

Memorandum

То	Edward Stribula	Page	1
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Subject	Cleveland Innerbelt Sewer Study Addendum (DRAFT)		
From	Daniel Rosenberg		
Date	March 31, 2010		

The purpose of this technical memorandum is to present the results of the hydraulic analysis of the following alternatives for the Easterly Interceptor associated with the proposed I-90 Innerbelt Realignment modifications:

- Alternative 2A 120-inch/102-inch RCP sewer to reroute the flow to the south of the existing sewer;
- Alternative 2B 110-inch/104-inch CCFRPMP sewer to reroute the flow to the south of the existing sewer and;
- Alternative 2C 120-inch/Twin 96-inch RCP sewer to reroute the flow to the south of the existing sewer.

This study is an addendum to the original study dated February, 2006. This technical memorandum discusses the various alternatives considered, hydraulic impacts of the alternatives based on the results of the model simulation and recommendations to maintain the conveyance capacity of the interceptor system. The alternatives evaluated in this memorandum were developed by DLZ Corp. (DLZ). AECOM's services have consisted of hydraulic analysis of the alternatives to evaluate the impact of each on the hydraulic grade line in the Easterly Interceptor.

The goal of this project is to evaluate the three specific alternatives provided by DLZ for the conveyance of waste water and wet weather flows in the Easterly Interceptor between E. 26th St. and E. 33rd St. This was accomplished by:

- Use of the Northeast Ohio Regional Sewer District's (NEORSD) Easterly baseline with Early Action Projects hydraulic model and Advanced Facilities Plan (AFP) hydraulic model as modified in the original study as a basis to construct models of the conceptual alternative plans provided by DLZ;
- Simulate dry weather flow, the 5-year, 6-hour design storm and the District's combined sewer overflow (CSO) control storms for each of the alternatives in the hydraulic model;
- Process and analyze hydraulic grade line (HGL) and velocity results for simulated storm events for each alternative;



- Compare hydraulic model results with calculations prepared in Excel for the AFP alternatives, and;
- Review CSO control storm results to determine if CSO control at adjacent CSO regulators is maintained.

BACKGROUND

The Northeast Ohio Regional Sewer District's (NEORSD) Easterly Interceptor conveys combined sewer flows to the Easterly Wastewater Treatment Plant (WWTP). It ranges from 8-feet in diameter at Lakeside Avenue and W. 9th Street to 13.5-feet in diameter at the WWTP influent near Lake Shore Boulevard and E. 140th Street.

The Easterly Interceptor Hydraulic Modeling project site, shown in Figure 1, is located at Lakeside Avenue and Interstate-90. The interceptor in the study area is an 11-ft 9-inch circular sewer constructed of four (4) rings of bricks. The sewer transports flow from west to east along Lakeside Avenue and crosses perpendicular under Interstate-90. There is one (1) 12-inch corrugated metal pipe (CMP) connection roughly 30-feet west of the west shoulder of Interstate-90 as proposed by the Innerbelt Realignment project.



Figure 1. Easterly Interceptor Hydraulic Modeling Project Site

The Innerbelt Realignment project proposes modifications that lower the elevation of Interstate-90 at the interceptor crossing. Under these proposed modifications, a portion of the outer brick layer of the existing interceptor crown would protrude into the Interstate-90 pavement section. One of the objectives of this hydraulic modeling project is to evaluate the Easterly Interceptor and nearby CSO regulators to determine whether CSO control is maintained. CSO control will be evaluated under conditions as they exist in the sewer system at the present time. In addition, CSO control will be



evaluated under future conditions with the District's CSO control plan in place. The future condition will be assessed by using the hydraulic model developed by NEORSD as part of the Easterly CSO Tunnel Storage Advanced Facilities Plan (AFP).

The hydraulic impact of the three alternatives on the conveyance capacity of the Easterly Interceptor during and after proposed Interstate-90 modifications was considered. The following sections describe the work that was completed and the results. It is important to note that for all of the alternatives evaluated it was assumed that the transitions between the existing and proposed pipe sections would not be abrupt and include rounded edges to minimize head loss through these sections.

REGULATOR E-11 DRY WEATHER OUTLET RECONNECTION

Additionally, the storm water outlet at regulator E-11, located at the just west of the Innerbelt crossing, was recommended to be bulkheaded during the Easterly CSO Phase II Facilities Planning Study (M&E, March, 2002). The dry weather connection currently connects to the Easterly Interceptor in the proposed abandoned section. This connection will have to be reestablished to the realigned interceptor as part of this project. The conveyance capacity of the new pipe will need to be at least as great as the existing connection.

ALTERNATIVES

The three (3) alternatives discussed as part of this technical memorandum are based on conceptual plans provided by DLZ Corp.

Alternative 2A: 102-inch Diameter RCP Sewer

Depicted in Figure 4A, Alternative 2A proposes that the sewer underneath I-90 be realigned to the south and replaced with two 120-inch sections and one 102-inch section of RCP sewer. Four (4) new junction chambers will direct flow to the new sewer sections. The existing interceptor is abandoned. In the hydraulic model, the roughness coefficient of the new RCP sewer was modeled as 0.013, which consistent with the February 2006 study. The upstream and downstream invert elevations of the new sewer match the existing upstream and downstream invert elevations of the brick interceptor.

Alternative 2B: 104-inch Diameter CCFRPMP Sewer

Depicted in Figure 4B, Alternative 2B proposes that the sewer underneath I-90 be realigned to the south and replaced with two 110-inch sections and one 104-inch section of CCFRPMP sewer. Four (4) new junction chambers will direct flow to the new sewer sections. The existing interceptor is abandoned. In the hydraulic model, the roughness coefficient of the new CCFRPMP sewer was modeled as 0.011, which consistent with the February 2006 study. The upstream and downstream invert elevations of the new sewer match the existing upstream and downstream invert elevations of the brick interceptor.

Alternative 2C: Twin 96-inch Diameter RCP Sewer

Depicted in Figure 4C, Alternative 2C proposes that the sewer underneath I-90 be realigned to the south and replaced with two 120-inch sections and one Twin 96-inch section of RCP sewer. Four (4) new junction chambers will direct flow to the new sewer sections. The existing interceptor is









abandoned. In the hydraulic model, the roughness coefficient of the new RCP sewer was modeled as 0.013, which consistent with the February 2006 study. The upstream and downstream invert elevations of the new sewer match the existing upstream and downstream invert elevations of the brick interceptor.

EVALUATION PROCEDURE

The NEORSD Easterly baseline with Early Action Projects hydraulic model and AFP hydraulic model were used to simulate the Easterly Interceptor's response to the three (3) alternatives under dryweather flow and various storm flows. The baseline hydraulic model conditions were developed under the Easterly CSO Phase II Facilities Planning Study. For more information on development of the Easterly baseline hydraulic model, see the Easterly CSO Phase II Hydraulic Modeling Report (Metcalf & Eddy, 2002). Since the sewer network tributary to the Easterly Interceptor under the AFP will be different than the existing sewer network, two sewer models were simulated as part of this project. The baseline hydraulic model network was constructed using the baseline sewer network plus the Early Action Projects and is called the "baseline with early action model" in this technical memorandum. The AFP hydraulic model represents future conditions of the sewer system under full CSO compliance and is called the "AFP model" in this technical memorandum. It represents a conservative future flow scenario in the Easterly Interceptor for design.

Dry-weather flow, the 5-year, 6-hour design storm and the top five (5) NEORSD CSO control storms were simulated in the baseline with early action model and the AFP model for the existing 11-ft 9-inch Easterly Interceptor brick sewer and for each of the five (5) alternatives.

The results of the baseline plus early action model and the AFP model were processed and analyzed for the simulated storm events for the existing brick interceptor and each of the alternatives. To accomplish this

- The CSO control storm results were reviewed to determine if CSO control at adjacent regulator E-12 was being maintained
- The peak HGL for the most severe hydraulic scenario was reviewed at key points along the interceptor

The model results were then compared with calculations done in Excel that calculated the friction loss through each conduit and the headloss at each manhole based on the change in direction and pipe size. The Excel calculations are provided in Appendix A.

CSO IMPACTS

The DWO from regulator E-12 is located approximately 500-feet upstream of the project site on the Easterly Interceptor and connects into the interceptor at an elevation of approximately 614.3-feet. If proposed alternatives raise the peak HGL above this elevation at the connection point, the overflow volume and frequency at this regulator may increase. The HGL of the recommended alternatives remains below the crown of the interceptor (approximately 602.0-feet) at the connection point for all of the CSO control storms; therefore, additional overflow does not occur as a result of the proposed alternatives.



EVALUATION RESULTS

Hydraulic scenarios were reviewed for the 5-year design storm and the CSO control storms for all of the alternatives. It was determined that the 5-year design storm had more severe hydraulic impacts on the alternatives than any of the CSO control storms. Therefore, the peak HGL under the 5-year design storm condition was evaluated along the interceptor to determine if proposed alternatives caused flooding or surcharging in the hydraulic models. In the AFP model, proposed sewer segments were surcharged for all of the alternatives, but the existing 11-feet 9-inch diameter interceptor was under free flow conditions. Although surcharging was present, the HGL remained between 0.9 and 1.4 feet below the minimum proposed ground surface elevation of Interstate-90 (approximately 601.76-feet) for the sewer section at the proposed Innerbelt crossing.

The Easterly Interceptor sewer system is designed to convey the 5-year 6-hour design storm. For storms larger than this, additional flow will be relieved from the system through the overflows. However, during these higher intensity or duration storms, some additional surcharging may be present in the Easterly Interceptor under any of the alternative conditions.

Manholes along the Easterly Interceptor between E. 26th Street and E. 33rd Street were chosen as key points for hydraulic review of the 5-year design storm. The sewer system further upstream or downstream did not appear to be affected by any of the alternatives. The peak water level and velocity during dry-weather flow and during the 5-year storm simulations are shown in Table 1 and Table 2 at the key points. Table 1 represents results from the baseline with early action model and Table 2 represents results from the AFP model. The peak water level at each key point is represented as depth above the manhole invert and is shown in feet. The velocity is determined in the downstream pipe and is shown in feet per second (ft/sec).

The shaded cells in Table 2 represent sewer sections of the alternatives where surcharging was evident during the 5-year storm in the hydraulic model, or where low velocities occur in the proposed sections. The HGL in each sewer section is higher than the crown of the pipe, but none exceed the ground surface elevation of Interstate-90.

Evaluation of the capacity at each of the proposed alternatives was compared to the peak flow rate in the Easterly Interceptor. All of the options have the capacity to convey the 5-year design storm with surcharging to ground surface under I-90. However, option 2C shows a dramatic reduction in velocity during dry weather flow.

CONCLUSIONS

Based on the information provided, Alternatives 2A and 2B effectively convey flows in the Easterly Interceptor at Lakeside Avenue and Interstate-90 for the 5-year design storm, maintain CSO control at adjacent regulator E-12 and provide velocities above 1.5 feet per second during dry weather flow. Alternative 2C (twin 96-inch diameter pipes) resulted in velocities less than 1.5 feet per second during dry weather flow. These velocities will further exacerbate the deposition of grit and debris through this portion of the Easterly Interceptor.

One further option that could be developed would be a combination of 120-inch RCP and 104-inch CCFRPMP.

Table 1. Baseline Flow Rates and Velocities																									
				Profile	Baseline				Pro	file Baselin	e Alternativ	e 2A			Pro	file Baseline	e Alternativ	e 2B			Prot	ile Baselin	e Alternativ	e 2C	
				Existing B	Brick Sewer					102-inch	RCP Sewer				1	04-inch CCI	RPMP Sewe	er			T	win 96-incl	n RCP Sewei	ſS	
		Pipe Size	Invert	Water L	.evel* (ft)	Velocit	y (ft/sec)	Pipe Size	Invert	Water L	evel* (ft)	Velocit	y (ft/sec)	Pipe Size	Invert	Water L	evel* (ft)	Velocity	(ft/sec)	Pipe Size	Invert	Water L	evel* (ft)	Velocity	/ (ft/sec)
Location on Lakeside Avenue	Manhole Name	(ft)	Elev. (ft)	DWF	5-year	DWF	5-year	(ft)	Elev. (ft)	DWF	5-year	DWF	5-year	(ft)	Elev. (ft)	DWF	5-year	DWF	5-year	(ft)	Elev. (ft)	DWF	5-year	DWF	5-year
E. 26th Street	EAA325	11.75	590.26	1.2	8.0	2.0	4.3	11.75	590.26	1.3	9.3	1.5	3.3	11.75	590.26	1.3	9.4	1.6	3.3	11.75	590.26	1.2	8.8	1.7	3.6
Temporary Pit w/Permanent Manhole																								1	
Access/ Junction Chamber #1	IBUPSTM	-	-	-	-	-	-	10	589.96	1.5	9.6	1.6	4.0	9.17	589.96	1.5	9.7	1.8	4.5	10	589.96	1.4	9.1	2.1	4.3
Interstate 90	EAA320	11.75	590	1.2	8.2	1.6	3.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	i - '	-
Junction Chamber #2	RLIGNUP	-	-	-	-	-	-	8.5	589.93	1.4	9.3	1.9	5.3	8.67	589.93	1.4	9.3	1.9	5.1	2@8.0	589.93	1.3	8.8	1.1	3.0
Junction Chamber #3	RLIGNDS	-	-	-	-	-	-	8.5	589.8	1.4	8.7	1.8	4.6	8.67	589.8	1.4	8.8	1.9	4.9	2@8.0	589.8	1.4	8.7	1.8	4.6
Temporary Receiving Pit w/ Junction																								1	
Chamber #4	IBDSTRM	-	-	-	-	-	-	10	589.75	1.3	8.5	1.5	3.9	9.17	589.75	1.3	8.5	1.5	3.9	10	589.75	1.3	8.5	1.5	3.9
E.33rd Street	EAA315	11.75	589.31	1.5	8.8	1.6	4.3	11.75	589.31	1.5	8.8	1.5	4.2	11.75	589.31	1.5	8.7	1.5	4.2	11.75	589.31	1.5	8.8	1.6	4.2

* Depth above pipe invert Water Level above crown of pipe

Low velocity

Table 2. AFP Flow Rates and Velocities																									
				Prof	ile AFP				Р	rofile AFP /	Alternative 2	2A			Р	rofile AFP A	Alternative 2	2B			Р	rofile AFP /	Alternative	2C	
				Existing E	Brick Sewer					102-inch	RCP Sewer				1	04-inch CCI	RPMP Sew	er			T	win 96-inc	h RCP Sewe	rs	
		Pipe Size	Invert	Water I	.evel* (ft)	Velocity	y (ft/sec)	Pipe Size	Invert	Water L	evel* (ft)	Velocit	y (ft/sec)	Pipe Size	Invert	Water L	evel* (ft)	Velocity	y (ft/sec)	Pipe Size	Invert	Water L	.evel* (ft)	Velocity	y (ft/sec)
Location on Lakeside Avenue	Manhole Name	(ft)	Elev. (ft)	DWF	5-year	DWF	5-year	(ft)	Elev. (ft)	DWF	5-year	DWF	5-year	(ft)	Elev. (ft)	DWF	5-year	DWF	5-year	(ft)	Elev. (ft)	DWF	5-year	DWF	5-year
E. 26th Street	EAA325	11.75	590.26	1.3	9.7	2.0	4.4	11.75	590.26	1.4	10.9	1.5	3.4	11.75	590.26	1.4	11.0	1.6	3.4	11.75	590.26	1.3	10.4	1.7	3.7
Temporary Pit w/Permanent Manhole																									
Access/ Junction Chamber #1	IBUPSTM	-	-	-	-	-	-	10	589.96	1.5	11.1	1.7	4.1	9.17	589.96	1.5	11.2	1.8	4.8	10	589.96	1.4	10.7	2.1	4.5
Interstate 90	EAA320	11.75	590	1.2	9.9	1.6	4.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Junction Chamber #2	RLIGNUP	-	-	-	-	-	-	8.5	589.93	1.5	10.9	2.0	5.7	8.67	589.93	1.5	10.8	2.0	5.5	2@8.0	589.93	1.4	10.4	1.1	3.4
Junction Chamber #3	RLIGNDS	-	-	-	-	-	-	8.5	589.8	1.4	10.2	1.9	4.7	8.67	589.8	1.4	10.3	2.0	5.2	2@8.0	589.8	1.4	10.4	1.9	4.8
Temporary Receiving Pit w/ Junction																									
Chamber #4	IBDSTRM	-	-	-	-	-	-	10	589.75	1.4	10.1	1.6	4.0	9.17	589.75	1.4	10.0	1.6	4.0	10	589.75	1.4	10.1	1.6	4.0
E.33rd Street	EAA315	11.75	589.31	1.5	10.4	1.6	4.3	11.75	589.31	1.5	10.3	1.6	4.3	11.75	589.31	1.5	10.3	1.6	4.3	11.75	589.31	1.5	10.4	1.6	4.3
* Depth above pipe invert																									

Water Level above crown of pipe

Low velocity



APPENDIX A

	-						
Number of manholes	8	Invert	Ground	Water Level	Distance upstream	Cumulative Distance upstream	Pipe Crown
Downstream	EAA315	589.31	627.11	599.62	0	0	601.06
Downstream of Expansion	IBDSTRM	589.75	628	599.82	723	723	601.5
Upstream of Expansion	IBDSTRM	589.75	628	599.90	0	723	599.75
Realigned Pipe Section Downstream Expansion	RLIGNDS	589.8	628	599.92	66	789	599.8
Realigned Pipe Section Upstream Expansion	RLIGNDS	589.8	628	600.09	0	789	598.3
Realigned Pipe Section Downstream Contraction	RLIGNUP	580.03	628	600.39	203	1082	508 /3
Realigned Pipe Section Downstream Contraction		500.00	620	600.53	235	1002	500.02
Realighed Fipe Section Opsilean Contraction	RUDOT	509.93	020	000.55	0	1082	599.95
Downstream of Contraction	IBUPSIM	589.96	628	600.56	66	1148	599.96
Upstream of Contraction	IBUPSIM	589.96	628	600.61	0	1148	601.71
	EAA325	590.26	628.26	600.74	490.53	1638.53	602.01
	EAA330	590.81	629.11	600.80	248.72	1887.25	602.56
Upstream	EAA335	591.48	630.97	600.97	594	2481.25	603.23
			İ				
Flow Pate through System (afc)	240	Licos 2% Sofoty Easter					
Plow Rate through System (CIS)	540	Oses 3% Salety Factor	Nerrel Flaur	505.00	Eleveria de energia en eleve	l	ha a la cal
Downstream water Level at EAA315 ()	599.623	Calculate water Level based (on Normal Flow =	595.29	Flow is therefore dow	Instream controlled, use model wa	ter level
Friction loss between IBDSTRM and EAA315							
$h_{f}=2.87n^{2}(LV^{2}/D^{4/3})$							
n~	Manning's roughness coefficient						
L~	Length of Pipe	1	İ				
	Velocity						
V~	Diameter of Pine	1					
U~							
n=	0.015						
L=	723	Fill in for Q and V will be calcul	ated				
V=	3.37	Q=	340				
D=	11.75						
DEPTH OF FLOW=	10.31	4.85	100.856473				
h=	0 199						
Olara of Pice	0.0000						
Slope of Pipe	0.0006						
INVERT AT DOWNSTREAM END (EAA315)	589.31						
INVERT AT UPSTREAM END (IBDSTRM)	589.75		ĺ				
Depth at downstream end (EAA315)	599.62						
Depth at upstream end (IBDSTRM)	599.82						
	000.02						
Compute losses due to Change in Direction							
	h _L = (h _{dir})						
	$h_{c} = K_{c}^{*}((V_{c}^{2}/2q) - (V_{c}^{2}/2q))$			Aroa (ftA2)			
				Alea (it 2)			
V1=	4.33	tt/sec		78.5398163			
V2=	3.37	ft/sec		100.856473			
K _{dir} =	0.44	From - Wastewater Engineerin	ng: Collection and F	umping of Wa	stwater, Metcalf and		
~	32.2	Eddy, 1981, Appendix C					
	02.2						
h _{dir} =	0.050	Int					
Depth upstream of Direction Change (IBDSTRM)	599.87	1					
Compute losses due to Expansion at IBDSTRM							
	h _L = (h _{expansion})						
	$h_{\text{averagesian}} = K_{2}^{*}((V_{1}^{2}/2q) - (V_{2}^{2}/2q))$	i	İ	Area (ft^2)			
	···expension ···e ((*1/-9/ (*2/-9//			7 i ca (it '2)			
V1=	4.33	It/sec		78.5398163			
V2=	3.37	ft/sec		100.856473			
K _e =	0.2	From - Wastewater Engineering	ng: Collection and F	umping of Wa	stwater, Metcalf and		
~~~	32.2	Eddy, 1981, pg 43 Table 2-7					
	02.2		1			l	
h _{expansion} =	0.023	ft					
Depth upstream of expansion (IBDSTRM)	599.90	1	İ				
	000.00				I	1	1

h _r =2.87n ² (LV ² /D ^{4/3} )							
n=	0.013					1	
	66	Fill in for O and V will be calcul	lated				
	4.22		240				
V=	4.35	Q=	340				
	10						
DEPTH OF FLOW=	10.15	6.28	78.53981627				
11 _f =	0.028						
INVERT AT DOWNSTREAM END (IBDSTRM)	589.75						
INVERT AT UPSTREAM END (RLIGNDS)	589.80						
Depth at downstream end (IBDSTRM)	599.90						
Depth at upstream end (RLIGNDS)	599.92						
Compute losses due to Change in Direction							
Compute losses due to Change in Direction							
	$\Pi_{L} = (\Pi_{dir})$						
	$h_{dir} = K_{dir}^{*}((V_1^{2}/2g) - (V_2^{2}/2g))$			Area (ft^2)			
)/1-	5.00	ft/200		56 7450172			
VI=	0.99	4/2.2.2		30.7430173			
V2=	4.33	Tivsec	 new Optile atting and F	78.5398163	aturtan Matarifand		
K _{dir} =	0.44	From - Wastewater Engineeri	ng: Collection and F	umping of wa	istwater, Metcalf and		
g=	32.2	Eddy, 1981, Appendix C					
h _{dir} =	0.117	ft					
un un	0						
Depth upstream of Direction Change (RLIGNDS)	600.04						
Compute losses due to Expansion at RLIGNDS							
	h _L = (h _{expansion} )						
	h $-K^{*}(1/\sqrt{2}/2\alpha)-(1/\sqrt{2}/2\alpha))$			Area (#A2)			
	Texpansion = (( ( 1/29) ( 2/29))			Alea (IP2)			
V1=	5.99	ft/sec		56.7450173			
V2=	4.33	ft/sec		78.5398163			
K _e =	0.2	From - Wastewater Engineering	ng: Collection and F	umping of Wa	stwater, Metcalf and		
0-	32.2	Eddy, 1981, pg 43 Table 2-7					
9	02.2						
b	0.050						
I lexpansion =	0.053	π					
Depth upstream of expansion (RLIGNDS)	600.09	]					
	1						1
	1	1				1	
		1					
h=2.87n ² (LV ² /D ^{4/3} )							
	0.013						
n=	0.013						
L=	293	Fill in for Q and V will be calcul	ated				
V=	5.99	Q=	340				
D=	8.5	ļ					
DEPTH OF FLOW=	10.29	6.28	56.74501726				
h _f =	0.294						
INVERT AT DOWNSTREAM END (RLIGNDS)	589.8				İ		
INV/ERT AT LIPSTREAM END (RLIGNUP)	580.06	1	1				
Depth at downstream end (RLIGNDS)	600.00						
Depth at upstream and (RLIGNUP)	600.09	1	1				
Deputat upsteament (KLIGNOF)	000.39	1	1		1	1	1

Compute losses due to Change in Direction							
	$h_{L} = (h_{dir})$					1	
	$h_{dir} = K_{dir}^{*}((V_2^{2}/2g) - (V_1^{2}/2g))$			Area (ft^2)			
V1=	4.33	ft/sec		78.5398163		(	
V2=	5.99	ft/sec		56,7450173		(	
K _{dir} =	0.44	From - Wastewater Engineerin	ng: Collection and F	Pumping of Wa	stwater, Metcalf and		
	32.2	Eddy, 1981, Appendix C	-			l	
	32.2				1		
h	0.117	ft		1			
	0.117						
Panth unstream of Direction Change (BLICNUR)	600.50						
Depin upsireant of Direction Change (RLIGNOP)	600.50						
						l	
Compute leases due to Contraction at RLICNUR							
Compute losses due to Contraction at REIGNOP	$ \mathbf{b} - (\mathbf{b}) $					<u> </u>	
	IL = (Ilcontraction)					Į	
	$h_{contraction} = K_c^*((V_2^2/2g) - (V_1^2/2g))$			Area (ft^2)		1	
V1=	4.33	ft/sec		78.5398163		l	
V2=	5.99	ft/sec		56.7450173			
K _c =	0.1	From - Wastewater Engineerin	ng: Collection and F	Pumping of Wa	astwater, Metcalf and		
q=	32.2	Eddy, 1981, pg 43 Table 2-7					
h _{contraction} =	0.027	ft					
Depth upstream of contraction (RLIGNUP)	600.53						
<u> </u>							
		1				(	
h _f =2.87n ² (LV ² /D ^{4/3} )							
n=	0.013						
L=	66	Fill in for Q and V will be calcula	ated			(	
V=	4.33	Q=	340				
D=	10						
DEPTH OF FLOW=	10.60	6.28	78.53981627				
h _f =	0.028						
INVERT AT DOWNSTREAM END (RLIGNUP)	589.93						
INVERT AT UPSTREAM END (IBUPSTM)	589.96						
Depth at downstream end (RLIGNUP)	600.53					l	
Depth at upstream end (IBUPSTM)	600.56						
Compute losses due to Change in Direction						ļ	
	$h_{L} = (h_{dir})$					1	
	$h_{dir} = K_{dir}^{*}((V_2^{2}/2g) - (V_1^{2}/2g))$			Area (ft^2)			
V1=	3.41	ft/sec		102.765952			
V2=	4.14	ft/sec		66.0432676			
K _{rii} =	0.44	From - Wastewater Engineerin	ng: Collection and F	umping of Wa	stwater, Metcalf and		
	32.2	Eddy, 1981, Appendix C	-			l	
y=							
hz. =	0.038	ft				l	
	0.030					l	
Dopth upstroom of Direction Change (IDUDETM)						l	
Deput upsitediti of Direction Change (IBOPSTM)	600.60					l	
						l	
		l	1		I	l	1

						1
Compute losses due to Contraction at IBUPSTM						
	$h_L = (h_{contraction})$					
	$h_{\text{contrastice}} = K_*((V_2^2/2q) - (V_4^2/2q))$			Area (ftA2)		
		*- 1		Alea (it 2)		
V1=	3.41	ft/sec		102.765952		
V2=	4.14	ft/sec		66.0432676		
K _c =	0.1	From - Wastewater Engineerin	ng: Collection and F	or Pumping of Wa	stwater, Metcalf and	
a=	32.2	Eddy, 1981, pg 43 Table 2-7				
3						
h	0.000	ft				
· · contraction	0.009					
Depth upstream of contraction (IBUPSTM)	600.61					
Friction loss between IBUPSTM and EAA325						
h _f =2.87n ² (LV ² /D ^{4/3} )						
n~	Manning's roughness coefficient					
	Length of Pine					
	Velocity					
V~	Diameter of Pipo					
D~				-		1
	0.045					
N=	0.015		L			
L=	490.53	Fill in for Q and V will be calcula	ated			
V=	3.31	Q=	340			
D=	11.75					
DEPTH OF FLOW=	10.57	4.99	102.7659522	Area		
h _f =	0.130					
				1		
INVERT AT DOWNSTREAM END (IBURSTM)	589.96					
	505.50					
INVERTAT UPSTREAM END (EAA325)	569.96					
Depth at downstream end (IBUPSTM)	600.61					
Depth at upstream end (EAA325)	600.74					
Friction loss between EAA325 and EAA330						
h _f =2.87n ² (LV ² /D ^{4/3} )						
n~	Manning's roughness coefficient					
L~	Length of Pipe					
V~	Velocity			1		
D~	Diameter of Pipe					
n-	0.015			-		
=======================================	249.72	Fill in for O and V will be asley	atod			
	240.72		240			 
V=	3.33	Q=	340			
U=	11.75					
DEPTH OF FLOW=	10.48	4.94	102.0755526	Area		
h _r =	0.067					
INVERT AT DOWNSTREAM END (EAA325)	590.26					
INVERT AT UPSTREAM END (EAA330)	590.26			1		
Depth at downstream end (EAA325)	600.74					
Depth at upstream end (EAA330)	600.4					 
	000.00			-		
	1	1		1		1

Friction loss between EAA330 and EAA335						
h _f =2.87n ² (LV ² /D ^{4/3} )						
n~	Manning's roughness coefficient					
L~	Length of Pipe					
V~	Velocity					
D~	Diameter of Pipe					
n=	0.015					
L=	594	Fill in for Q and V will be calcula	ated			
V=	3.46	Q=	340			
D=	11.75					
DEPTH OF FLOW=	9.99	4.69	98.27336366	Area		
h _i =	0.172					
INVERT AT DOWNSTREAM END (EAA330)	590.81					
INVERT AT UPSTREAM END (EAA335)	590.81					
Depth at downstream end (EAA330)	600.80					
Depth at upstream end (EAA335)	600.97					

Number of menholes	7	Invert	Ground	Water Level	Distance upstream	Cumulativo Distance upstream	Bino Crown
Number of mannoles	7	F80.21	GIOUNU	FOO 62		Cumulative Distance upstream	FIDE CTOWN
Downstream of Evenneign	IPDETRM	509.31	627.11	599.62	700	722	601.06
Downstream or Expansion	IBDSTRM	589.75	628	599.82	723	723	601.5
Upstream of Expansion	IBDSTRM	589.75	628	599.97	0	723	598.92
Realigned Pipe Section Downstream Expansion	RLIGNDS	589.8	628	600.00	66	789	598.97
Realigned Pipe Section Upstream Expansion	RLIGNDS	589.8	628	600.07	0	789	598.47
Realigned Pipe Section Downstream Contraction	RLIGNUP	589.93	628	600.26	293	1082	598.6
Realigned Pipe Section Upstream Contraction	RLIGNUP	589.93	628	600.32	0	1082	599.1
Downstream of Contraction	IBUPSTM	589.96	628	600.35	66	1148	599.13
Upstream of Contraction	IBUPSTM	589.96	628	600.45	0	1148	601.71
	EAA325	590.26	628.26	600.58	490.53	1638.53	602.01
	EAA330	590.81	629.11	600.65	248.72	1887.25	602.56
Upstream	EAA335	591.48	630.97	600.82	594	2481.25	603.23
Flow Rate through System (cfs)	340	Uses 3% Safety Factor					
Downstream Water Level at EAA315 ()	599.623	Calculate Water Level based of	n Normal Flow =	595.29	Flow is therefore dov	vnstream controlled, use model wat	ter level
Friction loss between IBDSTRM and EAA315							
h _f =2.87n ² (LV ² /D ^{4/3} )							
n	Manning's roughness coefficient						
	Length of Pipe						
	Velocity						
V~	Diamatan at Dian						
U~	Diameter of Pipe						
	0.045						
	0.015						
L=	723	Fill in for Q and V will be calcula	ated	-			
V=	3.37	Q=	340				
D=	11.75						
DEPTH OF FLOW=	10.31	4.85	100.856473				
h _i =	0.199						
Slope of Pipe	0.0006						
INVERT AT DOWNSTREAM END (EAA315)	589.31						
INVERT AT UPSTREAM END (IBDSTRM)	589.75						
Depth at downstream end (EAA315)	599.62						
Depth at upstream end (IBDSTRM)	599.82						
				1	İ	İ	1
Compute losses due to Change in Direction							
	$h_i = (h_{ij})$			1			1
	$n_{dir} = K_{dir} ((V_1^{-}/2g) - (V_2^{-}/2g))$			Area (ft^2)			
V1=	5.15	ft/sec		66.0432676			
V2=	3.37	ft/sec		100.856473			
K _{dir} =1.5*(1-cos(θ)	0.44	From - Wastewater Engineerin	g: Collection and F	umping of Wa	stwater, Metcalf and		
~	22.2	Eddy, 1981, Appendix C Figure	(C-9)				
g=	32.2		. ,	1			
L							
n _{expansion} =	0.103	n				<u> </u>	
Depth upstream of Direction Change (IBDSTRM)	599.93						
					1	1	

Compute losses due to Expansion at IBDSTRM						
	h _I = (h _{expansion} )					
	$h_{2} = K_{2}^{*}(V_{2}^{2}/2q) - (V_{2}^{2}/2q))$			Area (ftA2)		
		44/				 
V1=	5.15	IVSEC		100 956472		 
V2=	3.37	From - Wastewater Engineerin	a: Collection and P	100.656475	stwater Metcalf and	 
κ _e =	0.20	Eddy 1981 pg /3 Table 2-7	ig. Collection and P	umping or wa	Stwater, Metcali anu	 
	32.2	Ludy, 1901, pg 43 Table 2-7			1	 
L						 
n _{expansion} =	0.047	ft				
Depth upstream of expansion (IBDSTRM)	599.97					 <b></b>
$h = 2.97 n^2 (1 \sqrt{2} / D^{4/3})$						 l
II ₁ =2.0/II (LV /D  )						 <b> </b>
n=	0.011					 l
L=	66	Fill in for Q and V will be calcula	ated			 
V=	5.15	Q=	340			 
	9.17	6.00				 
DEPTH OF FLOW=	10.22	6.28	66.04326757			 
1 Y-	0.032					 l
						 l
	E90.75					 
	569.75					 
Depth at downstream end (IBDSTRM)	509.00					 
Depth at upstream end (RLIGNDS)	600.00					 
	000.00					
Compute losses due to Change in Direction						 
<u> </u>	$h_{I} = (h_{clir})$					
	$h = K (1/2^{2}/2a) - (1/2^{2}/2a)$			A		 
	ndir – ((v1 /29)-(v2 /29))			Area (ft ² )		 
V1=	5.76	ft/sec		59.037516		 <b></b>
V2=	5.15	Itt/sec	an O alla atiana and D	66.0432676	-turten Meterikand	 l
K _{dir} =	0.44	From - wastewater Engineerin	ig: Collection and P	umping of wa	stwater, ivietcali and	1
g=	32.2	Eudy, 1961, Appendix C Figure	3 (0-9)			 
h _{expansion} =	0.045	ft				1
Depth upstream of Direction Change (RLIGNDS)	600.05					

2/5

Compute losses due to Expansion at RLIGNDS						
	h _L = (h _{expansion} )					
	$h_{\text{expansion}} = K_0^* ((V_1^2/2q) - (V_2^2/2q))$			Area (ft^2)		 
	E 76	ft/202		F0.027516		 
VI=	5.76	ft/sec		59.037510		 
V2= K -	9.15	From - Wastewater Engineerin	ra: Collection and F	Pumping of Wa	stwater Metcalf and	 
1.6-	0.2	Eddy 1981 pg 43 Table 2-7	ig. Collection and r	unping of tru	stwater, metodii and	 l
	32.2	Eddy, 1001, pg 40 1000 2 1				 l
b	0.001	£1.				 
"expansion —	0.021	π				 
Depth upstream of expansion (BLICNDS)	600.07					 l
Deptil upstream of expansion (REIGNDS)	800.07					 l
h _f =2.87n ² (LV ² /D ^{4/3} )						
n=	0.011					 
L=	293	Fill in for Q and V will be calcula	ated			
V=	5.76	Q=	340			
D=	8.67					
DEPTH OF FLOW=	10.27	6.28	59.03751595			
h _i =	0.189					1
						1
INVERT AT DOWNSTREAM END (RLIGNDS)	589.8					
INVERT AT UPSTREAM END (RLIGNUP)	589.96					 
Depth at downstream end (RLIGNDS)	600.07					 
Depth at upstream end (RLIGNUP)	600.26					 
Compute leases due to Change in Direction						 l
Compute losses due to Change in Direction	$h = (h_{-})$					 
	11_= (11 _{dir} )					 
	$h_{dir} = K_{dir}^{*}((V_{1}^{2}/2g) - (V_{2}^{2}/2g))$			Area (ft^2)		1
V1=	5.15	ft/sec		66.0432676		
V2=	5.76	ft/sec		59.037516		 
K _{dir} =	0.44	From - Wastewater Engineerin	ig: Collection and F	or Wa	stwater, Metcalf and	1
	32.2	Eddy, 1981, Appendix C Figure	e (C-9)			
h _{dir} =	0.045	ft				
Depth upstream of Direction Change (RLIGNUP)	600.31					1

							1
Compute losses due to Contraction at RLIGNUP							1
	$h_{I} = (h_{contraction})$			1			
	$h_{contraction} = K_c^*((V_2^2/2g) - (V_1^2/2g))$			Area (ft^2)			1
V1=	5 15	ft/sec		66 0432676			
//2-	5.76	ft/sec		50.037516			
V2=	5.70	From Westsuptor Engineerin	a Collection and F	09.037510	atuator Mataolf and		
r _c =	0.10	FIOIT - Wastewater Engineerin	g. Collection and F	umping or wa	stwater, weicali and		1
g=	32.2	Eddy, 1981, pg 43 Table 2-7					
h	0.010	£4					
Contraction -	0.010	n					
							1
Depth upstream of contraction (RLIGNUP)	600.32						
· · · · · · · · · · · · · · · · · · ·							
$n_{f}=2.87 n^{-}(LV^{-}/D^{})$							
n=	0.011						
L=	66	Fill in for Q and V will be calcula	ated				
V-	5 15	0-	340				
V=	0.17	Q=	040				
D=	9.17						
DEPTH OF FLOW=	10.39	6.28	66.04326757				
h _f =	0.032						
INVERT AT DOWNSTREAM END (RLIGNLIP)	589.93					i	
	590.06						
INVERTAT UPSTREAM END (IBUPSTM)	569.90						
Depth at downstream end (RLIGNUP)	600.32						
Depth at upstream end (IBUPSTM)	600.35						1
Compute losses due to Change in Direction		ii				i	
	$h = (h_{-})$						
	n_ (ndir)						
	$h_{dir} = K_{dir}^*((V_1^2/2g) - (V_2^2/2g))$			Area (ft^2)			1
\/1_	2.20	ft/coo		109 121021			
V1=	3.30	1/360		100.434034			
V2=	4.81	It/sec		66.0432676			
K _{dir} =	0.44	From - Wastewater Engineerin	g: Collection and F	or Wa	stwater, Metcalf and		1
=	32.2	Eddy, 1981, Appendix C Figure	e (C-9)				
9-	02.2			1			
L							
n _{dir} =	0.080	π					1
Depth upstream of Direction Change (IBUPSTM)	600.43						
				1			
Compute losses due to Contraction at IBUPSTM							
	h _L = (h _{contraction} )						1
	$= K^{*}(1/2^{2}/2a) - (1/2^{2}/2a))$			A			
	Contraction - C ((V2 /29)-(V1 /29))			Area (11/2)			
V1=	3.38	ft/sec		108.434034			
V2=	4.81	ft/sec		66.0432676			
K -	0.10	From - Wastewater Engineerin	a: Collection and F	Pumping of Wa	stwater Metcalf and		
	0.10	Eddy 1981 pg 43 Table 2-7	.g. = 5110001011 dilui 1	pg 0. W0	and and		
g=	32.2	2-ddy, 1301, pg +3 1able 2-7					
h _{contraction} =	0.018	ft					
Contraction	0.010						
Deptn upstream of contraction (IBUPSTM)	600.45	1		1			1

	1						
Friction loss between IBLIPSTM and EAA325	i						
- 0.07-2/1.1/2/D4/3)							
$n_f = 2.87 n^2 (LV^2/D^{-2})$							
n~	Manning's roughness coefficient						
	Length of Dine						
L~	Lengin of Pipe						
V~	Velocity						
D~	Diameter of Pipe						
	Diameter of tipe						
n=	0.015						
1-	490.53	Fill in for O and V will be calcult	ated				
L_	450.55						
V=	3.36	Q=	340				
D=	11.75						
	10.26	4.99	404 4000750	Aree			
DEPTH OF FLOW=	10.30	4.00	101.1823758	Area			
h _t =	0.134						
	1						
	E00.00						
INVERTAL DOWINGTREAM END (IBUPSTM)	589.96	l					
INVERT AT UPSTREAM END (EAA325)	589.96				1	1	
Depth at downstream end (IBUPSTM)	600.45						
Depth at up the part and (EAACOS)	000.43						
Depth at upstream end (EAA325)	600.58						
	1					1	
Friction loss between EAA325 and EAA330							
h _f =2.87n ² (LV ² /D ^{4/3} )							
n~	Manning's roughness coefficient						
L~	Length of Pipe						
V	Velocity						
V≈	Velocity						
D~	Diameter of Pipe						
	0.045						
n=	0.015						
L=	248.72	Fill in for Q and V will be calculated	ated				
\/_	2.27	0-	240				
V=	3.37	Q=	340				
D=	11.75						
DEPTH OF FLOW=	10.32	4 86	100 9090364	Area			
b=:	0.068			7.000			
	0.066						
	1					1	
INVERT AT DOWNSTREAM END (EAA325)	590.26						
	500.00						
INVERTATOPOTREAMEND (EAASSU)	590.26					ļ	
Depth at downstream end (EAA325)	600.58						
Depth at upstream end (EAA330)	600.65						
	000.03						
Friction loss between EAA330 and EAA335							
1 HOUGH 1035 DEWEETT EAA330 ATHLEAA333							
II=2.0/II-(LV-/D)						1	
n	Manning's roughness coefficient						
11~							
L~	Length of Pipe						
V~	Velocity						
					1		
	Diameter of Pine						
D~	Diameter of Pipe						
D~	Diameter of Pipe						
D~	Diameter of Pipe						
D~	Diameter of Pipe	Fill in for O and V will be colored	atod				
D~  L=	Diameter of Pipe 0.015 594	Fill in for Q and V will be calcul	ated				
D~ 	0.015 594 3.51	Fill in for Q and V will be calcula	ated 340				
D~ 	Diameter of Pipe 0.015 594 3.51 11.75	Fill in for Q and V will be calcula Q=	ated 340				
D- 	Diameter of Pipe 0.015 594 3.51 11.75	Fill in for Q and V will be calcula Q=	ated 340				
D	Diameter of Pipe 0.015 594 3.51 11.75 9.84	Fill in for Q and V will be calcula Q= 4.62	ated 340 96.95962669	Area			
D	Diameter of Pipe 0.015 594 3.51 11.75 9.84 0.177	Fill in for Q and V will be calcula Q= 4.62	ated 340 96.95962669	Area			
D	Diameter of Pipe 0.015 594 3.51 11.75 9.84 0.177	Fill in for Q and V will be calcula Q= 4.62	ated 340 96.95962669	Area			
D	Diameter of Pipe 0.015 594 3.51 11.75 9.84 0.177	Fill in for Q and V will be calcula Q= 4.62	ated 340 96.95962669	Area			
D- 	Diameter of Pipe 0.015 594 3.51 11.75 9.84 0.177	Fill in for Q and V will be calcule Q= 4.62	ated 340 96.95962669	Area			
D	Diameter of Pipe 0.015 594 3.51 11.75 9.84 0.177	Fill in for Q and V will be calcula Q= 4.62	ated 340 96.95962669	Area			
D- 	Diameter of Pipe 0.015 594 3.51 11.75 9.84 0.177	Fill in for Q and V will be calcule Q= 4.62	ated  340  96.95962669	Area			
D-	Diameter of Pipe 0.015 594 3.51 11.75 9.84 0.177 590.81	Fill in for Q and V will be calcula Q= 4.62	ated 340 96.95962669	Area			
D- I I I I I I I I I I I I I I I I I I I	Diameter of Pipe 0.015 594 3.51 11.75 9.84 0.177 590.81 590.81	Fill in for Q and V will be calcule Q= 4.62	ated 340 96.95962669	Area			
D	Diameter of Pipe 0.015 594 3.51 11.75 9.84 0.177 590.81 590.81 590.81	Fill in for Q and V will be calcula Q= 4.62	ated 340 96.95962669	Area			
	Diameter of Pipe 0.015 594 3.51 11.75 9.84 0.177 590.81 590.81 600.65	Fill in for Q and V will be calcule Q= 4.62	ated 340 96.95962669	Area			

Number of manholes	8	Invert	Ground	Water Level	Distance upstream	Cumulative Distance upstream	Pipe Crown
Downstream	EAA315	589.31	627.11	599.62	0	0	601.06
Downstream of Expansion	IBDSTRM	589.75	628	599.82	723	723	601.5
Upstream of Expansion	IBDSTRM	589.75	628	599.90	0	723	599.75
Realigned Pipe Section Downstream Expansion	RLIGNDS	589.8	628	599.92	66	789	599.8
Realigned Pipe Section Upstream Expansion	RLIGNDS	589.8	628	600.05	0	789	597.8
Realigned Pipe Section Downstream Contraction	RLIGNUP	589.93	628	600.15	293	1082	597.93
Realigned Pipe Section Upstream Contraction	RLIGNUP	589.93	628	600.27	0	1082	599.93
Downstream of Contraction	IBUPSTM	589.96	628	600.30	66	1148	599.96
Upstream of Contraction	IBUPSTM	589.96	628	600.36	0	1148	601 71
	EAA325	590.26	628.26	600.50	490 53	1638.53	602.01
	EAA330	590.81	629.11	600.57	248 72	1887.25	602.56
Lipstream	EAA335	501.01	630.97	600.74	594	2481.25	603.23
opsileam	EAR000	531.40	030.37	000.74		2401.23	003.23
Flow Data through Sustam (afa)	240	Lines 20/ Safety Faster					
Province information System (CIS)	540	Oses 3% Salety Factor	No I Flam	505.00	Flam in the sector state	l	unter a la cont
Downstream water Level at EAA315 ()	599.623	Calculate Water Level based	on Normal Flow =	595.29	Flow is therefore do	whistream controlled, use model w	vater level
Friction loss between IBDS I RM and EAA315			-				
n=2.87n*(LV*/D***)		From Hydraulics (King)					
n~	Manning's roughness coefficient						
L~	Length of Pipe						
V~	Velocity						
D~	Diameter of Pipe						
	•						
n=	0.015	(					1
1=	723	Fill in for Q and V will be calcu	lated				
 V-	3 37		340				
	11.75	Q=	040				
	10.21	4.95	100 956 472				
DEPTH OF FLOW=	0.100	4.65	100.030473				
14-	0.199		-				
Slope of Pipe	0.0006						
INVERT AT DOWNSTREAM END (EAA315)	589.31						
INVERT AT UPSTREAM END (IBDSTRM)	589.75						
Depth at downstream end (EAA315)	599.62						
Depth at upstream end (IBDSTRM)	599.82						
· · · · · · · · · · · · · · · · · · ·		1					
Compute losses due to Change in Direction							
g	$h = (h_{re})$						
			-				
	$n_{dir} = K_{dir}^{((V_1^2/2g)-(V_2^2/2g))}$			Area (ft^2)			
V1=	4.33	ft/sec		78.5398163			
V2=	3.37	ft/sec		100.856473			
K _{dir} =	0.44	From - Wastewater Engineeri	ng: Collection and	Pumping of V	Vastwater, Metcalf		
	0.11	and Eddy, 1981, Appendix C	Figure (C-9)				
g=	32.2		3 ( ,				
L.							
n _{expansion} =	0.050	n				<u> </u>	
Depth upstream of Direction Change (IBDSTRM)	599.87						
						1	
Compute losses due to Expansion at IRDSTRM			1		<u> </u>	<u> </u>	-
	$\mathbf{b} = (\mathbf{b}_{\text{maxim}})$		1		1		
	in_ (vexpansion)						
	$h_{expansion} = K_e^*((V_1^2/2g)-(V_2^2/2g))$			Area (ft^2)			
V1=	4.33	ft/sec		78.5398163			1
V2=	3.37	ft/sec		100.856473			
K	0.2	From - Wastewater Engineeri	na: Collection and	Pumping of V	Vastwater, Metcalf	1	
N ₀ -	0.2	and Eddy 1981 og 43 Table	2-7	. amping of V			
g=	32.2	and Lody, 1301, pg 43 Table	<i>L</i> 1				
h _{expansion} =	0.023	ft					
						1	
Depth upstream of expansion (IBDSTRM)	599.90					1	1
	000.00		1		1		
						l	
1							

$h - 2.87 n^2 (1 \sqrt{2}/D^{4/3})$							
	0.012						
N=	66	Fill in for O and V will be color	l Ilated				
L=	4 33		340				
V=	10	Q=	340				
DEPTH OF FLOW=	10.15	6.28	78.53981627				
h=	0.028	0.20					
.,							
INVERT AT DOWNSTREAM END (IBDSTRM)	589.75						
INVERT AT UPSTREAM END (RLIGNDS)	589.80						
Depth at downstream end (IBDSTRM)	599.90						
Depth at upstream end (RLIGNDS)	599.92						
Compute losses due to Change in Direction							
	h _L = (h _{dir} )		İ		İ		
	$h_{zz} = K_{zz}^{*}(1/2^{2}/2\alpha) - (1/2^{2}/2\alpha))$			Area (ftA2)			
		<b>6</b> 1/2		Alea (it 2)			
V1=	3.38	TI/SEC		50.2654825			
V2=	4.33	IVSEC	na: Collection and	10.5398163	Vastwater Metcolf		
K _{dir} =	0.44	and Eddy 1981 Appendix C	Figure (C-9)		vasiwaler, Metcall		
g=	32.2	and Ludy, 1301, Appendix C	- iguie (0=9)				
· · · · ·		-					
h _{dir} =	0.050	ft					
Depth upstream of Direction Change (RLIGNDS)	599.97						
Compute losses due to Contraction at RLIGNDS							
	h _L = (h _{contraction} )						
	$h_{contraction} = K_c^*((V_2^2/2g)-(V_1^2/2g))$			Area (ft^2)			
\//1_	3 38	ft/sec		50 2654925			
VI= V/2_	4.33	ft/sec		78 5308162			
V2= K	0.7	From - Wastewater Engineeri	na: Collection and	Pumping of V	Vastwater, Metcalf		
Ne-	22.2	and Eddy, 1981. pd 43 Table	2-7				
g=	32.2	, .co., pg .o Table					
L.		4					
N _{contraction} =	0.079	n					
Depth upstream of expansion (RLIGNDS)	600.05						
h-2.87 ² /(1.\/ ² /D ^{4/3} )							
n=2.0/11 (LV /D )	0.010						
n=	0.013						
	293	Fill in for Q and V will be calcu	Jated				
V=	3.38 0	Q=	170				
	0	0.00	50.005400.11				
DEPTH OF FLOW=	0.102	6.28	50.20548241				
14=	0.102						
	500.0						
	589.8						
	509.90						
	600.05 600.45	L					
Sopera upsilean end (INLIGNOF)	600.15						
Compute losses due to Change in Direction							
	$\mathbf{h} = (\mathbf{h}_{\mathbf{x}})$						
	$u_{dir} = r_{dir} ((v_1 / 2g) - (v_2 / 2g))$			Area (ft^2)			
V ₁ =	4.33	ft/sec		78.5398163			
V ₂ =	3.38	ft/sec	İ	50.2654825			
K =	0.44	From - Wastewater Engineeri	ng: Collection and	Pumping of V	Vastwater, Metcalf		
	0.0	and Eddy, 1981 Annendix C	Figure (C-9)	. amping of V			
g= 32.2  and Eduy, 1961, Appendix C Figure (C-9)							

Depth upstream of Direction Change (RLIGNUP)	600.20					
						1
					ĺ	
Compute losses due to Expansion at RLIGNUP						
	h = (hexpansion)					
	-K * (1) (2/2a) (1/2/2a)					 
	$H_{expansion} = R_e \left( \left( \sqrt{\frac{1}{2}} / 2g \right)^2 \left( \sqrt{\frac{1}{2}} / 2g \right) \right)$			Area (ft^2)		
V1=	4.33	ft/sec		78.5398163		1
V2=	3.38	ft/sec		50.2654825		l.
K _c =	0.6	From - Wastewater Engineeri	ng: Collection and	Pumping of V	Vastwater, Metcalf	
0=	32.2	and Eddy, 1981, pg 43 Table	2-7			
9						
h	0.068	ft				 
•expansion —	0.000					 
Depth upstream of contraction (RLIGNUP)	600.27					L
						1
h _i =2.87n ² (LV ² /D ^{4/3} )						
n=	0.013					
L=	66	Fill in for Q and V will be calcu	ulated		ĺ	í
V=	4.33	Q=	340		İ	
D=	10					
DEPTH OF FLOW=	10.34	6.28	78,53981627			
h=	0.028					
INIVERTAT DOWNSTREAM END (RUGNUR)	580.03					 [
	509.95					
Depth at downstroom and (PLICNUR)	509.90					
Depth at upstroom and (IRLIDSTM)	600.27					
	000.30					 
Compute losses due to Change in Direction	h /h )					 
	$n_{L} = (n_{dir})$					1
	$h_{dir} = K_{dir}^{*}((V_{1}^{2}/2g)-(V_{2}^{2}/2g))$			Area (ft^2)		
V1=	3 37	ft/sec		100 848276		
V2=	4 33	ft/sec		78 5398163		 
K=	0.44	From - Wastewater Engineeri	ng: Collection and	Pumping of V	Vastwater, Metcalf	 
- '0	0.44	and Eddy, 1981, Appendix C	Figure (C-9)			 
g=	32.2		· ·g=· · (+ · ·)			 
L.						 
n _{dir} =	0.050	ft				L
Depth upstream of Direction Change (IBUPSTM)	600.35					1
					ĺ	í
Compute losses due to Contraction at IBUPSTM						
	hi = (heaptraction)					
	= -K */(1/2/2a) (1/2/2a)			A		
	$n_{\text{contraction}} = \kappa_c^{-1} ((v_2/2g) - (v_1/2g))$			Area (ft^2)		1
V1=	3.37	ft/sec		100.848276		1
V2=	4.33	ft/sec		78.5398163		1
K _c =	0.1	From - Wastewater Engineeri	ng: Collection and	Pumping of V	Vastwater, Metcalf	
0-	32.2	and Eddy, 1981, pg 43 Table	2-7			 
9-	02.2				1	 
h	0.011	ft				
· ·contraction —	0.011					 <b> </b>
Depth upstream of contraction (IBUPSTM)	600.36					 L
						L
Friction loss between IBUPSTM and EAA325						
h _f =2.87n ² (LV ² /D ^{4/3} )						
n~	Manning's roughness coefficient					
L~	Length of Pipe					
٧~	Velocity					

0.050 ft

h_{dir} =

D	Diamator of Ring					
U~	Diameter UI Filpe					
n=	0.015					
L=	490.53	Fill in for Q and V will be calcu	lated			
V=	3.37	Q=	340			
D=	11.75					
DEPTH OF FLOW=	10.31	4.85	100.848276	Area		
h=	0.135					
	0.155					
INVERT AT DOWNSTREAM END (IBUPSTM)	589.96					
INVERT AT LIPSTREAM END (EAA325)	589.96					
Depth at downstream and (IBLIPSTM)	600.36					 
Depth at upstream and (EAA225)	600.50					 
Depin al upstream end (EAA325)	600.50					
Friction loss between EAA325 and EAA330						
h _i =2.87n ² (LV ² /D ^{4/3} )						
n	Manning's roughness coefficient					 
11	Length of Dine					
L~	Velocity					 
V~	velocity					
D~	Diameter of Pipe					
n=	0.015					
L=	248.72	Fill in for Q and V will be calcu	lated			
V=	3 39	O=	340			
D-	11 75	<u> </u>	010			
	10.24	4.04	400 050 400	A ====		 
DEPTH OF FLOW=	10.24	4.01	100.259402	Area		
n _i =	0.069					
INVERT AT DOWNSTREAM END (EAA325)	590.26					
	530.20 E00.36					
Death at development and (EAA005)	590.20					 
Depth at downstream end (EAA325)	600.50					
Depth at upstream end (EAA330)	600.57					
Friction loss between EAA330 and EAA335						
h=2.87n ² (LV ² /D ^{4/3} )						
Manufada yayahasa						 
n~ Manning's roughness coefficient						
L~ Length of Pipe						
V~ Velocity						
D~	Diameter of Pipe					
n=	0.015				i i	
	594	Fill in for O and V will be calcu	lated			
	2 52		240			 
V=	3.33	Q=	340			
D=	11.75					 
DEPTH OF FLOW=	9.76	4.58	96.23676423	Area		
h _i =	0.179					
	F00.04					
INVERTAT DOWNSTREAM END (EAA330)	590.81					
INVERT AT UPSTREAM END (EAA335)	590.81					
Depth at downstream end (EAA330)	600.57					
Depth at upstream end (EAA335)	600.74					