Pickering

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February 16, 2021

Michael J. Reso
City Manager, City of Diamondhead, MS
5000 Diamondhead Circle
Diamondhead, MS 39525
Sent via Email: mreso@diamondhead.ms.gov

Re: Hilo Street Culvert

Mike –

Pursuant to Work Assignment number 00-09-2021, "Hilo Street Culvert Replacement – Investigation", as executed on December 16, 2020, please accept this letter-form report outlining existing conditions, proposed recommendations, and effects of these proposed recommendations on the existing culvert under Hilo Street, its out-falling channel, and the downstream retention pond on the golf course.

Project Scope

In general, Pickering performed a survey (through a subcontractor, Crosby Surveying) and engineering investigations relative to the replacement or rehabilitation of the culvert that crosses Hilo Street just north of Diamondhead Drive. The survey included the culvert's western beginning (at the end of a ditch on the golf course) to its eastern end at a ditch on the east side of Hilo Street. This survey and investigation further considered dredging the golf course pond and improvements to the ditch from the aforementioned culvert and to this pond.

Hilo Street Culvert

Pipe Information

From site visits and survey data, it was determined that the 48" equivalent corrugated metal arch pipe (CMAP) (53" x 41") is split in two sections by a concrete junction box located on the west side of Hilo Street; the two culverts total approximately 245 feet long. Because the top of the junction box is solid concrete with no external access, the invert where the upstream and downstream culverts meet was not able to be determined; therefore, a uniform slope from the upstream end of the upstream section to the downstream end of the downstream section was determined to be 0.8%. A culvert at this size and at this slope will have a flowing full capacity of approximately 130 cubic feet per second (cfs).

The watershed that flows through this pipe was determined through site visits and studying publicly-available GIS information to be approximately 75 acres; of these 75 acres, 59 is residential subdivisions,

10 is golf course, and the remaining 6 is wooded. A map showing the limits of this basin is included in "Appendix One – Watershed".

Peak runoff handled by a drainage culvert is influenced by ground cover, the area of the watershed, the intensity of the storm event, and the time it takes for the flow to reach the culvert from the most-hydraulicly distant point (time of concentration). A storm drain culvert is typically designed to handle the peak flow expected from a design storm event. Typically, on the Mississippi Gulf Coast, the design storm for a culvert is the 25-year storm, though the City of Biloxi considers the 100-year event.

Shown on "Appendix Two – Hydrograph", for this watershed, the SCS method was used to determine the peak flow. Parameters included a dimensionless "curve number" of 63 (ground cover factor), a time of concentration of 73.5 minutes, and an area of 75 acres; this resulted in a 190 cfs peak flow in the 25-year event (307.94 cfs in the 100-year event). Note the existing culverts' capacities of 130 cfs is less than this design capacity required.

Pipe Condition

An initial site visit was made to determine the condition of the existing culvert(s). Referencing "Appendix Three – Project Photos", the culvert was found to be in serious disrepair. Both pipe sections exhibited section loss and heavy corrosion.

On the downstream culvert, a large (approximately 3"- 4") gash was found to run longitudinally along the majority of the pipe and a seam along the top of the culvert was apparent. This top seam appears to be further separating and does not appear to be part of the pipe's construction (i.e. this seam is not present on the end of this section as viewed from the concrete junction box nor does it appear in the upstream pipe section). This downstream pipe also had a large horizontal deflection and a notable vertical deflection. A large gap was noted between the outside diameter of this culvert and the concrete junction box. Finally collected sediment, including a "pile", was noted in various portions of this culvert.

The upstream culvert similarly had a vertical deflection and collected sediment. Most notable, the upstream end of this upstream culvert has experienced significant section loss along the flow line of the pipe; this section loss is estimated to be 25% of the entire pipe's inner diameter. This upstream culvert had a surficial sinkhole above the culvert further suggesting sediment loss through the pipe walls.

Pipe Condition - Analysis

This culvert appears to be an old galvanized metal culvert, possibly upwards of 50+ years old. While this pipe is generally considered serviceable for drainage in parts of the country, it is highly susceptible to corrosion from salts and the galvanized coating can be damaged, whereby exposing the bare metal underneath. While Diamondhead is not immediately adjacent to the Mississippi Sound, there is

potential, particularly during tropical events that brackish water would flow through these culverts whereby exacerbating corrosion and pipe failures.

In the downstream section, the horizontal deflection is likely an installation issue, however, the vertical deflection could be indicative of settlement of a section(s) of the culvert. In this case, the vertical deflection is near the sediment pile suggesting it possible that vertical deflection has compromised the pipe integrity and is allowing sediment to enter the culvert; were this the case, it appears the vertical deflection is under Hilo Street which may lead to road failure. The obvious longitudinal failure along the flow line and the probable longitudinal failure along the culvert's top compromise the overall structural integrity of the culvert; a complete circular or arch culvert will evenly distribute load around the pipe's circumference (similar to trying to squeeze an egg in your hand). The "breaks" in these sections will limit the distribution of the loading and cause the upper sections to bear more of the loading likely to failure. The annular space between the culvert and concrete junction box further allows for water flow on the outside of the culvert which can similarly cause sediment loss around the pipe. Collectively the failures noted create high potential for sediment loss which will eventually cause failure of Hilo Street.

The upstream culvert analysis is similar to the downstream culvert. Notably, it appears the vertical deflection in the culvert has sediment collected underneath it; this appears to be approximately in line with the above grade sinkhole. The flowline section loss at the upstream end is compromising structural integrity.

Recommendations

Two trenchless and one remove and replace repair options will be discussed below along with probable construction costs for each (construction costs will assume third party construction). Regardless of method, it is advisable for the City of Diamondhead to implement improvements as soon as feasible due to the serious deterioration noted and possibility of damage to adjacent infrastructure, homes, fences, driveways, etc.

Option 1 – Remove and Replace

The remove and replace option would utilize heavy equipment to dig a trench to remove the existing culvert and replace with a new concrete drainage culvert. This option would allow for horizontal and vertical deflections to be removed, allow for a uniform slope across the flowline of the pipe to be established, provide for concrete-pipe strength, and eliminate concern of further deterioration in the existing CMP. Additionally, this option will allow the City of Diamondhead to install whatever size line it deems beneficial; a 54" (or equivalent) arch pipe should provide capacity closer to the 25 year event. However, this option would require cutting of Hilo Street and installing an asphalt patch across the trench; milling and overlaying a strip of pavement on either side of the trench will generally allow for a smoother ride across the trench repair. This option could be completed in approximately 30 days of dry

weather. Per "Appendix Four – Cost Estimates", the project total for this option would be approximately $135,000.

Option 2 – Cured In Place Pipe (CIPP)

The CIPP option is a trenchless rehabilitation option that uses a seamless resin-impregnated felt liner ("sock") that is expanded to the diameter of the host pipe and heat-cured to provide a new interior surface. While this option is often less than full removal and replacement, would require no trenching (including no road cuts), and be less invasive for local residents and motorists, this particular installation would present various issues that may affect its efficacy. For instance, some of the existing sharp edges of corroded CMP could cut the liner or cause it to unfurl unevenly; both of which could prevent the CIPP from providing a uniform seamless liner. Additionally, the significant CMP section loss would have to be filled with grout or concrete to prevent the liner from reflecting the dips and irregularities associated with the section loss. The compromised structural integrity of the host CMP would also require a thicker than (and costlier than) usual liner to ensure structural stability. This option will leave all horizontal and vertical deflections intact and will not allow for a change in pipe size. In discussing with a trenchless repair contractor (Spencer Tuell with Gulf Coast Underground, LLC), it appears this method is accomplishable, but the additional considerations caused by the severe deterioration of the host CMP will drive project costs to approximately $195,000 (see "Appendix Four – Cost Estimates")

Option 3 – Slip Line Exist CMP

Slip-lining, like CIPP, is a trenchless option for pipe rehabilitation. In this option, a smaller culvert is simply pushed or pulled through the existing culvert and the annular space between the host pipe and the new carrier pipe is filled with a grout slurry. While possible, slip-lining arch pipe is less common than a circular pipe which allows for some twist (during installation) whereas an arch pipe has to stay completely straight. What's more, slip-lining typically reduces the carrying capacity of the culvert due to the decrease in line size. Slip lining will reflect any existing vertical and horizontal deflections and possibly will resist installation across any significant bends in which the liner pipe can't pass through. The grout slurry can restore some structural strength, but in this case such significant section loss and sediment loss around the pipe there is concern that the grout will not adequately fill all the voids. After consideration, slip lining was deemed inappropriate for this situation. No cost estimate was created for this option.

Preferred Option

Due to the severe existing pipe deterioration, its lower cost, the higher likelihood of providing a structurally-sound culvert, the ability to select the culvert size, the ability to remove horizontal and vertical deflections, and concrete's less corrosive nature, it is recommended to perform a complete removal and replacement of this culvert with a 40"x65" reinforced concrete arch pipe.

Mike Reso
Hilo Street Culvert
2/16/21

Golf Course Pond

Pond and Channel Information

**Note; at the time of this draft, survey information for the pond banks was complete, yet pond bottom information was yet unavailable.* From site visits and survey data, the existing pond is relatively small (approximately 1/4 – 1/5 acre) and with similar sized inflowing and outflowing culverts, the pond appears to serve more of an aesthetic feature for the golf course than a typical engineered function (i.e. detention). The pond has obvious signs of sedimentation (i.e. silt mounds in areas of the pond, banks flattening at the water line, etc.). *Until such time that the pond bottom is surveyed, this report will assume a uniform excess sediment depth of 2' across the pond.*

The existing 175 linear foot channel between this pond and the Hilo Street culvert is an unlined earthen trapezoidal channel with a minimum depth of 2'-9", a minimum bottom width of 6.5', and average side slopes of 2.5 (H) to 1' (V). The channel is about 175 feet long from the upstream culvert outfall to a 48" reinforced concrete pipe under the cart path; between these two culverts a linear slope of approximately 1.3% is achievable, but in its current state, the bottom is non-uniform with pools and sediment deposits causing an uneven bottom width and profile. There is no rip rap or other velocity dissipator at the mouth of the upstream culvert.

Pond and Channel Information Analysis & Recommendations.

Pond

While the pond does not seem to serve a typical engineered function, any permanently wet storage basin will serve to improve water quality by allowing suspended sediments and other debris to settle. These settled particles will collect overtime and a general dredging maintenance program is required to remove these accumulated sediments before the full storage capacity is utilized. *Assuming the uniform 2' sediment depth described above,* to dredge this pond would require the removal of approximately *625* cubic yards of material; the pond is small enough that dredging could be done with traditional construction equipment from the bank.

Channel

At the measured existing conditions, the channel is capable of handling 275 cfs of runoff. Per calculations described in the culvert section above, this will handle the 25-year event (about 190 cfs) and the 50-year event (235 cfs), however, could overtop in the 100-year event (290 cfs). Should this channel overtop, the overbanks are along the golf course so that there is minimal threat to public infrastructure or private properties. As such, it appears the channel is sufficient in its current design,

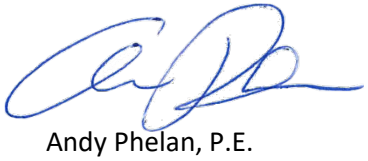
however maintenance dredging and reshaping of this channel is recommended. An engineered velocity dissipater (i.e. rip rap) shall be installed at the downstream end of Hilo Street.

Probable project costs for both the pond and channel are shown in "Appendix Four – Cost Estimates." It is estimated that project cost to dredge the pond would be approximately $20,700 and to restore the channel will cost approximately $6,200. Note that costs presented below assume each project is performed individually; project savings may be realized if two or more of the options below are combined into one project.

We appreciate the opportunity to serve you on this project. Should you have any questions concerning our recommendation, please do not hesitate to contact me.

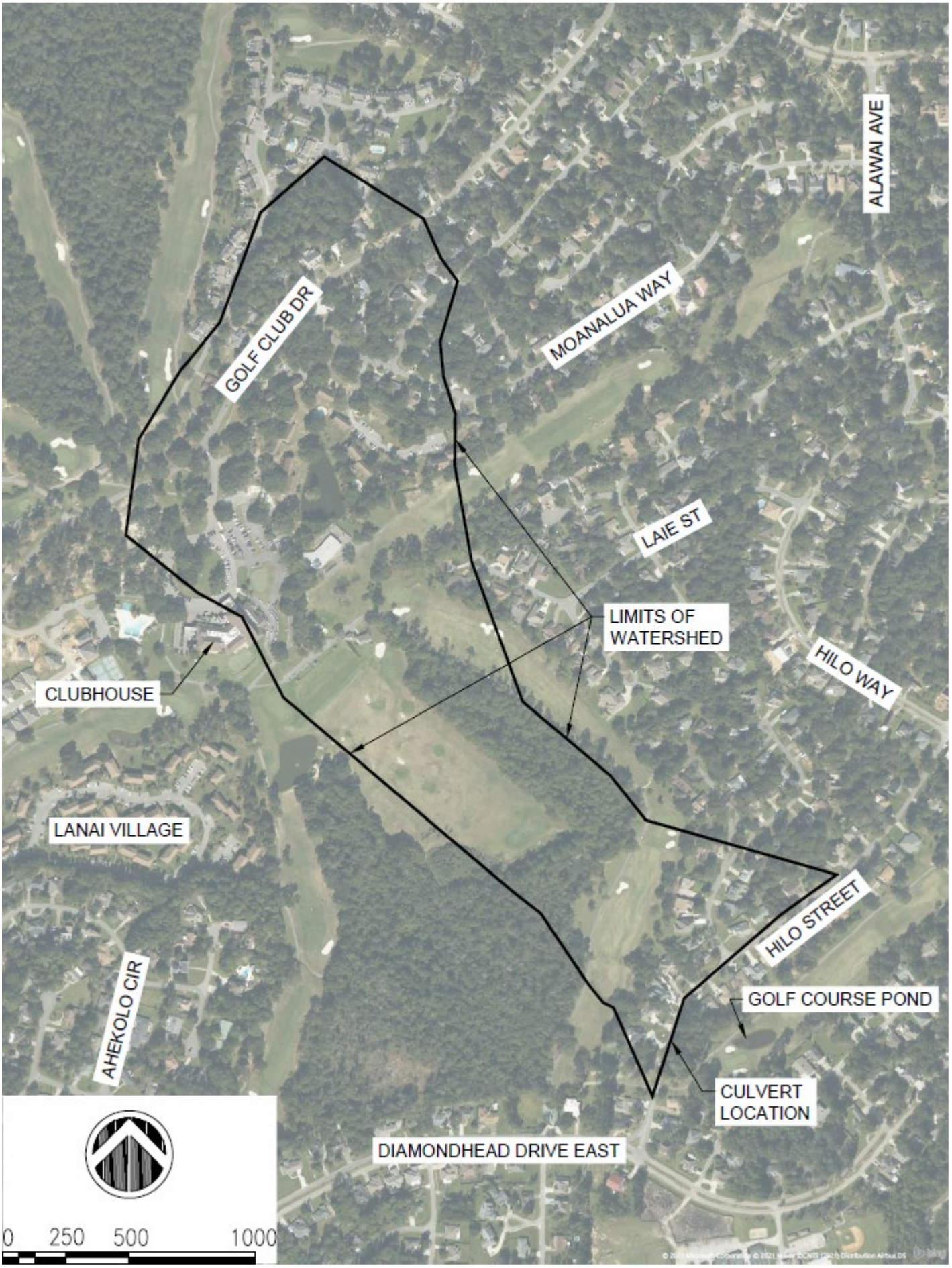
Sincerely,

PICKERING FIRM, INC.



Andy Phelan, P.E.
Principal Owner of Pickering

Appendix One – Watershed


ALAWAI AVE
GOLF CLUB DR
MOANALUA WAY
LAIE ST
LIMITS OF WATERSHED
HILO WAY
CLUBHOUSE
LANAI VILLAGE
HILO STREET
AHEKOLO CIR
GOLF COURSE POND
CULVERT LOCATION
DIAMONDHEAD DRIVE EAST
0 250 500 1000

Appendix Two – Hydrograph

Hydrograph Report

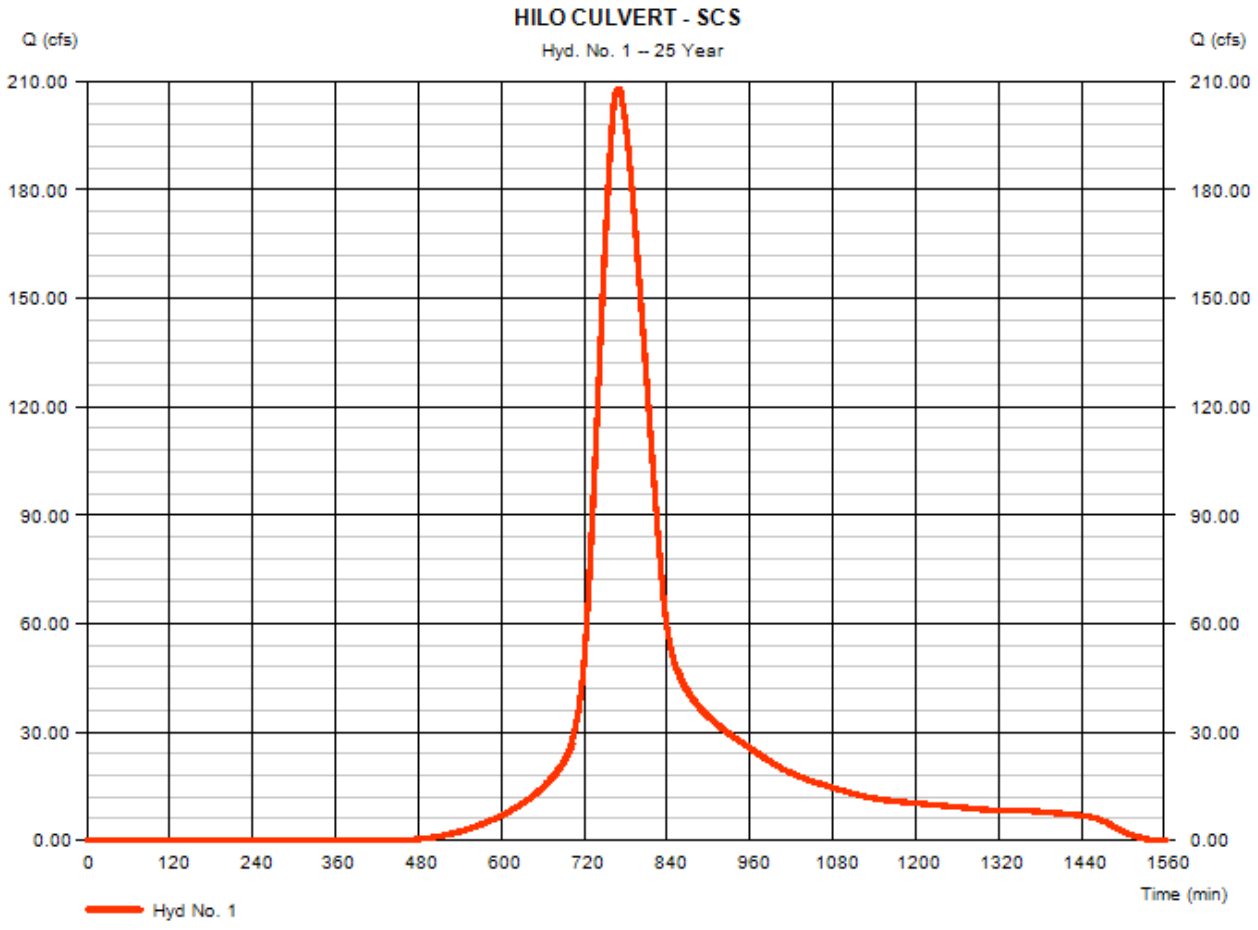
Hydraflow Hydrographs Extension for Autodesk® Civil 3D® by Autodesk, Inc. v2021 Monday, 02 / 1 / 2021

Hyd. No. 1

HILO CULVERT - SCS

Hydrograph type	= SCS Runoff	Peak discharge	= 207.90 cfs
Storm frequency	= 25 yrs	Time to peak	= 768 min
Time interval	= 1 min	Hyd. volume	= 1,774,189 cuft
Drainage area	= 75.000 ac	Curve number	= 67*
Basin Slope	= 1.5 %	Hydraulic length	= 4140 ft
Tc method	= TR55	Time of conc. (Tc)	= 73.50 min
Total precip.	= 10.80 in	Distribution	= Type III
Storm duration	= 24 hrs	Shape factor	= 484

* Composite (Area/CN) = [(59.000 x 70) + (10.000 x 58) + (6.000 x 55)] / 75.000



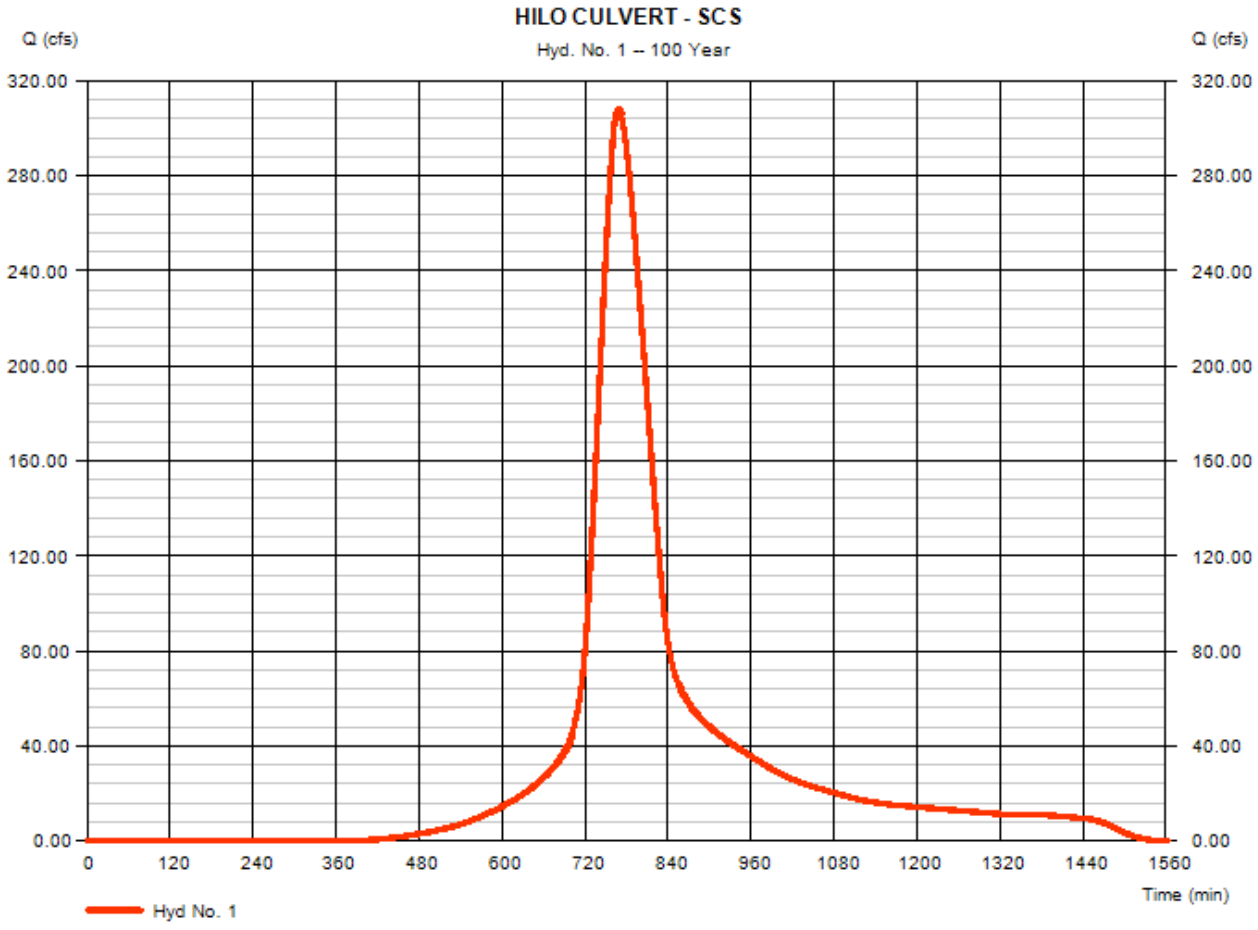
Hydrograph Report

Hyd. No. 1

HILO CULVERT - SCS

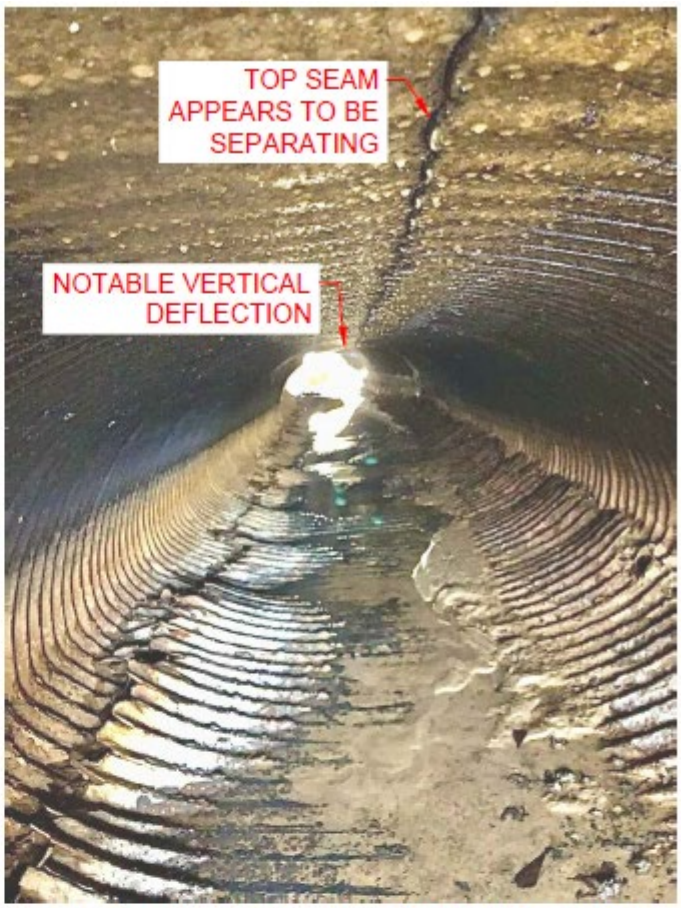
Hydrograph type	= SCS Runoff	Peak discharge	= 307.94 cfs
Storm frequency	= 100 yrs	Time to peak	= 768 min
Time interval	= 1 min	Hyd. volume	= 2,638,629 cuft
Drainage area	= 75.000 ac	Curve number	= 67*
Basin Slope	= 1.5 %	Hydraulic length	= 4140 ft
Tc method	= TR55	Time of conc. (Tc)	= 73.50 min
Total precip.	= 14.30 in	Distribution	= Type III
Storm duration	= 24 hrs	Shape factor	= 484

* Composite (Area/CN) = [(59.000 x 70) + (10.000 x 58) + (6.000 x 55)] / 75.000



Appendix Three– Project Photos

LOOKING UPSTREAM ON DOWNSTREAM CULVERT

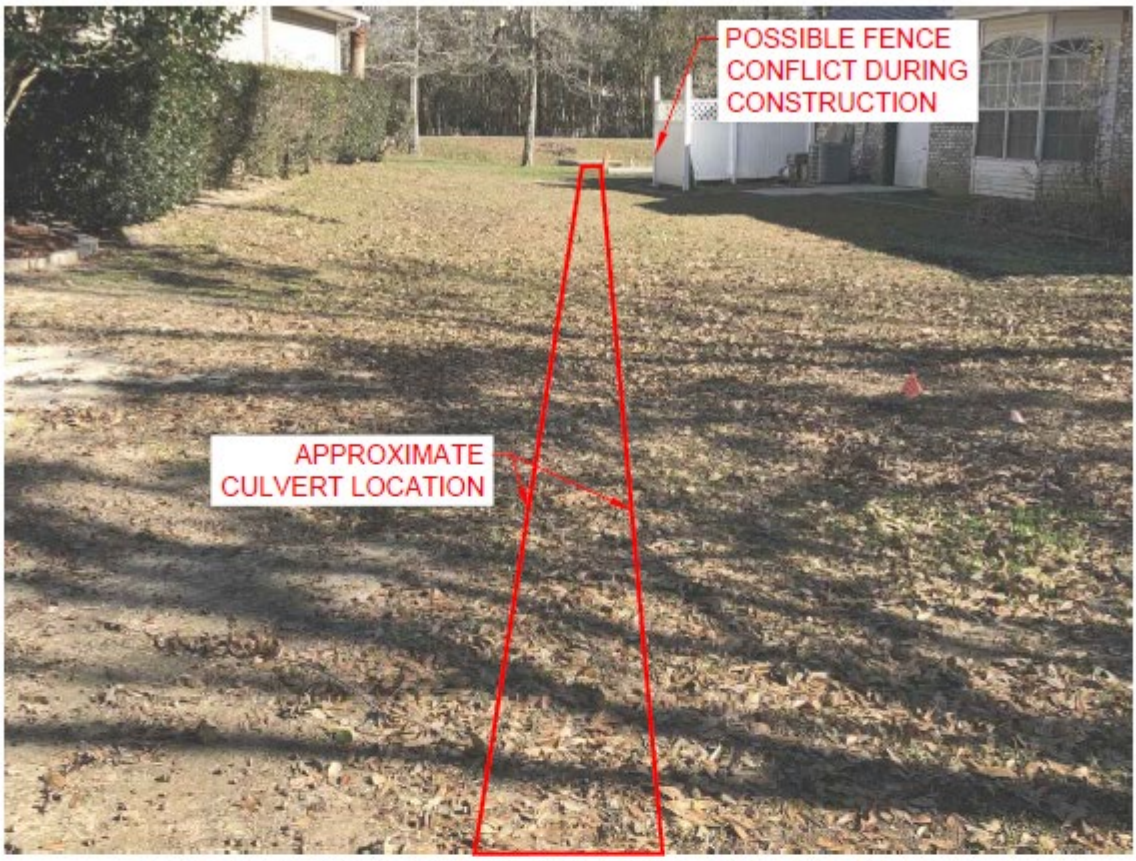


LOOKING UPSTREAM ON DOWNSTREAM CULVERT

INTERIOR OF JUNCTION BOX LOOKING DOWNSTREAM

LOOKING UPSTREAM ON UPSTREAM CULVERT

LOOKING DOWNSTREAM ON UPSTREAM CULVERT



LOOKING DOWNSTREAM ON UPSTREAM CULVERT (GRADE LEVEL)

AT-GRADE SINKHOLE

Appendix Four – Cost Estimates

HILO STREET CULVERT - REMOVE AND REPLACE					
Item No.	**Item Description**	**Qty**	**Unit**	**Unit Price**	**Total Cost**
1	Mobilization	1.0	LS	$10,000.00	$10,000.00
2	Erosion Control Blanket	240.0	SY	$6.00	$1,440.00
3	Removal of Exist CMP	275.0	LF	$35.00	$9,625.00
4	Unclassified Excavation (FM)	140.0	CY	$12.00	$1,680.00
5	Borrow Excavation (FM)	250.0	CY	$18.00	$4,500.00
6	Excess Excavation (FM)	250.0	CY	$12.00	$3,000.00
7	Bedding Material (FM)	130.0	CY	$25.00	$3,250.00
8	Riprap	30.0	SY	$50.00	$1,500.00
9	Grassing	240.0	SY	$1.20	$288.00
10	Asphalt Road Repair	30.0	SY	$100.00	$3,000.00
11	Pavement Striping	20.0	LF	$20.00	$400.00
12	Reinforced Concrete Arch Pipe 40" x 65"	275.0	LF	$200.00	$55,000.00
13	Concrete Junction Box	1.0	EA	$5,000.00	$5,000.00
14	Concrete Arch Pipe Headwall 40" x 65"	1.0	EA	$5,000.00	$5,000.00
				Subtotal	**$103,683.00**
				Construction Contingency	**$10,368.30**
				CONSTRUCTION TOTAL	**$114,051.30**
				Engineering Design (per MDA Charts @ 11.2%)	**$12,773.75**
				Construction Inspection (per MDA Charts at 6.5%)	**$7,413.33**
				PROJECT TOTAL	**$134,238.38**

HILO STREET CULVERT - CURED IN PLACE PIPE (CIPP)					
Item No.	**Item Description**	**Qty**	**Unit**	**Unit Price**	**Total Cost**
1	CIPP plus incidentals	1.0	EA	$150,000.00	$150,000.00
				Subtotal	**$150,000.00**
				Construction Contingency	**$15,000.00**
				CONSTRUCTION TOTAL	**$165,000.00**
				Engineering Design (per MDA Charts @ 11.2%)	**$18,480.00**
				Construction Inspection (per MDA Charts at 6.5%)	**$10,725.00**
				PROJECT TOTAL	**$194,205.00**

HILO STREET CHANNEL – CLEARING AND SHAPING					
Item No.	**Item Description**	**Qty**	**Unit**	**Unit Price**	**Total Cost**
1	Channel Clearing/Shaping (incl Mobilization)	175.0	LF	$27.50	$4,812.50
				Subtotal	**$4,812.50**
				Construction Contingency	**$481.25**
				CONSTRUCTION TOTAL	**$5,293.75**
				Engineering Design (per MDA Charts @ 11.2%)	**$592.90**
				Construction Inspection (per MDA Charts at 6.5%)	**$344.09**
				PROJECT TOTAL	**$6,230.74**

GOLF COURSE POND - MAINTENANCE DREDGING (assuming 2' uniform sediment depth)					
Item No.	***Item Description***	***Qty***	***Unit***	***Unit Price***	***Total Cost***
1	*Maintenance Dredging*	*675.0*	*CY*	*$20.00*	*$13,500.00*
2	*Site Restoration*	*0.25*	*AC*	*$10,000.00*	*$2,500.00*
				Subtotal	***$16,000.00***
				Construction Contingency	***$1,600.00***
				CONSTRUCTION TOTAL	***$17,600.00***
				Engineering Design (per MDA Charts @ 11.2%)	***$1,971.20***
				Construction Inspection (per MDA Charts at 6.5%)	***$1,144.00***
				PROJECT TOTAL	***$20,715.20***