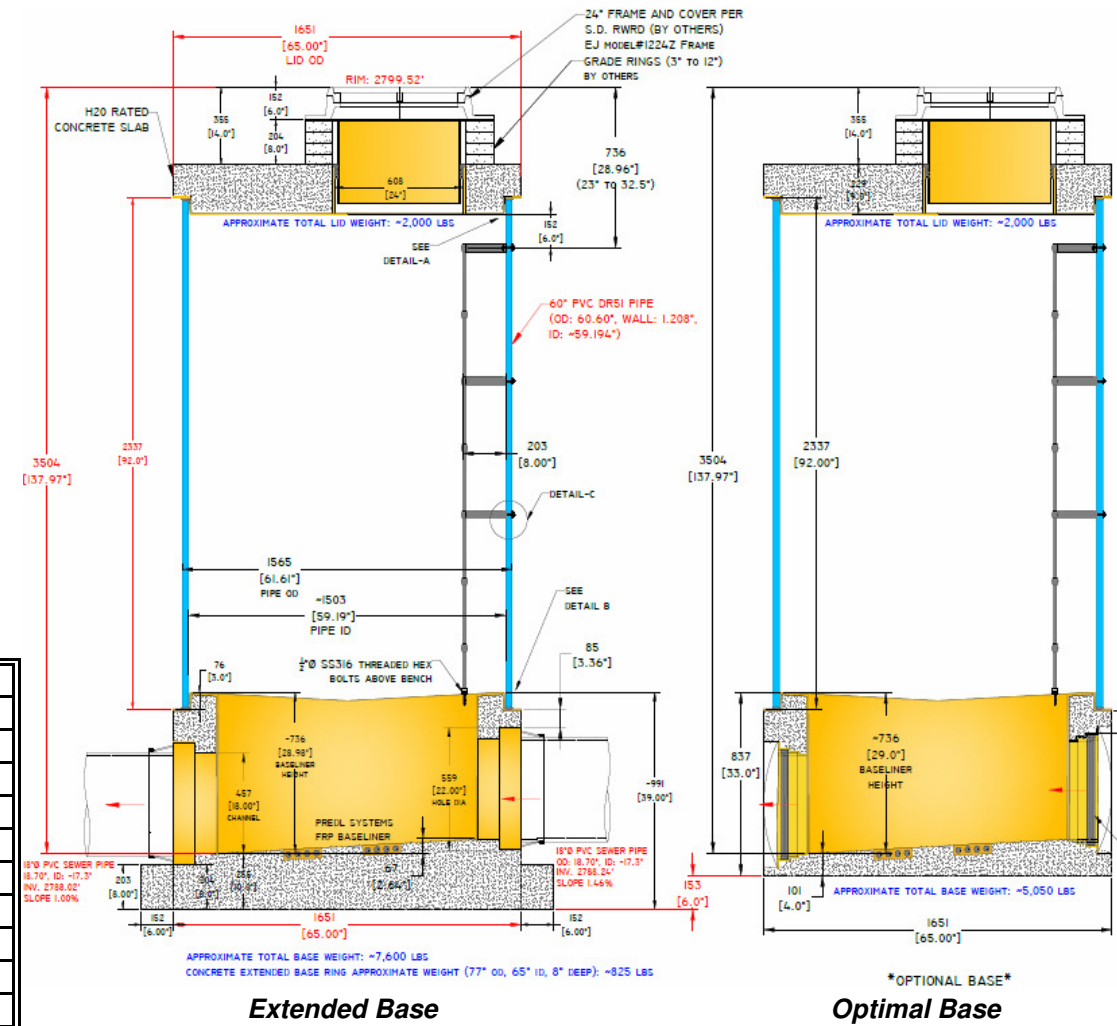
Buoyancy Effect Check

Counter Weights considered in the calculation:

1. Backfill soil weight on top of the lid
2. Self-weight of base and lid
3. Soil carried by the extened base or anti-floatation Ring
4. PVC self-weight
5. Down Drag Force by soils

Calculation Sheet

Manhole Depth	PVC Length	D.D.Sheer Stress	D.D. Force	Buoyancy Force	Bouyancy Effect		Safety factor
					Extended Base	Optimal Base	
4.00	1.00	27.23	444.87	4900.88	2.60	2.18	
5.00	2.00	38.12	1245.63	6126.11	2.25	1.90	
6.00	3.00	49.01	2402.29	7351.33	2.07	1.77	
7.00	4.00	59.90	3914.85	8576.55	1.99	1.71	
8.00	5.00	70.79	5783.30	9801.77	1.96	1.71	
9.00	6.00	81.68	8007.65	11026.99	1.97	1.74	
10.00	7.00	92.57	10587.89	12252.21	2.01	1.79	
11.00	8.00	103.46	13524.03	13477.43	2.06	1.86	
12.00	9.00	114.35	16816.06	14702.65	2.13	1.94	
13.00	10.00	125.24	20463.99	15927.87	2.22	2.03	
14.00	11.00	136.13	24467.81	17153.10	2.31	2.13	
15.00	12.00	147.02	28827.53	18378.32	2.41	2.23	
16.00	13.00	157.91	33543.15	19603.54	2.51	2.34	
17.00	14.00	168.80	38614.66	20828.76	2.62	2.46	
18.00	15.00	179.69	44042.06	22053.98	2.74	2.58	
19.00	16.00	190.58	49825.36	23279.20	2.85	2.70	
20.00	17.00	201.47	55964.56	24504.42	2.97	2.82	
21.00	18.00	212.36	62459.65	25729.64	3.09	2.94	
22.00	19.00	223.25	69310.64	26954.86	3.22	3.07	
23.00	20.00	234.14	76517.52	28180.09	3.34	3.20	
24.00	21.00	245.03	84080.30	29405.31	3.47	3.33	
25.00	22.00	255.92	91998.97	30630.53	3.60	3.46	



D.D.FORCE: Down Drag Force

Counter weight Extended base =	7600	lbs
Counter weight Optimal base =	5650	lbs
Counter weight (lid) =	2000	lbs
PVC Riser Weight (per foot length)=	155	lbs/ft