MBK ENGINEERS

Water Resources • Flood Control • Water Rights

MEMORANDUM

DATE: September 15, 2005

TO: Ken Petruzzelli

FROM: Tami Thompson, PE, MBK Engineers

SUBJECT: Linkside Place Inspection, ACL Order review

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Attorney/Client Communication

Ken,

The Board's Inspection Report is clear and the pictures are useful, but I have a number of concerns about the ACL Order and the discharge calculations:

1. The discharge calculations should only include water being discharged from the site. Pictures #5 and #15 taken 18 February 2004 and included in Attachment B of the Inspection Report show that the outlet of the dewatering pipe is on the LP phase I property. It looks like this water flows overland and off of the property through the "South" culvert which can be seen in picture #17 in Attachment B. On the calculation sheet for Feb 18, this dewatering flow is added to the "Off site" flow when it is really a portion of the flow going through the south culvert.

2. All calculations for this review were performed using Haestad's FlowMaster 5.17. FlowMaster solves Manning's equation to solve open channel flow problems ($Q = 1.49/n * A * R^{2/3} * S^{1/2}$ where Q is flow in cfs, A is cross sectional area of flow, R is the hydraulic radius, S is the friction slope). MBK Engineers verified the Board's discharge calculations, and using their input values, we arrived at the same flow rates that were reported. However, I have concerns about the input values used:
    - Butte County Improvement Standards requires a Mannings roughness coefficient (n-value) of 0.025 be used for plain unlined corrugated metal pipe. Calculations supplied by the Board used n-values of 0.022. The discharge of a pipe or culvert is inversely proportional to this constant, so a 14% increase in the n-value used would result in a 14% decrease in the discharge. Verification of the Board's calculations and calculations with Manning's n-value = 0.025 were performed. Results of the Board's calculations are attached as figures 1-3. Results of MBK's calculations are attached as figures 4-6 (n=0.025, water depth and pipe slope as reported). Table 1 on the next page is a summary of these results:

Table 1		
	Board calculated Volume with n = 0.022 (gallons)	MBK calculated volume with n = 0.025 (gallons)
18-Feb 04		
Dewatering	8160	0
Off site	2430	2020
25-Feb-04		
North Culvert	3000	2693
South Culvert	6450	6059
Total	20040	10771
Less 1000 gallons	19040	9771

- There is no indication on how the "Water depth" values were determined, and depth has a significant effect on discharge. If the depth of flow in the South culvert was 1.2 inches instead of the reported 1.5 inches the discharge would have been calculated at 0.05 cfs. Figure 7 plots discharge versus depth for the South culvert, figure 8 shows discharge versus depth for the North culvert (both figures used n=0.025).

- There is no indication on how the "Pipe Slope" values were determined. Discharge is proportional to the square root of the slope (as the slope decreases, the discharge decreases). The reported slope for the North culvert was 0.0078 feet/foot, over a 20 foot culvert this would be a change in elevation of 1.9 inches. The reported slope for the South culvert was 0.0145 feet/foot, over a 20 foot culvert this would be a change in elevation of 3.5 inches. Just looking at the photos, it is impossible to tell if these slope values are accurate, but if the south culvert was the same slope as the North culvert, the calculated discharge would have been significantly less. Figure 9 plots discharge versus slope for the South culvert with the originally reported 1.5 inch water depth (with the proposed 0.025 Manning's n-value). Figure 10 plots discharge versus slope for the South culvert with a water depth of 1.2 inches (n= 0.025). If the water depth was 1.2 inches and the slope was 0.0145 feet/foot, the discharge from the South culvert would have been 0.039 cfs for a total of 2625 gallons on February 25.

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Figure 1

South Culvert Board 2/18/04 values
Worksheet for Circular Channel

Project Description	
Project File	c:\haestad\academic\fmw\linkside.fm2
Worksheet	South Culvert
Flow Element	Circular Channel
Method	Manning's Formula
Solve For	Discharge

Input Data		
Mannings Coefficient	0.022	
Channel Slope	0.014500	ft/ft
Depth	0.10	ft
Diameter	15.00	in

Results		
Discharge	0.06	cfs
Flow Area	0.05	ft²
Wetted Perimeter	0.72	ft
Top Width	0.68	ft
Critical Depth	0.09	ft
Percent Full	8.00	
Critical Slope	0.018932	ft/ft
Velocity	1.30	ft/s
Velocity Head	0.03	ft
Specific Energy	0.13	ft
Froude Number	0.88	
Maximum Discharge	4.94	cfs
Full Flow Capacity	4.60	cfs
Full Flow Slope	0.000002	ft/ft
Flow is subcritical.		

Figure 2

North Culvert Board 2/25/04 values
Worksheet for Circular Channel

Project Description	
Project File	c:\haestad\academic\fmw\linkside.fm2
Worksheet	South Culvert
Flow Element	Circular Channel
Method	Manning's Formula
Solve For	Discharge

Input Data		
Mannings Coefficient	0.022	
Channel Slope	0.007800	ft/ft
Depth	0.10	ft
Diameter	15.00	in

Results		
Discharge	0.04	cfs
Flow Area	0.05	ft²
Wetted Perimeter	0.72	ft
Top Width	0.68	ft
Critical Depth	0.08	ft
Percent Full	8.00	
Critical Slope	0.019754	ft/ft
Velocity	0.96	ft/s
Velocity Head	0.01	ft
Specific Energy	0.11	ft
Froude Number	0.65	
Maximum Discharge	3.63	cfs
Full Flow Capacity	3.37	cfs
Full Flow Slope	0.000001	ft/ft
Flow is subcritical.		

Figure 3

South Culvert Board 2/25/04 values
Worksheet for Circular Channel

Project Description	
Project File	c:\haestad\academic\fmw\linkside.fm2
Worksheet	South Culvert
Flow Element	Circular Channel
Method	Manning's Formula
Solve For	Discharge

Input Data		
Mannings Coefficient	0.022	
Channel Slope	0.014500	ft/ft
Depth	0.13	ft
Diameter	15.00	in

Results		
Discharge	0.10	cfs
Flow Area	0.06	ft^2
Wetted Perimeter	0.80	ft
Top Width	0.75	ft
Critical Depth	0.12	ft
Percent Full	10.00	
Critical Slope	0.017811	ft/ft
Velocity	1.50	ft/s
Velocity Head	0.04	ft
Specific Energy	0.16	ft
Froude Number	0.91	
Maximum Discharge	4.94	cfs
Full Flow Capacity	4.60	cfs
Full Flow Slope	0.000006	ft/ft
Flow is subcritical.		

Figure 4

South Culvert Butte Co. Mannings 2/18/04
Worksheet for Circular Channel

Project Description	
Project File	c:\haestad\academic\fmw\linkside.fm2
Worksheet	South Culvert
Flow Element	Circular Channel
Method	Manning's Formula
Solve For	Discharge

Input Data		
Mannings Coefficient	0.025	
Channel Slope	0.014500	ft/ft
Depth	0.10	ft
Diameter	15.00	in

Results		
Discharge	0.05	cfs
Flow Area	0.05	ft^2
Wetted Perimeter	0.72	ft
Top Width	0.68	ft
Critical Depth	0.09	ft
Percent Full	8.00	
Critical Slope	0.024873	ft/ft
Velocity	1.15	ft/s
Velocity Head	0.02	ft
Specific Energy	0.12	ft
Froude Number	0.78	
Maximum Discharge	4.35	cfs
Full Flow Capacity	4.04	cfs
Full Flow Slope	0.000002	ft/ft
Flow is subcritical.		

Figure 5

North Culvert Butte Co. Mannings Worksheet for Circular Channel

Project Description	
Project File	c:\haestad\academic\fmw\linkside.fm2
Worksheet	South Culvert
Flow Element	Circular Channel
Method	Manning's Formula
Solve For	Discharge

Input Data		
Mannings Coefficient	0.025	
Channel Slope	0.007800	ft/ft
Depth	0.10	ft
Diameter	15.00	in

Results		
Discharge	0.04	cfs
Flow Area	0.05	ft^2
Wetted Perimeter	0.72	ft
Top Width	0.68	ft
Critical Depth	0.08	ft
Percent Full	8.00	
Critical Slope	0.025973	ft/ft
Velocity	0.84	ft/s
Velocity Head	0.01	ft
Specific Energy	0.11	ft
Froude Number	0.57	
Maximum Discharge	3.19	cfs
Full Flow Capacity	2.97	cfs
Full Flow Slope	0.000001	ft/ft
Flow is subcritical.		

Figure 6

South Culvert Butte Co. Mannings 2/25/04
Worksheet for Circular Channel

Project Description	
Project File	c:\haestad\academic\fmw\linkside.fm2
Worksheet	South Culvert
Flow Element	Circular Channel
Method	Manning's Formula
Solve For	Discharge

Input Data		
Mannings Coefficient	0.025	
Channel Slope	0.014500	ft/ft
Depth	0.13	ft
Diameter	15.00	in

Results		
Discharge	0.09	cfs
Flow Area	0.07	ft²
Wetted Perimeter	0.82	ft
Top Width	0.76	ft
Critical Depth	0.12	ft
Percent Full	10.40	
Critical Slope	0.023136	ft/ft
Velocity	1.36	ft/s
Velocity Head	0.03	ft
Specific Energy	0.16	ft
Froude Number	0.80	
Maximum Discharge	4.35	cfs
Full Flow Capacity	4.04	cfs
Full Flow Slope	0.000007	ft/ft
Flow is subcritical.		

Figure 7

South Culvert sensitivity to water depth
Plotted Curves for Circular Channel

Project Description	
Project File	c:\haestad\academic\fmw\linkside.fm2
Worksheet	South Culvert
Flow Element	Circular Channel
Method	Manning's Formula
Solve For	Discharge

Constant Data		
Mannings Coefficient	0.025	
Channel Slope	0.014500	ft/ft
Diameter	15.00	in

Input Data			
	Minimum	Maximum	Increment
Depth	0.04	0.13	0.01 ft

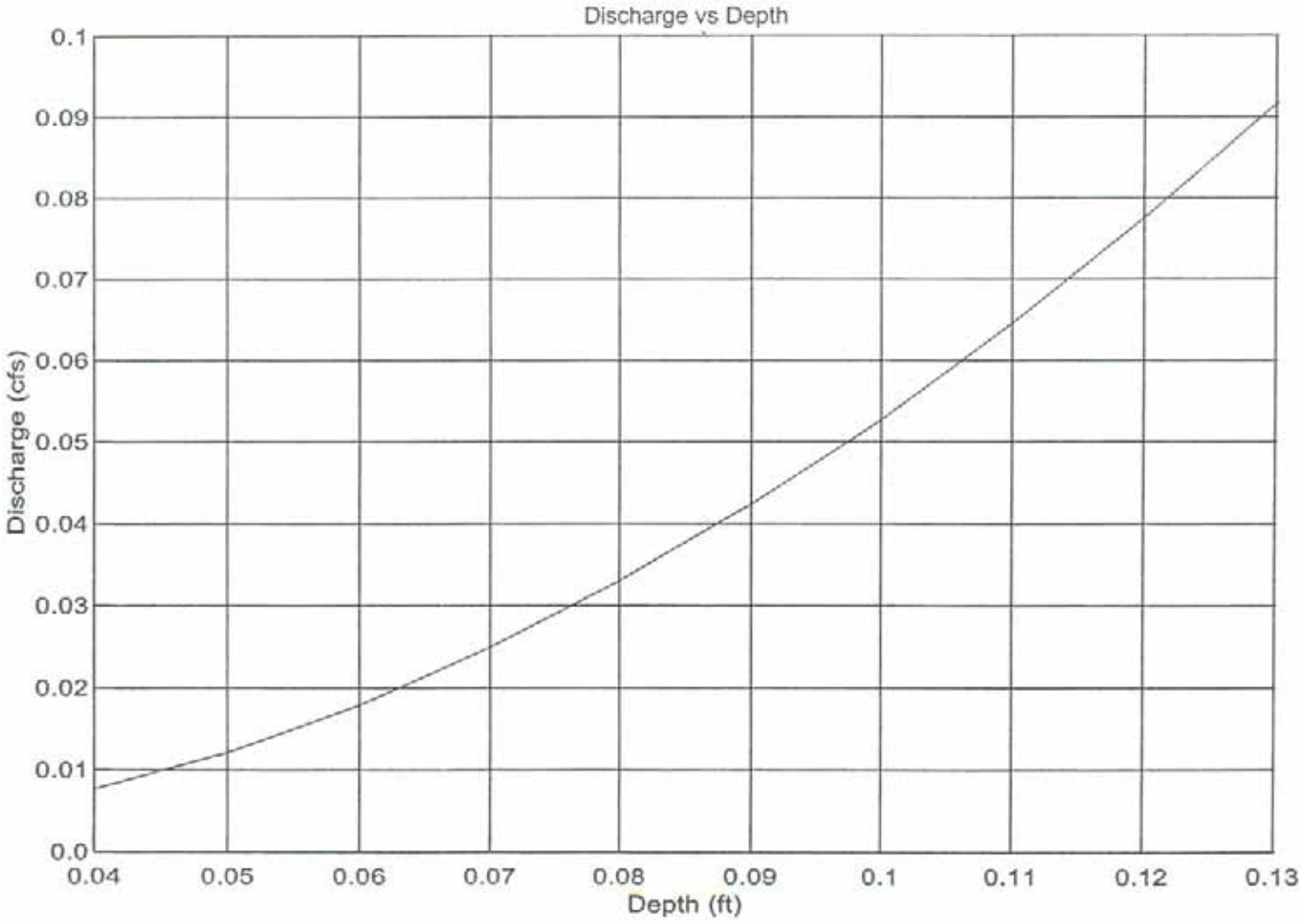

Figure 8

North Culvert sensitivity to water depth
Plotted Curves for Circular Channel

Project Description	
Project File	c:\haestad\academic\fmw\linkside.fm2
Worksheet	South Culvert
Flow Element	Circular Channel
Method	Manning's Formula
Solve For	Discharge

Constant Data		
Mannings Coefficient	0.025	
Channel Slope	0.007800	ft/ft
Diameter	15.00	in

Input Data			
	Minimum	Maximum	Increment
Depth	0.04	0.10	0.01 ft

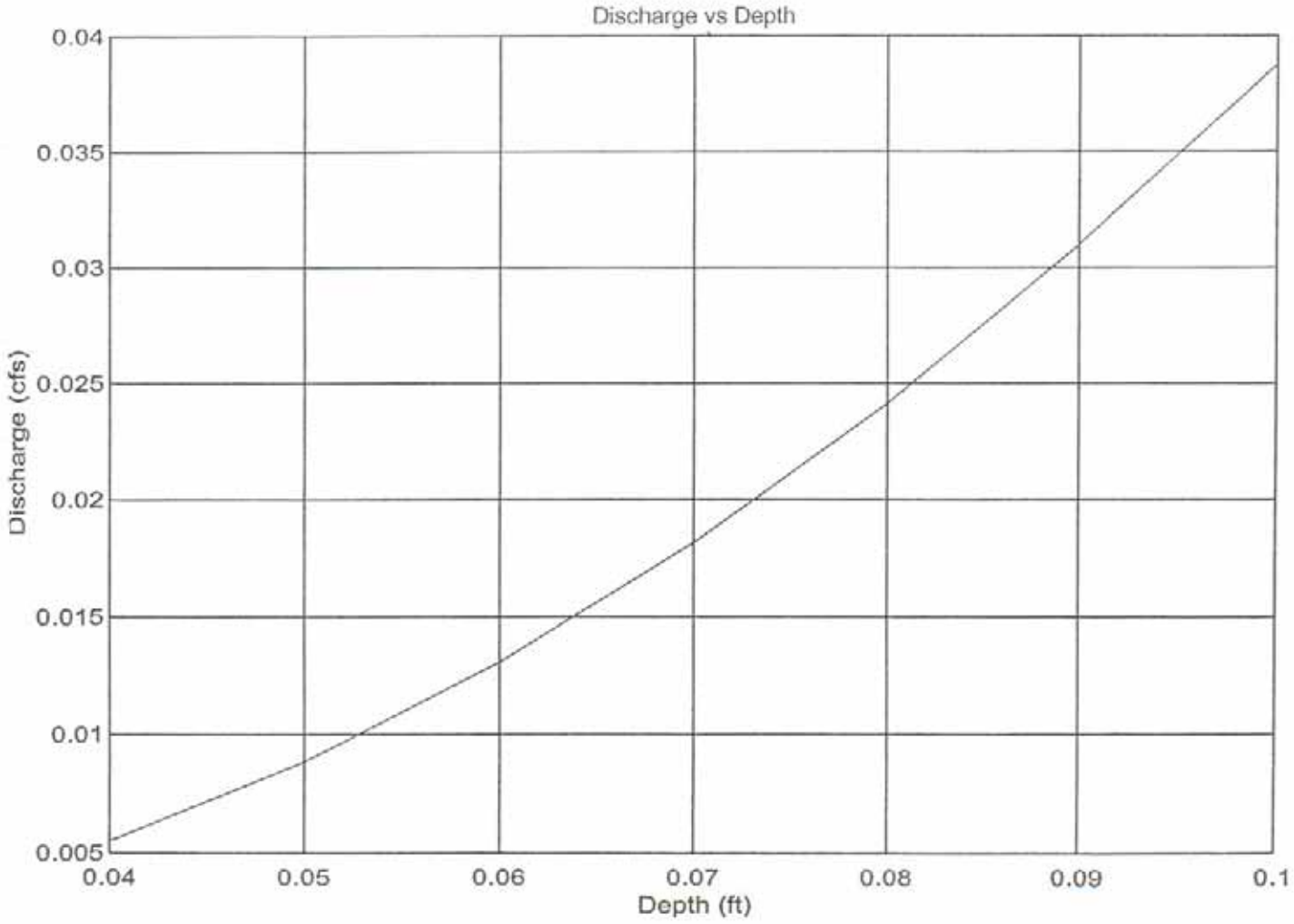

Figure 9

South Culvert sensitivity to culvert slope
Plotted Curves for Circular Channel

Project Description	
Project File	c:\haestad\academic\fmw\linkside.fm2
Worksheet	South Culvert
Flow Element	Circular Channel
Method	Manning's Formula
Solve For	Discharge

Constant Data	
Mannings Coefficient	0.025
Depth	0.13 ft
Diameter	15.00 in

Input Data			
	Minimum	Maximum	Increment
Channel Slope	0.007800	0.014500	0.001000 ft/ft

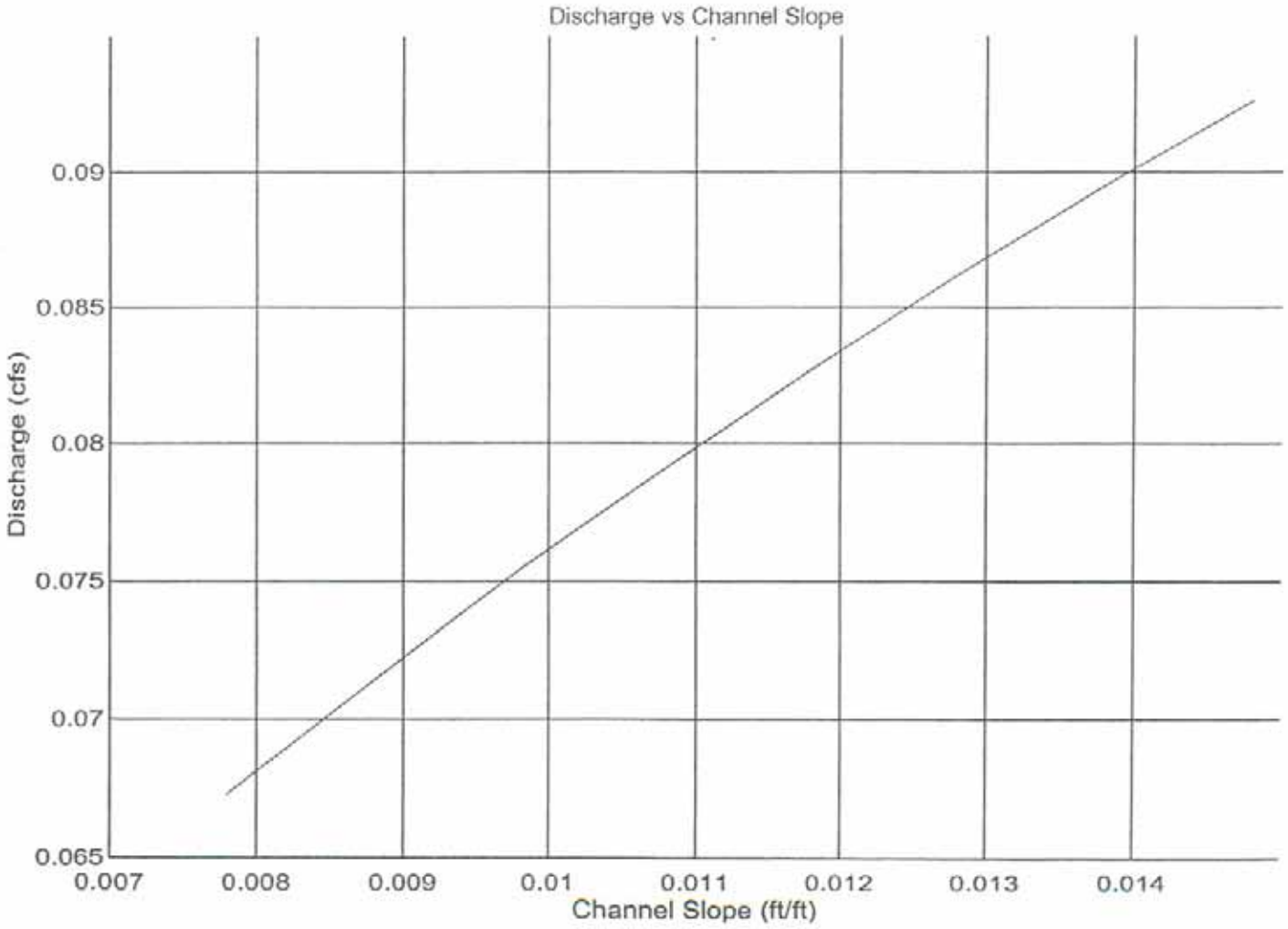

Figure 10

South Culvert sensitivity to culvert slope
Plotted Curves for Circular Channel

Project Description	
Project File	c:\haestad\academic\fmw\linkside.fm2
Worksheet	South Culvert
Flow Element	Circular Channel
Method	Manning's Formula
Solve For	Discharge

Constant Data	
Mannings Coefficient	0.025
Depth	0.10 ft
Diameter	15.00 in

Input Data			
	Minimum	Maximum	Increment
Channel Slope	0.007800	0.014500	0.001000 ft/ft