Kansas Citys, Missouri and Kansas
Flood Damage Reduction Feasibility Study

Engineering Appendix to the Final Feasibility Report

Chapter A-5

CIVIL DESIGN

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This chapter presents the results of the civil design evaluation performed as part of the future conditions analysis for the Armourdale Unit of the Kansas Citys, Missouri and Kansas, Flood Protection Project.

A-5.1 SITE SELECTION AND PROJECT DEVELOPMENT (ARMOURDALE UNIT)

A-5.1.1 Introduction

The U.S. Army Corps of Engineers (USACE), Kansas City District designed and constructed the Kansas Citys protection system. This portion of the study considers raises on the Armourdale Unit to the 0.2% (500-year), 0.2% (500-year)-plus-3-feet, and the 0.2% (500-year)-plus-5-feet water surface profile elevations, hereafter referred to as N500+0, N500+3, and N500+5 elevations.

The Armourdale Unit is located in Wyandotte County, Kansas, along the left bank of the Kansas River from mile 6.7 (Mattoon Creek) to mile 0.3, near the junction of the Kansas River with the Missouri River. The flood protection unit includes levees, floodwalls, riprap and levee toe protection, toe drains along the concrete floodwalls, surfaced levee crown, ramps and turnouts, seeded landside slopes of levees, stop log gaps, sandbag gaps, drainage structures, relief wells, and pumping plants. Stationing of the unit consists of the upper end (U.E.) extension, the lower end (L.E.) extension, and the area in between. The unit begins at Station 0+05 U.E. and ends at Station 61+00 L.E. Stationing is summarized below along with station equations:

- 0+05 U.E. to 20+08.89 (Station Equation 20+08.89 U.E. BK = 9+71.16 AH)
- 9+71.16 to 206+12.43 BK (Station Equation 206+12.43 BK = 212+00 AH)
- 212+00 to 257+66.26 (Station Equation 257+66.26 BK = 257+64.97 AH)
- 257+64.97 to 322+85.41 (Station Equation 322+85.41 BK = 39+71.83 L.E. AH)
- 39+71.83 L.E. to 61+00 L.E. (N500+3 ft will end at Sta 42+50 L.E.)

A-5.1.2 Levee Footprint

The unit includes sections of levee and floodwall. All alternatives include widening the levee footprint, modifying floodwall, replacing floodwalls or placing a floodwall on top of existing levee. Stability berms or underseepage features are needed as indicated by the geotechnical analysis.

A-5.1.3 Borrow Area

Prospective borrow areas were identified by the Sponsor and screened through joint Corps and Sponsor efforts during the Phase I portion of this feasibility project. Regarding borrow area, Phase 1 focused on the Argentine Unit. The borrow area for Armourdale Unit will be the same as for Argentine. See attachment titled “Borrow Area for Proposed Armourdale Unit

Raise" (Exhibit 1) for a discussion of the borrow area for the project.

A-5.1.4 Haul Routes

Haul routes from the borrow site at WaterOne to various points along the levee/floodwall alignment were generated based on the limited access points to the levee/floodwall system along the Armourdale Unit. Exhibit 2 shows the haul routes and their distances from WaterOne to various access points along the Armourdale Unit.

A-5.2 REAL ESTATE CONSIDERATIONS (ARMOURDALE UNIT)

Research is currently being conducted by NWK Real Estate Staff to complete Preliminary Attorney's Opinion of Compensability as utilities are identified. Any conclusion or categorization that an item is a utility or facility relocation would result in work to be performed at the cost of the non-federal sponsor as part of LERRD responsibilities and is preliminary only. During PED, the Government will make a final determination of the relocations necessary for the construction, operation or maintenances of the project after further analysis and completion and approval of Final Attorney's Opinions of Compensability for each of the impacted utilities and facilities. Further detail on all real estate issues, will be discussed in the Real Estate Plan, Appendix B to be included in future ITR reviews and as part of the main Engineering Feasibility Report. See also the real estate plan for a discussion of real estate issues pertaining to borrow area.

A-5.3 UTILITY RELOCATIONS (ARMOURDALE UNIT)

A review of the Kansas City District's criteria for utility lines was performed. Based on discussions, a criteria document specific to this project was developed, see attached document "Kansas City's Levee Gravity and Utility Pipeline Guidance - Revised" (Exhibit 3). This document was used in determining the disposition of existing utility lines crossing the Armourdale Unit.

A-5.3.1 Utility Levee Crossings

The study of utilities crossing the Armourdale Unit was conducted to estimate costs for relocation or removal of functioning or abandoned utilities. Using the criteria indicated above, it was determined that most pressure pipelines currently passing under the levee would be relocated over the levee. See attached drawing titled "Existing Utility Features Crossing Unit" (See sheet E2 in the mapbook). See attached table titled "Armourdale Utility Crossings: Inventory and Action for N500+3 Raise" (Exhibit 4) for the recommended action for each utility crossing the levee. Some utilities are to remain in place, others will be relocated up and over the levee, see attached drawings titled "Typical Utility Crossing" (Exhibit 5).

Utility crossing recommendations are based on the N500+3 raise, therefore the quantities for the cost estimate is also based on the N500+3 raise. For the N500+0 and N500+5 alternatives, recommendations for utility crossings are the same as for N500+3. Cost estimates and quantities used for determining the N500+3 cost will be used for the N500+0 and the

N500+5. There is negligible difference between the three raises in regards to recommended utility crossings. This approach for estimating the N500+0 and the N500+5 raise is similar to the approach taken in Phase 1 when cost estimating the Argentine Unit utility crossings.

A-5.3.2 Special Design and Construction Considerations

The project team will conduct specific utilities relocation coordination and design planning prior to levee raise construction contract award. In recent projects, this relocation work has proven very problematic if not thoroughly scheduled and coordinated. Even though sponsors (and utility owners) are responsible for most utilities relocations (for those utilities deemed without legal compensability), the Kansas City District must be consulted for approval of the relocation design and schedule. Detailed planning for utility relocations and assignment of responsibilities is fully developed by the latter stages of the PED phase. All parties (sponsor, utility owner, and Corps of Engineers) must prepare for a highly coordinated utility relocation effort as the levee raise begins.

Where lines are shown as abandoned or to be abandoned, the Kansas City's Levee and Floodwall Utility Crossings Criteria will be followed.

A-5.3.3 Power Lines

Several large capacity power lines cross the Armourdale Unit. Most of the lines that cross the levee also cross the Kansas River and therefore have substantial structures holding them in place. These structures that interfere with the proposed levee raise will be avoided with the use of T-wall on levee or retaining walls when levee raises would extend the footprint. Following is a list of the stations currently crossed by power lines:

Station 74+00 – no apparent interference observed in field
Station 92+00 – levee raise or berm would interfere with power line support structure but the proposed T-wall on levee will not
Station 110+00 - levee raise or berm would interfere with power line support structure; T-wall on levee would not. Overhead power lines are located near the transition between levee and T-wall on levee, therefore this interference will need to be determined during detailed design when a land survey is completed.
Station 156+00 – no apparent interference observed in field as Mill Street pump plant is located between power line support structure and levee unit
Station 184+00 – levee raise or berm may interfere with power line support structure; this interference will need to be determined during detailed design when a land survey is completed.
Station 196+00 – levee raise or berm would interfere with power line support structure but the proposed T-wall on levee will not
Station 228+00 - levee raise or berm may interfere with power line support structure but the proposed T-wall on levee will not

The existing clearance between most of the power lines and top of levee is approximately 40 feet although this will need to be verified during a land survey during detailed design phases. The N500+3 alternative results in a levee raise in the range of 3 feet to 5 feet. Coordination with

the Board of Public Utilities (BPU) determined that the required clearance between the power lines and the levee is 20.9 feet. This clearance is based on the National Electric Safety Code (NESC). With the maximum raise of 5 feet reducing the minimum clearance to 35 feet, the clearance between the power lines and the levee is adequate.

Power lines running parallel (landward) with the levee will have to be protected during construction. Depending on proposed stability berm and relief wells, some small power lines may need to be relocated or protected during and after construction.

A-5.3.4 Utility Uplift

The study of uplift on existing utilities was conducted to estimate costs for relocation or removal of functioning or abandoned utilities. Regions were identified for utility uplift concern, based on geotechnical and N500+3 conditions. The region extends 500 feet landward of the levee/ floodwall centerline and corresponds with the "critical zone" of the levee/floodwall.

Water and sanitary sewer utility mapping was obtained from the Unified Government of Wyandotte County and the Board of Public Utilities. Storm sewers that do not cross the levee were not mapped because uplift is generally not a concern as long as both ends of the pipe are open to atmosphere. Being open to atmosphere at both ends allows the pipe to fill during inundation. Storm sewers are typically metal and heavy enough not to float when filled with water. For the purposes of uplift it was assumed that underground electrical lines (UGE) were not affected. The information on natural gas lines and petroleum lines within the 500-foot zone was limited but was evaluated where the information was available. No known petroleum lines are located within the critical zone. Natural gas and water service lines to buildings are generally less than 6 inches in diameter and not located near the levee. Based on the uplift spreadsheets, lines 6 inches and smaller are generally not affected by uplift, therefore only lines 6 inches and greater have been evaluated.

For this study, the Armourdale Unit was broken into seven segments for analysis with each segment having its own geotechnical features. The geotechnical input consisted of impervious blanket thickness and foundation sands thickness as well as levee dimensions, berm dimensions, bedrock depth, and soil density. Exhibit 6 "Armourdale Utility Uplift Spreadsheet: Data Entry Worksheet" displays the existing geotechnical and dimensional conditions for each levee segment. For this study, the driving head of water represents the nominal 500-year plus 3 feet level of protection. The geotechnical designers provided the dissipation of the hydraulic gradient through the impervious blanket for use in calculating uplift on utilities. The locations of underseepage control features (cutoff walls) and wells were also considered in regards to uplift on utility lines.

Exhibit 7 contains a sample calculation for utility uplift. It shows how each of the geotechnical, dimensional, and hydraulic gradient inputs are used to calculate potential uplift concerns. The utility uplift spreadsheets for levees are based on this sample calculation. A set of spreadsheets was developed for each levee segment for 6-inch, 12-inch, 16-inch, 24-inch and 48-inch pipes. Uplift was evaluated for each pipe size beginning at the toe of the levee. If uplift was not a concern at the toe of the levee at 40 inches deep, then no further evaluation was done on

that pipe size and the result displayed on the Utility Uplift Concern maps is that there is no uplift concern for that pipe size in that stretch of the levee. There are three uplift maps for Armordale utilities: water, sanitary sewer, and natural gas (See Exhibits 8-10).

If uplift is found to be a concern at the toe of the levee at 40 inches deep, then uplift was evaluated further from the toe up to 500 feet from the toe of the levee. The distance from the levee at which the factor of safety equals 1.1 is the result displayed on the Utility Uplift Zone maps.

The final product of the uplift spreadsheet analysis provided the limits from the centerline of the levee that a given type, size and depth of pipe must be located in order to meet the minimum uplift factor of safety. The attached detailed spreadsheets are titled "Armourdale Area" (Exhibits A-5.11) and are labeled for the various raise and levee segments.

The areas of uplift concern were overlaid on the utilities map to develop maps of "Uplift Concern" (Exhibits 8-10). The Utility Uplift Zones were used to estimate the total length of pipe that would have to be lowered or covered with additional material to eliminate the uplift concern.

The results are summarized in the attached tables labeled, "N500+3 Utility Uplift" (Exhibit ?). The tables provide a list of utilities, indicating the levee segment, the size and type of line, and the length of line to be lowered or covered to alleviate uplift concern.

Utility uplift recommendations are based on the N500+3 raise, therefore the quantities for the cost estimate is also based on the N500+3 raise. For the N500+0 and N500+5 alternatives, quantities for utility uplift are not the same as for N500+3. Quantities used for determining the N500+3 cost will be adjusted up for the N500+5 alternative and down for the N500+0 alternative. This approach for estimating the N500+0 and the N500+5 raise is similar to the approach taken in Phase 1 for estimating the Argentine Unit utility uplift recommendations. Based on Argentine quantities for uplift, the quantity of piping for the N500+0 raise will be calculated at 80% of the N500+3 quantity. The quantity of piping for the N500+5 raise will be calculated at 120% of the N500+3 quantity. The number of manholes to be replaced will remain the same for all alternatives, N500+0, N500+3, and N500+5.

A-5.3.5 Inspection Trench

Since the proposed construction primarily involves raising the existing protection, no specific locations for new inspection trenches are indicated or considered. In the event that conditions are encountered in the field which warrant investigation, an inspection trench may be used.

A-5.4 REFERENCES

1 American Water Works Association "Steel Pipe – A Guide for Design and Installation", AWWA M11 4, 2004.

2 Hydraulic Institute "Hydraulic Institute Engineering Data Book" Hydraulic Institute, Cleveland, Ohio.

3 EM 1110-2-1913, "Engineering and Design – Design and Construction of Levees"

4 Kansas City District regional specific guidance
www.nwk.usace.army.mil/local_protection/levees.html

EXHIBIT 1
Borrow Area for Proposed Armourdale Unit Raise

Prospective borrow areas were identified by the Sponsor and screened through joint Corps and Sponsor efforts during the Phase I portion of this feasibility project. Regarding borrow area, Phase 1 focused on the Argentine Unit. Because the borrow area for Armourdale will be the same as for Argentine, this write-up was taken from the Phase I report and updated to include the Armourdale Unit raises.

ARGENTINE

Total required fill quantities for Argentine are 90,301, 257,881, and 508,281 compacted cubic yards (ccy) for N500, N500+3, and N500+5 raises, respectively. The N500+3 raise is the recommended alternative for Phase 1, therefore 258,000 ccy will be used for estimating borrow needs. For Argentine, the proposed levee raise accounts for about half of the fill requirement and stability or underseepage berms account for the other half. Subsurface investigation of the borrow area provided the required geotechnical information for the materials to be used in the levee.

ARMOURDALE

Total required borrow quantities from WaterOne for Armourdale is approximately 350,000 bcy for the N500+3 raise. This quantity is based on balancing cut and fill on site and then calculating what is required to supplement on-site material with that from WaterOne.

The attached WaterOne Borrow Area Typical Cross Section and table summarize the borrow material needs for Argentine, Armourdale and CID-KS. See “WaterOne Borrow Area Typical Cross Section”, for a typical cross section for the borrow area excavation.

Fifty acres will be needed for Armourdale’s 350,000 bank cubic yard requirement. This assumes that impervious material is obtained in a 3-foot layer with random material obtained below that from a 2 to 3-foot layer. For all of borrow requirements for Argentine, Armourdale, and CID-KS, approximately 100 acres will be needed assuming impervious material is obtained from a 3-foot layer and random obtained from a 2 to 3 foot layer below that. The impervious layer thickness assumption is critical to estimating the acreages to be used from WaterOne. The 3-foot impervious thickness assumption was derived from the eight boring logs.

Cultural resource investigation into the WaterOne borrow site resulted in a maximum excavation depth of 10 feet. The US Army Corps of Engineers recommended a maximum excavation depth of 10 feet and the Kansas State Historic Preservation Officer has concurred with Corps’ recommendation that no archeological survey is needed for borrow activity kept to a depth of 10 feet or less.

BORROW AREA SEARCH

Originally, the Argentine & Armourdale foreshore areas were considered due to their close proximity to the Argentine unit. As HTRW investigations were undertaken for areas of interest, however, various regions of contamination were discovered which eliminated most of these areas from consideration. Total remaining available fill in these areas, ASSUMING NO FURTHER HTRW DISCOVERIES, is approximately 143,000 CY (see FIGURE 1 - "FORESHORE"). Figure 1 reflects avoidance of known HTRW concerns, a minimum 300' standoff distance from existing levees or floodwalls, and maximum depth of excavation of ordinary high water (OHW) minus 4 feet. It is recommended that this area be retained for further consideration during project engineering & design, though there is a possibility that further HTRW investigations will make even the remaining material unusable. Even if no further HTRW issues are discovered, any borrow from this area would need chemical analysis sampling at a rate of 1 sample (about $1000) per 5000 cy of borrow due to the known contamination and associated legal entanglements in the area.

Since the remaining foreshore quantity alone (assuming future HTRW clearance) is marginal for the N500 raise and insufficient for the other two prospective modifications to the Argentine unit, efforts were taken to identify alternative borrow areas as close to the project as possible. FIGURE 2 - "VICINITY MAP" shows various sites considered and investigated. Many of the sites near the project area were either very small or had other undesirable characteristics such as extremely high land values or prior industrial use. Several areas, as discussed on the following pages, were further investigated.

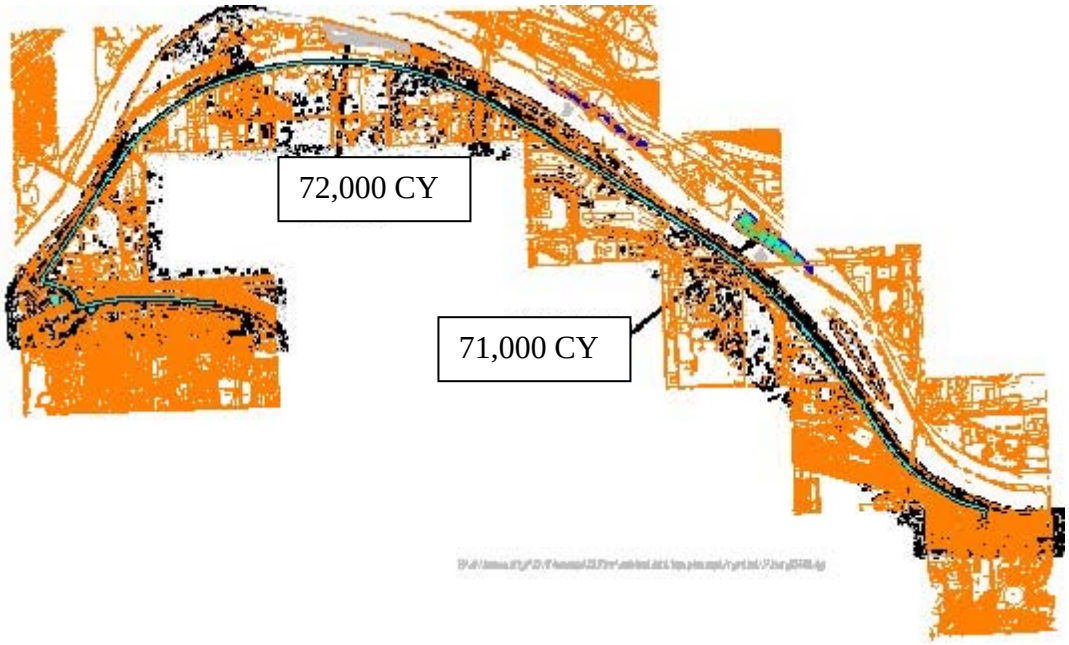

FIGURE 1 – FORESHORE

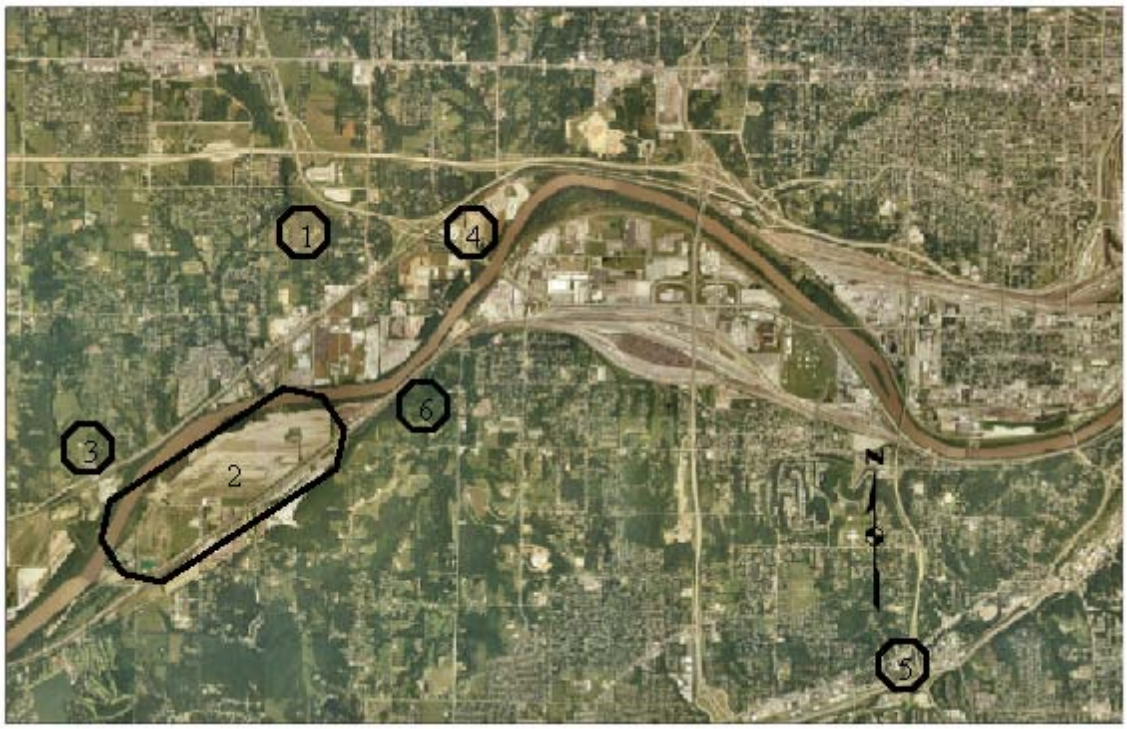

FIGURE - 2 VICINITY MAP

Area 1 is an open field south of the Turner Diagonal. The area is approximately 40 acres and appears to have been previously used as a borrow area. Since access to and from the area requires travel through residential neighborhoods on narrow routes, the area was not considered for further study.

Area 2 is in the Kansas River floodplain. The area is approximately 500 acres, 380 of which are owned by Water District One of Johnson County (WaterOne). This area appeared to be a good candidate for further consideration, and is discussed in detail below.

Area 3 is owned by Amino Brothers Construction and has previously been used as source of borrows. Approximately 200,000 cy of material is available, per conversation with the owner. This site may be a viable backup source for impervious materials, if required.

Area 4 is approximately 50 acres and used for a variety of commercial / industrial purposes. Since current appraised land values are in excess of $2000 per acre, this area was not considered for further study.

Area 5 is owned by Sandifer Leasing and has previously been used as source of borrows. Field investigations show little to no remaining fill, therefore the site was not considered for further study.

Area 6 is a large wooded hillside, which appears to be undisturbed. The area below is covered by a network of tunnels, originally used for limestone mining and currently for cold storage. Due to the likelihood of disturbing the tunnels below during earth moving operations,

this area was not considered for further study.

See TABLE 1 "BORROW AREA COMPARISON" for a summary comparison of prospective sites.

TABLE 1 - BORROW AREA COMPARISON

AREA	OWNER	HAUL DIST	PROS	CONS	ACTION
1	Unknown	2 miles	Close to site	Residential access, small	Remove from consideration
2	WaterOne	4 miles	Little or no cost	Haul distance	Investigate as primary source
3	Amino Bros.	5 miles	Bank source – expected to be impervious	Haul distance, cost of fill	Keep for possible contingency
4	5701 LLC	2 miles	Close to site	High cost of comm/ind property, developed	Remove from consideration
5	Sandifer	5 miles	None	Haul distance, look like no fill left	Remove from consideration
6	Unkonwn	3 miles	Bank	Haul distance,	Remove

AREA	OWNER	HAUL DIST	PROS	CONS	ACTION
			source-expected impervious	likelihood of damaging tunnels below	from consideration
Foreshore	KVDD easement	0 (Argentine) 4 miles (Armourdale)	Very close to site	Potential HTRW, legal entanglements, high chemical sampling cost	Keep for possible contingency

Area 2, shown below in additional detail in FIGURE 3, contains approximately 500 acres and is bounded by the Kansas River and Holliday Drive. WaterOne owns 380 acres in this area and uses the site for disposal of quicklime used in the water treatment process. Individual cells, each 5-10 acres and 20 feet deep, are excavated and, over the course of 3-5 years, filled with dewatered lime (40-60% solids). The cells are then capped with soil, and the excess soil stockpiled elsewhere onsite. During an October 2004 meeting with WaterOne staff, the requirements for the Argentine levee raise project were discussed in detail. WaterOne staff indicated a desire to dispose of excess materials and was interested in pursuing an agreement for

use of the excess materials. Soil boring logs for previous WaterOne well and disposal cell construction indicate significant deposits of silt and silty clay, both of which would qualify as impervious fill, in the area.

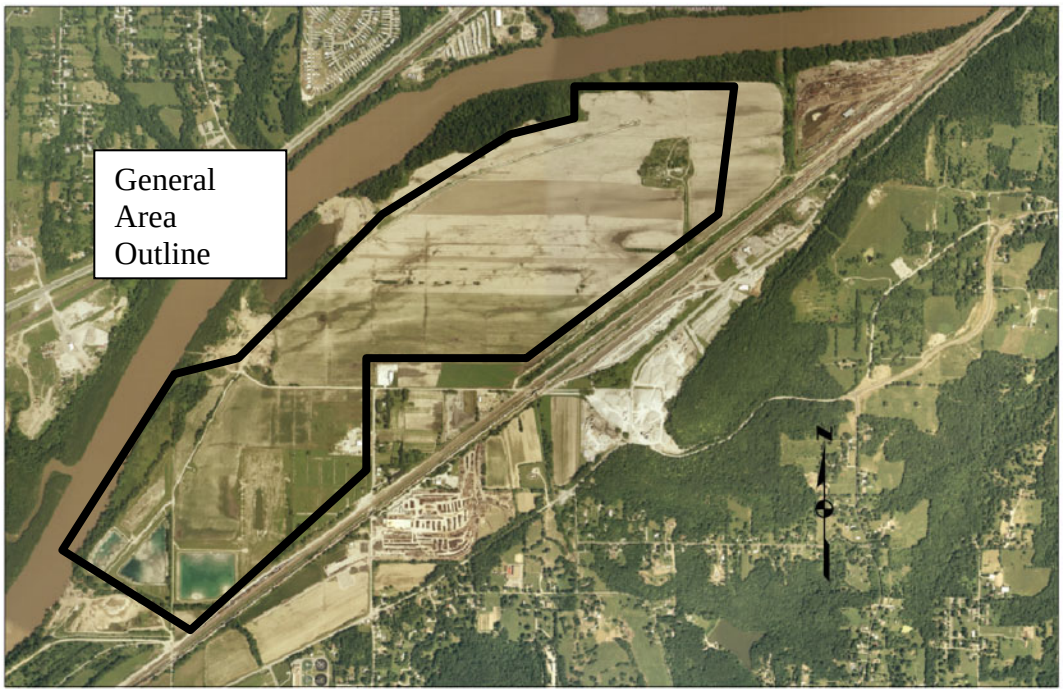

FIGURE 3 – BORROW AREA 2 - WATER ONE

Exploratory soil borings and chemical analysis sampling was conducted in January 2005. Chemical analysis entailed 3 grab samples for volatile organic compounds (VOCs) and three composite samples for metals, pesticides herbicides, and semivolatile organic compounds (SVOCs). Chemical analysis sampling points differed from soil boring locations, but were taken at various locations throughout the WaterOne property to assure representative results. All parameters tested were below action levels.

Subsurface Investigation.

Exploratory Borings.

The subsurface investigation of the borrow area consisted of 8 exploratory borings, 10 - feet deep, drilled with 3 ¾ ID Hollow Stem Auger with 3-inch inner barrel sampler. The borings location with WaterOne property delineated is shown in FIGURE 4 and the strip logs are included at the end of the paragraph. All holes were backfilled prior to leaving the site. No water was encountered during drilling or 24 hours after drilling. Forty (40) jar samples and 8 sack samples (1 composite sack sample for each boring) were collected from all borings. The boring logs show an impervious soil layer consisting of silts and clays extending up to 6 feet below the surface followed by a sandy aquifer. The central part of the borrow area has a thin layer of sand at the surface, varying between 1 and 4.5 feet in thickness, followed by 3 to 4 feet of silts and clay, on the top of the sandy aquifer. The sandy material can be used as backfill in the random portion of the landside levee embankment.

Laboratory Testing.

Selected samples of material obtained during the field exploration were tested to determine engineering and physical properties of the soils. Laboratory testing was performed by Geotechnology, Inc. The laboratory testing included Atterberg Limits, natural moisture contents, and Standard Proctor tests. The samples were grouped in 5 categories of similar characteristics and Atterberg Limits were performed on a representative sample of each category. The moisture content varies between 4 and 35%. Overburden clay and silt material was classified in accordance with ASTM D 2487 as lean clay (CL) or silt (ML). Three of the groups were determined to be non plastic, the other 2 groups were classified one as a lean clay (CL) and the other as silt (ML). The silt was determined to be non-plastic material. The Liquid Limit (LL) of the CL material varies between 39 and 47 and the Plasticity Index (PI) between 19 and 28. The results of the natural moisture content tests and performed on twenty five (25) disturbed samples and of the Atterberg Limits tests performed on 2 selected representative samples of clay material are shown in an enclosure at the end of the paragraph.

Three Standard Proctor Tests were performed on composite samples collected from the borrow areas conform ASTM D-698. The materials were classified as low plasticity clay with the LL between 52 and 55 and PI between 35 and 37 respectively. The maximum dry density varied between 107.5 and 102 pcf with the optimum moisture content varying between 18.5% and 20.5%.

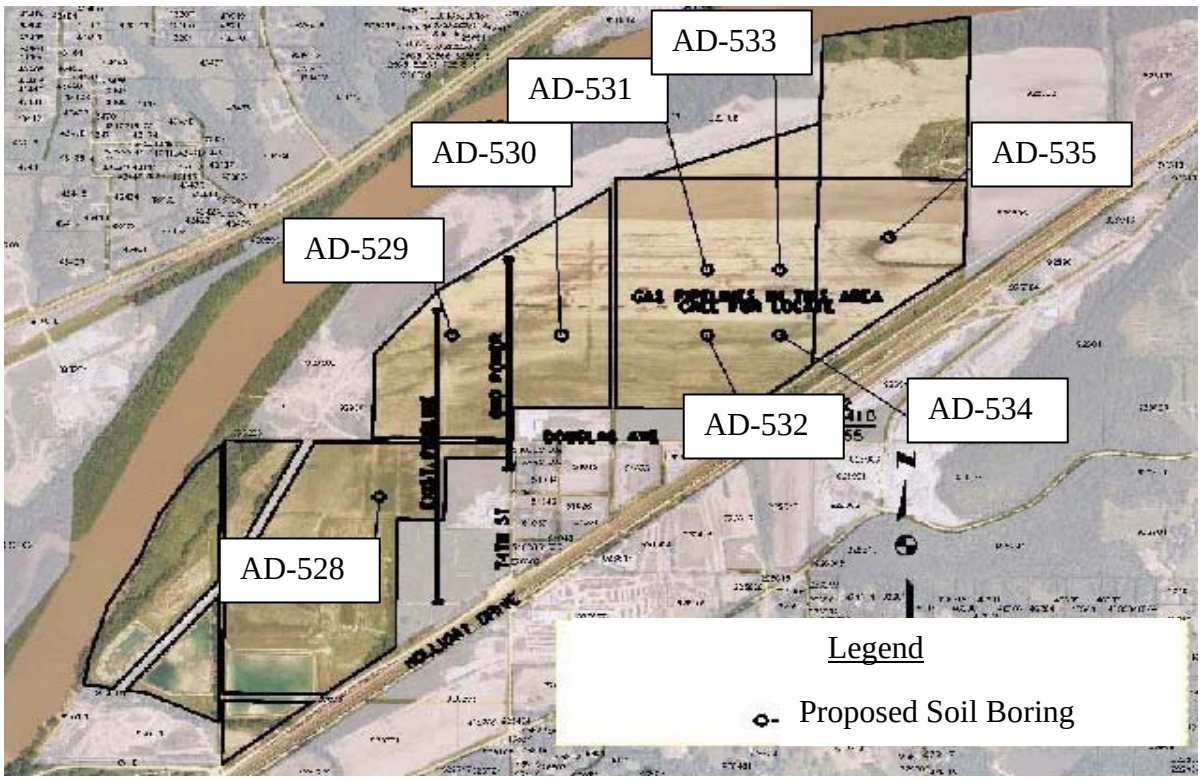

FIGURE 4 - SOIL BORINGS

KANSAS CITYS LEVEES FEASIBILITY PHASE 2

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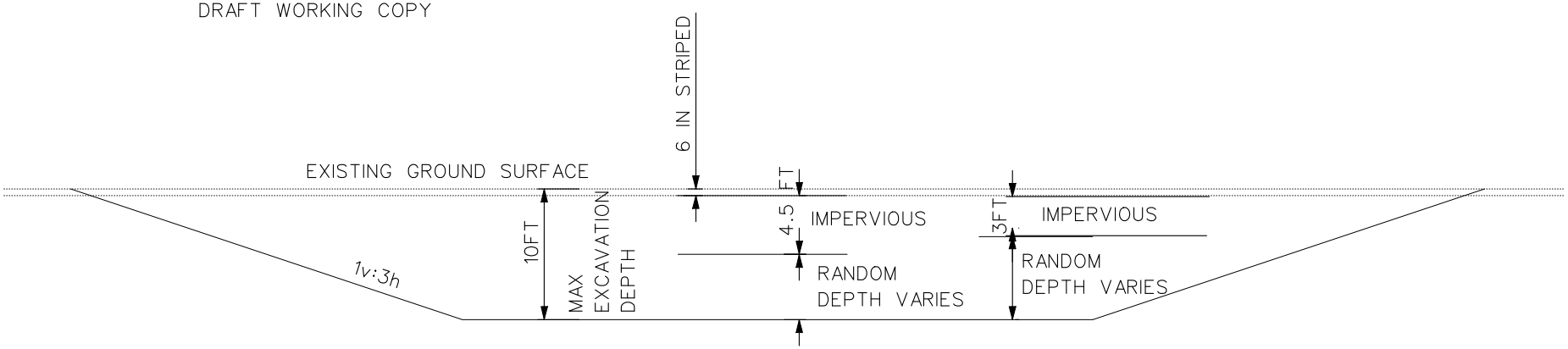
WATERONE BORROW AREA TYPICAL CROSS SECTION



Borrow Area Needs - Current Recommendation N500+3
Using Two Depths (3' and 5') for Impervious Excavation

					Impervious		Random - Alt. 1 (2)		Random - Alt. 2 (3)		Total		
	Total Borrow Quantity	Impervious	Random	Strip Top 6"	Depth of Excavation	Area of Excavation	Depth of Excavation	Area of Excavation	Depth of Excavation	Area of Excavation	Maximum Depth of Excavation (1)	Minimum Depth of Excavation (4)	Total Area of Excavation (5)
	BCY	BCY	BCY		Feet	Acres	Feet	Acres	Feet	Acres	Feet	Feet	Acres
Armourdale	440,500	279,558	160,895	0.5	3	58	3	33	2	58	10	5	58
	440,500	279,558	160,895	0.5	5.0	35	4.5	22	3	35	10	8	35
CID-KS	79,700	59,331	20,371	0.5	3	12	3	4	1	12	10	4	12
	79,700	59,331	20,371	0.5	5.0	7	4.5	3	2	7	10	7	7
Argentine	282,700	144,226	138,490	0.5	3	30	3	29	3	30	10	6	30
	282,700	144,226	138,490	0.5	5.0	18	4.5	19	4.5	19	10	10	19
Total	802,900	483,115	319,756	0.5	3	100	3	66	2	100	10	5	100
	802,900	483,115	319,756	0.5	5.0	60	4.5	44	3	60	10	8	60

Notes

CCY Compacted Cubic Yards
BCY Bank Cubic Yards = CCY/0.8
BOTEA Back of the Envelope Analysis

Assumptions: Impervious material is generally located above other material
Estimate will be revised as levee/floodwall alignment is refined.

(1) Maximum depth of excavation is set to 10 feet.
Kansas State Historic Preservation Officer has concurred with Corps' recommendation that no archeological survey is needed for borrow activity kept to a depth of 10' or less
(2) Alternative 1 is when random excavation depth is equal to impervious excavation depth
(3) Alternative 2 is when random excavation area is equal to impervious excavation area (this minimizes depth of total excavation)
(4) Minimum excavation depth is calculated using Alternative 2 - setting the acreage needed for random fill equal to that needed for impervious fill.
(5) Total area of excavation is the greater value returned when comparing the Impervious Area of Excavation and the Random Alt. 1 Area of Excavation

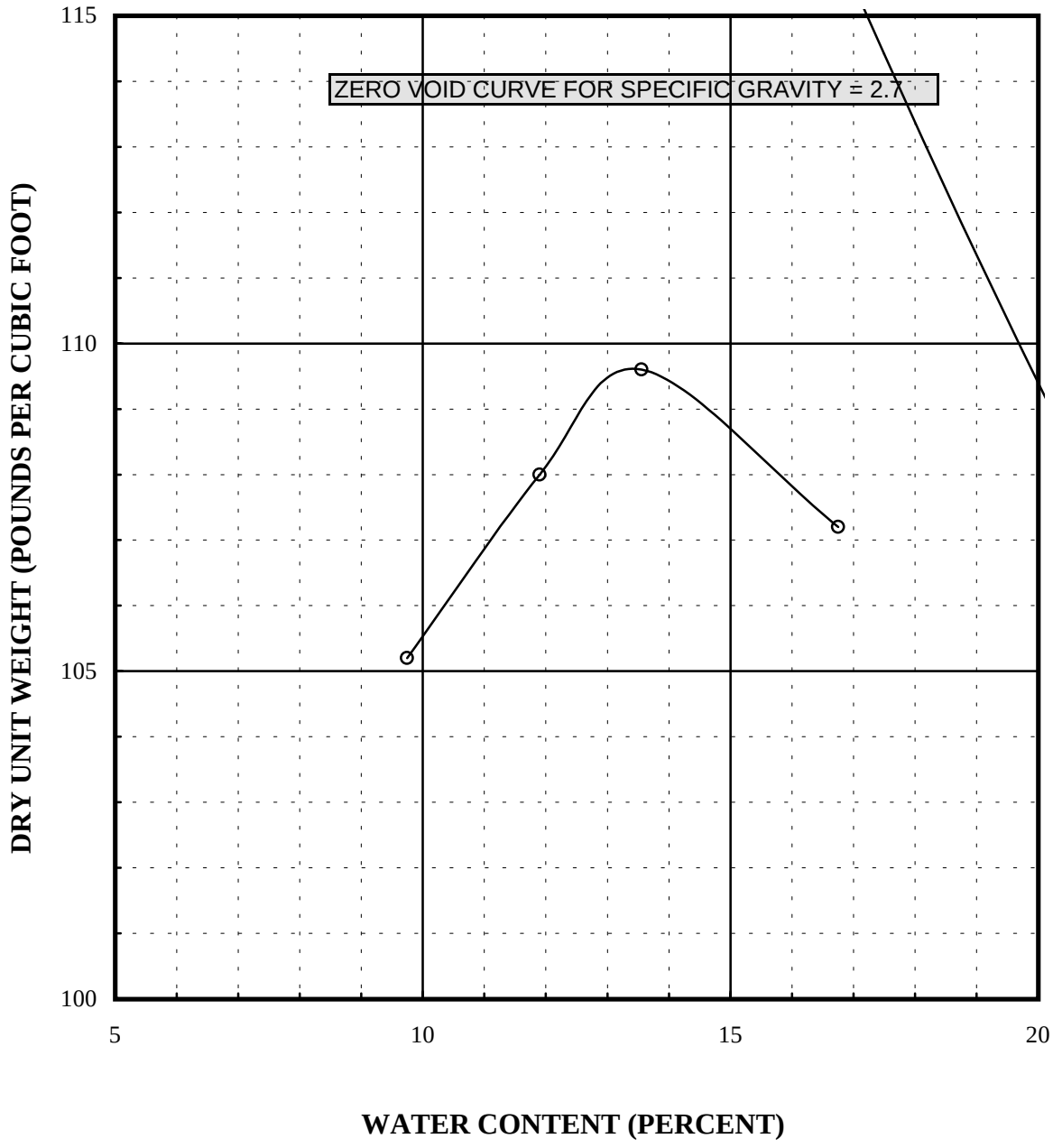
By: Melissa Corkill
Date: December 14, 2006

	BORING NO.	Sample Depth (feet)	Sample No.	LABORATORY TESTS							Classification or Group Classification ASTM D2487
				Group Class.	Moisture Content %	Atterberg Limits			Standard Proctor		
						Liquid Limit	Plastic Limit	Plasticity Index	Max. Dry Density	Optima Water Content	
					ASTM D2216	ASTM D4318			ASTM 698 Method A		
SACK SAMPLES	AD-528	0.8-4.0	Sack-1	--	--	29	21	8	104.7	18.2	CL-dark brown sandy low plasticity CLAY
SACK SAMPLES	AD-529	3.0-6.0	Sack-1	--	--	27	17	10	113.9	14.6	SC-dark brown clayey SAND
SACK SAMPLES	AD-535	1.0-4.5	Sack-1	--	--	47	19	28	102.5	19.0	CL-dark brown sandy low plasticity CLAY
DISTURBED SAMPLES	AD-528	0.0-0.5	J-1	5	29.2	Not enough sample					
DISTURBED SAMPLES	AD-528	0.5-0.8	J-2	5							
DISTURBED SAMPLES	AD-528	0.8-4.0	J-3	1							
DISTURBED SAMPLES	AD-528	4.0-4.6	J-4	1	25.0	39	20	19			
DISTURBED SAMPLES	AD-528	4.6-8.4	J-5	3							
DISTURBED SAMPLES	AD-528	8.4-9.0	J-6	2							
DISTURBED SAMPLES	AD-529	0.0-1.0	J-1	4	27.5						
DISTURBED SAMPLES	AD-529	1.0-3.0	J-2	3							
DISTURBED SAMPLES	AD-529	3.0-4.0	J-3	4	21.2						
DISTURBED SAMPLES	AD-529	4.5-6.0	J-4	1	24.9						
DISTURBED SAMPLES	AD-529	6.0-10.0	J-5	3							
DISTURBED SAMPLES	AD-530	0.0-1.0	J-1	4							
DISTURBED SAMPLES	AD-530	1.0-1.5	J-2	3	4.0						
DISTURBED SAMPLES	AD-530	1.5-2.5	J-3	2	20.1	Non-plastic					
DISTURBED SAMPLES	AD-530	2.5-4.3	J-4	2	11.3						
DISTURBED SAMPLES	AD-530	4.3-8.0	J-5	2	25.2						
DISTURBED SAMPLES	AD-530	8.0-9.3	J-6	4		Non-plastic					

Group Classification Number:

1. CL - dark brown sandy low plasticity CLAY
2. ML - light brown low plasticity SILT
3. SP - tan fine-grained SAND
4. SM - dark brown silty SAND
5. FILL - dark brown gravelly low plasticity CLAY with sand
6. CL - dark brown low plasticity CLAY

BORING NO.	Sample Depth (feet)	Sample No.	LABORATORY TESTS							Classification or Group Classification ASTM D2487
			Group Class.	Moisture Content %	Atterberg Limits			Standard Proctor		
					Liquid Limit	Plastic Limit	Plasticity Index	Max. Dry Density	Optima Water Content	
				ASTM D2216	ASTM D4318			ASTM 698 Method A		
AD-531	0.0-1.0	J-1	4	14.4						
	1.0-3.5	J-2	1	22.2						
	3.5-4.0	J-3	2							
	4.0-6.5	J-4	2	25.1						
	6.5-9.0	J-5	3		Non-plastic					
AD-532	0.0-4.3	J-1	1	26.3						
	4.3-6.3	J-2	1	30.7						
	6.3-8.3	J-3	2							
AD-533	0.0-2.3	J-1	1	18.9						
	2.3-4.3	J-2	2	9.9						
	4.3-6.0	J-3	2	14.9						
	6.0-8.0	J-4	1	26.2						
	8.0-9.3	J-5	2							
ADU-534	0.0-4.0	J-1	1	25.7						
	4.0-6.0	J-2	2	30.7						
	6.0-6.5	J-3	6	35.4						
	6.5-7.0	J-4	1	28.3						
	7.0-9.0	J-5	2	15.5						
AD-535	0.0-4.5	J-1	6	20.3	47	19	28			
	4.5-7.5	J-2	1	29.5						
	7.5-8.5	J-3	2							
	8.5-9.5	J-4	3							
	9.5-10.0	J-5	2							



PROJECT NAME

Argentine Levee Unit – Borrow Area

SPECIFICATIONS

Standard Proctor
ASTM D 698 Method A
Percent of Compaction N/A
Moisture Range ±% N/A

PROCTOR TEST RESULTS

Max. Dry Density	Optimum Water Content
104.7 pcf	18.2%

ATTERBERG LIMITS (ASTM D-4318)

Liquid Limit	Plastic Limit	Plasticity Index
29	21	8

DESCRIPTION

Dark brown, sandy low plasticity CLAY

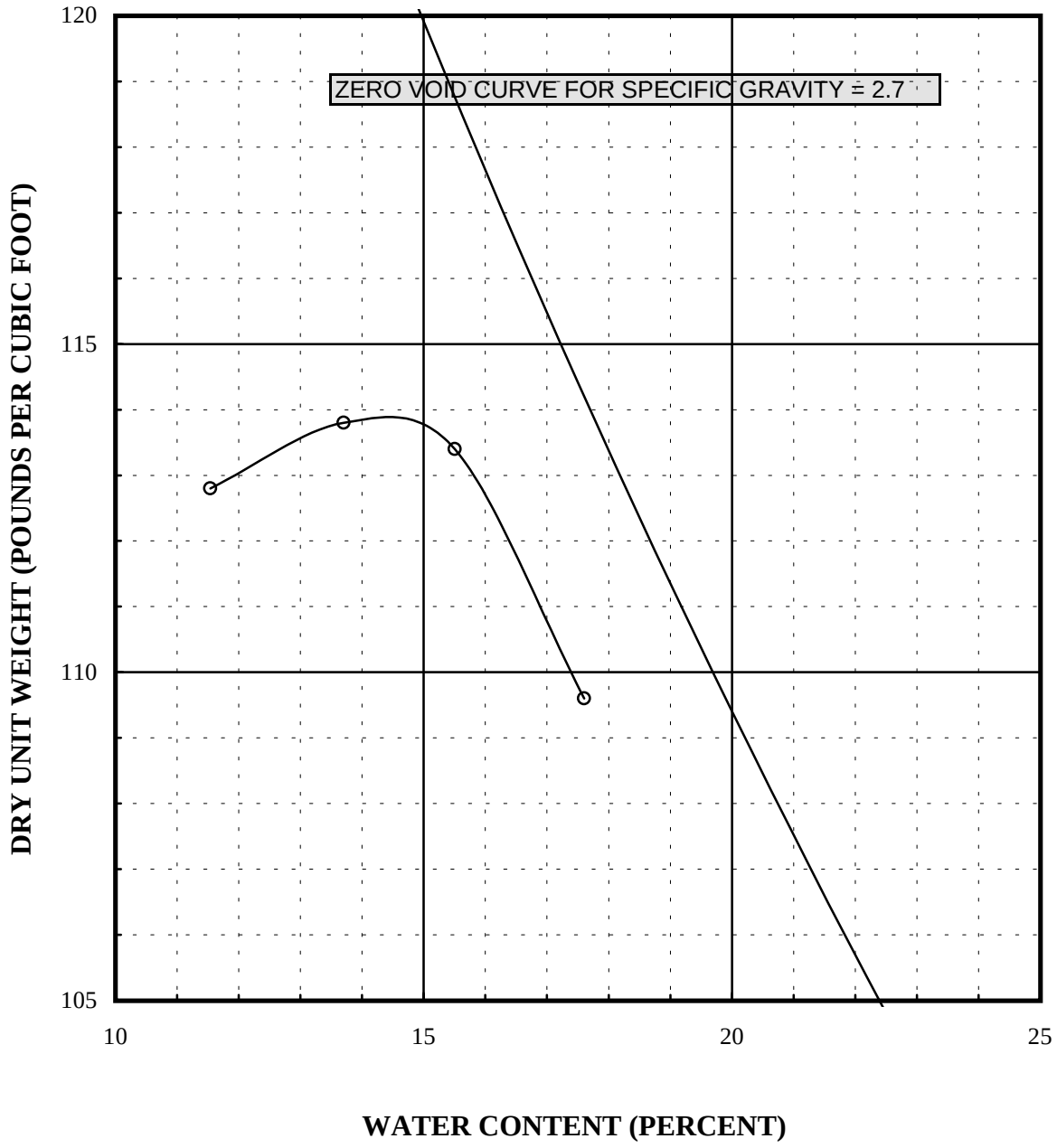
SAMPLE LOCATION

AD 528, 0.8-4.0 feet below grade

GEOTECHNOLOGY, INC.
ENGINEERING AND ENVIRONMENTAL SERVICES
St. Louis, Collinsville, Kansas City

COMPACTION TEST

Job No.	0680806.52KM	**Test Date**	3/4/2005
Sampled By	USCOE	**Tested By**	SD
Sample Date	1/18/2005	**Calc. By**	YAW
Proctor No.	1075	**Ch'd By**	ARK



PROJECT NAME

Argentine Levee Unit – Borrow Area

SPECIFICATIONS

Standard Proctor
ASTM D 698 Method A
Percent of Compaction N/A
Moisture Range ±% N/A

PROCTOR TEST RESULTS

Max. Dry Density	Optimum Water Content
113.9 pcf	14.6%

ATTERBERG LIMITS (ASTM D-4318)

Liquid Limit	Plastic Limit	Plasticity Index
27	17	10

DESCRIPTION

Dark brown clayey SAND

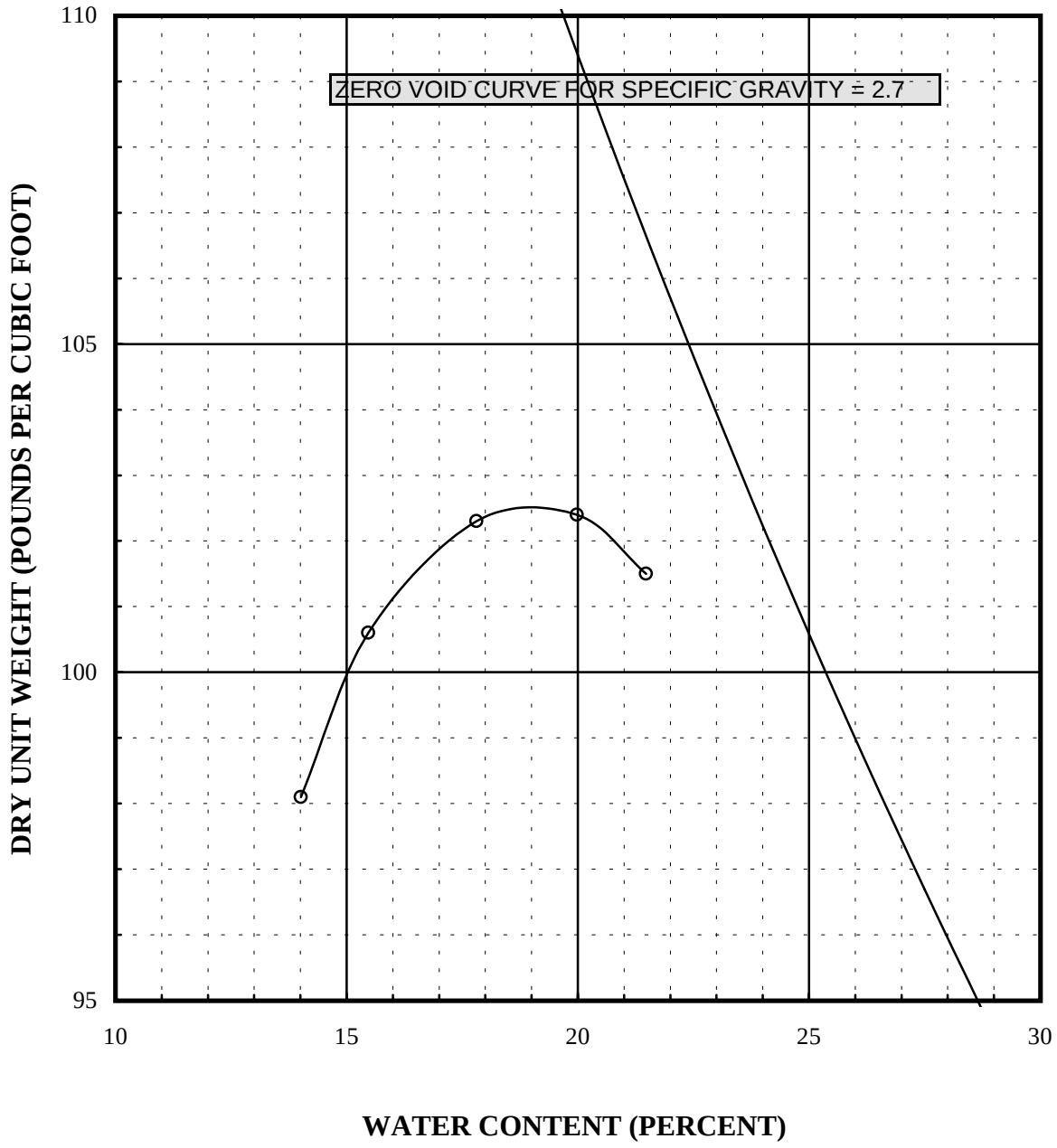
SAMPLE LOCATION

AD 529, 3.0-6.0 feet below grade

GEOTECHNOLOGY, INC.
ENGINEERING AND ENVIRONMENTAL SERVICES
St. Louis, Collinsville, Kansas City

COMPACTION TEST

Job No.	0681901.32KT	**Test Date**	3/7/2005
Sampled By	USCOE	**Tested By**	SD
Sample Date	1/18/2005	**Calc. By**	YAW
Proctor No.	1077	**Ch'd By**	ARK



PROJECT NAME

Argentine Levee Unit – Borrow Area

SPECIFICATIONS

Standard Proctor
ASTM D 698 Method A
Percent of Compaction N/A
Moisture Range ±% N/A

PROCTOR TEST RESULTS

Max. Dry Density	Optimum Water Content
102.5 pcf	19.0%

ATTERBERG LIMITS (ASTM D-4318)

Liquid Limit	Plastic Limit	Plasticity Index
47	19	28

DESCRIPTION

Dark brown sandy low plasticity CLAY

SAMPLE LOCATION

AD 535, , 1.0-4.5 feet below grade

GEOTECHNOLOGY, INC.
ENGINEERING AND ENVIRONMENTAL SERVICES
St. Louis, Collinsville, Kansas City

COMPACTION TEST

Job No.	0681901.32KT	**Test Date**	3/4/2005
Sampled By	USCOE	**Tested By**	SD
Sample Date	1/18/2005	**Calc. By**	YAW
Proctor No.	1076	**Ch'd By**	ARK

LOG OF BORING AD-528

SHEET 1 of 1

US Army Corps of Engineers

Department of the Army
Kansas City District
Corps of Engineers
700 Federal Building
Kansas City, MO 64106

INSTALLATION: Kansas City, Seven Levees
PROJECT: Argentine Levee Unit-Borrow Area
BORING NUMBER: AD-528
LOCATION: Kansas and Missouri
COORDINATES: N 14190735.79, E 1141877.29 ; NAD 83 UTM 15N feet
ELEVATION: 0.0 (ft)
DATE(S) DRILLED: 1/18/05 - 1/18/05

FIELD DATA

DRILLING METHOD(S): Diedrich D-90, 3 3/4" ID hollow stem auger, 3" ID inner barrel sampler

Driller: Mike Cooney Geologist:Jennifer Denzer

GROUNDWATER INFORMATION:
No water encountered during drilling or after. Dry 1/19/05

Water Level during drilling ▼ Water level after drilling

LABORATORY DATA

DEPTH (ft)	DESCRIPTION OF STRATUM	USCS SYMBOL	LIQUID LIMIT (LL)	PLASTIC INDEX (PI)	MOISTURE CONTENT (%)	VG=Visual Grouping FC=Field Classification	OTHER LAB DATA
0	CLAY				29.2	VG5	
0.5	HARD					VG5	
0.8	DRY BROWN frozen GRAVELLY COBBLES MODERATELY HARD GREY decomposed rock LEAN CLAY MEDIUM DAMP - MOIST DARK BROWN	CL	29	8		VG1	
4.6		CL	39	19	25	VG1	
	FINE SAND LOOSE - MEDIUM COMPACT DRY LIGHT BROWN					VG3	
8.4	SILT LOOSE DRY GREY					VG2	
10.0	Bottom of hole - No Refusal Backfilled to surface with cuttings and 3 bags Holeplug						

LEGEND

- Fill (made ground)
- USCS Low Plasticity Clay
- USCS Poorly-graded Sand
- USCS Silt

OTHER LAB DATA: S: Minus 200 Sieve (%); U: Unconfined Compressive Strength (tsf); C: Confining Pressure (psi); F: Failure Strain (%); T: Total Sulfates; P: Soil pH

R: BLOW COUNT REFUSAL = >50 blows/1/2 foot for SPT, > 100 blows for drive barrel
T - TORVANE EQUALLY SPACED ALONG SAMPLE
RC - ROCK CORE RECOVERY
RQD - ROCK QUALITY DESIGNATION

REMARKS: Coordinates Trimble Hand GPS
VG1 - CL(LL=39,PI=19); VG2 - ML; VG3 - SP; VG5 - FILL

LOG OF BORING AD-529

SHEET 1 of 1

US Army Corps of Engineers

Department of the Army
Kansas City District
Corps of Engineers
700 Federal Building
Kansas City, MO 64106

INSTALLATION: Kansas City, Seven Levees
PROJECT: Argentine Levee Unit-Borrow Area
BORING NUMBER: AD-529
LOCATION: Kansas and Missouri
COORDINATES: N 14192413.68, E 1142543.89 ; NAD 83 UTM 15N feet
ELEVATION: 0.0 (ft)
DATE(S) DRILLED: 1/18/05 - 1/18/05

FIELD DATA

DRILLING METHOD(S): Diedrich D-90, 3 3/4" ID hollow stem auger, 3" ID inner barrel sampler

Driller: Mike Cooney Geologist:Jennifer Denzer

GROUNDWATER INFORMATION:
No water encountered during drilling or after. Dry 1/19/05

▽ Water Level during drilling ▼ Water level after drilling

LABORATORY DATA

DEPTH (ft)	SOIL SYMBOL	BREAKS: bb or mb	SAMPLE/DRILL METHOD	BLOWS	T: TORVANE KG/CM SQ	RC: % RQD: % Additional Field Data	DESCRIPTION OF STRATUM	USCS SYMBOL	LIQUID LIMIT (LL)	PLASTIC INDEX (PI)	MOISTURE CONTENT (%)	VG=Visual Grouping FC=Field Classification	OTHER LAB DATA (S: Minus 200 Sieve (%) U: Unconfined Compressive Strength (tsf) C: Confining Pressure (psi) F: Failure Strain (%) T: Total Sulfates P: Soil pH)
0							FINE SAND FROZEN DARK BROWN (1.0)				27.5	VG4	
							FINE SAND LOOSE DRY BROWN (3.0)					VG3	
2													
4							CLAYEY SAND MEDIUM COMPACT DAMP-MOIST DARK BROWN (4.5)	SC	27	10	21.2	VG4	
							CLAY SOFT DAMP DARK BROWN very silty (6.0)				24.9	VG1	
6							FINE SAND LOOSE-MEDIUM DRY-DAMP LIGHT BROWN silty (10.0)					VG3	
8													
10							Bottom of hole - No Refusal Backfilled to surface with cuttings and 3 bags Holeplug						

LEGEND

- USCS Silty Sand
- USCS Poorly-graded Sand
- USCS Clayey Sand
- USCS Low Plasticity Clay

R: BLOW COUNT REFUSAL = >50 blows/1/2 foot for SPT, > 100 blows for drive barrel
T - TORVANE EQUALLY SPACED ALONG SAMPLE
RC - ROCK CORE RECOVERY
RQD - ROCK QUALITY DESIGNATION

REMARKS: Coordinates Trimble Hand GPS
VG1 - CL(LL=39,PI=19); VG3 - SP; VG4 - SM

LOG OF BORING AD-530

SHEET 1 of 1

US Army Corps of Engineers

Department of the Army
Kansas City District
Corps of Engineers
700 Federal Building
Kansas City, MO 64106

INSTALLATION: Kansas City, Seven Levees
PROJECT: Argentine Levee Unit-Borrow Area
BORING NUMBER: AD-530
LOCATION: Kansas and Missouri
COORDINATES: N 14192416.14, E 1143534.5 ; NAD 83 UTM 15N feet
ELEVATION: 0.0 (ft)
DATE(S) DRILLED: 1/12/05 - 1/18/05

FIELD DATA

DRILLING METHOD(S): Diedrich D-90, 3 3/4" ID hollow stem auger, 3" ID inner barrel sampler

Driller: Mike Cooney Geologist:Jennifer Denzer

GROUNDWATER INFORMATION:
No water encountered during drilling or after. Dry 1/19/05

▽ Water Level during drilling ▼ Water level after drilling

LABORATORY DATA

DEPTH (ft)	SOIL SYMBOL	BREAKS: bb or mb	SAMPLE/DRILL METHOD	BLOWS	T: TORVANE KG/CM SQ	RC: % RQD: % Additional Field Data	DESCRIPTION OF STRATUM	USCS SYMBOL	ATTERBERG LIMITS LL	ATTERBERG LIMITS PI	MOISTURE CONTENT (%)	VG=Visual Grouping FC=Field Classification	OTHER LAB DATA
0							SILTY SAND FROZEN DARK BROWN fine grained (1.0)					VG4	
							(1.5)				4	VG3	
2							FINE SAND LOOSE DRY-DAMP BROWN poorly graded (2.5)				20	VG2	
							SILT MEDIUM COMPACT DAMP DARK BROWN (4.3)				11	VG2	
4							SILT MEDIUM COMPACT LIGHT BROWN				25	VG2	
6							SILT MEDIUM COMPACT DAMP GRAYISH BROWN sandy wet zone (8.0)						
8							SILTY SAND MEDIUM COMPACT DAMP LIGHT BROWN laminated fine grained (10.0)					VG4	
10							Bottom of hole - No Refusal Backfilled to surface with cuttings and 3 bags Holeplug						

LEGEND

- USCS Silty Sand
- USCS Poorly-graded Sand
- USCS Silt

R: BLOW COUNT REFUSAL = >50 blows/1/2 foot for SPT, > 100 blows for drive barrel
T - TORVANE EQUALLY SPACED ALONG SAMPLE
RC - ROCK CORE RECOVERY
RQD - ROCK QUALITY DESIGNATION

REMARKS: Coordinates Trimble Hand GPS
VG2 - ML; VG3 - SP; VG4 - SM

OTHER LAB DATA: S: Minus 200 Sieve (%); U: Unconfined Compressive Strength (tsf); C: Confining Pressure (psi); F: Failure Strain (%); T: Total Sulfates; P: Soil pH

LOG OF BORING AD-531

SHEET 1 of 1

US Army Corps of Engineers

Department of the Army
Kansas City District
Corps of Engineers
700 Federal Building
Kansas City, MO 64106

INSTALLATION: Kansas City, Seven Levees
PROJECT: Argentine Levee Unit-Borrow Area
BORING NUMBER: AD-531
LOCATION: Kansas and Missouri
COORDINATES: N 14193052.59, E 1144847.77 ; NAD 83 UTM 15N feet
ELEVATION: 0.0 (ft)
DATE(S) DRILLED: 1/18/05 - 1/18/05

FIELD DATA

DRILLING METHOD(S): Diedrich D-90, 3 3/4" ID hollow stem auger, 3" ID inner barrel sampler

Driller: Mike Cooney Geologist:Jennifer Denzer

GROUNDWATER INFORMATION:
No water encountered during drilling or after. Dry 1/19/05

Water Level during drilling ▼ Water level after drilling

LABORATORY DATA

DEPTH (ft)	SOIL SYMBOL	BREAKS: bb or mb	SAMPLE/DRILL METHOD	BLOWS	T: TORVANE KG/CM SQ	RC: % RQD: % Additional Field Data	DESCRIPTION OF STRATUM	USCS SYMBOL	ATTERBERG LIMITS: LIQUID LIMIT (LL)	ATTERBERG LIMITS: PLASTIC INDEX (PI)	MOISTURE CONTENT (%)	VG=Visual Grouping FC=Field Classification	OTHER LAB DATA (S: Minus 200 Sieve (%) U: Unconfined Compressive Strength (tsf) C: Confining Pressure (psi) F: Failure Strain (%) T: Total Sulfates P: Soil pH)
0							SILTY SAND FROZEN LIGHT BROWN very fine grained (1.0)				14	VG4	
2							LEAN CLAY SOFT-VERY SOFT DAMP DARK BROWN very silty ~ 30-40 % silt (3.5)				22	VG1	
4							SILT LOOSE DRY BROWN with fine sand (4.0)					VG2	
6							SILT MEDIUM COMPACT DAMP BROWN slightly sandy ~ 10-15 % very fine sand (6.5)				25	VG2	
8							FINE SAND MEDIUM COMPACT - LOOSE DAMP-DRY LIGHT BROWN (10.0)					VG3	
10							Bottom of hole - No Refusal Backfilled to surface with cuttings and 3 bags Holeplug						

LEGEND

- USCS Silty Sand
- USCS Low Plasticity Clay
- USCS Silt
- USCS Poorly-graded Sand

R: BLOW COUNT REFUSAL = >50 blows/1/2 foot for SPT, > 100 blows for drive barrel
T - TORVANE EQUALLY SPACED ALONG SAMPLE
RC - ROCK CORE RECOVERY
RQD - ROCK QUALITY DESIGNATION

REMARKS: Coordinates Trimble Hand GPS
VG1 - CL(LL=39,PI=19); VG2 - ML; VG3 - SP; VG4 - SM

LOG OF BORING AD-532

SHEET 1 of 1

US Army Corps of Engineers

Department of the Army
Kansas City District
Corps of Engineers
700 Federal Building
Kansas City, MO 64106

INSTALLATION: Kansas City, Seven Levees
PROJECT: Argentine Levee Unit-Borrow Area
BORING NUMBER: AD-532
LOCATION: Kansas and Missouri
COORDINATES: N 14192422.33, E 1144971.11 ; NAD 83 UTM 15N feet
ELEVATION: 0.0 (ft)
DATE(S) DRILLED: 1/18/05 - 1/18/05

FIELD DATA

DRILLING METHOD(S): Diedrich D-90, 3 3/4" ID hollow stem auger, 3" ID inner barrel sampler

Driller: Mike Cooney Geologist:Jennifer Denzer

GROUNDWATER INFORMATION:
No water encountered during drilling or after. Dry 1/19/05

▽ Water Level during drilling ▼ Water level after drilling

LABORATORY DATA

DEPTH (ft)	SOIL SYMBOL	BREAKS: bb or mb	SAMPLE/DRILL METHOD	BLOWS	T: TORVANE KG/CM SQ	RC: % RQD: % Additional Field Data	DESCRIPTION OF STRATUM	LEGEND	USCS SYMBOL	ATTERBERG LIMITS: LIQUID LIMIT (LL)	ATTERBERG LIMITS: PLASTIC INDEX (PI)	MOISTURE CONTENT (%)	VG=Visual Grouping FC=Field Classification	OTHER LAB DATA (S: Minus 200 Sieve (%) U: Unconfined Compressive Strength (tsf) C: Confining Pressure (psi) F: Failure Strain (%) T: Total Sulfates P: Soil pH)
0							LEAN CLAY MEDIUM MOIST DARK BROWN frozen to 1.0 ft 4.3					26	VG1	
2														
4														
							LEAN CLAY MEDIUM MOIST-WET DARK BROWN silty 6.3					31	VG1	
6														
							SILT MEDIUM COMPACT DRY-DAMP LIGHT BROWN sandy 10.0	USCS Low Plasticity Clay USCS Silt					VG2	
8														
10							Bottom of hole - No Refusal Backfilled to surface with cuttings and 3 bags Holeplug							

R: BLOW COUNT REFUSAL = >50 blows/1/2 foot for SPT, > 100 blows for drive barrel
T - TORVANE EQUALLY SPACED ALONG SAMPLE
RC - ROCK CORE RECOVERY
RQD - ROCK QUALITY DESIGNATION

REMARKS: Coordinates Trimble Hand GPS
VG1 - CL(LL=39,PI=19); VG2 - ML

LOG OF BORING AD-533

SHEET 1 of 1

US Army Corps of Engineers

Department of the Army
Kansas City District
Corps of Engineers
700 Federal Building
Kansas City, MO 64106

INSTALLATION: Kansas City, Seven Levees
PROJECT: Argentine Levee Unit-Borrow Area
BORING NUMBER: AD-533
LOCATION: Kansas and Missouri
COORDINATES: N 14193066.09, E 1145518.24 ; NAD 83 UTM 15N feet
ELEVATION: 0.0 (ft)
DATE(S) DRILLED: 1/18/05 - 1/18/05

FIELD DATA

DRILLING METHOD(S): Diedrich D-90, 3 3/4" ID hollow stem auger, 3" ID inner barrel sampler

Driller: Mike Cooney Geologist:Jennifer Denzer

GROUNDWATER INFORMATION:
No water encountered during drilling or after. Dry 1/19/05

▽ Water Level during drilling ▼ Water level after drilling

LABORATORY DATA

DEPTH (ft)	SOIL SYMBOL	BREAKS: bb or mb	SAMPLE/DRILL METHOD	BLOWS	T: TORVANE KG/CM SQ	RC: % RQD: % Additional Field Data	DESCRIPTION OF STRATUM	USCS SYMBOL	ATTERBERG LIMITS: LIQUID LIMIT (LL)	ATTERBERG LIMITS: PLASTIC INDEX (PI)	MOISTURE CONTENT (%)	VG=Visual Grouping FC=Field Classification	OTHER LAB DATA (S: Minus 200 Sieve (%) U: Unconfined Compressive Strength (tsf) C: Confining Pressure (psi) F: Failure Strain (%) T: Total Sulfates P: Soil pH)
0							LEAN CLAY MEDIUM DAMP DARK BROWN silty 2.3				19	VG1	
2							SILT MEDIUM COMPACT DRY-DAMP LIGHT BROWN with fine-grained sand 4.3				10	VG2	
4							SILT MEDIUM COMPACT DRY-DAMP BROWN with very fine-grained sand 6.0				15	VG2	
6							LEAN CLAY MEDIUM MOIST DARK BROWN with silt 8.0				26	VG1	
8							SILT MEDIUM COMPACT DRY-DAMP LIGHT BROWN with very fine-grained sand 10.0					VG2	
10							Bottom of hole - No Refusal Backfilled to surface with cuttings and 3 bags Holeplug						

LEGEND

USCS Low Plasticity Clay

USCS Silt

R: BLOW COUNT REFUSAL = >50 blows/1/2 foot for SPT, > 100 blows for drive barrel
T - TORVANE EQUALLY SPACED ALONG SAMPLE
RC - ROCK CORE RECOVERY
RQD - ROCK QUALITY DESIGNATION

REMARKS: Coordinates Trimble Hand GPS
VG1 - CL(LL=39,PI=19); VG2 - ML

LOG OF BORING AD-534

SHEET 1 of 1

US Army Corps of Engineers

Department of the Army
Kansas City District
Corps of Engineers
700 Federal Building
Kansas City, MO 64106

INSTALLATION: Kansas City, Seven Levees
PROJECT: Argentine Levee Unit-Borrow Area
BORING NUMBER: AD-534
LOCATION: Kansas and Missouri
COORDINATES: N 14192405.24, E 1145517.16 ; NAD 83 UTM 15N feet
ELEVATION: 0.0 (ft)
DATE(S) DRILLED: 1/19/05 - 1/19/05

FIELD DATA

DRILLING METHOD(S): Diedrich D-90, 3 3/4" ID hollow stem auger, 3" ID inner barrel sampler

Driller: Mike Cooney Geologist:Jennifer Denzer

GROUNDWATER INFORMATION:
No water encountered during drilling or after. Dry 1/19/05

▽ Water Level during drilling ▼ Water level after drilling

LABORATORY DATA

DEPTH (ft)	SOIL SYMBOL	BREAKS: bb or mb	SAMPLE/DRILL METHOD	BLOWS	T: TORVANE KG/CM SQ	RC: % RQD: % Additional Field Data	DESCRIPTION OF STRATUM	LEGEND	USCS SYMBOL	ATTERBERG LIMITS: LIQUID LIMIT (LL)	ATTERBERG LIMITS: PLASTIC INDEX (PI)	MOISTURE CONTENT (%)	VG=Visual Grouping FC=Field Classification	OTHER LAB DATA (S: Minus 200 Sieve (%) U: Unconfined Compressive Strength (tsf) C: Confining Pressure (psi) F: Failure Strain (%) T: Total Sulfates P: Soil pH)
0							LEAN CLAY MEDIUM DAMP DARK BROWN silty					26	VG1	
2														
4							4.0							
							SILT MEDIUM COMPACT WET DARK BROWN clayey					31	VG2	
6							6.0							
							LEAN CLAY SOFT MOIST-WET DARK BROWN silty					35	VG6	
							6.5					28	VG1	
							7.0					16	VG2	
8							LEAN CLAY MEDIUM MOIST-WET DARK BROWN silty	USCS Low Plasticity Clay USCS Silt						
							SILT MEDIUM COMPACT DRY-DAMP LIGHT BROWN with very fine-grained sand							
10							10.0							
							Bottom of hole - No Refusal Backfilled to surface with cuttings and 3 bags Holeplug							

R: BLOW COUNT REFUSAL = >50 blows/1/2 foot for SPT, > 100 blows for drive barrel
T - TORVANE EQUALLY SPACED ALONG SAMPLE
RC - ROCK CORE RECOVERY
RQD - ROCK QUALITY DESIGNATION

REMARKS: Coordinates Trimble Hand GPS
VG1 - CL(LL=39,PI=19); VG2 - ML; VG6 - CL(LL=47,PI=28)

LOG OF BORING AD-535

SHEET 1 of 1

US Army Corps of Engineers

Department of the Army
Kansas City District
Corps of Engineers
700 Federal Building
Kansas City, MO 64106

INSTALLATION: Kansas City, Seven Levees
PROJECT: Argentine Levee Unit-Borrow Area
BORING NUMBER: AD-535
LOCATION: Kansas and Missouri
COORDINATES: N 14193402.93, E 1146504.01 ; NAD 83 UTM 15N feet
ELEVATION: 0.0 (ft)
DATE(S) DRILLED: 1/18/05 - 1/18/05

FIELD DATA

DRILLING METHOD(S): Diedrich D-90, 3 3/4" ID hollow stem auger, 3" ID inner barrel sampler

Driller: Mike Cooney Geologist:Jennifer Denzer

GROUNDWATER INFORMATION:
No water encountered during drilling or after. Dry 1/19/05

▽ Water Level during drilling ▼ Water level after drilling

LABORATORY DATA

DEPTH (ft)	SOIL SYMBOL	BREAKS: bb or mb	SAMPLE/DRILL METHOD	BLOWS	T: TORVANE KG/CM SQ	RC: % RQD: % Additional Field Data	DESCRIPTION OF STRATUM	USCS SYMBOL	ATTERBERG LIMITS: LIQUID LIMIT LL	ATTERBERG LIMITS: PLASTIC INDEX PI	MOISTURE CONTENT (%)	VG=Visual Grouping FC=Field Classification	OTHER LAB DATA (S: Minus 200 Sieve (%) U: Unconfined Compressive Strength (tsf) C: Confining Pressure (psi) F: Failure Strain (%) T: Total Sulfates P: Soil pH)
0							LEAN CLAY SOFT DAMP DARK BROWN silty ~ 10-15% silt	CL CL	47 47	28 28	20	VG6	
2													
4							4.5						
							LEAN CLAY MEDIUM WET DARK BROWN silty				30	VG1	
6							7.5						
8							SILT MEDIUM COMPACT DAMP LIGHT BROWN with very fine-grained sand					VG2	
							8.5						
							FINE SAND LOOSE DRY LIGHT BROWN poorly graded					VG3	
							9.5						
10							SILT MEDIUM COMPACT DAMP-MOIST BROWN sandy					VG2	
							10.0						
							Bottom of hole - No Refusal Backfilled to surface with cuttings and 3 bags Holeplug						

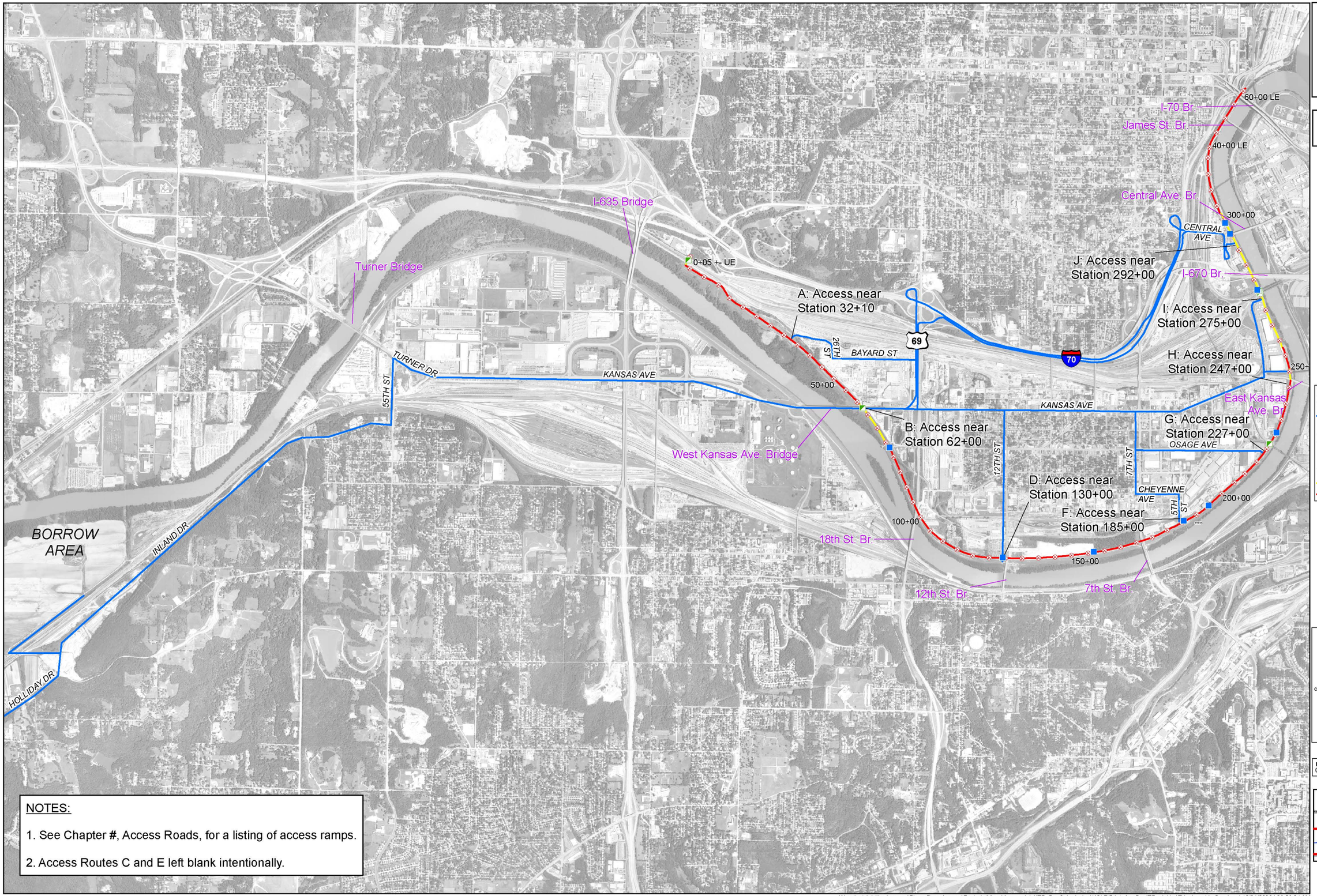
LEGEND

- USCS Low Plasticity Clay
- USCS Silt
- USCS Poorly-graded Sand

R: BLOW COUNT REFUSAL = >50 blows/1/2 foot for SPT, > 100 blows for drive barrel
T - TORVANE EQUALLY SPACED ALONG SAMPLE
RC - ROCK CORE RECOVERY
RQD - ROCK QUALITY DESIGNATION

REMARKS: Coordinates Trimble Hand GPS
VG1 - CL(LL=39,PI=19); VG2 - ML; VG3 - SP; VG6 - CL(LL=47,PI=28)

Exhibit 2: Haul Routes



Kansas Citys, Missouri and Kansas Flood Damage Reduction Project

Feasibility Study

31 JAN 2007

December ITR Submission
Haul Routes and Borrow Area Location

Armourdale Unit

DRAFT
Working document
Not for public release

NOTES:

1. See Chapter #, Access Roads, for a listing of access ramps.

2. Access Routes C and E left blank intentionally.

Exhibit 3
KANSAS CITY'S LEVEE AND FLOODWALL GRAVITY AND UTILITY PIPELINE GUIDANCE

PURPOSE

The purpose of this document is to provide specific guidance during the feasibility phase of the Kansas City's Levee project as to the disposition of existing utilities and drainage structures within the sections of levee and floodwall to be raised. This guidance will be used for the feasibility level of effort in order to develop reasonable costs associated with the modification of drainage structures and the relocation of utilities.

Uplift of utilities within the critical zone of the levee or floodwall will be addressed in accordance with COE criteria. Uplift is not addressed in this KCL guidance.

REFERENCES

	Local Protection – Web page guidance
	Local Protection - Guidebook on web page (Guidance for work Proposed Near or within Federally Constructed Flood Risk Management Projects)
EM 1110-2-1913	Design and Construction of Levees
EM 1110-2-2902	Conduits, Culverts, and Pipes
EM 1110-2-3102	General Principles of Pumping Station Design and Layout
EM 1110-2-3104	Structural and Architectural Design of Pumping Stations
EM 1110-2-3105	Mechanical and Electrical Design of Pumping Stations (Changes 1 of 2)

GRAVITY PIPELINES

Existing pipelines crossing the levee that do not meet current COE criteria shall be replaced with pipelines that are compliant. Existing pipelines that meet current COE criteria shall remain with the following exceptions:

Any Corrugated Metal Pipe (CMP) with a diameter greater than 36" shall be replaced with a minimum diameter 48" Reinforced Concrete Pipe (RCP).

Any pipe inadequate to handle the drainage shall be replaced with a minimum diameter 48" RCP.

Any pipe known to have joints that are not watertight shall be replaced with a minimum diameter 48" RCP.

For new pipe installations, CMP will not be allowed.

Pipe strengths, unless otherwise known, will be assumed to be that required by Corps criteria at the time of their installation. Pipe condition shall be determined by field assessment.

GATEWELLS AND POSITIVE CLOSURES

In areas where levee raises are performed, positive closure will be provided for all drainage and utility lines crossing the levee. EM 1110-2-1913 states that gravity lines that penetrate the embankment or foundation of a levee must be provided with devices to assure positive closure. This criteria also states that gravity lines should be provided with flap-type or slide-type service gates on the riverside of the levee. Because the KS River and MO River are not fast rising rivers, a flap gate will not be recommended on existing outfalls where sluice gates are present but no flap gate. For new outfall structures, however, flap gates will generally be installed.

Emergency means of closure is suggested for gravity lines in addition to the positive closure device. Historically, a flap gate on the end of the pipe has acted as this second closure device. However, it is possible to use sandbags or concrete to fill a gatewell as a means of emergency closure during a flood situation, although this is not the recommended alternative.

All gatewells within the Kansas City Levee study area are considered confined spaces. OSHA regulations and Corp EM 385-1-1 require anyone entering a confined space to comply with specific confined space entry requirements. New or modified gatewells will be designed so that these confined space entry requirements can be met. For example, space will be provided above the gatewell opening so that a tripod can be set to facilitate non-entry rescue.

NON-GRAVITY PIPELINES CROSSING THROUGH OR UNDER LEVEES

It is preferable for all pipes or conduits to cross over the levee rather than penetrate the embankment or foundation materials. This includes pipes carrying fiber optic, pressurized gas or pressurized liquid. Where raises are made to the levee, existing non-gravity pipelines should be relocated over the crest of the new levee raise. See detail “Typical Utility Crossing Levee Raise”. A determination to relocate existing lines will be made on a case-by-case basis.

Pressure pipe

All pipes allowed to penetrate the embankment or foundation of a levee must be provided with devices to assure positive closure. These valves shall be placed in close proximity to the levee and have capability to be closed rapidly to prevent gas or fluid from escaping within or beneath a levee should the pipe rupture within these areas.

Provisions for closure of pressure pipes on the water side must also be provided to prevent backflow of floodwater into the protected area should the pipe rupture.

Casing Pipes, Cased Pipes and Conduits Crossing Through or Under Levees (Telecommunications)

It is preferred that conduits or casing pipes cross up and over the levee. However, where it is not possible to go over the levee, casing pipes or conduits must be installed in accordance with COE criteria. Refer to COE Guidebook located on the KC District website for directional drilling procedures.

ABANDONED PIPELINES

Pipelines, which are currently abandoned and grouted in accordance with COE criteria under or through the levee, will not be disturbed. Pipes that have been abandoned and do not meet criteria or it is unknown if they meet criteria shall be removed or properly abandoned according to COE criteria. Pipelines that are currently active but are to be abandoned as part of this project will be removed or abandoned according to COE criteria.

Removal

For feasibility purposes only, the following guidance is used in determining if an abandoned pipeline will be removed or abandoned in-place in accordance with Corps criteria.

> Where levee heights are less than 10 feet and when an abandoned utility is buried less than 5 feet below the base of the levee, the abandoned utility crossing under the levee should be removed unless special circumstances warrant a different approach.

Exploration Trench

For cost estimating purposes during feasibility, all known pipes are assumed to be located as shown on maps and plans or as located in the field during feasibility site visits.

No exploration trenches will be specified during feasibility. However, it is noted that during PED phase, it may be determined that exploration trenches will be needed during construction in order to find some utilities or to verify that some utilities do not exist as shown on the drawings.

Grouting Abandoned Pipelines

If a pipe does not meet the requirement for removal, the pipe should be properly abandoned by filling with a grout based substance, e.g., cement-bentonite, or flowable fill. The grout or flowable fill mix should be approved by the Corps of Engineers. The grout shall be fluid enough, and pumped in the up-slope direction so that the pipe will be completely filled leaving no voids. Points of access need to be made into the pipe at

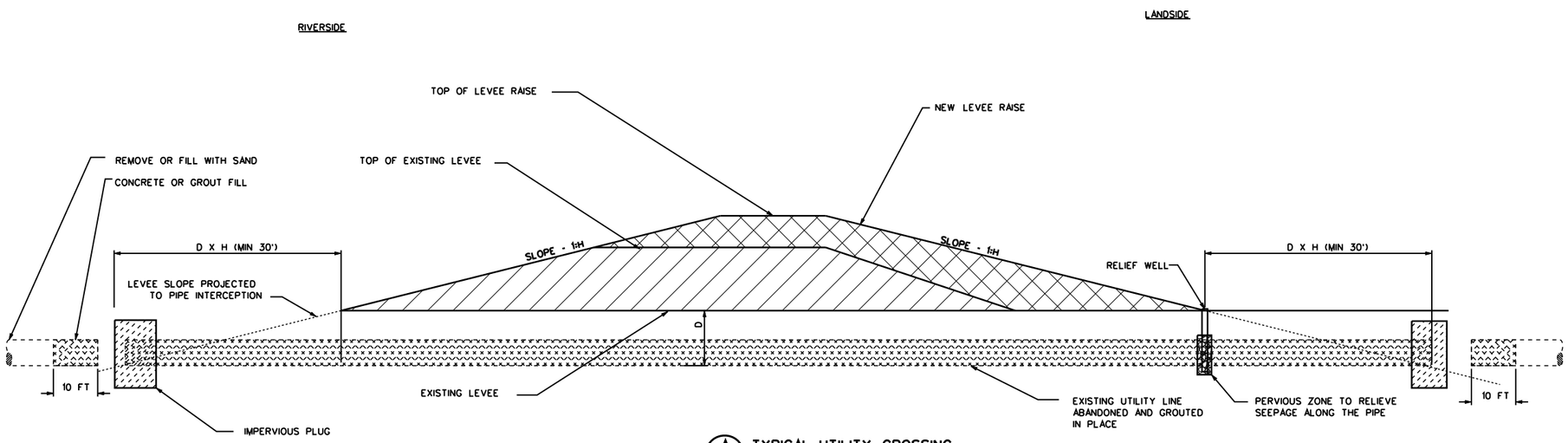
sufficient intervals to accomplish the grouting, see detail "Typical Utility Abandonment" for additional details regarding abandoning a utility in place.

OTHER CONSIDERATIONS

Special consideration will be given to existing pipe crossings on a case-by-case basis when hazardous, toxic, and radioactive waste (HTRW) concerns or real estate issues exist. HTRW concerns exist in various locations along the Kansas City Seven Levee system. When it is not desirable to disturb the existing ground due to HTRW concerns, the final recommendation for removing/relocating an existing utility will weigh the risks involved with disturbing the ground against leaving an existing utility in place. When real estate issues exist, the final recommendation will consider how real estate is affected.

SUMMARY OF RECOMMENDATIONS

For sections of levee or floodwall to be raised or modified, current Corps requirements will be extended to all components of that levee section, including any pipes and closure structures therein. When it is not practical to meet Corps requirement, each utility will be evaluated on a case-by-case basis.



A TYPICAL UTILITY CROSSING

SCALE: NTS

NOTES:
1. THE PREFERENCE IS TO REMOVE PIPES LOCATED IN OR UNDER THE LEVEE. IF NOT FEASIBLE, THIS DETAIL SHOULD BE ADHERED TO UNLESS APPROVED OTHERWISE. THIS DETAIL IS FEASIBILITY LEVEL DETAIL AND WILL REQUIRE ADDITIONAL INFORMATION FOR PED.

US Army Corps of Engineers
Kansas City District

Symbol	Description	Date	Appr.

Date: DECEMBER 2006
Drawing code: X
Plot scale: NA
CADD File Name: UTILCROSSINGDETAIL V8

Designed by: MRC
Drawn by: MRC
Checked by: HWM
Submitted by: HWM

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
KANSAS CITY, MISSOURI

KANSAS CITY LEVEES
FEASIBILITY STUDY PHASE 2
ARMOURDALE

TYPICAL UTILITY
ABANDONMENT - LEFT IN PLACE

Sheet Reference Number:
XX

Exhibti 4:Armordale Utility Crossings: Inventory and Action for N500+3 Raise

Armourdale Utility Crossings: Inventory and Action for N500+3 Raise
Created by: Melissa Corkill
Peer Reviewed by: Hank Mildenberger

DRAFT

Date: 23-Aug-2006
Modified: 02-Mar-2007

UTILITY IDENTIFICATION			UTILITY CROSSING GENERAL INFORMATION AND RECOMMENDED ACTION FOR N500+3 RAISE								
Station (ft.)	Conduit Size	Conduit Function	Flow Direction	Flow Type	Conduit Composition	Conduit Length Below Flood Protection (ft.) Existing Conditions	Control Structure Type	Depth below existing levee crest (ft)	Owner/ Compensable	Comments	Action
-9+63 (0+75 UE)	36"	City: San. Sewer Force Main	Riv to Land	Pressure	DIP	Under Floodwall	Valve	17' / Invert Elev. = 757		Structure is part of RR closure gap. Forcemain is buried about 2.5' to 3' below grade outside of levee/floodwall	Relocate forcemain around the stop log gap/high ground tie-in. Gatewell structure and valve should be located at highpoint of line to allow positive closure of pipeline. Remove the abandoned part of the forcemain between existing stop log structure and riverside of new stop log structure. Fill gatewell and pipe within gatewell with flowable fill.
-4+58 (5+80 UE)	*	Fiber Optic	NA	NA	*	200	None - NA	0.5"		2 cables	Relocate fiber optic lines up and over levee. Remove abandoned fiber optic.
7+50 UE	24"	Storm Sewer	Land to Riv	Gravity	RCP	100	Sluice and Flap	Invert Elev 755.9			No Action. SEE STRUCTURAL EVALUATION
12+79 UE	12'x8'	Storm Sewer	Land to Riv	Gravity	RCB	150	Sluice	25' below levee		Drains Matoon Creek, Riverside Gatewell Structure	No Action. SEE STRUCTURAL EVALUATION
4+93 (15+33 UE)	8'x8'	Storm Sewer	Land to Riv	Gravity	*	150	Sluice and Flap	Elev ~740			No Action. SEE STRUCTURAL EVALUATION
28+22	6"	Sand Pipe	NA	*	SP	30	None	~4.5' / Elev 769		American Sand Company -- Pipe Abandoned	Find and Remove
28+30	18"	Sand Pipe	NA	*	SP	30	None	~ 5' / Elev 768.5		American Sand Company -- Pipe Abandoned	Find and Remove
28+33	6"	Sand Pipe	NA	*	SP	30	None	~ 4.5' / Elev 769		American Sand Company -- Pipe Abandoned	Find and Remove
32+80	42"	Storm Sewer	Land to Riv	Gravity	RCP	80	Sluice and Flap	33' / Invert Elev 750		Installed 1980	SEE STRUCTURAL EVALUATION
41+45	48"	San. Sewer Force Main	NA	Pressure	CIP	240	Valve	30' / Invert Elev 740		Removed	No Action
52+45	3"	Water for Proctor and Gamble Fire Testing Area	Land to Riv	Pressure	DIP	120	Post Indicator Valve	4' below levee crest		Pipe is uncovered along portions of the riverside levee.	Relocate up and over floodwall. Water line is not used every day or every week. Remove abandoned line once line is relocated.
58+44	36"	Storm Sewer	Land to Riv	Gravity	RCP w/ Steel Liner	140	Gate Valve and Flap	20' - 27'		Abandoned. Once used to drain cooling water from Proctor & Gamble	Find and Grout
61+81	36"	Storm Sewer	Land to Riv	Gravity	CIP	200	Gate Valve and Flap	23'		Abandoned. Proctor & Gamble used to drain cooling water	Find and Grout

UTILITY IDENTIFICATION			UTILITY CROSSING GENERAL INFORMATION AND RECOMMENDED ACTION FOR N500+3 RAISE								
62+10	18"	Sanitary Sewer	NA	Gravity	SP	50	*	16'		Abandoned	Remove (as long as floodwall is replaced with levee)
62+10	24"	Gas	NA	Pressure	SP	Above Floodwall	NA	Above Floodwall		On Kansas Avenue Bridge	No Action
62+10	24"	Gas	NA	Pressure	SP	Under Floodwall	Gate	15' / Elev 758.1		Abandoned. Located under former stop log gap used prior to KS Ave. Bridge Installation. No info on removal but KGE replaced with line on bridge.	Remove (as long as floodwall is replaced with levee)
62+65	12"	Water	NA	Pressure	SP	Above Floodwall	NA	Above Floodwall		On Kansas Avenue Bridge	No Action
62+65	10"	Water	NA	Pressure	SP	Under Floodwall	*	Elev 758.7		Abandoned	Remove (as long as floodwall is replaced with levee)
62+70	6"	Fiber Optic	NA	Electrical	Duct	Above Floodwall	NA	1" Above Floodwall		Near Kansas Avenue Bridge	Relocate over floodwall raise
64+71	42"	Storm Sewer	Land to Riv	Gravity	RCP	Under Floodwall	Sluice and Flap	30' / Invert Elev 742		Drainage Structure adjacent to floodwall	No Action. SEE STRUCTURAL EVALUATION
75+12	48"	KAW PP Recirculation Line	*	Gravity	RCP	160 (floodwall)	Power Plant Process Controls Flow of Water through Pipe	15' to 20'/Centerline Elev 751.7		KAW Power Plant	Remove 48" line from sealing weir to landside toe of levee and continue removal under levee/floodwall to the intake structure. Do not re-establish utility.
75+22	6"	KAW PP Intake Water	*	Pressure	SP	160 (floodwall)	*	18' below floodwall top		KAW Power Plant	Remove pipe. Do not re-establish utility.
75+32	72"	KAW PP Intake Influent #1	Riv to Land	Pressure	RCP	160 (floodwall)	Power Plant Intake Pumps Control Flow of Water through pipe	25' to 30' below floodwall top		KAW Power Plant	Remove pipe. Do not re-establish utility.
75+45	3"	KAW PP Intake Chlorine	*	*	SP or PVC	160 (floodwall)	*	8' to 11' below floodwall top		KAW Power Plant	Remove pipe. Do not re-establish utility.
75+50	1" OR 2"	KAW PP Intake Gas	Land to Riv	Pressure	SP	160 (floodwall)	*	18" below floodwall top		KAW Power Plant	Remove pipe. Do not re-establish utility.
75+50	4"	KAW PP Conduit	NA	Electrical	PVC	160 (floodwall)	NA	8' to 11' below floodwall top		KAW Power Plant	Remove conduit. Do not re-establish utility.
75+62	17"W X 43"H	KAW Power Plant Electrical	NA	Electrical	DUCT	160 (floodwall)	NA	8' below floodwall top		KAW Power Plant - Duct has 12-4" inner ducts	Remove duct bank. Do not re-establish utility
75+89	72"	KAW PP Intake Influent #2	Riv to Land	Pressure	RCP	160 (floodwall)	Power Plant Intake Pumps Control Flow of Water through Pipe	27' to 32' below floodwall top		KAW Power Plant	Remove pipe. Do not re-establish utility.

Armourdale Utility Crossings: Inventory and Action for N500+3 Raise
Created by: Melissa Corkill
Peer Reviewed by: Hank Mildenberger

DRAFT

Date: 23-Aug-2006
Modified: 02-Mar-2007

UTILITY IDENTIFICATION			UTILITY CROSSING GENERAL INFORMATION AND RECOMMENDED ACTION FOR N500+3 RAISE								
75+90	2"	Water Emergency	Land to Riv	Pressure	SP	160 (floodwall)	Valve	4' to 9' below floodwall top		Normally not under pressure	Remove pipe. Do not re-establish utility.
76+83	72"	Osage Pump Plant Outfall	Land to Riv	SEE PUMP STATION EVAL.	RCP	NA	Sluice and Drop Leaf	30+ below levee			SEE STRUCTURAL EVALUATION AND PUMP PLANT EVALUATION - Reconnect discharge pipes through cutoff wall
79+60	84"	KAW PP Discharge	Land to Riv	Gravity	RCP	180	Sluice Gate	40+ below levee			Grout from seiling weir to drainage structure. Remove from drainage structure to outfall.
79+80	60"	KAW PP Discharge	Land to Riv	Gravity	RCP	180	Sluice Gate	40+ below levee			Grout from seiling weir to drainage structure. Remove from drainage structure to outfall.
81+07	2.5" in 4"	Calcium Carbonate	NA	*	SP in SP	150	*	20' below levee		Abandoned. Discharged to KAW PP discharge headwall area	Find and Grout
90+79	30"	Sanitary Sewer (Inverted)	Riv to Land	Gravity	DIP	125	Sluice Gate	40' below levee	City of KCK		No Action. SEE STRUCTURAL EVALUATION
91+76	30"	Storm Sewer	Land to Riv	Gravity	CIP	125	Sluice and Flap	40' below levee			No Action. SEE STRUCTURAL EVALUATION
99+63	4"	Discharge Line	Land to Riv	Gravity	SP	150	*	6' below levee	Private	Could not located outfall or inlet source. Likely abandoned	Find and Remove
108+95	42"	Sanitary Sewer	Riv to Land	Gravity	RCP	NA	Sluice Gate (Riverside)	40'+ below levee	City of KCK	Argentine Inter. River Crossing, 42" through levee, 30" under River	No Action. SEE STRUCTURAL EVALUATION
127+20	24"	Potable Water	NA	Pressure	CIP	120	Gate Valve	22' below levee	BPU	Abandoned but no appearance of being grouted	Grout line and valve pit. Fill pipe on riverside of levee with sand.
129+20	5'X6'	12th St. Pump Plant Outfall	Land to Riv	SEE PUMP STATION EVAL.	RCB	120	Sluice Gate	Gravity: 30' to 40' below levee			No Action. SEE STRUCTURAL EVALUATION
129+20	20" x 2	12th St. Pump Plant Outfall	Land to Riv	SEE PUMP STATION EVAL.	DIP	120	NA	Elev 767.2 (~3')		These two lines are the pump station pressurized discharge lines that are routed over the levee into the gatewell	Relocate pressure discharge pipe up and over levee. And remove abandoned lines from pump station to gatewell.
129+60	72"	12th St. Storm Sewer	Land to Riv	Gravity	BRICK	60	*	*		Plugged and filled with impervioius or pervious mateiral. Brick sewer for 12th Street PS area. Not Active.	No Action
156+75	6'X8'	Mill St. Pump Plant Outfall	Land to Riv	SEE PUMP STATION EVAL.	RCB	120	Sluice Gate	30' to 40' below levee		Riverside gatewell	No Action. SEE STRUCTURAL EVALUATION
156+75	20" x 2	Mill St. Pump Plant Outfall	Land to Riv	SEE PUMP STATION EVAL.	DIP	120	NA			These two lines are the pump station pressurized discharge lines that are routed over the levee into the gatewell	Relocate pressure discharge pipe up and over levee. And remove abandoned lines from pump station to gatewell.
172+05	12"	KS Gas	NA	Pressure	APCS	NA	NA	NA		Routed over levee on 7th Street bridge	No Action

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UTILITY IDENTIFICATION			UTILITY CROSSING GENERAL INFORMATION AND RECOMMENDED ACTION FOR N500+3 RAISE								
185+70	72"	5th St. Pump Plant Outfall	Land to Riv	SEE PUMP STATION EVAL.	RCP	120	Sluice and Flap	40' below levee	City of KCK		No Action. SEE PUMP PLANT EVALUATION
186+74	30"	Sanitary Sewer	Riv to Land	Gravity	DIP	100	Sluice Gate	44' below ground		Greystone Heights Sewer River Crossing	No Action. SEE STRUCTURAL EVALUATION
194+60	18" and 12"	Midwest Cold Storage Pump Plant Outfall	Land to Riv	SEE PUMP STATION EVAL.	CIP and CIP	100	Sluice and Flap	18" Invert ~740 12" Invert ~746		Pump Plant abandoned. These two lines parallel each other, one 6' above the other and connect the landside and riverside levee.	Grout in both pipes but during PED confirm if the 12" line is still connected and in use by Midwest Cold Storage.
212+76	24"	Storm Sewer	Land to Riv	Gravity	CIP	120	Sluice and Flap	30' below levee			No Action. SEE STRUCTURAL EVALUATION
220+64	24	Storm Sewer	Land to Riv	Gravity	CIP	120	Sluice and Flap	30'+ below levee			No Action. SEE STRUCTURAL EVALUATION
230+77	7.5' X 7.5'	Shawnee Ave Pump Plant Outfall	Land to Riv	SEE PUMP STATION EVAL.	RCB	110	2 Sluice and 2 Flap	35' below levee			No Action. SEE PUMP PLANT EVALUATION
231+38.91	57"	Storm Sewer	Land to Riv	Gravity	Concrete	100	None	30' below levee		Plugged at both ends but could not find.	Find and Grout
240+73	48"	Storm Sewer	Land to Riv	Gravity	RCP	110	Sluice and Flap	30'+ below levee			No Action. SEE STRUCTURAL EVALUATION
244+70	24"	Storm Sewer	Land to Riv	Gravity	CIP	90	Sluice and Flap	25' below levee			No. Action. SEE STRUCTURAL EVALUATION
246+53	30"	Storm Sewer Forcemain	Land to Riv	Pressure	CIP	100	Valve and Flap	30' below levee		Termination of Railroad Storm Force Main	No Action. Pipe may freeze if routed over floodwall. If levee is placed here then should consider routing up and over. SEE STRUCTURAL EVALUATION
250+31	12"	Storm Sewer	Land to Riv	Gravity	CIP	118	Gate Valve and Flap	25' below floodwall top			No Action
253+43	12"	Storm Sewer	Land to Riv	Gravity	CIP	118	Gate Valve and Flap	25' below levee		Abandoned and Grouted	No Action
256+71	12"	Storm Sewer	Land to Riv	Gravity	CIP	100	Gate Valve and Flap	25' below levee		Abandoned	Grout Pipe and Fill Gatewell
260+00	30"	Storm Sewer	Land to Riv	Gravity	CIP	100	Gate Valve and Flap	30'+ below floodwall top			No Action. SEE STRUCTURAL EVALUATION
260+84	12"	Storm Sewer	Land to Riv	Gravity	CIP	40	Gate Valve and Flap	25' below floodwall top		Abandoned	Grout Pipe and Fill Gatewell
262+89	12"	Storm Sewer	Land to Riv	Gravity	CIP	50	Gate Valve and Flap	25' below floodwall top			No Action. SEE STRUCTURAL EVALUATION
266+76	16"	Storm Sewer	Land to Riv	Gravity	CIP	70	Sluice and Flap	25' below floodwall top			No Action. SEE STRUCTURAL EVALUATION
276+00	NA	Fiber Optic	NA	NA	NA	NA	NA	NA			Relocate over floodwall raise
276+79	42"	Kansas City Southern Pump Plant Outfall	Land to Riv	SEE PUMP STATION EVAL.	CIP	80	Sluice and Flap	35' below floodwall top		Slot Area	No Action. SEE STRUCTURAL EVALUATION AND PUMP STATION EVALUATION.
281+50	42"	Storm Sewer	Land to Riv	Gravity	RCP	110	Sluice and Flap	35' below floodwall top			No Action. SEE STRUCTURAL EVALUATION
286+59	24"	PBI Gordon Pump Plant Gravity Storm Flow	Land to Riv	SEE PUMP STATION EVAL.	CIP	110	Sluice and Flap	30'+ below floodwall top		Pipe under floodwall through piles	No Action. SEE STRUCTURAL EVALUATION

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Created by: Melissa Corkill
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Date: 23-Aug-2006
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UTILITY IDENTIFICATION			UTILITY CROSSING GENERAL INFORMATION AND RECOMMENDED ACTION FOR N500+3 RAISE								
286+59	6"	PBI Gordon Pump Plant Discharge Pipe	Land to Riv	SEE PUMP STATION EVAL.	*					6" discharge through floodwall.	SEE STRUCTURAL EVALUATION AND PUMP PLANT EVALUATION. Relocate 6" discharge up and over floodwall. Fill in abandoned pipe through floodwall.
290+52	24"	Storm Sewer	Land to Riv	Gravity	CIP	110	Sluice and Flap	30'+ below floodwall top		Located under piles	No Action. SEE STRUCTURAL EVALUATION
295+45	18"	Storm Sewer	Land to Riv	Gravity	RCP	*	Sluice Gate	25' below floodwall top		Landside Gatewell is at grade located west of pump station	No Action. SEE STRUCTURAL EVALUATION
295+52	24"	National Beef Pumping Plant / KCK Pump Plant / (Central Ave. PP - KVDD)	Land to Riv	SEE PUMP STATION EVAL.	CIP	90	Sluice and Flap	30' below floodwall top	City of KCK	10" pump discharge penetrates floodwall	PENDING PUMP STATION EVALUATION
295+79	2"	National Beef Pumping Plant / KCK Pump Plant / (Central Ave. PP - KVDD)	Land to Riv	Pressure	SP	Through floodwall	Valve	8' below floodwall top		Plug at both ends. Exposed on riverside of floodwall. Buried on landside of floodwall	PENDING PUMP STATION EVALUATION
295+80	10"	National Beef Pumping Plant / KCK Pump Plant / (Central Ave. PP - KVDD)	Land to Riv	*	CIP	Through floodwall	Flap and Valve	8' below floodwall top		Exposed on riverside of floodwall. Buried on landside of floodwall	PENDING PUMP STATION EVALUATION
299+20	3"	Central Ave. Pumping Plant - Sump Pump	Land to Riv	SEE PUMP STATION EVAL.	CIP		Gate Valve	10' below floodwall top		Discharge is through wall	PENDING PUMP STATION EVALUATION
299+20	2-14"	Central Ave. Pump Plant - Discharge	Land to Riv	SEE PUMP STATION EVAL.	CIP		2 gate valves and 2 flap gates	10' below floodwall top		Discharge is through wall	PENDING PUMP STATION EVALUATION
311+11	7.5' X 7.5'	Storm Sewer	Land to Riv	Gravity	RCB	90	Sluice Gate	33	City of KCK		No Action. SEE STRUCTURAL EVALUATION
315+10	5' X 4'	Storm Sewer	Land to Riv	Gravity	RCB	80	Sluice Gate	25			No Action. SEE STRUCTURAL EVALUATION
324+58 (41+45 LE)	48"	Sanitary Force Main	Land to Riv	Pressure	CIP	180	Gate Valve (Riverside)	18	City of KCK	Armourdale Interceptor	No Action. SEE STRUCTURAL EVALUATION
328+18 (45+05 LE)	42"	Storm Sewer/Sanitary Sewer	Land to Riv	Gravity	CMP	60	Unknown	16		Existing conditions: Drains high ground. With levee raise, will need new pipe and closure structure. This is also a CSO.	No Action: No longer part of protected area
329+35 (46+22 L.E.)	24"	Storm Sewer	Land to Riv	Gravity	CMP	50	Flap Gate	5		Existing conditions: Drains high ground. With levee raise, will need new pipe and closure structure	No Action: No longer part of protected area
50+00	8"	KS Gas	NA	Pressure	APCS	NA	NA	NA		Routed over levee on bridge	No Action
334+08 (50+ 95 LE)	24"	Storm Sewer	Land to Riv	Gravity	CMP	100	Flap Gate	5			No Action: No longer part of protected area
334+83 (51+70 L.E.)	12"	Spring Sump Drain	Land to Riv	Gravity	*	40	NA	NA		Spring Sump Drain - Located on Riverside of Levee and does not cross levee	No Action

Armourdale Utility Crossings: Inventory and Action for N500+3 Raise
Created by: Melissa Corkill
Peer Reviewed by: Hank Mildenberger

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Date: 23-Aug-2006
Modified: 02-Mar-2007

UTILITY IDENTIFICATION			UTILITY CROSSING GENERAL INFORMATION AND RECOMMENDED ACTION FOR N500+3 RAISE								
339+54 (56+41 L.E)	24"	Storm Sewer	Land to Riv	Gravity	CMP	100	Flap Gate	5		Existing conditions: Drains high ground. With levee raise, will need new pipe and closure structure	No Action: No longer part of protected area
339+63 (56+60 LE)	1 - 36"	Sanitary Force Main	Land to Riv	Pressure	DIP	NA	1 Gate Valve	NA		River crossing: Armourdale Forcemain and Fairfax Forcemain. Armourdale crossed unit at 41.45 LE	No Action
340+49 (57+36 LE)	12"	Storm Sewer	Land to Riv	Gravity	CMP	50	Flap Gate	4		Possibly Plugged. Historical conditions: Drained high ground. With levee raise, will need closure structure if still in use	No Action: No longer part of protected area
341+43 (58+30 LE)	25" X 16"	Storm Sewer	Land to Riv	Gravity	CMP Arch	100	NA	6		Plugged	No Action: No longer part of protected area
343+59 (60+45 LE)	25" X 16"	Storm Sewer	Land to Riv	Gravity	CMP Arch	75	Flap Gate	5		Existing conditions: Drains high ground. With levee raise, will need new pipe and closure structure	No Action: No longer part of protected area
LE		Oxygen		Pressure					Praxair	Oxygen line	No Action: No longer part of protected area

Table Legend and Notes

*	Information not found
APCS	Anode Protected Coated Steel
CIP	cast iron pipe
CMP	corrugated metal pipe
DIP	ductile iron pipe
DS	Drainage Structure
FW	Floodwall
Land to Riv	Landside to Riverside
LEV	Levee
NA	Not Applicable
OH	Overhead utility (does not penetrate flood protection)
PP	Pump Plant
RCB	Reinforced Concrete Box
RCP	Reinforced Concrete Pipe
Riv to Land	Riverside to Landside
SL	Stop Log Gap
SP	steel pipe

All Drainage Structures that say No Action, mean there is no action recommended for utility outlet relocation.
Structural or pumping analysis may indicate other recommendations and should be referred to for gatewell structural analysis

Direction of Flow for sanitary sewers was obtained from Wyandotte County Sewer AutoCad files

All elevations presented in this spreadsheet are based on NGVD 29

Armourdale Utility Crossings: Inventory and Action for N500+3 Raise
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UTILITY IDENTIFICATION			CASE BY CASE REVIEW MEETING WITH LOCAL PROTECTION SECTION: NOTES FOR EACH UTILITY CROSSING
Station (ft.)	Conduit Size	Conduit Function	Case-by-Case Review Conducted Feb. 20, 2007, See meeting minutes for general recommendations. Where Feb 26 meeting over rides Feb 20 recommendations, it is so noted at the end of the comment.
-9+63 (0+75 UE)	36"	City: San. Sewer Force Main	FEB 20: Reroute forcemain around the stop log gap/high ground tie-in. This would essentially be up and over line of protection. Gatewell structure and valve should be located at the highpoint of line to allow positive closure of pipeline as well as provide a siphon breaker. Will need to remove the abandoned part of the forcemain between existing stop log structure and riverside of new stop log structure. Fill gatewell and pipe within gatewell with flowable fill up to the ground surface.
-4+58 (5+80 UE)	*	Fiber Optic	FEB 20: Reroute fiber optic lines up and over levee. Remove abandoned fiber optic
7+50 UE	24"	Storm Sewer	FEB 20: OK
12+79 UE	12'x8'	Storm Sewer	FEB 20: It is OK that there is no flap gate on this discharge line. The primary closure device is the sluice gate, the emergency closure can be to fill the gatewell with sand.
4+93 (15+33 UE)	8'x8'	Storm Sewer	FEB 20: OK
28+22	6"	Sand Pipe	FEB 20: During construction, investigate on the riverside of the levee by digging a trench to 1 foot below the recorded depth of the pipes and 10' either side of the recorded station of the pipe. Remove piping believed to be about 50' long. Backfill trench. If pipe is not encountered at expected depth, contractor shall consult with COE.
28+30	18"	Sand Pipe	FEB 20: During construction, investigate on the riverside of the levee by digging a trench to 1 foot below the recorded depth of the pipes and 10' either side of the recorded station of the pipe. Remove piping believed to be about 50' long. Backfill trench. If pipe is not encountered at expected depth, contractor shall consult with COE.
28+33	6"	Sand Pipe	FEB 20: During construction, investigate on the riverside of the levee by digging a trench to 1 foot below the recorded depth of the pipes and 10' either side of the recorded station of the pipe. Remove piping believed to be about 50' long. Backfill trench. If pipe is not encountered at expected depth, contractor shall consult with COE.
32+80	42"	Storm Sewer	FEB 20: OK
41+45	48"	San. Sewer Force Main	FEB 20: OK
52+45	3"	Water for Proctor and Gamble Fire Testing Area	FEB 20: Once line is relocated, remove old line from its riverside end point to the landside tie-in point.
58+44	36"	Storm Sewer	FEB 20: Because this line is deep, grout in the pipe beneath the footprint of the levee, construct an impervious cut-off area at the toe of the levee on the riverside, install a vertical drain on the landside toe of the levee if the bedding material warrants or can't be inspected. FEB 26: See meeting minutes and detail for additional information
61+81	36"	Storm Sewer	FEB 20: Because this line is deep, grout in the pipe beneath the footprint of the levee, construct an impervious cut-off area at the toe of the levee on the riverside, install a vertical drain on the landside toe of the levee if the bedding material warrants or can't be inspected. FEB 26: See meeting minutes and detail for additional information

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UTILITY IDENTIFICATION			CASE BY CASE REVIEW MEETING WITH LOCAL PROTECTION SECTION: NOTES FOR EACH UTILITY CROSSING
62+10	18"	Sanitary Sewer	FEB 20: Because this line is deep, grout in the pipe beneath the footprint of the levee, construct an impervious cut-off area at the toe of the levee on the riverside, install a vertical drain on the landside toe of the levee if the bedding material warrants or can't be inspected, FEB 26: Remove pipeline since this floodwall is being replaced with a levee and the line is not that deep below the footing of the floodwall.
62+10	24"	Gas	OK
62+10	24"	Gas	FEB 20: Because this line is deep, grout in the pipe beneath the footprint of the levee, construct an impervious cut-off area at the toe of the levee on the riverside, install a vertical drain on the landside toe of the levee if the bedding material warrants or can't be inspected, FEB 26: Remove pipeline since this floodwall is being replaced with a levee and the line is not that deep below the footing of the floodwall.
62+65	12"	Water	OK
62+65	10"	Water	FEB 20: Because this line is deep, grout in the pipe beneath the footprint of the levee, construct an impervious cut-off area at the toe of the levee on the riverside, install a vertical drain on the landside toe of the levee if the bedding material warrants or can't be inspected, FEB 26: Remove pipeline since this floodwall is being replaced with a levee and the line is not that deep below the footing of the floodwall.
62+70	6"	Fiber Optic	OK
64+71	42"	Storm Sewer	OK
75+12	48"	KAW PP Recirculation Line	FEB 20: On the landside, remove the 48" line from the sealing weir to the landside toe of the levee. (about 440' of removal). Grout in the line under the floodwall up to within 20' of the intake structure with excavatable flowable fill so that when the slurry wall is installed it cuts through the pipe and the flowable fill. (about 180' of flowable fill) On the riverside, remove the pipe from intake structure back about 20'. FEB 26: Remove 48" line from the seiling weir all the way to the intake structure (640').
75+22	6"	KAW PP Intake Water	FEB 20: Grout in the line under the floodwall with excavatable flowable fill so that when the slurry wall is installed it cuts through the pipe and the flowable fill (about 180' of grout). On the riverside, remove the pipe from the intake structure back about 20'. FEB 26: Remove pipeline since the floodwall is being replaced with a new floodwall and the pipe is not too deep.
75+32	72"	KAW PP Intake Influent #1	FEB 20: Grout in the line under the floodwall up to within 20' of the intake structure with excavatable flowable fill so that when the slurry wall is installed it cuts through the pipe and the flowable fill. (about 180' of flowable fill) On the riverside, remove the pipe from intake structure back about 20'. On the landside, fill with grout or remove within the critical zone. This critical zone removal suggestion will likely not be possible. Should revisit. FEB 26: Remove pipe landside of levee to intake structure.
75+45	3"	KAW PP Intake Chlorine	FEB 20: Remove utility within the footprint of the levee. Will likely not have to remove outside of levee footprint. FEB 26: Remove utility from landside of levee to intake structure. If the pipe also runs along the landside toe, may need to remove.
75+50	1" OR 2"	KAW PP Intake Gas	FEB 20: Remove utility within the footprint of the levee. Will likely not have to remove outside of levee footprint. FEB 26: Remove utility from landside of levee to intake structure. If the pipe also runs along the landside toe, may need to remove.
75+50	4"	KAW PP Conduit	FEB 20: Remove utility within the footprint of the levee. Will likely not have to remove outside of levee footprint.
75+62	17"W X 43"H	KAW Power Plant Electrical	FEB 20: Remove utility within the footprint of the levee. Will likely not have to remove outside of levee footprint.
75+89	72"	KAW PP Intake Influent #2	FEB 20: Grout in the line under the floodwall up to within 20' of the intake structure with excavatable flowable fill so that when the slurry wall is installed it cuts through the pipe and the flowable fill. (about 180' of flowable fill) On the riverside, remove the pipe from intake structure back about 20'. On the landside, fill with grout or remove within the critical zone. This critical zone removal suggestion will likely not be possible. Should revisit. FEB 26: Remove pipe landside of levee to intake structure.

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75+90	2"	Water Emergency	FEB 20: Remove utility within the footprint of the levee. Will likely not have to remove outside of levee footprint.
76+83	72"	Osage Pump Plant Outfall	FEB 20: Need to meet with construction people to determine how reconnection pipe after installation of cutoff wall will be completed.
79+60	84"	KAW PP Discharge	FEB 20: Grout in the line under the floodwall up to within 20' of the intake structure with excavatable flowable fill so that when the slurry wall is installed it cuts through the pipe and the flowable fill. (about 180' of flowable fill) On the riverside, remove the pipe from intake structure back about 20'. On the landside, fill with grout or remove back to sealing weir. FEB 26: Grout the line from the seiling weir to the drainage structure. Remove the pipe from the drainage structure to the outfall structure.
79+80	60"	KAW PP Discharge	FEB 20: Grout in the line under the floodwall up to within 20' of the intake structure with excavatable flowable fill so that when the slurry wall is installed it cuts through the pipe and the flowable fill. (about 180' of flowable fill) On the riverside, remove the pipe from intake structure back about 20'. On the landside, fill with grout or remove back to sealing weir. FEB 26: Grout the line from the seiling weir to the drainage structure. Remove the pipe from the drainage structure to the outfall structure.
81+07	2.5" in 4"	Calcium Carbonate	FEB 20: Grout under the levee. FEB 26: Grout under the levee and remove pipe out to outfall structure.
90+79	30"	Sanitary Sewer (Inverted)	OK
91+76	30"	Storm Sewer	OK
99+63	4"	Discharge Line	FEB 20: During construction, install an inspection trench at the riverside toe to find the pipe, then remove pipe from discharge point back to source which appears to have been an inlet on the private property to the north. (Approximately 200 feet of removal) FEB 26: Remove pipe from 30' from landside toe to outfall Sinde line is shallow.
108+95	42"	Sanitary Sewer	OK
127+20	24"	Potable Water	FEB 20: Remove pipeline from river's edge back to riverside toe of levee (approximately 400'). Although a conservative approach, Local Protection felt that removal of the pipe from the river's edge is necessary to prevent the seepage entry point from moving from the river's edge to the landside end of the abandoned pipe. Fill pipe with grout under the levee footprint. Remove pipeline on the landside within the critical zone. Grout pipe if removal is not possible within the critical zone. Will need to verify that removal within the critical zone is possible under this project. Fill valve pit with grout (box is estimated to be 12' x 12' by 10 feet deep - not field measured.) FEB 26: Grout line under levee and extend grout according to Typical Abandonment Detail
129+20	5'X6'	12th St. Pump Plant Outfall	OK
129+20	20" x 2	12th St. Pump Plant Outfall	FEB 20: Once lines are relocated up and over the levee, remove the abandoned 20" DIPs from Pump Station to Gatewell.
129+60	72"	12th St. Storm Sewer	FEB 20: Since this is a critical sewer, we need to find this sewer during PED and determine exactly where it is and how we will fill it in if possible. FEB 26: Following meeting we found the design memo that stated the following: During 1952 construction, the original brick sewer from the PP to the river "was plugged with concrete at each end, then filled with pervious and impervious material zoned with the restored levee section.", therefore, no action needed.
156+75	6'X8'	Mill St. Pump Plant Outfall	OK
156+75	20" x 2	Mill St. Pump Plant Outfall	FEB 20: Once lines are relocated up and over the levee, remove the abandoned 20" DIPs from Pump Station to Gatewell.
172+05	12"	KS Gas	OK

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185+70	72"	5th St. Pump Plant Outfall	OK
186+74	30"	Sanitary Sewer	OK
194+60	18" and 12"	Midwest Cold Storage Pump Plant Outfall	OK
212+76	24"	Storm Sewer	OK
220+64	24	Storm Sewer	OK
230+77	7.5' X 7.5'	Shawnee Ave Pump Plant Outfall	OK
231+38.91	57"	Storm Sewer	
240+73	48"	Storm Sewer	
244+70	24"	Storm Sewer	
246+53	30"	Storm Sewer Forcemain	
250+31	12"	Storm Sewer	
253+43	12"	Storm Sewer	
256+71	12"	Storm Sewer	
260+00	30"	Storm Sewer	
260+84	12"	Storm Sewer	
262+89	12"	Storm Sewer	
266+76	16"	Storm Sewer	
276+00	NA	Fiber Optic	
276+79	42"	Kansas City Southern Pump Plant Outfall	
281+50	42"	Storm Sewer	
286+59	24"	PBI Gordon Pump Plant Gravity Storm Flow	

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286+59	6"	PBI Gordon Pump Plant Discharge Pipe	
290+52	24"	Storm Sewer	
295+45	18"	Storm Sewer	
295+52	24"	National Beef Pumping Plant / KCK Pump Plant / (Central Ave. PP - KVDD)	
295+79	2"	National Beef Pumping Plant / KCK Pump Plant / (Central Ave. PP - KVDD)	
295+80	10"	National Beef Pumping Plant / KCK Pump Plant / (Central Ave. PP - KVDD)	
299+20	3"	Central Ave. Pumping Plant - Sump Pump	
299+20	2-14"	Central Ave. Pump Plant - Discharge	
311+11	7.5' X 7.5'	Storm Sewer	
315+10	5' X 4'	Storm Sewer	
324+58 (41+45 LE)	48"	Sanitary Force Main	FEB 20: Local Protection suggested we leve this pipe in place and create an inpsection program whereby this pipe is taken out of service and inpsected. Local protection is a little concerned that this pipe runs parellel with the levee near the toe for quite a distance (as much as 1000'). FEB 26: Leave pipe in place. See meeting minutes for reasoning.
328+18 (45+05 LE)	42"	Storm Sewer/Sanitary Sewer	
329+35 (46+22 L.E.)	24"	Storm Sewer	
50+00	8"	KS Gas	
334+08 (50+ 95 LE)	24"	Storm Sewer	
334+83 (51+70 L.E.)	12"	Spring Sump Drain	

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339+54 (56+41 L.E)	24"	Storm Sewer	
339+63 (56+60 LE)	1 - 36"	Sanitary Force Main	
340+49 (57+36 LE)	12"	Storm Sewer	
341+43 (58+30 LE)	25" X 16"	Storm Sewer	
343+59 (60+45 LE)	25" X 16"	Storm Sewer	
LE		Oxygen	

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UTILITY IDENTIFICATION			BACKGROUND DOCUMENTS AND RESEARCH NOTES FOR EACH UTILITY CROSSING						
Station (ft.)	Conduit Size	Conduit Function	Reference Sited o&m Manual (1978)	Reference Sited: Operations Manual (1979)	Reference Sited: HNTB	Reference Sited: Site visits in Fall 2006 and winter 2007	Reference Sited: Wyandotte County CAD files (not QC checked by County)	Reference Sited: KVDD Drainage Structure List	Other
-9+63 (0+75 UE)	36"	City: San. Sewer Force Main	Structure is part of RR closure gap. Forcemain is buried about 2.5' to 3' below grade outside of levee/floodwall. Plate 267				Forcemain is buried about 2.5' to 3' below grade outside of levee/floodwall	x	
-4+58 (5+80 UE)	*	Fiber Optic				Conduits are buried less than 2 feet deep			
7+50 UE	24"	Storm Sewer						x	
12+79 UE	12'x8'	Storm Sewer	Could not find pipes during August 2006 site visit.	Elev 746		No flap gate (Jan 2007 site visit)		X Matoon Creek	
4+93 (15+33 UE)	8'x8'	Storm Sewer	Sluice and Flap					X	
28+22	6"	Sand Pipe	5' below levee	~5' below levee/ Elev 769	Abandoned	Could not find pipes during August 2006 site visit.			
28+30	18"	Sand Pipe	5' below levee	~5' below levee/ Elev 768.5	Abandoned	Could not find pipes during August 2006 site visit.			
28+33	6"	Sand Pipe	5' below levee	~5' below levee/ Elev 769	Abandoned	Could not find pipes during August 2006 site visit.			
32+80	42"	Storm Sewer	Not Shown	33' / Invert Elev 750	Installed 1980			X	
41+45	48"	San. Sewer Force Main		30' / Invert Elev 740. Line is "xxxx" crossed out. Drwg says "valve"			Line not shown. Believed to be removed		
52+45	3"	Water for Proctor and Gamble Fire Testing Area	Not Shown	Not Shown		Pipe is not buried along portions of levee			
58+44	36"	Storm Sewer	20' below levee	27' / Invert Elev 746.5, Gate and Flap	Abandoned			X Not Active, Proctor and Gamble	Design Memo 1971: RCP installed in 1951. 30", 1/2" thick steel liner installed in 1961. Active line as of this 1971 design memo.
61+81	36"	Storm Sewer	23' below levee	23' below levee	Abandoned			X Not Active, Proctor and Gamble	Design Memo 1971: Proctor and Gamble's used to drain cooling water. CIP in good shape.

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62+10	18"	Sanitary Sewer	16' below floodwall	16' below floodwall	Abandoned		There is a 24" VCP MH that starts near the bridge. Possibly started at this MH - MH SAN090-001 (AutoCAD file)		KS DOT Drwgs of KS Ave Bridge say abandoned
62+10	24"	Gas	14' below floodwall						
62+10	24"	Gas	14' below floodwall			KGS does not have record of the buried gas line being removed			
62+65	12"	Water	12' below floodwall						
62+65	10"	Water	12' below floodwall						KS DOT Drwgs of KS Ave Bridge
62+70	6"	Fiber Optic	not shown						
64+71	42"	Storm Sewer		Invert Elev 742				X	KS DOT Drwgs of KS Ave Bridge
75+12	48"	KAW PP Recirculation Line	25' below floodwall			BPU Drawings. Power Plant is moth-balled (inactive) Centerline Elev 751.7 - Drwg Sheet 2-3 (Contract No. K-76: Circulating Water Pipe Layout and Profile (Inf.)			
75+22	6"	KAW PP Intake Water	18' below floodwall	18' below floodwall					
75+32	72"	KAW PP Intake Influent #1	20' below floodwall			It appears that seepage rings were used on most of the pipes crossing the levee. EM 1110-2-1913 now states that seepage rings should not be provided. We will not be recommending removal of these seepage rings for Phase 2.			
75+45	3"	KAW PP Intake Chlorine	Chlorine Pipe Elev~ 761 - SP			Chlorine PVC pipe Elev 764.5' Info from BPU drawings: Sheet P48-2, Contract K-87: Chlorine Piping (1960)			
75+50	1" OR 2"	KAW PP Intake Gas		9' below levee / Eleve 763		Gas line also has a meter on it located under the bridge. The pipe penetrates the floodwall approximately 18" below the top of the floodwall.			
75+50	4"	KAW PP Conduit				Took picture of 4" conduit penetrating floodwall and leading to corrugated handhole at landside "toe" of floodwall fill material. Ernie states that conduit runs along toe of levee and ends at BPU "sealing weir" (discharge building)			
75+62	17"W X 43"H	KAW Power Plant Electrical		Elev. 762.5: 18" x 48" duct		Elev 756 according to BPU 1952 As-Built			
75+89	72"	KAW PP Intake Influent #2		Elev 742 / 30' below floodwall					

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75+90	2"	Water Emergency		Not shown		BPU Drawings: Normally not under pressure. Valve and 4' cover (in 1959 at lower levee elevation). Since levee was raised ~5', line may be 9' buried			
76+83	72"	Osage Pump Plant Outfall		30+ below levee				X	
79+60	84"	KAW PP Discharge		40+ below levee				X	
79+80	60"	KAW PP Discharge		40+ below levee				X	
81+07	2.5" in 4"	Calcium Carbonate	20' below levee	20' below levee. Drainage structure exists on drwy but no indication of closure device	Abandoned. Gate valve. Used to discharge calcium carbonate.			Not listed	
90+79	30"	Sanitary Sewer (Inverted)		Elev 731.3				X	
91+76	30"	Storm Sewer		Elev 732.2				X	
99+63	4"	Discharge Line	6' below levee	6' below levee		Could not find inlet. Did not go to river to find outlet. Likely that inlet is covered up and line is not in use.			
108+95	42"	Sanitary Sewer		42" RCP with Sluice Gate. Interceptor San. Sewer				X	
127+20	24"	Potable Water	20' below levee	20' below levee	Abandoned	Found control structure with valve. Appeared that everything was intact. Saw cuts in structure indicate some sort of work done in pit after construction. Should check with BPU about functionality	Appears on Wyandotte CAD files	X Abandoned	
129+20	5'X6'	12th St. Pump Plant Outfall		30' to 40' below levee				X	
129+20	20" x 2	12th St. Pump Plant Outfall							DRG Pump Station Record Drawings. Elev of DIP 767.24
129+60	72"	12th St. Storm Sewer	Elevation unknown, plugged to remain in place	not shown					Design Memo 1971: During 1952 construction, the original brick sewer from the PP to the river was plugged with concrete at each end, then filled with pervious and impervious material zoned with the restored levee section.
156+75	6'X8'	Mill St. Pump Plant Outfall				Discharge pipe is about 2' below levee.		X	No Flap Gate, Site Visit 1-9-07
156+75	20" x 2	Mill St. Pump Plant Outfall							
172+05	12"	KS Gas							KGE Maps, Date: 9-15-2005

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185+70	72"	5th St. Pump Plant Outfall						X	
186+74	30"	Sanitary Sewer	elevation unknown	Greystone Heights Sewer. Gate Elevation Unknown			48" DIP - 44' below ground	X	
194+60	18" and 12"	Midwest Cold Storage Pump Plant Outfall				Outlet was wet indicating it could still be used to drain interior drainage. Drainage structure did not appear to have any other contributing flows other than from Plant		X	Design Memo 1971: A 12" CIP was installed 6 feet above the 18" CIP between the landside and riverside gatewells for use in providing a connection to the drainage system for the ice plant condensers and pump.
212+76	24"	Storm Sewer						X	
220+64	24	Storm Sewer						X	
230+77	7.5' X 7.5'	Shawnee Ave Pump Plant Outfall		2 Sluice and 2 Flap				X	
231+38.91	57"	Storm Sewer	32' below levee - 57" concrete conduit, Old Shawnee Ave Pumping Plant Discharge (removed)	PLUGGED BOTH ENDS					
240+73	48"	Storm Sewer	Flapgate on outfall	sluice gate and flap gate				X	
244+70	24"	Storm Sewer		Elev 739.3				X	
246+53	30"	Storm Sewer Forcemain	15' below levee Elev 745	25' below levee. Elev 733.3				X Termination of RR Forcemain	
250+31	12"	Storm Sewer		Elev 735				X	
253+43	12"	Storm Sewer		Elev 736.4		KVDD stated it was grouted properly		X Abandoned	
256+71	12"	Storm Sewer	22' below levee	22' below levee Elev 736.5	Not listed			X Abandoned	
260+00	30"	Storm Sewer		Elev 725.4. Gate and Flap				X Slot Gate and Flap	
260+84	12"	Storm Sewer	20' below levee	Elev 737	Listed on HNTB's list. No indication of abandonment			X Slot Abandoned	
262+89	12"	Storm Sewer		Elev 736.8			X Gate Valve and Flap		
266+76	16"	Storm Sewer		Elev 736.4			X Slot, Sluice and Flap		
276+00	NA	Fiber Optic				Oct 24 site visit: fiber optic observed between bridges			
276+79	42"	Kansas City Southern Pump Plant Outfall		Elev 727.4				X	
281+50	42"	Storm Sewer		Invert Elev 728, Sluice and Flap	RCP. Pipe is under pressure due to flows coming from elevated interstate			X I-670 Storm Sewer	
286+59	24"	PBI Gordon Pump Plant Gravity Storm Flow		Elev 729.7				X	

UTILITY IDENTIFICATION			BACKGROUND DOCUMENTS AND RESEARCH NOTES FOR EACH UTILITY CROSSING						
286+59	6"	PBI Gordon Pump Plant Discharge Pipe							
290+52	24"	Storm Sewer		Elev 724.6				X	
295+45	18"	Storm Sewer		Elev 735	18" RCP			X - Sluice Gate	
295+52	24"	National Beef Pumping Plant / KCK Pump Plant / (Central Ave. PP - KVDD)		Elev 731.7		Active: Water flowing during site visit. There are two 18" CIP pipes on the bridge		X City - Central Ave PS	
295+79	2"	National Beef Pumping Plant / KCK Pump Plant / (Central Ave. PP - KVDD)	Elev 753.4, Penetrates Floodwall						
295+80	10"	National Beef Pumping Plant / KCK Pump Plant / (Central Ave. PP - KVDD)	Elev 753.6, Penetrates Floodwall						
299+20	3"	Central Ave. Pumping Plant - Sump Pump		Elev 757.7					
299+20	2-14"	Central Ave. Pump Plant - Discharge						X - City - 2 flaps, 1 gate	
311+11	7.5' X 7.5'	Storm Sewer		only sluice gate, Elev 727.4	Called the split log outfall. Sluice Gate			X 7.5 x 7.5 City	
315+10	5' X 4'	Storm Sewer		only sluice gate, Elev 735.3	This is possibly the outfall for the Fowler Street Sewer System			X - 5x5	
324+58 (41+45 LE)	48"	Sanitary Force Main	Line not present	Gate Valve, Elev 740	Pressure Sewer			Gate Valve	Invert Elev ~ 740 (Armourdale Interceptor Drawings)
328+18 (45+05 LE)	42"	Storm Sewer/Sanitary Sewer		No sluice gate or flap. Invert Elev 732.5	Sluice Gate		Wyandotte County maps show this as a CSO.	Not listed	No gate in structure per gatewell inventory table
329+35 (46+22 L.E.)	24"	Storm Sewer	No sluice gate indicated	Invert Elev. 753.8 No sluice gate or flap indicated	Flap Gate			Not listed	
50+00	8"	KS Gas						Not listed	KGS Maps
334+08 (50+ 95 LE)	24"	Storm Sewer	24" CMP	24" CMP Invert Elev. 753.6 No sluice gate or flap indicated	Flap Gate			Not listed	
334+83 (51+70 L.E.)	12"	Spring Sump Drain	12" spring sump drain	12" spring sump drain	Not included in list			Not listed	

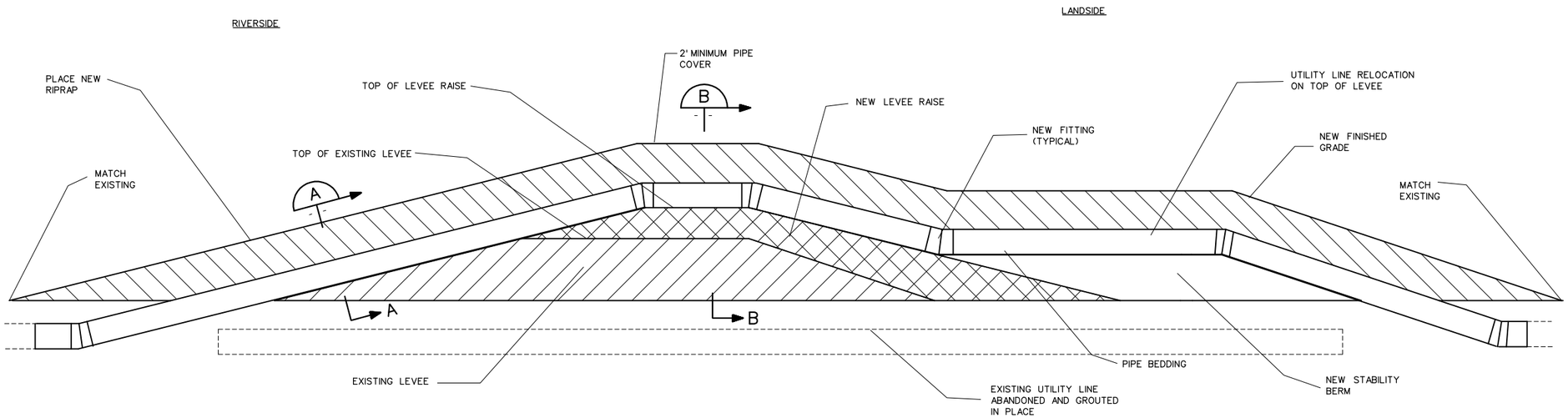
Armourdale Utility Crossings: Inventory and Action for N500+3 Raise
Created by: Melissa Corkill
Peer Reviewed by: Hank Mildenberger

DRAFT

Date: 23-Aug-2006
Modified: 02-Mar-2007

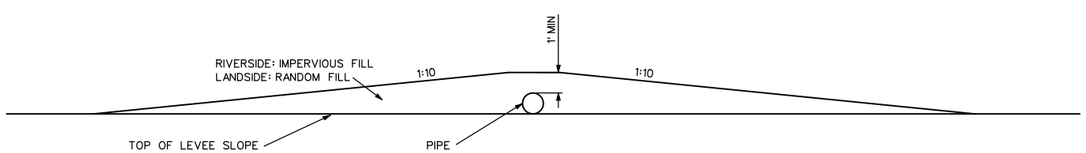
UTILITY IDENTIFICATION			BACKGROUND DOCUMENTS AND RESEARCH NOTES FOR EACH UTILITY CROSSING						
339+54 (56+41 L.E)	24"	Storm Sewer	No sluice gate or flap	No sluice gate or flap	Flap Gate, No Sluice Gate Required due to high ground		Storm Pipe Shown	Not listed	
339+63 (56+60 LE)	1 - 36"	Sanitary Force Main	No line exists	no sewer exists	Forcemain, River Crossing		1 - 36"	X	1963 Drawings show Armourdale Interceptor Forcemain
340+49 (57+36 LE)	12"	Storm Sewer	Working not plugged	Active, Elev 755.5	Listed on HNTB's list only because of its inclusion in the inventory from previous feasibility phase. List indicates flap gate present. HNTB indicates only 2 pipes operational in this area.		Storm Pipe Shown	Not listed	
341+43 (58+30 LE)	25" X 16"	Storm Sewer	Working not plugged	Plugged, elev 755	Not included in list		Storm Pipe Shown	Not listed	
343+59 (60+45 LE)	25" X 16"	Storm Sewer	No sluice gate or flap gate	Invert Elev 755	Flap Gate, No Sluice Gate Required due to high ground		Storm Pipe Shown	Not listed	
LE		Oxygen	Not on drawings	Not on drawings	Not listed				

Exhitbit 5: Typical Utility Crossing



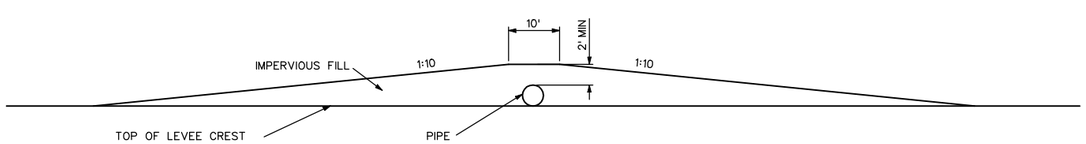
A TYPICAL UTILITY CROSSING

SCALE: NTS



A RIVERSIDE AND LANDSIDE SLOPE

SCALE: NTS



B LEVEE CREST

SCALE: NTS

NOTES:
1. IF PERMISSION IS GRANTED FOR A PIPELINE TO CROSS THE LEVEE BELOW THE TOP OF LEVEE, A POSITIVE CUTOFF VALVE OR GATE CLOSURE WILL BE INSTALLED AT THE RIVERSIDE SHOULDER OF THE LEVEE ROAD.

US Army Corps of Engineers
Kansas City District

Symbol	Description	Date	Appr.

Designed by: MRC
Date: MARCH 2007
Drawing code:
Drawn by: MRC
Plot scale: NA
CADD File Name: TYPICALUTILITYCROSS...
Checked by: HWM
Submitted by: HWM

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
KANSAS CITY, MISSOURI

KANSAS CITY LEVEES
FEASIBILITY LEVEL DESIGN

TYPICAL UTILITY CROSSING FOR LEVEE RAISE

Sheet Reference Number:
XX

Exhibit 6

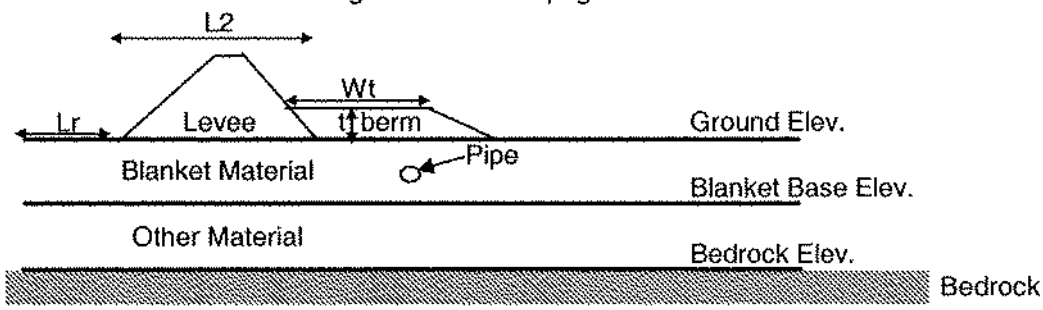
Armourdale Utility Uplift Spreadsheet: Data Entry Worksheet - DRAFT WORKING COPY
Kansas City Levees Phase 2

Created By: Melissa Corkill Date: 11-Aug-06
Date Modified: 6-Mar-07

Peer Reviewed By: Date:

How to Use this Spreadsheet

Insert parameters into cells highlighted in orange and the corresponding spreadsheets will update automatically.
Spreadsheets are linked, therefore spreadsheets must stay in their original directories to maintain links.
Armourdale Unit was separated seven stretches based on geotech and seepage criteria and numbered L1 to L7



Levee Type Number		L1	L2	L3	L4	L5	L6	L7
Station Start		5+00UE	66+00	79+00	190+00	254+00	296+00	313+00
Station End		66+00	79+00	190+00	254+00	296+00	313+00	40+00LE
Levee Width, L2 (from geotech)		100		100		50		100
Riverside Blanket Width, Lr (from		200		65		100		110
Top of Levee Elev. (n500 + 3ft)		777.5	777	775	769.5	765.8	763	762
Berm Width for the w/ Berm option, Wt (ft) (from geotech)		NA	NA	NA	NA	NA	NA	NA
Berm Height for the w/Berm option, t (feet) (from geotech)		NA	NA	NA	NA	NA	NA	NA
Ground Elev. Landside		762	760	760	751	750	747	750
Blanket Base Elev.		740	748	730	728	725	729	725
Bedrock Elev. (from O&M manual Borings)		670	671	667	668	678	678	700
Pipe Depth ft. (enter on spreadsheet		Varies	Varies	Varies	Varies	Varies	Varies	Varies
Pipe Diameter in. (enter on spreadsheet)		Varies	Varies	Varies	Varies	Varies	Varies	Varies
Blanket Soil Type (from geotech)		ML				ML-CL		ML-CL
Blanket Soil Unit Weight, soil density (pcf)		115	115	115	115	115	115	115
Blanket Thickness Dbo ft (from geotech EC-GD) landside		22		30		25		25
Depth of Sands Df ft (from Geotech EC-GD)		70		63		47		25
Max Head or Levee Height ft (from geotech EC-GD)		15.5	17.0	15.0	18.5	15.8	16.0	12.0
Notes			Cutoff Wall		Relief Wells		Relief Wells	

Input Data
Calculated
NA Not Applicable

NOMENCLATURE for all Uplift Spreadsheets

Input

(Kf/Kb)R = riverside permeability
(Kf/Kb)L = landside permeability
DbL = landside blanket thickness
Dbr = riverside blanket thickness
Dbo = levee toe blanket thickness
Df = thickness of pervious foundation
Lr = length of riverside blanket
LL = length of landside blanket
H = max head or levee height
L2 = levee base width
t = berm height, ft
ground elevation = average elevation of landside ground

Output

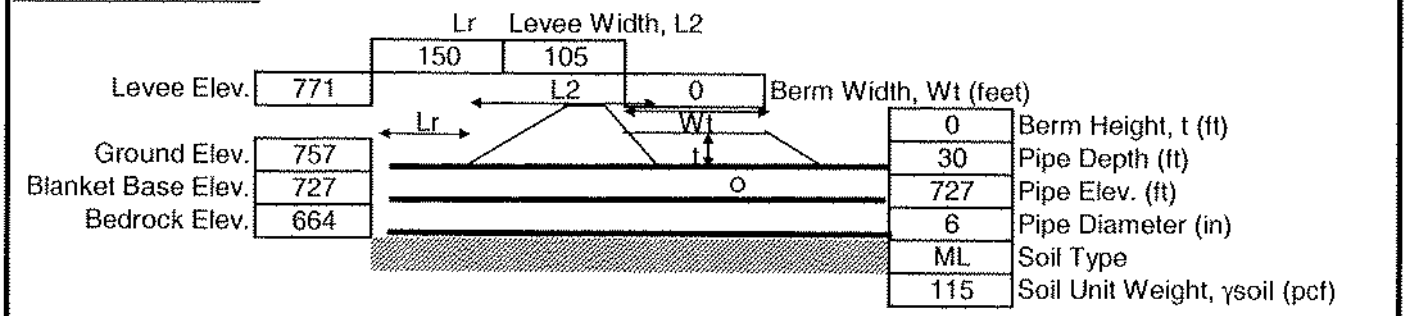
Cr = riverside effective length coefficient
CL = landside effective length coefficient
where C = [(Kf/Kb) * Df * Db]1/2
L1 = riverside effective length
where L1 = C * (e (2LR/C-1)) / (e(2LR/C+1))
Le = landside effective length
Lt = total effective length
ho = head above tailwater at levee toe
io = seepage gradient
ic = critical gradient = (γsat-γwater)/γwater

Exhibit 7

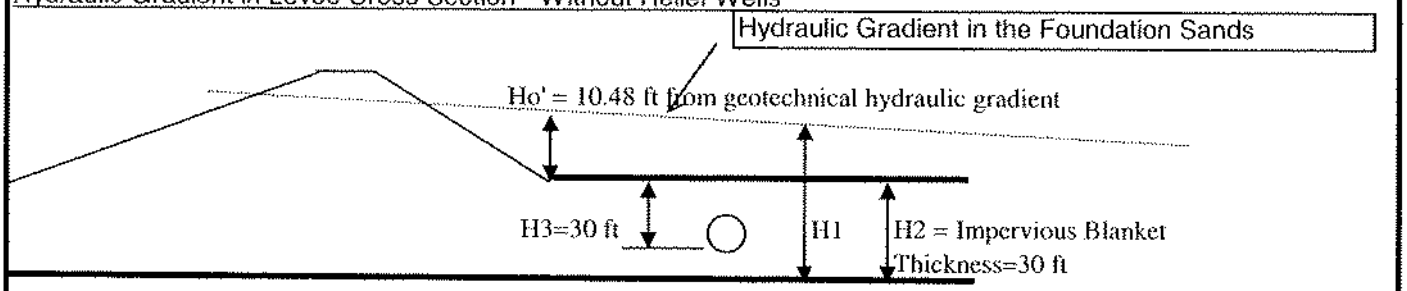
Kansas City's Levees - Phase 2
Armourdale - Utility Uplift Sample Calculation at Station 200+00 (Distance from toe - 0ft)

By: Melissa Corkill	Date Created:	14-Aug-06
	Date Modified:	15-Aug-06
Peer Reviewed By: Scott Loehr	Date Reviewed:	15-Aug-06

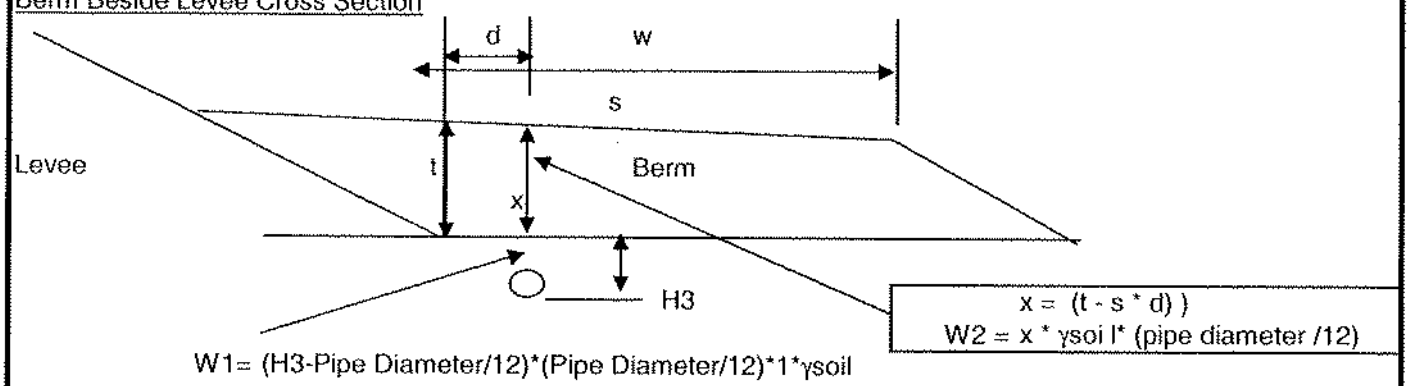
Levee Cross Section



Hydraulic Gradient in Levee Cross Section - Without Relief Wells



Berm Beside Levee Cross Section



Definitions

H1 = Height of Hydraulic Gradient above base of Impervious Blanket - ft
H2 = Impervious Blanket Thickness - ft
H3 = Depth of Pipe Invert -ft
Ho' = Excess head above ground surface (initial Ho' is calculated at toe of levee by geotechnical engineer) - ft
Lr = Length of riverside blanket (determined by geotechnical engineer) - ft
L1 = Riverside effective length (calculated by geotechnical engineer) - ft
L2 = Levee Width (toe to toe) - ft
Wt = Berm Width - ft
t = Berm Height at toe of levee- ft

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x = Berm Height at structure (pipe)- ft
s = slope of berm
Ws = weight of structure (pipe) per foot of length
18.97 lb per ft (6" Diameter Steel Pipe, .280" wall thickness, Manual of Steel Construction)
Wc = weight of water contained in the structure = pi * r^2 * 1 = 3.1416*((3/12)^2) *1*62.4 = 12 lb/lf
S = surcharge loads = weight of saturated soils above structure = W1 + W2
W1 = Surcharge load above structure (not including berm)
W2 = Surcharge load of berm above structure
P1 = Pressure at the base of the impervious blanket at the location of the structure being investigated
P3 = Pressure at the base of the structure (pipe) being investigated
U = Uplift force on the project area of structure = Area of pipe * P3
Wg = weight of surcharge water above top surface of structure control by gravity flow = 0 for pipes
SFf = Flotation Safety Factor = (Ws+Wc+S)/(U-Wg)

Sample Calculations

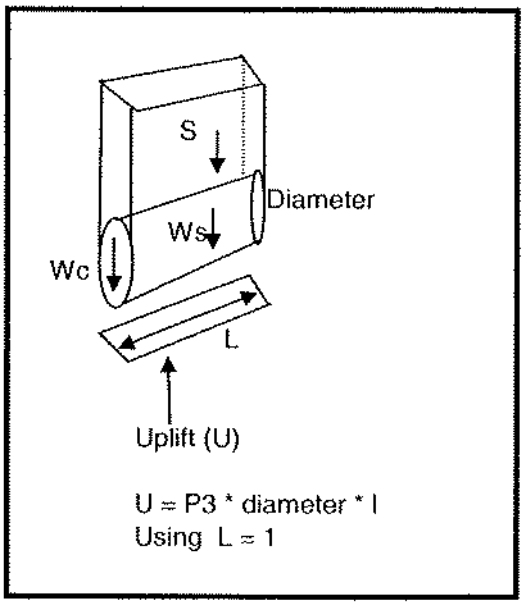
Sample Calculations are done at the toe of the levee (distance from toe = 0 ft)

H1

H1 = Ho' + Ground Elev - Impervious Blanket Base Elev
H1 = 10.48 ft + 757 ft - 727 ft = 40.48 ft

P3

P3 = H3 x (H1/H2) x γwater
P3 = 30 ft x (40.48ft /30ft) x 62.4 pcf = 2525.9 psf



Wc

Wc = pi x r^2 x γwater
Wc = 3.1416 x ((3"/12)^2) x 62.4 pcf = 12 lb/lf

S

S = W1 + W2
W1 = (H3-Pipe Diameter/12)*(Pipe Diameter/12)*1*γsoil
W1 = (30 ft - 6"/12) x (6"/12) x 115 pcf x 1 lf
W1 = 1696 pounds
W2 = (t - s x d) (Pipe Diameter/12) x 1 lf x γsoil
W2 = (5 - (0.05 x 0))x (6/12 x 1 lf x 115 psf) = 287.5 pounds
S = W1 + W2 = 1696 + 287.5 = 1983.5 pounds

U

U = Area of pipe * P3 = (Pipe Diameter/12) x 1 ft x P3
U = 6"/12 x 2525.9 psf x 1 ft
U = 1263 lb

SFf (Pipe Full)
SFf = Flotation Safety Factor = (Ws+Wc+S)/(U-Wg)
SFf = (19 + 12 + 1696)/(1263-0)
SFf = 1.37

SFf (Pipe Empty)
SFf = (19 + 1696)/(1263-0)
SFf = 1.36

DRAFT

Exhibit 8

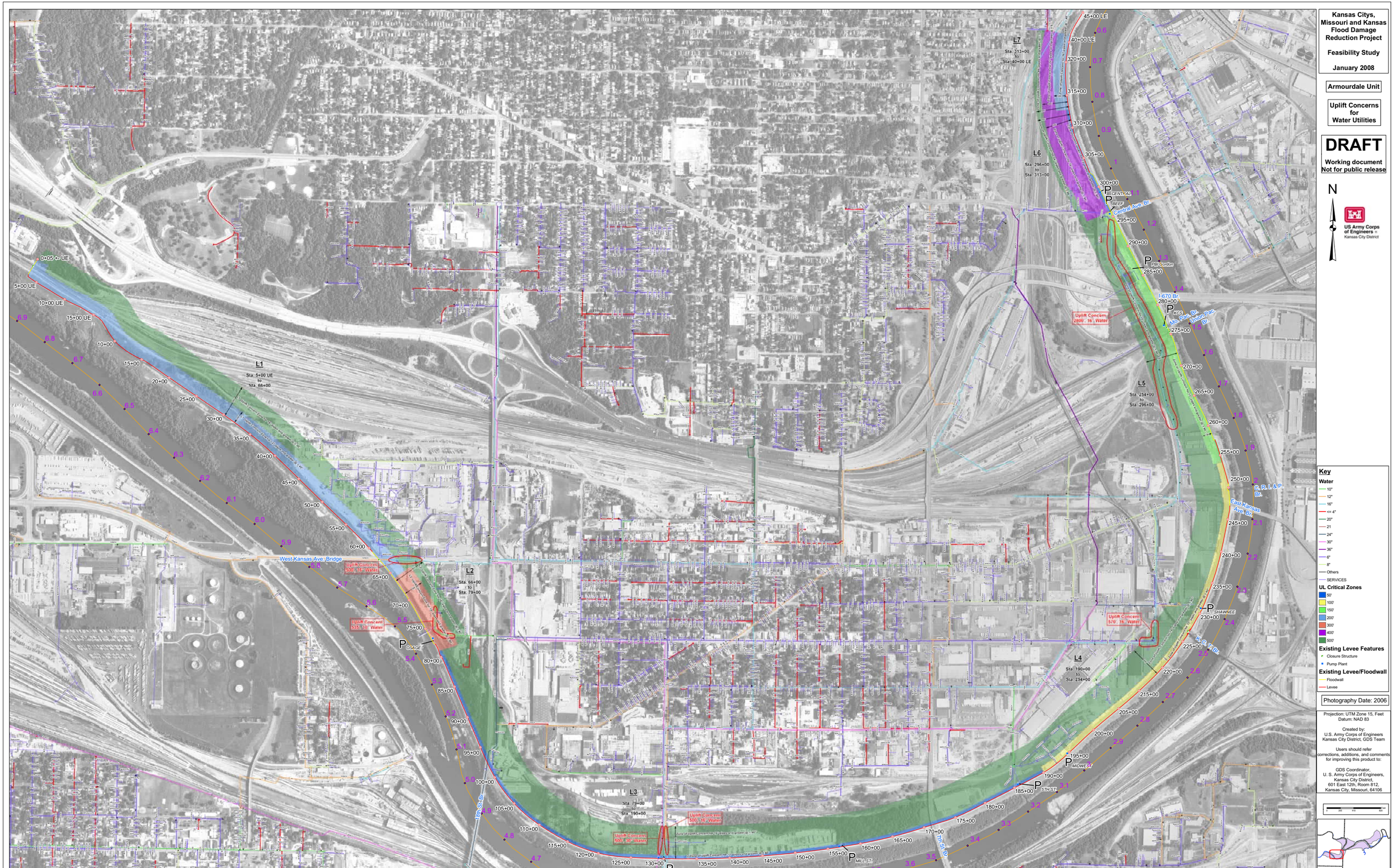


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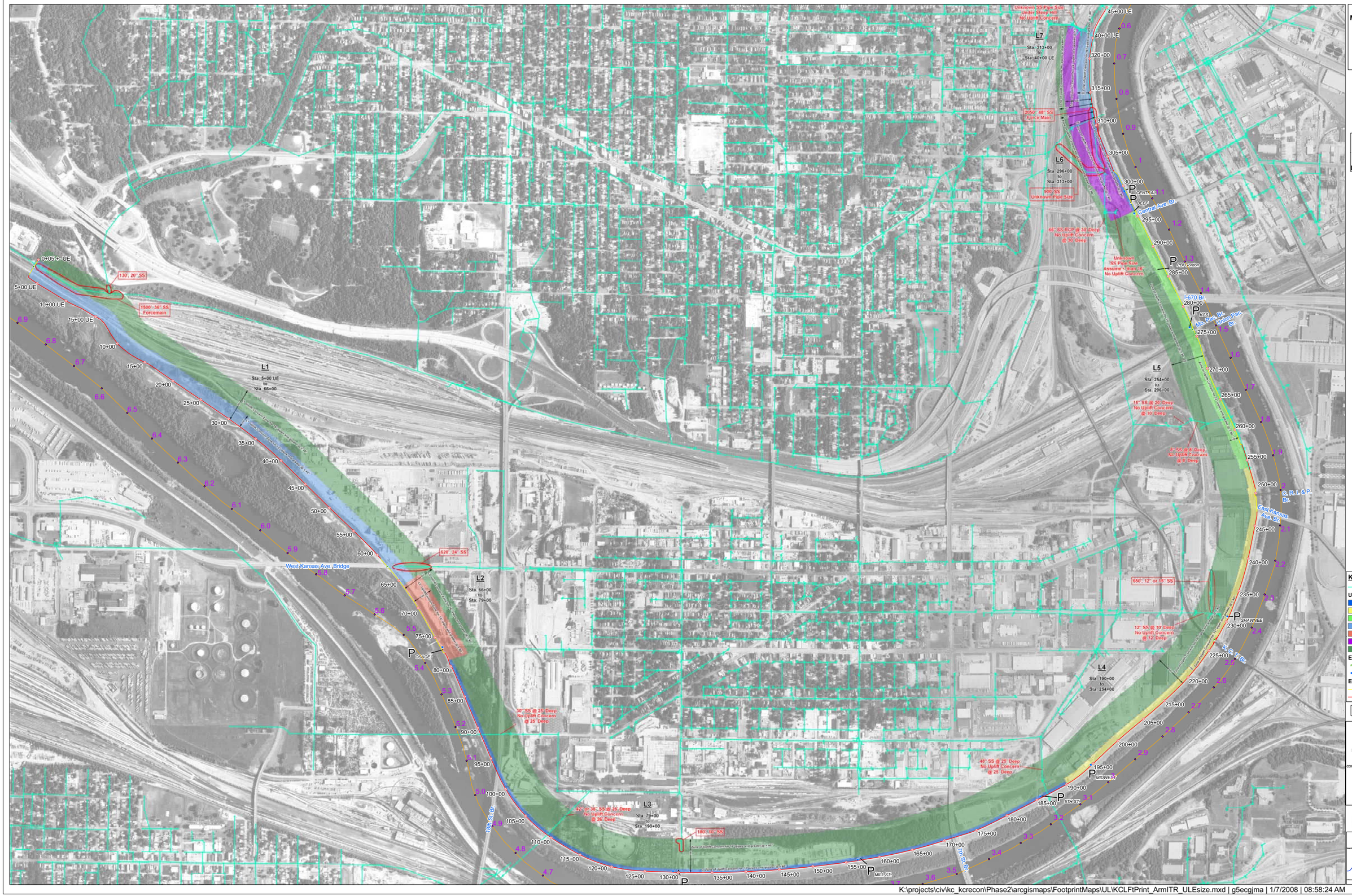
Exhibit 9



Kansas Citys, Missouri and Kansas Flood Damage Reduction Project

Feasibility Study

January 2008

Armourdale Unit

Uplift Concerns for Sanitary Sewer Utilities

DRAFT

Working document
Not for public release

N

US Army Corps of Engineers
Kansas City District

Key

- Sewer

UL Critical Zones

- 50'
- 100'
- 150'
- 200'
- 300'
- 400'
- 500'

Existing Levee Features

- Closure Structure
- Pump Plant

Existing Levee/Floodwall

- Floodwall
- Levee

Photography Date: 2006

Projection: UTM Zone 15, Feet
Datum: NAD 83

Created by:
U.S. Army Corps of Engineers
Kansas City District, GDS Team

Users should refer corrections, additions, and comments for improving this product to:

GDS Coordinator,
U. S. Army Corps of Engineers,
Kansas City District,
601 East 12th, Room 812,
Kansas City, Missouri, 64106

0 205 410 820

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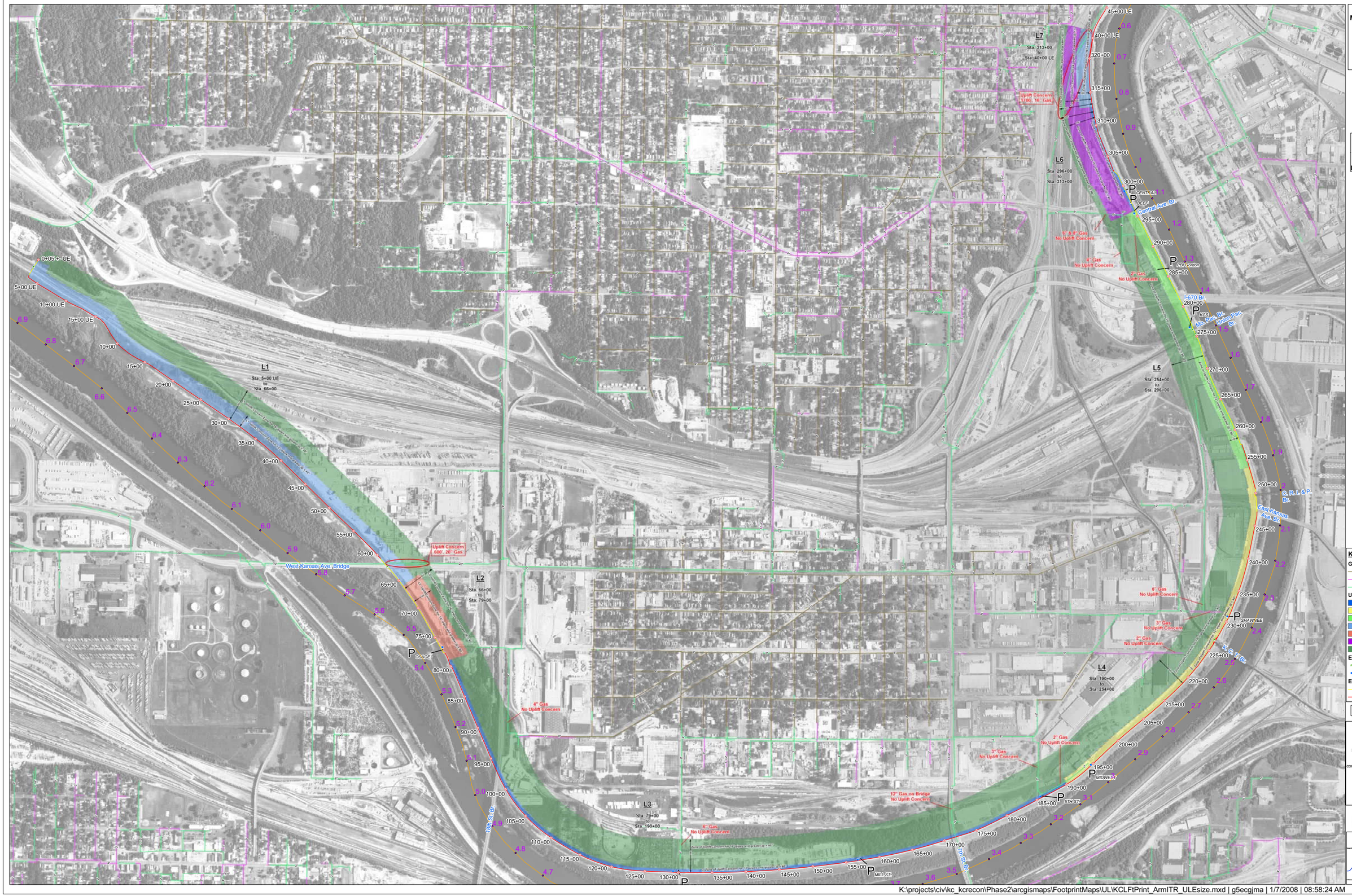
Exhibit 10



Kansas Citys, Missouri and Kansas Flood Damage Reduction Project

Feasibility Study

January 2008

Armourdale Unit

Uplift Concerns for Gas Utilities

DRAFT

Working document
Not for public release

N

US Army Corps of Engineers
Kansas City District

Key

Gas
- Cast Iron
- PE
- Steel

UL Critical Zones
- 50'
- 100'
- 150'
- 200'
- 300'
- 400'
- 500'

Existing Levee Features
- Closure Structure
- Pump Plant

Existing Levee/Floodwall
- Floodwall
- Levee

Photography Date: 2006

Projection: UTM Zone 15, Feet
Datum: NAD 83

Created by:
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Kansas City, Missouri, 64106

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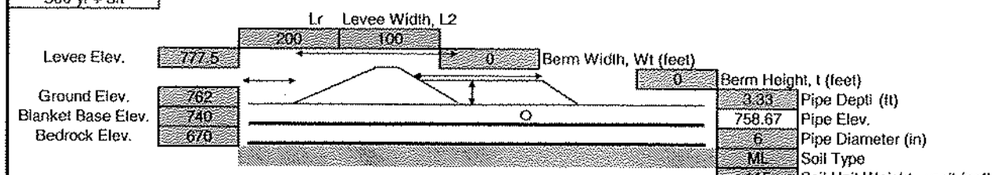
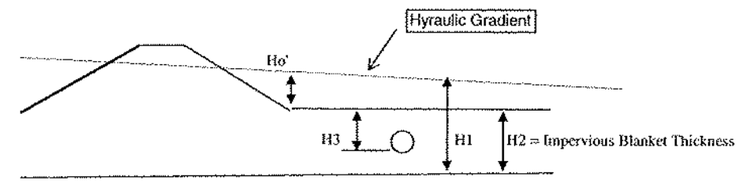
Exhibit 11

Armourdale Area L1 Stationing Range 5+00UE 66+00 500-yr + 3ft	K-r	K-L	DbL	Dbo	Dbr	Df	H	i-c	Lr	Wt	Safety	L1	L2	Le	Lt	L't	Ho'	Hwt/2	Hwt	i-o	Cr	Cl	t	s
																							feet	
	300	300	22	22	22	70	15.5	0.84	200	0	1.71	194	100	680	974	974	10.82	10.82	10.82	0.49	680	680	0	0.000

Geotechnical data (above) presented in this spreadsheet was provided by Geotechnical Engineers and is used to develop the Hydraulic Gradient at various distances from the toe.





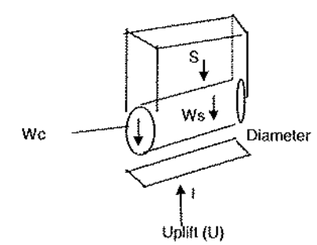
d=Landside Distance from Toe Feet	No Berm Calcs Excess Head Feet, Ho'	Invert Elev of pipe 6 -in steel	Design Base Blanket Feet, MSL	Ground Elev Feet, MSL	H3 Feet	H2 Feet	H1 Feet	P3 Psf	Ws lb	Wc lb	S lb	U lb	Wg lb	SFf (Full)	SFf (Empty)
0	10.82	758.67	740	762	3.33	22	32.8	309.9	19	12	163	155	0	1.25	1.17
25	10.42	758.67	740	762	3.33	22	32.4	306.3	19	12	163	153	0	1.27	1.19
50	10.05	758.67	740	762	3.33	22	32.0	302.7	19	12	163	151	0	1.28	1.20
100	9.34	758.67	740	762	3.33	22	31.3	296.0	19	12	163	148	0	1.31	1.23
125	9.00	758.67	740	762	3.33	22	31.0	292.8	19	12	163	146	0	1.32	1.24
150	8.67	758.67	740	762	3.33	22	30.7	289.7	19	12	163	145	0	1.34	1.25
200	8.06	758.67	740	762	3.33	22	30.1	283.9	19	12	163	142	0	1.37	1.28
300	6.96	758.67	740	762	3.33	22	29.0	273.5	19	12	163	137	0	1.42	1.33
400	6.00	758.67	740	762	3.33	22	28.0	264.5	19	12	163	132	0	1.47	1.37
500	5.18	758.67	740	762	3.33	22	27.2	256.7	19	12	163	128	0	1.51	1.42

Ws Calc 6 -in steel 1lf
19
Wc Calc 12

See Sample Calculations for list of abbreviations and sample calculations
Ws = weight of structure per foot of length = 18.97 lb per ft (6-inch Diameter Steel Pipe, .280" thick)
Wc = weight of water contained in the structure = pi * r^2 * 1 = 3.1416*((3/12)^2) *1*62.4 = 12 plf
S = surcharge loads = weight of satuarted soils above = (H3-Pipe Diameter/12)*(Pipe Diameter/12)*1*γsoil
P3 = H3*(H1/H2)*γwater
U = Uplift force on the project area of structure = Area of pipe * P3 = (Pipe Diameter/12)*1*P3
Wg = weight of surcharge water above top surface of structure control by gravity flow
SFf = Flotation Safety Factor (Ws+Wc+S)/(U-Wg)

Use this table to determine the distance from toe at which the Safety Factor is met
Enter the Distance from toe and change the value until the SFf is equal to that required

Ground Elev 762		Distance from toe (ft) 0			Uplift Safety Extreme Case (1.1 REQ'D)	
	Ws = 19		Wc = 12 Full			
Pipe Inv Elev, Ft	Surcharge Load, S, lbs/ft	Uplift (U) Force, lbs/ft	Pipe Weight, Lbs/ft	Full water Wt, Lbs / ft	SFf Full	SFf Empty
762	0		19	12		
758.67	163	155	19	12	1.25	1.17
757.67	220	202	19	12	1.25	1.19
756.67	278	248	19	12	1.25	1.20
755.67	335	295	19	12	1.24	1.20
754.67	393	341	19	12	1.24	1.21
753.67	450	388	19	12	1.24	1.21
752.67	508	434	19	12	1.24	1.21
751.67	565	481	19	12	1.24	1.22
750.67	623	527	19	12	1.24	1.22



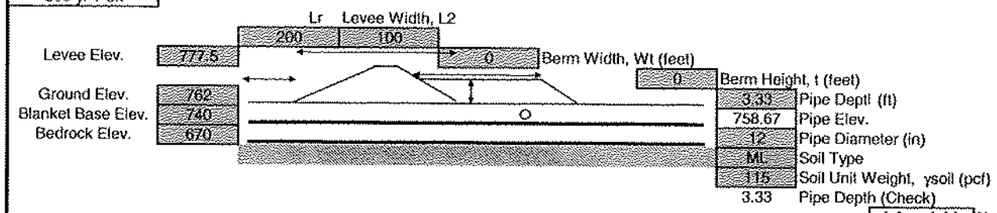
U = P3 * diameter * l
Using l = 1

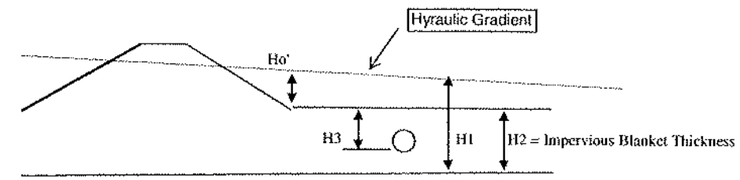
Conclusions
For levee stretch: 5+00UE to 66+00
For pipe diam (in): 6
There is no uplift concern at a depth of 40 inches (3.3 feet) or greater within 500 feet landward of the levee

DRAFT
MARCH 8, 2007

Armourdale Area L1 Stationing Range	K-r	K-L	DbL	Dbo	Dbr	Df	H	i-c	Lr	Wt	Safety	L1	L2	Le	Lt	L't	Ho'	Hwt/2	Hwt	i-o	Cr	Cl	t	s
																							feet	
5+00UE 66+00 500-yr + 3ft	300	300	22	22	22	70	15.5	0.84	200	0	1.71	194	100	680	974	974	10.82	10.82	10.82	0.49	680	680	0	0.000

Geotechnical data (above) presented in this spreadsheet was provided by Geotechnical Engineers and is used to develop the Hydraulic Gradient at various distances from the toe.





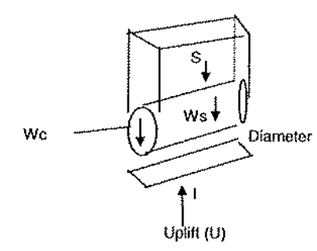
d=Landside Distance from Toe Feet	No Berm Calcs Excess Head Feet, Ho'	Invert Elev of pipe 12 -in steel	Design Base Blanket Feet, MSL	Ground Elev Feet, MSL	H3 Feet	H2 Feet	H1 Feet	P3 Psf	Ws lb	Wc lb	S lb	U lb	Wg lb	SFf (Full)	SFf (Empty)
0	10.82	758.67	740	762	3.33	22	32.8	309.9	50	49	268	310	0	1.18	1.02
25	10.42	758.67	740	762	3.33	22	32.4	306.3	50	49	268	306	0	1.20	1.04
50	10.05	758.67	740	762	3.33	22	32.0	302.7	50	49	268	303	0	1.21	1.05
100	9.34	758.67	740	762	3.33	22	31.3	296.0	50	49	268	296	0	1.24	1.07
125	9.00	758.67	740	762	3.33	22	31.0	292.8	50	49	268	293	0	1.25	1.08
150	8.67	758.67	740	762	3.33	22	30.7	289.7	50	49	268	290	0	1.27	1.10
200	8.06	758.67	740	762	3.33	22	30.1	283.9	50	49	268	284	0	1.29	1.12
300	6.96	758.67	740	762	3.33	22	29.0	273.5	50	49	268	273	0	1.34	1.16
400	6.00	758.67	740	762	3.33	22	28.0	264.5	50	49	268	265	0	1.39	1.20
500	5.18	758.67	740	762	3.33	22	27.2	256.7	50	49	268	257	0	1.43	1.24

Ws Calc 12 -in steel 1lf
50
Wc Calc
49

See Sample Calculations for list of abbreviations and sample calculations
Ws = weight of structure per foot of length = 50 lb per ft (12-inch Diameter Steel Pipe, .375" thick)
Wc = weight of water contained in the structure = pi * r^2 * 1 = 3.1416*((6/12)^2) *1*62.4 = 49 plf
S = surcharge loads = weight of satuarted soils above = (H3-Pipe Diameter/12)*(Pipe Diameter/12)*1*γsoil
P3 = H3*(H1/H2)*γwater
U = Uplift force on the project area of structure = Area of pipe * P3 = (Pipe Diameter/12)**1**P3
Wg = weight of surcharge water above top surface of structure control by gravity flow
SFf = Flotation Safety Factor (Ws+Wc+S)/(U-Wg)

Use this table to determine the distance from toe at which the Safety Factor is met
Enter the Distance from toe and change the value until the SFf is equal to that required

Ground Elev 762		Distance from toe (ft) 0			Uplift Safety Extreme Case (1.1 REQ'D)	
	Ws = 50		Wc = 49 Full			
Pipe Inv Elev, Ft	Surcharge Load, S, lbs/ft	Uplift (U) Force, lbs/ft	Pipe Weight, Lbs/ft	Full water Wt, Lbs / ft	SFf Full	SFf Empty
762	0		50	49		
758.67	268	310	50	49	1.18	1.02
757.67	383	403	50	49	1.19	1.07
756.67	498	496	50	49	1.20	1.10
755.67	613	589	50	49	1.21	1.12
754.67	728	682	50	49	1.21	1.14
753.67	843	775	50	49	1.21	1.15
752.67	958	868	50	49	1.22	1.16
751.67	1073	961	50	49	1.22	1.17
750.67	1188	1055	50	49	1.22	1.17



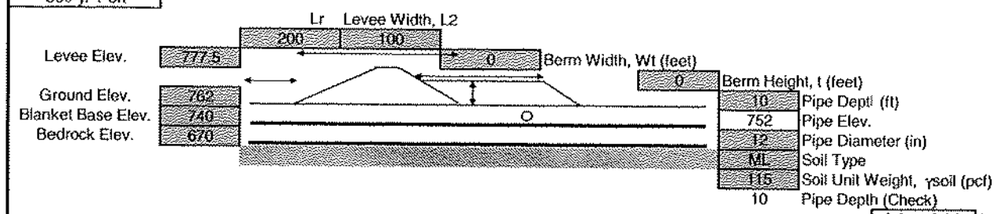
U = P3 * diameter * l
Using l = 1

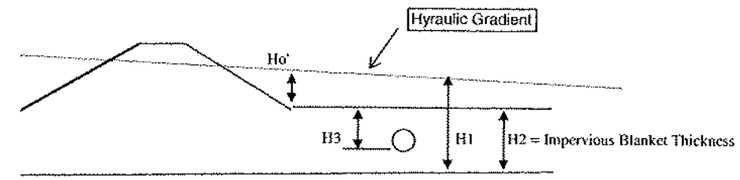
Conclusions
For levee stretch: 5+00UE to 66+00
For pipe diam (in): 12
There is uplift concern at a depth of 40 inches (3.3 feet) and less within 200 feet landward of the levee
There is uplift concern at a depth of 4.33 feet and less at the landward toe

DRAFT
MARCH 8, 2007

Armourdale Area L1 Stationing Range 5+00UE 66+00 500-yr + 3ft	K-r	K-L	DbL	Dbo	Dbr	Df	H	i-c	Lr	Wt	Safety	L1	L2	Le	Lt	L't	Ho'	Hwt/2	Hwt	i-o	Cr	Cf	t	s
																							feet	
	300	300	22	22	22	70	15.5	0.84	200	0	1.71	194	100	680	974	974	10.82	10.82	10.82	0.49	680	680	0	0.000

Geotechnical data (above) presented in this spreadsheet was provided by Geotechnical Engineers and is used to develop the Hydraulic Gradient at various distances from the toe.





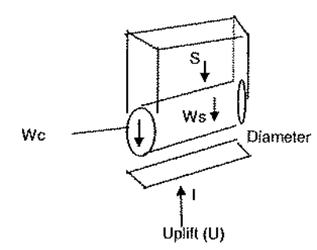
d=Landside Distance from Toe Feet	No Berm Calcs Excess Head Feet, Ho'	Invert Elev of pipe 12 -in steel	Design Base Blanket Feet, MSL	Ground Elev Feet, MSL	H3 Feet	H2 Feet	H1 Feet	P3 Psf	Ws lb	Wc lb	S lb	U lb	Wg lb	SFf (Full)	SFf (Empty)
0	10.82	752	740	762	10	22	32.8	930.8	50	49	1035	931	0	1.22	1.17
25	10.42	752	740	762	10	22	32.4	919.7	50	49	1035	920	0	1.23	1.18
50	10.05	752	740	762	10	22	32.0	909.0	50	49	1035	909	0	1.25	1.19
100	9.34	752	740	762	10	22	31.3	888.8	50	49	1035	889	0	1.28	1.22
125	9.00	752	740	762	10	22	31.0	879.2	50	49	1035	879	0	1.29	1.23
150	8.67	752	740	762	10	22	30.7	870.0	50	49	1035	870	0	1.30	1.25
200	8.06	752	740	762	10	22	30.1	852.6	50	49	1035	853	0	1.33	1.27
300	6.96	752	740	762	10	22	29.0	821.3	50	49	1035	821	0	1.38	1.32
400	6.00	752	740	762	10	22	28.0	794.3	50	49	1035	794	0	1.43	1.37
500	5.18	752	740	762	10	22	27.2	771.0	50	49	1035	771	0	1.47	1.41

Ws Calc 12 -in steel 1lf
50
Wc Calc
49

See Sample Calculations for list of abbreviations and sample calculations
Ws = weight of structure per foot of length = 50 lb per ft (12-inch Diameter Steel Pipe, .375" thick)
Wc = weight of water contained in the structure = pi * r^2 * 1 = 3.1416*((6/12)^2) *1*62.4 = 49 plf
S = surcharge loads = weight of saturated soils above = (H3-Pipe Diameter/12)*(Pipe Diameter/12)*1*γsoil
P3 = H3*(H1/H2)*γwater
U = Uplift force on the project area of structure = Area of pipe * P3 = (Pipe Diameter/12)**1**P3
Wg = weight of surcharge water above top surface of structure control by gravity flow
SFf = Flotation Safety Factor (Ws+Wc+S)/(U-Wg)

Use this table to determine the distance from toe at which the Safety Factor is met
Enter the Distance from toe and change the value until the SFf is equal to that required

Ground Elev 762		Distance from toe (ft) 0			Uplift Safety Extreme Case (1.1 REQ'D)	
	Ws = 50		Wc = 49 Full			
Pipe Inv Elev, Ft	Surcharge Load, S, lbs/ft	Uplift (U) Force, lbs/ft	Pipe Weight, Lbs/ft	Full water Wt, Lbs / ft	SFf Full	SFf Empty
762	0		50	49		
752	1035	931	50	49	1.22	1.17
751	1150	1024	50	49	1.22	1.17
750	1265	1117	50	49	1.22	1.18
749	1380	1210	50	49	1.22	1.18
748	1495	1303	50	49	1.22	1.19
747	1610	1396	50	49	1.22	1.19
746	1725	1489	50	49	1.22	1.19
745	1840	1582	50	49	1.23	1.19
744	1955	1675	50	49	1.23	1.20

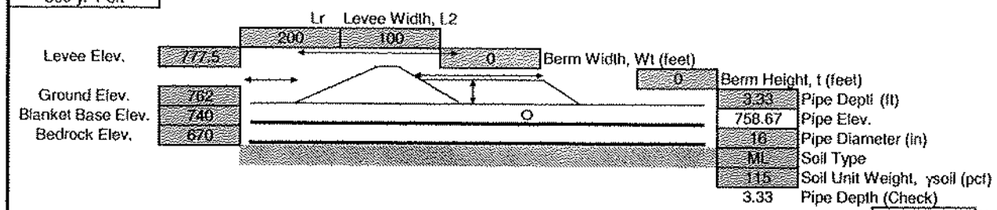


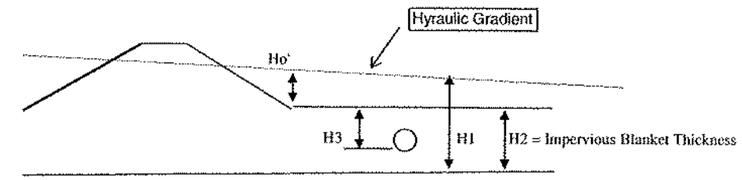
U = P3 * diameter * l
Using l = 1

Conclusions
For levee stretch: 5+00UE to 66+00
For pipe diam (in): 12
There is no uplift concern at a depth of 10 feet or deeper within 500 feet landward of the levee

DRAFT
MARCH 8, 2007

Armourdale Area L1 Stationing Range	K-r	K-L	DbL	Dbo	Dbr	Df	H	i-c	Lr	Wt	Safety	L1	L2	Le	Lt	L't	Ho'	Hwt/2	Hwt	i-o	Cr	Cl	t	s
																							feet	
5+00UE	300	300	22	22	22	70	15.5	0.84	200	0	1.71	194	100	680	974	974	10.82	10.82	10.82	0.49	680	680	0	0.000
66+00	Geotechnical data (above) presented in this spreadsheet was provided by Geotechnical Engineers and is used to develop the Hydraulic Gradient at various distances from the toe.																							
500-yr + 3ft																								





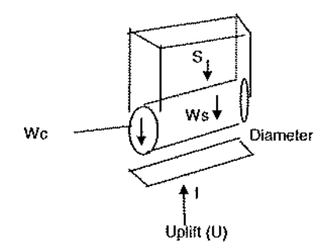
d=Landside Distance from Toe Feet	No Berm Calcs Excess Head Feet, Ho'	Invert Elev of pipe 16 -in steel	Design Base Blanket Feet, MSL	Ground Elev Feet, MSL	H3 Feet	H2 Feet	H1 Feet	P3 Psf	Ws lb	Wc lb	S lb	U lb	Wg lb	SFf (Full)	SFf (Empty)
0	10.82	758.67	740	762	3.33	22	32.8	309.9	63	87	306	413	0	1.10	0.89
25	10.42	758.67	740	762	3.33	22	32.4	306.3	63	87	306	408	0	1.12	0.90
50	10.05	758.67	740	762	3.33	22	32.0	302.7	63	87	306	404	0	1.13	0.91
100	9.34	758.67	740	762	3.33	22	31.3	296.0	63	87	306	395	0	1.16	0.94
125	9.00	758.67	740	762	3.33	22	31.0	292.8	63	87	306	390	0	1.17	0.95
150	8.67	758.67	740	762	3.33	22	30.7	289.7	63	87	306	386	0	1.18	0.96
200	8.06	758.67	740	762	3.33	22	30.1	283.9	63	87	306	379	0	1.21	0.98
300	6.96	758.67	740	762	3.33	22	29.0	273.5	63	87	306	365	0	1.25	1.01
400	6.00	758.67	740	762	3.33	22	28.0	264.5	63	87	306	353	0	1.29	1.05
500	5.18	758.67	740	762	3.33	22	27.2	256.7	63	87	306	342	0	1.33	1.08

Ws Calc 16 -in steel 1lf
63
Wc Calc
87

See Sample Calculations for list of abbreviations and sample calculations
Ws = weight of structure per foot of length = 62.58 lb per ft (16-inch Diameter Steel Pipe, .375* thick)
Wc = weight of water contained in the structure = pi * r^2 * 1 = 3.1416*((8/12)^2) *1*62.4 = 49 plf
S = surcharge loads = weight of satuarted soils above = (H3-Pipe Diameter/12)*(Pipe Diameter/12)*1*γsoil
P3 = H3*(H1/H2)*γwater
U = Uplift force on the project area of structure = Area of pipe * P3 = (Pipe Diameter/12)^*1*P3
Wg = weight of surcharge water above top surface of structure control by gravity flow
SFf = Flotation Safety Factor (Ws+Wc+S)/(U-Wg)

Use this table to determine the distance from toe at which the Safety Factor is met
Enter the Distance from toe and change the value until the SFf is equal to that required

	Ground Elev 762		Distance from toe (ft) 0			Uplift Safety Extreme Case (1.1 REQ'D)	
		Ws = 63		Wc = 87 Full			
Depth Below Ground	Pipe Inv Elev, Ft	Surcharge Load, S, lbs/ft	Uplift (U) Force, lbs/ft	Pipe Weight, Lbs/ft	Full water Wt, Lbs / ft	SFf Full	SFf Empty
	762	0		63	87		
3.33	758.67	306	413	63	87	1.10	0.89
4.33	757.67	459	537	63	87	1.13	0.97
5.33	756.67	613	661	63	87	1.15	1.02
6.33	755.67	766	786	63	87	1.17	1.06
7.33	754.67	919	910	63	87	1.18	1.08
8.33	753.67	1073	1034	63	87	1.18	1.10
9.33	752.67	1226	1158	63	87	1.19	1.11
10.33	751.67	1379	1282	63	87	1.19	1.13
11.33	750.67	1533	1406	63	87	1.20	1.13



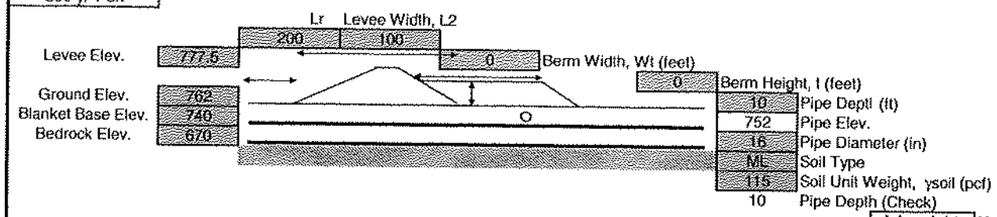
U = P3 * diameter * l
Using l = 1

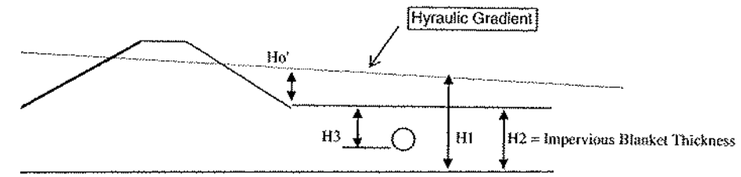
Conclusions
For levee stretch: 5+00UE to 66+00
For pipe diam (in): 16
There is uplift concern at a depth of 40 inches (3.3 feet) and less within 500 feet landward of the levee
There is uplift concern at a depth of 8.33 feet and less at the landward toe

DRAFT
MARCH 8, 2007

Armourdale Area L1 Stationing Range	K-r	K-L	DbL	Dbo	Dbr	Df	H	i-c	Lr	Wt	Safcty	L1	L2	Le	Lt	L't	Ho'	Hwt/2	Hwt	i-o	Cr	Cl	t	s
																							feet	
5+00UE 66+00 500-yr + 3ft	300	300	22	22	22	70	15.5	0.84	200	0	1.71	194	100	680	974	974	10.82	10.82	10.82	0.49	680	680	0	0.000

Geotechnical data (above) presented in this spreadsheet was provided by Geotechnical Engineers and is used to develop the Hydraulic Gradient at various distances from the toe.





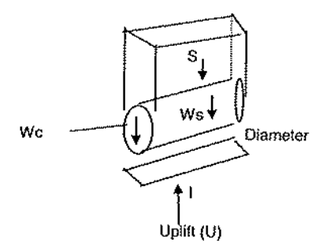
d=Landside Distance from Toe Feet	No Berm Calcs Excess Head Feet, Ho'	Invert Elev of pipe 16 -in steel	Design Base Blanket Feet, MSL	Ground Elev Feet, MSL	H3 Feet	H2 Feet	H1 Feet	P3 Psf	Ws lb	Wc lb	S lb	U lb	Wg lb	SFf (Full)	SFf (Empty)
0	10.82	752	740	762	10	22	32.8	930.8	63	87	1329	1241	0	1.19	1.12
25	10.42	752	740	762	10	22	32.4	919.7	63	87	1329	1226	0	1.21	1.14
50	10.05	752	740	762	10	22	32.0	909.0	63	87	1329	1212	0	1.22	1.15
100	9.34	752	740	762	10	22	31.3	888.8	63	87	1329	1185	0	1.25	1.17
125	9.00	752	740	762	10	22	31.0	879.2	63	87	1329	1172	0	1.26	1.19
150	8.67	752	740	762	10	22	30.7	870.0	63	87	1329	1160	0	1.27	1.20
200	8.06	752	740	762	10	22	30.1	852.6	63	87	1329	1137	0	1.30	1.22
300	6.96	752	740	762	10	22	29.0	821.3	63	87	1329	1095	0	1.35	1.27
400	6.00	752	740	762	10	22	28.0	794.3	63	87	1329	1059	0	1.40	1.31
500	5.18	752	740	762	10	22	27.2	771.0	63	87	1329	1028	0	1.44	1.35

Ws Calc 16 -in steel 1lf
63
Wc Calc 87

See Sample Calculations for list of abbreviations and sample calculations
Ws = weight of structure per foot of length = 62.58 lb per ft (16-inch Diameter Steel Pipe, .375" thick)
Wc = weight of water contained in the structure = pi * r^2 * 1 = 3.1416*((8/12)^2) *1*62.4 = 49 plf
S = surcharge loads = weight of satuarted soils above = (H3-Pipe Diameter/12)*(Pipe Diameter/12)*1*γsoil
P3 = H3*(H1/H2)*γwater
U = Uplift force on the project area of structure = Area of pipe * P3 = (Pipe Diameter/12)*1*P3
Wg = weight of surcharge water above top surface of structure control by gravity flow
SFf = Flotation Safety Factor (Ws+Wc+S)/(U-Wg)

Use this table to determine the distance from toe at which the Safety Factor is met
Enter the Distance from toe and change the value until the SFf is equal to that required

	Ground Elev 762		Distance from toe (ft) 0			
		Ws = 63		Wc = 87 Full		Uplift Safety Extreme Case (1.1 REQ'D)
Depth Below Ground	Pipe Inv Elev, Ft	Surcharge Load, S, lbs/ft	Uplift (U) Force, lbs/ft	Pipe Weight, Lbs/ft	Full water Wt, Lbs / ft	SFf Full / SFf Empty
	762	0		63	87	
10	752	1329	1241	63	87	1.19 / 1.12
11	751	1482	1365	63	87	1.20 / 1.13
12	750	1636	1489	63	87	1.20 / 1.14
13	749	1789	1613	63	87	1.20 / 1.15
14	748	1942	1737	63	87	1.20 / 1.15
15	747	2096	1862	63	87	1.21 / 1.16
16	746	2249	1986	63	87	1.21 / 1.16
17	745	2402	2110	63	87	1.21 / 1.17
18	744	2556	2234	63	87	1.21 / 1.17



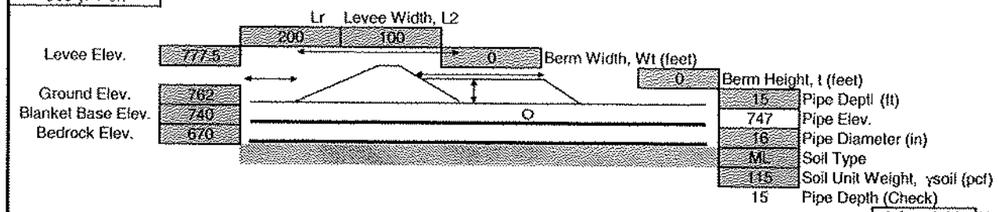
U = P3 * diameter * l
Using l = 1

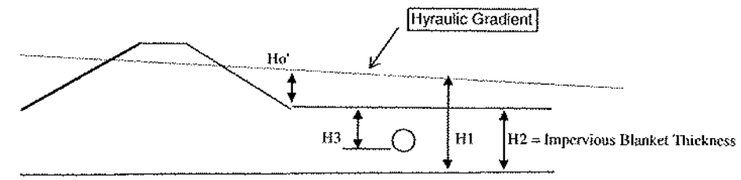
Conclusions
For levee stretch: 5+00UE to 66+00
For pipe diam (in): 16
There is no uplift concern at a depth of 10 feet or deeper within 500 feet landward of the levee

DRAFT
MARCH 8, 2007

Armourdale Area L1 Stationing Range	K-r	K-L	DbL	Dbo	Dbr	Df	H	i-c	Lr	Wt	Safety	L1	L2	Le	Lt	L't	Ho'	Hwt/2	Hwt	i-o	Cr	Cl	t	s
																							feet	
5+00UE 66+00 500-yr + 3ft	300	300	22	22	22	70	15.5	0.84	200	0	1.71	194	100	680	974	974	10.82	10.82	10.82	0.49	680	680	0	0.000

Geotechnical data (above) presented in this spreadsheet was provided by Geotechnical Engineers and is used to develop the Hydraulic Gradient at various distances from the toe.





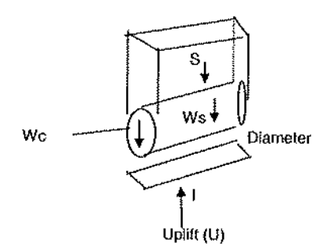
d=Landside Distance from Toe Feet	No Berm Calcs Excess Head Feet, Ho'	Invert Elev of pipe 16 -in steel	Design Base Blanket Feet, MSL	Ground Elev Feet, MSL	H3 Feet	H2 Feet	H1 Feet	P3 Psf	Ws lb	Wc lb	S lb	U lb	Wg lb	SFf (Full)	SFf (Empty)
0	10.82	747	740	762	15	22	32.8	1396.1	63	87	2096	1862	0	1.21	1.16
25	10.42	747	740	762	15	22	32.4	1379.5	63	87	2096	1839	0	1.22	1.17
50	10.05	747	740	762	15	22	32.0	1363.5	63	87	2096	1818	0	1.24	1.19
100	9.34	747	740	762	15	22	31.3	1333.2	63	87	2096	1778	0	1.26	1.21
125	9.00	747	740	762	15	22	31.0	1318.8	63	87	2096	1758	0	1.28	1.23
150	8.67	747	740	762	15	22	30.7	1305.0	63	87	2096	1740	0	1.29	1.24
200	8.06	747	740	762	15	22	30.1	1278.8	63	87	2096	1705	0	1.32	1.27
300	6.96	747	740	762	15	22	29.0	1231.9	63	87	2096	1643	0	1.37	1.31
400	6.00	747	740	762	15	22	28.0	1191.5	63	87	2096	1589	0	1.41	1.36
500	5.18	747	740	762	15	22	27.2	1156.5	63	87	2096	1542	0	1.46	1.40

Ws Calc 16 -in steel 1lf
63
Wc Calc 87

See Sample Calculations for list of abbreviations and sample calculations
Ws = weight of structure per foot of length = 62.58 lb per ft (16-inch Diameter Steel Pipe, .375" thick)
Wc = weight of water contained in the structure = pi * r^2 * 1 = 3.1416*((8/12)^2) *1*62.4 = 49 plf
S = surcharge loads = weight of saturated soils above = (H3-Pipe Diameter/12)*(Pipe Diameter/12)*1*γsoil
P3 = H3*(H1/H2)*γwater
U = Uplift force on the project area of structure = Area of pipe * P3 = (Pipe Diameter/12)*1*P3
Wg = weight of surcharge water above top surface of structure control by gravity flow
SFf = Flotation Safety Factor (Ws+Wc+S)/(U-Wg)

Use this table to determine the distance from toe at which the Safety Factor is met
Enter the Distance from toe and change the value until the SFf is equal to that required

	Ground Elev 762		Distance from toe (ft) 0			Uplift Safety Extreme Case (1.1 REQ'D)	
		Ws = 63		Wc = 87 Full			
Depth Below Ground	Pipe Inv Elev, Ft	Surcharge Load, S, lbs/ft	Uplift (U) Force, lbs/ft	Pipe Weight, Lbs/ft	Full water Wt, Lbs / ft	SFf Full	SFf Empty
	762	0		63	87		
15	747	2096	1862	63	87	1.21	1.16
16	746	2249	1986	63	87	1.21	1.16
17	745	2402	2110	63	87	1.21	1.17
18	744	2556	2234	63	87	1.21	1.17
19	743	2709	2358	63	87	1.21	1.18
20	742	2862	2482	63	87	1.21	1.18
21	741	3016	2606	63	87	1.21	1.18
22	740	3169	2730	63	87	1.22	1.18
23	739	3322	2854	63	87	1.22	1.19

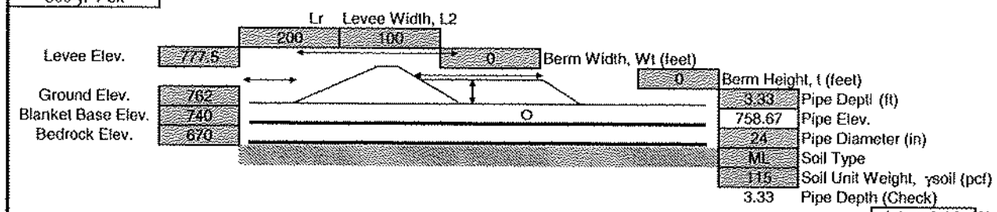


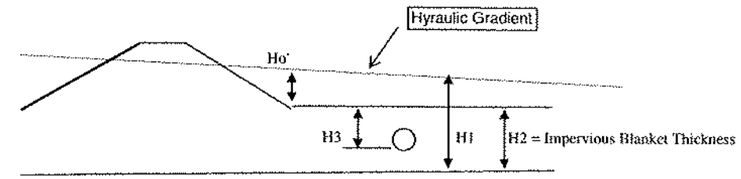
U = P3 * diameter * l
Using l = 1

Conclusions
For levee stretch: 5+00UE to 66+00
For pipe diam (in): 16
There is no uplift concern at a depth of 10 feet or deeper within 500 feet landward of the levee

DRAFT
MARCH 8, 2007

Armourdale Area L1 Stationing Range	K-r	K-L	DbL	Dbo	Dbr	Df	H	i-c	Lr	Wt	Safety	L1	L2	Le	Lt	L't	Ho'	Hwt/2	Hwt	i-o	Cr	Cl	t	s
																							feet	
5+00UE	300	300	22	22	22	70	15.5	0.84	200	0	1.71	194	100	680	974	974	10.82	10.82	10.82	0.49	680	680	0	0.000
66+00	Geotechnical data (above) presented in this spreadsheet was provided by Geotechnical Engineers and is used to develop the Hydraulic Gradient at various distances from the toe.																							
500-yr + 3ft																								





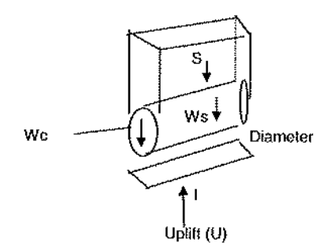
d=Landside Distance from Toe Feet	No Berm Calcs Excess Head Feet, Ho'	Invert Elev of pipe 24 -in steel	Design Base Blanket Feet, MSL	Ground Elev Feet, MSL	H3 Feet	H2 Feet	H1 Feet	P3 Psf	Ws lb	Wc lb	S lb	U lb	Wg lb	SFf (Full)	SFf (Empty)
0	10.82	758.67	740	762	3.33	22	32.8	309.9	95	196	306	620	0	0.96	0.65
25	10.42	758.67	740	762	3.33	22	32.4	306.3	95	196	306	613	0	0.97	0.65
50	10.05	758.67	740	762	3.33	22	32.0	302.7	95	196	306	605	0	0.99	0.66
100	9.34	758.67	740	762	3.33	22	31.3	296.0	95	196	306	592	0	1.01	0.68
125	9.00	758.67	740	762	3.33	22	31.0	292.8	95	196	306	586	0	1.02	0.68
150	8.67	758.67	740	762	3.33	22	30.7	289.7	95	196	306	579	0	1.03	0.69
200	8.06	758.67	740	762	3.33	22	30.1	283.9	95	196	306	568	0	1.05	0.71
300	6.96	758.67	740	762	3.33	22	29.0	273.5	95	196	306	547	0	1.09	0.73
400	6.00	758.67	740	762	3.33	22	28.0	264.5	95	196	306	529	0	1.13	0.76
500	5.18	758.67	740	762	3.33	22	27.2	256.7	95	196	306	513	0	1.16	0.78

Ws Calc 24 -in steel 1lf
95
Wc Calc
196

See Sample Calculations for list of abbreviations and sample calculations
Ws = weight of structure per foot of length = 94.62 lb per lf (24-inch Diameter Steel Pipe, .375" thick)
Wc = weight of water contained in the structure = pi * r^2 * 1 = 3.1416*((12/12)^2) *1*62.4 = 196 plf
S = surcharge loads = weight of saturated soils above = (H3-Pipe Diameter/12)*(Pipe Diameter/12)*1*γsoil
P3 = H3*(H1/H2)*γwater
U = Uplift force on the project area of structure = Area of pipe * P3 = (Pipe Diameter/12)*1*P3
Wg = weight of surcharge water above top surface of structure control by gravity flow
SFf = Flotation Safety Factor (Ws+Wc+S)/(U-Wg)

Use this table to determine the distance from toe at which the Safety Factor is met
Enter the Distance from toe and change the value until the SFf is equal to that required

	Ground Elev 762		Distance from toe (ft) 0			Uplift Safety Extreme Case (1.1 REQ'D)	
		Ws = 95		Wc = 196 Full			
Depth Below Ground	Pipe Inv Elev, Ft	Surcharge Load, S, lbs/ft	Uplift (U) Force, lbs/ft	Pipe Weight, Lbs/ft	Full water Wt, Lbs / ft	SFf Full	SFf Empty
	762	0		95	196		
3.33	758.67	306	620	95	196	0.96	0.65
4.33	757.67	536	806	95	196	1.03	0.78
5.33	756.67	766	992	95	196	1.07	0.87
6.33	755.67	996	1178	95	196	1.09	0.93
7.33	754.67	1226	1364	95	196	1.11	0.97
8.33	753.67	1456	1551	95	196	1.13	1.00
9.33	752.67	1686	1737	95	196	1.14	1.03
10.33	751.67	1916	1923	95	196	1.15	1.05
11.33	750.67	2146	2109	95	196	1.16	1.06
12.33	749.67	2376	2295	95	196	1.16	1.08
13.33	748.67	2606	2481	95	196	1.17	1.09
14.33	747.67	2836	2668	95	196	1.17	1.10
15.33	746.67	3066	2854	95	196	1.18	1.11



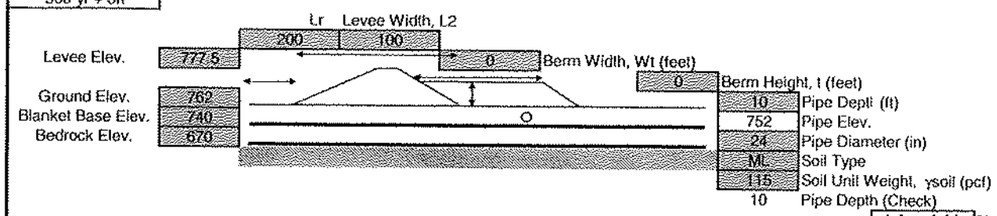
U = P3 * diameter * l
Using l = 1

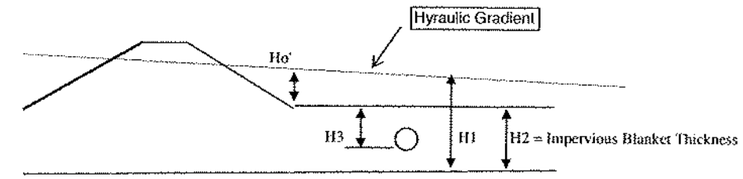
Conclusions
For levee stretch: 5+00UE to 66+00
For pipe diam (in): 24
There is uplift concern at a depth of 40 inches (3.3 feet) and less within 500 feet landward of the levee
There is uplift concern at a depth of 14.33 feet and less at the landward toe

DRAFT
MARCH 8, 2007

Armourdale Area L1 Stationing Range 5+00UE 66+00 500-yr + 3ft	K-r	K-L	DbL	Dbo	Dbr	Df	H	i-c	Lr	Wt	Safety	L1	L2	Lc	Lt	L't	Ho'	Hwt/2	Hwt	i-o	Cr	Cl	t feet	s
	300	300	22	22	22	70	15.5	0.84	200	0	1.71	194	100	680	974	974	10.82	10.82	10.82	0.49	680	680	0	0.000

Geotechnical data (above) presented in this spreadsheet was provided by Geotechnical Engineers and is used to develop the Hydraulic Gradient at various distances from the toe.





d=Landside Distance from Toe Feet	No Berm Calcs Excess Head Feet, Ho'	Invert Elev of pipe 24 -in steel	Design Base Blanket Feet, MSL	Ground Elev Feet, MSL	H3 Feet	H2 Feet	H1 Feet	P3 Psf	Ws lb	Wc lb	S lb	U lb	Wg lb	SFf (Full)	SFf (Empty)
0	10.82	752	740	762	10	22	32.8	930.8	95	196	1840	1862	0	1.14	1.04
25	10.42	752	740	762	10	22	32.4	919.7	95	196	1840	1839	0	1.16	1.05
50	10.05	752	740	762	10	22	32.0	909.0	95	196	1840	1818	0	1.17	1.06
100	9.34	752	740	762	10	22	31.3	888.8	95	196	1840	1778	0	1.20	1.09
125	9.00	752	740	762	10	22	31.0	879.2	95	196	1840	1758	0	1.21	1.10
150	8.67	752	740	762	10	22	30.7	870.0	95	196	1840	1740	0	1.22	1.11
200	8.06	752	740	762	10	22	30.1	852.6	95	196	1840	1705	0	1.25	1.13
300	6.96	752	740	762	10	22	29.0	821.3	95	196	1840	1643	0	1.30	1.18
400	6.00	752	740	762	10	22	28.0	794.3	95	196	1840	1589	0	1.34	1.22
500	5.18	752	740	762	10	22	27.2	771.0	95	196	1840	1542	0	1.38	1.25

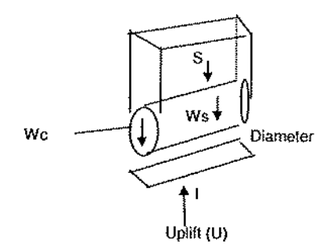
Ws Calc 24 -in steel 1lf
95

Wc Calc
196

See Sample Calculations for list of abbreviations and sample calculations
Ws = weight of structure per foot of length = 94.62 lb per ft (24-inch Diameter Steel Pipe, .375" thick)
Wc = weight of water contained in the structure = pi * r^2 * 1 = 3.1416*((12/12)^2) *1*62.4 = 196 plf
S = surcharge loads = weight of saturated soils above = (H3-Pipe Diameter/12)*(Pipe Diameter/12)*1*γsoil
P3 = H3*(H1/H2)*γwater
U = Uplift force on the project area of structure = Area of pipe * P3 = (Pipe Diameter/12)*1*P3
Wg = weight of surcharge water above top surface of structure control by gravity flow
SFf = Flotation Safety Factor (Ws+Wc+S)/(U-Wg)

Use this table to determine the distance from toe at which the Safety Factor is met
Enter the Distance from toe and change the value until the SFf is equal to that required

	Ground Elev 762		Distance from toe (ft) 0			Uplift Safety Extreme Case (1.1 REQ'D)	
		Ws = 95		Wc = 196 Full			
Depth Below Ground	Pipe Inv Elev, Ft	Surcharge Load, S, lbs/ft	Uplift (U) Force, lbs/ft	Pipe Weight, Lbs/ft	Full water Wt, Lbs / ft	SFf Full	SFf Empty
	762	0		95	196		
10	752	1840	1862	95	196	1.14	1.04
11	751	2070	2048	95	196	1.15	1.06
12	750	2300	2234	95	196	1.16	1.07
13	749	2530	2420	95	196	1.17	1.08
14	748	2760	2606	95	196	1.17	1.10
15	747	2990	2792	95	196	1.18	1.10
16	746	3220	2978	95	196	1.18	1.11
17	745	3450	3165	95	196	1.18	1.12
18	744	3680	3351	95	196	1.19	1.13
19	743	3910	3537	95	196	1.19	1.13
20	742	4140	3723	95	196	1.19	1.14
21	741	4370	3909	95	196	1.19	1.14
22	740	4600	4095	95	196	1.19	1.15



U = P3 * diameter * l

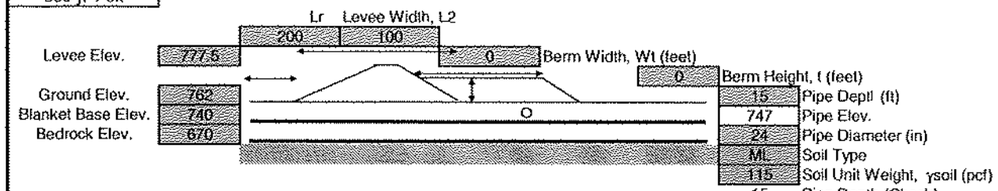
Using l = 1

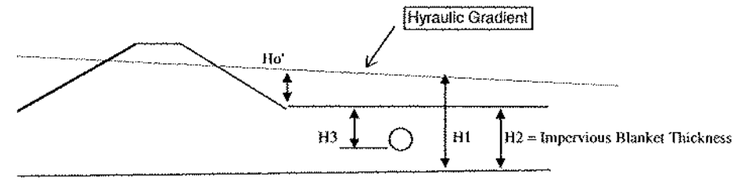
Conclusions
For levee stretch: 5+00UE to 66+00
For pipe diam (in): 24
There is uplift concern at a depth of 10 feet and less within 100 feet landward of the levee
There is uplift concern at a depth of 14 feet and less at the landward toe

DRAFT
MARCH 8, 2007

Armourdale Area L1 Stationing Range 5+00UE 66+00 500-yr + 3ft	K-r	K-L	DbL	Dbo	Dbr	Df	H	i-c	Lr	Wt	Safety	L1	L2	Lc	Lt	L't	Ho'	Hwt/2	Hwt	i-o	Cr	Cl	t	s
																							feet	
	300	300	22	22	22	70	15.5	0.84	200	0	1.71	194	100	680	974	974	10.82	10.82	10.82	0.49	680	680	0	0.000

Geotechnical data (above) presented in this spreadsheet was provided by Geotechnical Engineers and is used to develop the Hydraulic Gradient at various distances from the toe.





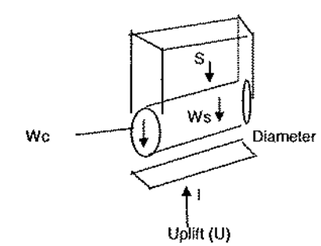
d=Landside Distance from Toe Feet	No Berm Calcs Excess Head Feet, Ho'	Invert Elev of pipe 24 -in steel	Design Base Blanket Feet, MSL	Ground Elev Feet, MSL	H3 Feet	H2 Feet	H1 Feet	P3 Psf	Ws lb	Wc lb	S lb	U lb	Wg lb	SFf (Full)	SFf (Empty)
0	10.82	747	740	762	15	22	32.8	1396.1	95	196	2990	2792	0	1.18	1.10
25	10.42	747	740	762	15	22	32.4	1379.5	95	196	2990	2759	0	1.19	1.12
50	10.05	747	740	762	15	22	32.0	1363.5	95	196	2990	2727	0	1.20	1.13
100	9.34	747	740	762	15	22	31.3	1333.2	95	196	2990	2666	0	1.23	1.16
125	9.00	747	740	762	15	22	31.0	1318.8	95	196	2990	2638	0	1.24	1.17
150	8.67	747	740	762	15	22	30.7	1305.0	95	196	2990	2610	0	1.26	1.18
200	8.06	747	740	762	15	22	30.1	1278.8	95	196	2990	2558	0	1.28	1.21
300	6.96	747	740	762	15	22	29.0	1231.9	95	196	2990	2464	0	1.33	1.25
400	6.00	747	740	762	15	22	28.0	1191.5	95	196	2990	2383	0	1.38	1.29
500	5.18	747	740	762	15	22	27.2	1156.5	95	196	2990	2313	0	1.42	1.33

Ws Calc 24 -in steel 1lf
95
Wc Calc
196

See Sample Calculations for list of abbreviations and sample calculations
Ws = weight of structure per foot of length = 94.62 lb per ft (24-inch Diameter Steel Pipe, .375" thick)
Wc = weight of water contained in the structure = pi * r^2 * 1 = 3.1416*((12/12)^2) *1*62.4 = 196 plf
S = surcharge loads = weight of satuarted soils above = (H3-Pipe Diameter/12)*(Pipe Diameter/12)*1*γsoil
P3 = H3*(H1/H2)*γwater
U = Uplift force on the project area of structure = Area of pipe * P3 = (Pipe Diameter/12)*1*P3
Wg = weight of surcharge water above top surface of structure control by gravity flow
SFf = Flotation Safety Factor (Ws+Wc+S)/(U-Wg)

Use this table to determine the distance from toe at which the Safety Factor is met
Enter the Distance from toe and change the value until the SFf is equal to that required

	Ground Elev 762		Distance from toe (ft) 0			Uplift Safety Extreme Case (1.1 REQ'D)	
		Ws = 95		Wc = 196 Full			
Depth Below Ground	Pipe Inv Elev, Ft	Surcharge Load, S, lbs/ft	Uplift (U) Force, lbs/ft	Pipe Weight, Lbs/ft	Full water Wt, Lbs / ft	SFf Full	SFf Empty
	762	0		95	196		
15	747	2990	2792	95	196	1.18	1.10
16	746	3220	2978	95	196	1.18	1.11
17	745	3450	3165	95	196	1.18	1.12
18	744	3680	3351	95	196	1.19	1.13
19	743	3910	3537	95	196	1.19	1.13
20	742	4140	3723	95	196	1.19	1.14
21	741	4370	3909	95	196	1.19	1.14
22	740	4600	4095	95	196	1.19	1.15
23	739	4830	4281	95	196	1.20	1.15
24	738	5060	4468	95	196	1.20	1.15
25	737	5290	4654	95	196	1.20	1.16
26	736	5520	4840	95	196	1.20	1.16
27	735	5750	5026	95	196	1.20	1.16



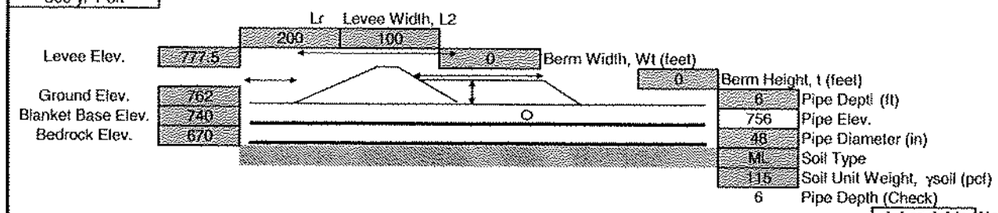
U = P3 * diameter * l
Using l = 1

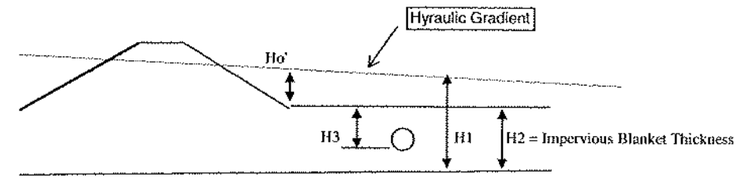
Conclusions
For levee stretch: 5+00UE to 66+00
For pipe diam (in): 24
There is no uplift concern at a depth of 15 feet or deeper within 500 feet landward of the levee

DRAFT
MARCH 8, 2007

Armourdale Area L1 Stationing Range	K-r	K-L	DbL	Dbo	Dbr	Df	H	i-c	Lr	Wt	Safety	L1	L2	Lc	Lt	L't	Ho'	Hwt/2	Hwt	i-o	Cr	Cl	t	s
																							feet	
5+00UE 66+00 500-yr + 3ft	300	300	22	22	22	70	15.5	0.84	200	0	1.71	194	100	680	974	974	10.82	10.82	10.82	0.49	680	680	0	0.000

Geotechnical data (above) presented in this spreadsheet was provided by Geotechnical Engineer, Scott Loehr, and is used to develop the Hydraulic Gradient at various distances from the toe. Verification of these numbers is done separately.





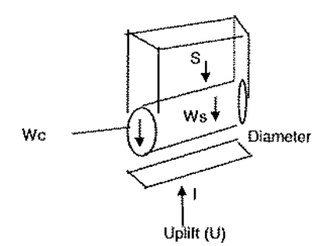
d=Landside Distance from Toe Feet	No Berm Calcs Excess Head Feet, Ho'	Invert Elev of pipe 48 -in steel	Design Base Blanket Feet, MSL	Ground Elev Feet, MSL	H3 Feet	H2 Feet	H1 Feet	P3 Psf	Ws lb	Wc lb	S lb	U lb	Wg lb	SFf (Full)	SFf (Empty)
0	10.82	756	740	762	6	22	32.8	558.5	191	784	920	2234	0	0.85	0.50
25	10.42	756	740	762	6	22	32.4	551.8	191	784	920	2207	0	0.86	0.50
50	10.05	756	740	762	6	22	32.0	545.4	191	784	920	2182	0	0.87	0.51
100	9.34	756	740	762	6	22	31.3	533.3	191	784	920	2133	0	0.89	0.52
125	9.00	756	740	762	6	22	31.0	527.5	191	784	920	2110	0	0.90	0.53
150	8.67	756	740	762	6	22	30.7	522.0	191	784	920	2088	0	0.91	0.53
200	8.06	756	740	762	6	22	30.1	511.5	191	784	920	2046	0	0.93	0.54
300	6.96	756	740	762	6	22	29.0	492.8	191	784	920	1971	0	0.96	0.56
400	6.00	756	740	762	6	22	28.0	476.6	191	784	920	1906	0	0.99	0.58
500	5.18	756	740	762	6	22	27.2	462.6	191	784	920	1850	0	1.02	0.60

Ws Calc 48 -in steel 1lf
191
Wc Calc 784

See Sample Calculations for list of abbreviations and sample calculations
Ws = weight of structure per foot of length = 190.70 lb per ft (48-inch Diameter Steel Pipe, .375" thick)
Wc = weight of water contained in the structure = pi * r^2 * 1 = 3.1416*((24/12)^2) *1*62.4 = 780 plf
S = surcharge loads = weight of satuarted soils above = (H3-Pipe Diameter/12)*(Pipe Diameter/12)*1*γsoil
P3 = H3*(H1/H2)*γwater
U = Uplift force on the project area of structure = Area of pipe * P3 = (Pipe Diameter/12)*1*P3
Wg = weight of surcharge water above top surface of structure control by gravity flow
SFf = Flotation Safety Factor (Ws+Wc+S)/(U-Wg)

Use this table to determine the distance from toe at which the Safety Factor is met
Enter the Distance from toe and change the value until the SFf is equal to that required

	Ground Elev 762		Distance from toe (ft) 0			Uplift Safety Extreme Case (1.1 REQ'D)	
		Ws = 191		Wc = 784 Full			
Depth Below Ground	Pipe Inv Elev, Ft	Surcharge Load, S, lbs/ft	Uplift (U) Force, lbs/ft	Pipe Weight, Lbs/ft	Full water Wt, Lbs / ft	SFf Full	SFf Empty
	762	0		191	784		
6	756	920	2234	191	784	0.85	0.50
10	752	2760	3723	191	784	1.00	0.79
14	748	4600	5212	191	784	1.07	0.92
18	744	6440	6701	191	784	1.11	0.99
22	740	8280	8191	191	784	1.13	1.03
26	736	10120	9680	191	784	1.15	1.07
30	732	11960	11169	191	784	1.16	1.09
34	728	13800	12658	191	784	1.17	1.11
38	724	15640	14148	191	784	1.17	1.12



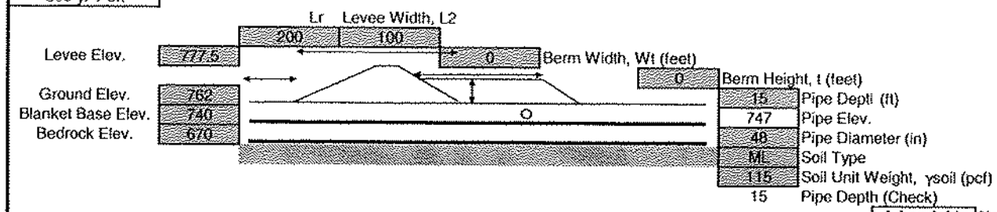
U = P3 * diameter * l
Using l = 1

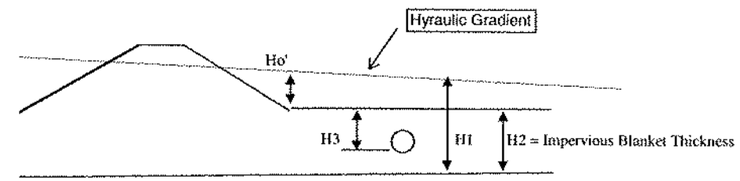
Conclusions
For levee stretch: 5+00UE to 66+00
For pipe diam (in): 48
There is uplift concern at a depth of 6 feet and less within 500 feet landward of the levee
There is uplift concern at a depth of 30 feet and less at the landward toe

DRAFT
MARCH 8, 2007

Armourdale Area L1 Stationing Range 5+00UE 66+00 500-yr + 3ft	K-r	K-L	DbL	Dbo	Dbr	Df	H	i-c	Lr	Wt	Safety	L1	L2	Le	Lt	L't	Ho'	Hwt/2	Hwt	i-o	Cr	Cl	t	s
																							feet	
	300	300	22	22	22	70	15.5	0.84	200	0	1.71	194	100	680	974	974	10.82	10.82	10.82	0.49	680	680	0	0.000

Geotechnical data (above) presented in this spreadsheet was provided by Geotechnical Engineer, Scott Loehr, and is used to develop the Hydraulic Gradient at various distances from the toe. Verification of these numbers is done separately.





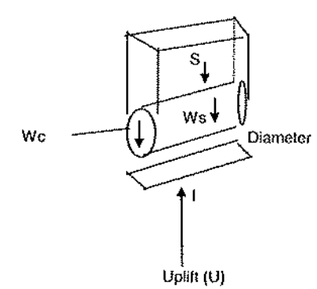
d=Landside Distance from Toe Feet	No Berm Calcs Excess Head Feet, Ho'	Invert Elev of pipe 48 -in steel	Design Base Blanket Feet, MSL	Ground Elev Feet, MSL	H3 Feet	H2 Feet	H1 Feet	P3 Psf	Ws lb	Wc lb	S lb	U lb	Wg lb	SFf (Full)	SFf (Empty)
0	10.82	747	740	762	15	22	32.8	1396.1	191	784	5060	5585	0	1.08	0.94
25	10.42	747	740	762	15	22	32.4	1379.5	191	784	5060	5518	0	1.09	0.95
50	10.05	747	740	762	15	22	32.0	1363.5	191	784	5060	5454	0	1.11	0.96
100	9.34	747	740	762	15	22	31.3	1333.2	191	784	5060	5333	0	1.13	0.98
125	9.00	747	740	762	15	22	31.0	1318.8	191	784	5060	5275	0	1.14	1.00
150	8.67	747	740	762	15	22	30.7	1305.0	191	784	5060	5220	0	1.16	1.01
200	8.06	747	740	762	15	22	30.1	1278.8	191	784	5060	5115	0	1.18	1.03
300	6.96	747	740	762	15	22	29.0	1231.9	191	784	5060	4928	0	1.22	1.07
400	6.00	747	740	762	15	22	28.0	1191.5	191	784	5060	4766	0	1.27	1.10
500	5.18	747	740	762	15	22	27.2	1156.5	191	784	5060	4626	0	1.30	1.14

Ws Calc 48 -in steel 1lf
191
Wc Calc
784

See Sample Calculations for list of abbreviations and sample calculations
Ws = weight of structure per foot of length = 190.70 lb per ft (48-inch Diameter Steel Pipe, .375" thick)
Wc = weight of water contained in the structure = pi * r^2 * 1 = 3.1416*((24/12)^2) *1*62.4 = 780 plf
S = surcharge loads = weight of satuarted soils above = (H3-Pipe Diameter/12)*(Pipe Diameter/12)*1*γsoil
P3 = H3*(H1/H2)*γwater
U = Uplift force on the project area of structure = Area of pipe * P3 = (Pipe Diameter/12)*1*P3
Wg = weight of surcharge water above top surface of structure control by gravity flow
SFf = Flotation Safety Factor (Ws+Wc+S)/(U-Wg)

Use this table to determine the distance from toe at which the Safety Factor is met
Enter the Distance from toe and change the value until the SFf is equal to that required

	Ground Elev 762		Distance from toe (ft) 0			Uplift Safety Extreme Case (1.1 REQ'D)	
		Ws = 191		Wc = 784 Full			
Depth Below Ground	Pipe Inv Elev, Ft	Surcharge Load, S, lbs/ft	Uplift (U) Force, lbs/ft	Pipe Weight, Lbs/ft	Full water Wt, Lbs / ft	SFf Full	SFf Empty
	762	0		191	784		
15	747	5060	5585	191	784	1.08	0.94
17	745	5980	6329	191	784	1.10	0.97
19	743	6900	7074	191	784	1.11	1.00
21	741	7820	7818	191	784	1.12	1.02
23	739	8740	8563	191	784	1.13	1.04
25	737	9660	9308	191	784	1.14	1.06
27	735	10580	10052	191	784	1.15	1.07
29	733	11500	10797	191	784	1.16	1.08
31	731	12420	11541	191	784	1.16	1.09
33	729	13340	12286	191	784	1.17	1.10
35	727	14260	13031	191	784	1.17	1.11



U = P3 * diameter * I
Using I = 1

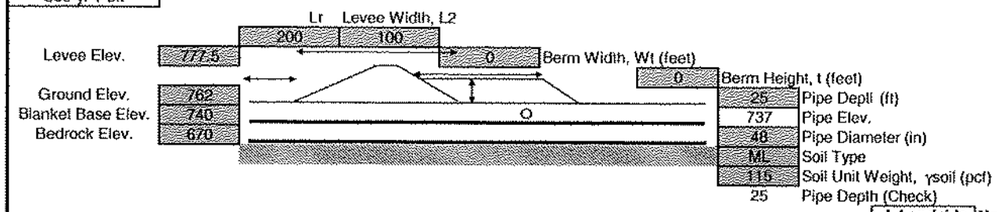
Conclusions

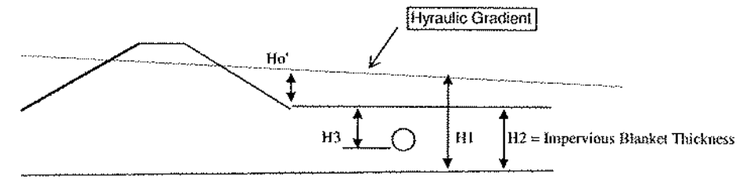
For levee stretch: 5+00UE to 66+00
For pipe diam (in): 48
There is uplift concern at a depth of 15 feet and less within 300 feet landward of the levee
There is uplift concern at a depth of 31 feet and less at the landward toe

DRAFT
MARCH 8, 2007

Armourdale Area L1 Stationing Range 5+00UE 66+00 500-yr + 3ft	K-r	K-L	DbL	Dbo	Dbr	Df	H	i-c	Lr	Wt	Safety	L1	L2	Le	Lt	L't	Ho'	Hwt/2	Hwt	i-o	Cr	Cl	t	s
																							feet	
	300	300	22	22	22	70	15.5	0.84	200	0	1.71	194	100	680	974	974	10.82	10.82	10.82	0.49	680	680	0	0.000

Geotechnical data (above) presented in this spreadsheet was provided by Geotechnical Engineer, Scott Loehr, and is used to develop the Hydraulic Gradient at various distances from the toe. Verification of these numbers is done separately.





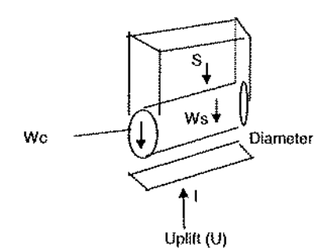
d=Landside Distance from Toe Feet	No Berm Calcs Excess Head Feet, Ho'	Invert Elev of pipe 48 -in steel	Design Base Blanket Feet, MSL	Ground Elev Feet, MSL	H3 Feet	H2 Feet	H1 Feet	P3 Psf	Ws lb	Wc lb	S lb	U lb	Wg lb	SFf (Full)	SFf (Empty)
0	10.82	737	740	762	25	22	32.8	2326.9	191	784	9660	9308	0	1.14	1.06
25	10.42	737	740	762	25	22	32.4	2299.2	191	784	9660	9197	0	1.16	1.07
50	10.05	737	740	762	25	22	32.0	2272.5	191	784	9660	9090	0	1.17	1.08
100	9.34	737	740	762	25	22	31.3	2222.0	191	784	9660	8888	0	1.20	1.11
125	9.00	737	740	762	25	22	31.0	2198.1	191	784	9660	8792	0	1.21	1.12
150	8.67	737	740	762	25	22	30.7	2175.0	191	784	9660	8700	0	1.22	1.13
200	8.06	737	740	762	25	22	30.1	2131.4	191	784	9660	8526	0	1.25	1.16
300	6.96	737	740	762	25	22	29.0	2053.2	191	784	9660	8213	0	1.29	1.20
400	6.00	737	740	762	25	22	28.0	1985.8	191	784	9660	7943	0	1.34	1.24
500	5.18	737	740	762	25	22	27.2	1927.5	191	784	9660	7710	0	1.38	1.28

Ws Calc 48 -in steel 1lf
191
Wc Calc 784

See Sample Calculations for list of abbreviations and sample calculations
Ws = weight of structure per foot of length = 190.70 lb per ft (48-inch Diameter Steel Pipe, .375" thick)
Wc = weight of water contained in the structure = pi * r^2 * 1 = 3.1416*((24/12)^2) *1*62.4 = 780 plf
S = surcharge loads = weight of satuarted soils above = (H3-Pipe Diameter/12)*(Pipe Diameter/12)*1*γsoil
P3 = H3*(H1/H2)*γwater
U = Uplift force on the project area of structure = Area of pipe * P3 = (Pipe Diameter/12)*1*P3
Wg = weight of surcharge water above top surface of structure control by gravity flow
SFf = Flotation Safety Factor (Ws+Wc+S)/(U-Wg)

Use this table to determine the distance from toe at which the Safety Factor is met
Enter the Distance from toe and change the value until the SFf is equal to that required

	Ground Elev 762		Distance from toe (ft) 0			Uplift Safety Extreme Case (1.1 REQ'D)	
		Ws = 191		Wc = 784 Full			
Depth Below Ground	Pipe Inv Elev, Ft	Surcharge Load, S, lbs/ft	Uplift (U) Force, lbs/ft	Pipe Weight, Lbs/ft	Full water Wt, Lbs / ft	SFf Full	SFf Empty
	762	0		191	784		
25	737	9660	9308	191	784	1.14	1.06
26	736	10120	9680	191	784	1.15	1.07
27	735	10580	10052	191	784	1.15	1.07
28	734	11040	10425	191	784	1.15	1.08
29	733	11500	10797	191	784	1.16	1.08
30	732	11960	11169	191	784	1.16	1.09
31	731	12420	11541	191	784	1.16	1.09
32	730	12880	11914	191	784	1.16	1.10
33	729	13340	12286	191	784	1.17	1.10



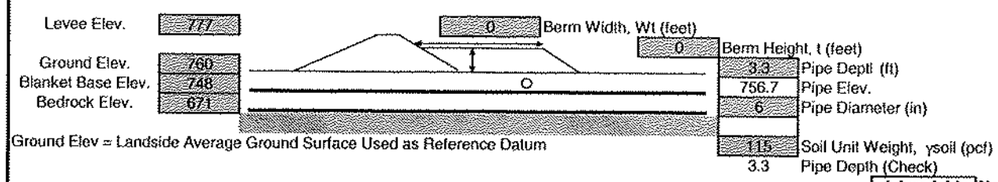
U = P3 * diameter * l
Using l = 1

Conclusions

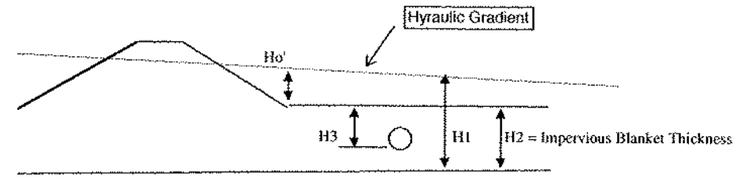
For levee stretch: 5+00UE to 66+00
For pipe diam (in): 48
There is uplift concern at a depth of 25 feet and less within 50 feet landward of the levee
There is uplift concern at a depth of 32 feet and less at the landward toe

DRAFT
MARCH 8, 2007

Armourdale Area
L2
Stationing Range
66+00
79+00
500-yr + 3ft



Ground Elev = Landside Average Ground Surface Used as Reference Datum



From Geotechnical Seepage Calculations with Cutoff Wall (2-27-2007)

Dist from toe FT	Ho FT
0	7
500	4

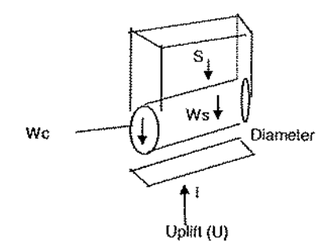
No Berm Calcs With WELLS

d=Landside Distance from Toe Feet	Excess Head Feet, Ho'	Invert Elev of pipe 6 -in steel	Design Base Blanket Feet, MSL	Ground Elev Feet, MSL	H3 Feet	H2 Feet	H1 Feet	P3 Psf	Ws lb	Wc lb	S lb	U lb	Wg lb	SFf (Full)	SFf (Empty)
0	7.0	756.7	748	760	3.3	12	19.0	326.0	19	12	161	163	0	1.18	1.10
25	6.9	756.7	748	760	3.3	12	18.9	323.5	19	12	161	162	0	1.19	1.11
50	6.7	756.7	748	760	3.3	12	18.7	320.9	19	12	161	160	0	1.20	1.12
100	6.4	756.7	748	760	3.3	12	18.4	315.7	19	12	161	158	0	1.22	1.14
125	6.3	756.7	748	760	3.3	12	18.3	313.2	19	12	161	157	0	1.23	1.15
150	6.1	756.7	748	760	3.3	12	18.1	310.6	19	12	161	155	0	1.24	1.16
200	5.8	756.7	748	760	3.3	12	17.8	305.4	19	12	161	153	0	1.26	1.18
300	5.2	756.7	748	760	3.3	12	17.2	295.2	19	12	161	148	0	1.30	1.22
400	4.6	756.7	748	760	3.3	12	16.6	284.9	19	12	161	142	0	1.35	1.26
500	4.0	756.7	748	760	3.3	12	16.0	274.6	19	12	161	137	0	1.40	1.31

Ws Calc 6 -in steel 1lf
19
Wc Calc 12

See Sample Calculations for list of abbreviations and sample calculations
Ws = weight of structure per foot of length = 18.97 lb per ft (6-inch Diameter Steel Pipe, .280" thick)
Wc = weight of water contained in the structure = pi * r^2 * 1 = 3.1416*((3/12)^2) *1*62.4 = 12 plf
S = surcharge loads = weight of satuarted soils above = (H3-Pipe Diameter/12)*(Pipe Diameter/12)*1*γsoil
P3 = H3*(H1/H2)*γwater
U = Uplift force on the project area of structure = Area of pipe * P3 = (Pipe Diameter/12)*1*P3
Wg = weight of surcharge water above top surface of structure control by gravity flow
SFf = Flotation Safety Factor (Ws+Wc+S)/(U-Wg)

Conclusions
For levee stretch: 66+00 to 79+00
For pipe diam (in): 6
There is no uplift concern at a depth of 3.33 feet or deeper within 500 feet landward of the levee

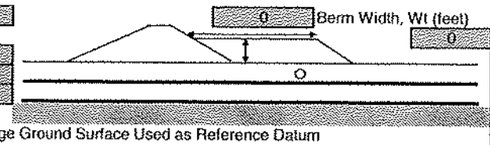


U = P3 * diameter * l
Using l = 1

DRAFT
MARCH 8, 2007

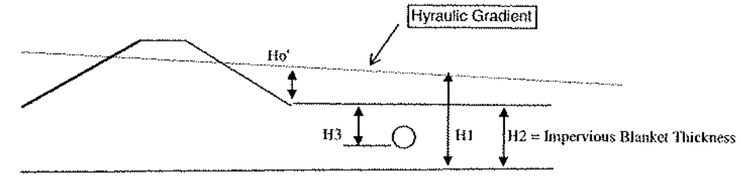
Armourdale Area
L2
Stationing Range
66+00
79+00
500-yr + 3ft

Levee Elev.	777
Ground Elev.	760
Blanket Base Elev.	748
Bedrock Elev.	671



0	Berm Width, Wt (feet)
0	Berm Height, t (feet)
3.3	Pipe Depth (ft)
756.7	Pipe Elev.
12	Pipe Diameter (in)
115	Soil Unit Weight, γsoil (pcf)
3.3	Pipe Depth (Check)

Ground Elev = Landside Average Ground Surface Used as Reference Datum



From Geotechnical Seepage Calculations with Cutoff Wall (2-27-2007)

Dist from toe FT	Ho FT
0	7
500	4

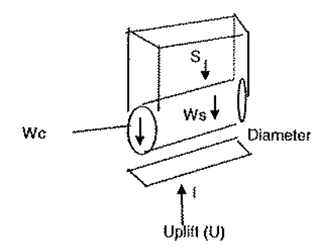
No Berm Calcs With WELLS

d=Landside Distance from Toe Feet	Excess Head Feet, Ho'	Invert Elev of pipe 12 -in steel	Design Base Blanket Feet, MSL	Ground Elev Feet, MSL	H3 Feet	H2 Feet	H1 Feet	P3 Psf	Ws lb	Wc lb	S lb	U lb	Wg lb	SFf (Full)	SFf (Empty)
0	7.0	756.7	748	760	3.3	12	19.0	326.0	50	49	264	326	0	1.11	0.96
25	6.9	756.7	748	760	3.3	12	18.9	323.5	50	49	264	323	0	1.12	0.97
50	6.7	756.7	748	760	3.3	12	18.7	320.9	50	49	264	321	0	1.13	0.98
100	6.4	756.7	748	760	3.3	12	18.4	315.7	50	49	264	316	0	1.15	0.99
125	6.3	756.7	748	760	3.3	12	18.3	313.2	50	49	264	313	0	1.16	1.00
150	6.1	756.7	748	760	3.3	12	18.1	310.6	50	49	264	311	0	1.17	1.01
200	5.8	756.7	748	760	3.3	12	17.8	305.4	50	49	264	305	0	1.19	1.03
300	5.2	756.7	748	760	3.3	12	17.2	295.2	50	49	264	295	0	1.23	1.06
400	4.6	756.7	748	760	3.3	12	16.6	284.9	50	49	264	285	0	1.27	1.10
500	4.0	756.7	748	760	3.3	12	16.0	274.6	50	49	264	275	0	1.32	1.14

Ws Calc 12 -in steel 1lf
50
Wc Calc
49

See Sample Calculations for list of abbreviations and sample calculations
Ws = weight of structure per foot of length = 50 lb per ft (12-inch Diameter Steel Pipe, .375" thick)
Wc = weight of water contained in the structure = pi * r^2 * 1 = 3.1416*((6/12)^2) *1*62.4 = 49 plf
S = surcharge loads = weight of satuarted soils above = (H3-Pipe Diameter/12)*(Pipe Diameter/12)*1*γsoil
P3 = H3*(H1/H2)*γwater
U = Uplift force on the project area of structure = Area of pipe * P3 = (Pipe Diameter/12)*1*P3
Wg = weight of surcharge water above top surface of structure control by gravity flow
SFf = Flotation Safety Factor (Ws+Wc+S)/(U-Wg)

Conclusions
For levee stretch: 66+00 to 79+00
For pipe diam (in): 12
There is uplift concern at a depth of 40 inches (3.3 feet) and less within 300 feet landward of the levee

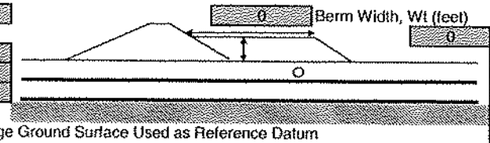


U = P3 * diameter * l
Using l = 1

DRAFT
MARCH 8, 2007

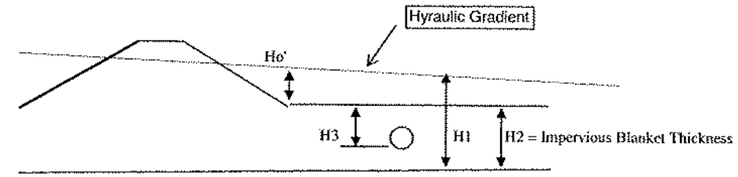
Armourdale Area
L2
Stationing Range
66+00
79+00
500-yr + 3ft

Levee Elev.	777
Ground Elev.	760
Blanket Base Elev.	748
Bedrock Elev.	671



0	Berm Width, Wt (feet)
0	Berm Height, t (feet)
10	Pipe Deptl (ft)
750	Pipe Elev.
12	Pipe Diameter (in)
115	Soil Unit Weight, γsoil (pcf)
10	Pipe Depth (Check)

Ground Elev = Landside Average Ground Surface Used as Reference Datum



From Geotechnical Seepage Calculations with Cutoff Wall (2-27-2007)

Dist from toe FT	Ho FT
0	7
500	4

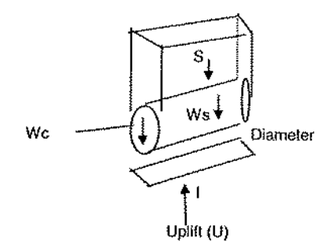
No Berm Calcs With WELLS

d=Landside Distance from Toe Feet	Excess Head Feet, Ho'	Invert Elev of pipe 12 -in steel	Design Base Blanket Feet, MSL	Ground Elev Feet, MSL	H3 Feet	H2 Feet	H1 Feet	P3 Psf	Ws lb	Wc lb	S lb	U lb	Wg lb	SFf (Full)	SFf (Empty)
0	7.0	750	748	760	10	12	19.0	988.0	50	49	1035	988	0	1.15	1.10
25	6.9	750	748	760	10	12	18.9	980.2	50	49	1035	980	0	1.16	1.11
50	6.7	750	748	760	10	12	18.7	972.4	50	49	1035	972	0	1.17	1.12
100	6.4	750	748	760	10	12	18.4	956.8	50	49	1035	957	0	1.18	1.13
125	6.3	750	748	760	10	12	18.3	949.0	50	49	1035	949	0	1.19	1.14
150	6.1	750	748	760	10	12	18.1	941.2	50	49	1035	941	0	1.20	1.15
200	5.8	750	748	760	10	12	17.8	925.6	50	49	1035	926	0	1.22	1.17
300	5.2	750	748	760	10	12	17.2	894.4	50	49	1035	894	0	1.27	1.21
400	4.6	750	748	760	10	12	16.6	863.2	50	49	1035	863	0	1.31	1.26
500	4.0	750	748	760	10	12	16.0	832.0	50	49	1035	832	0	1.36	1.30

Ws Calc 12 -in steel 1lf
50
Wc Calc 49

See Sample Calculations for list of abbreviations and sample calculations
Ws = weight of structure per foot of length = 50 lb per ft (12-inch Diameter Steel Pipe, .375" thick)
Wc = weight of water contained in the structure = pi * r^2 * 1 = 3.1416*((6/12)^2) *1*62.4 = 49 plf
S = surcharge loads = weight of satuarted soils above = (H3-Pipe Diameter/12)*(Pipe Diameter/12)*1*γsoil
P3 = H3*(H1/H2)*γwater
U = Uplift force on the project area of structure = Area of pipe * P3 = (Pipe Diameter/12)*1*P3
Wg = weight of surcharge water above top surface of structure control by gravity flow
SFf = Flotation Safety Factor (Ws+Wc+S)/(U-Wg)

Conclusions
For levee stretch: 66+00 to 79+00
For pipe diam (in): 12
There is uplift concern at a depth of 40 inches (3.3 feet) and less at the toe of the levee



U = P3 * diameter * i
Using i = 1

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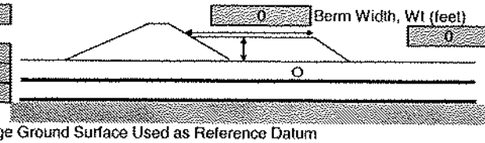
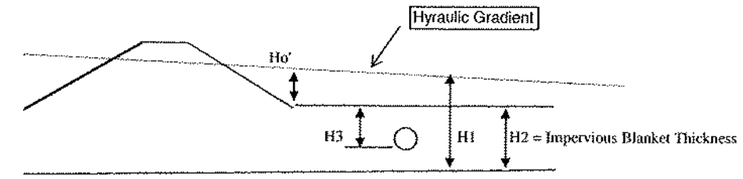
MARCH 2007

Armourdale Area
L2
Stationing Range
66+00
79+00
500-yr + 3ft

Levee Elev.	777	0 Berm Width, Wt (feet)	
		0	Berm Height, t (feet)
Ground Elev.	760	3.33	Pipe Deptl (ft)
Blanket Base Elev.	748	756.67	Pipe Elev.
Bedrock Elev.	671	16	Pipe Diameter (in)
		115	Soil Unit Weight, γsoil (pcf)
		3.33	Pipe Depth (Check)

Ground Elev = Landside Average Ground Surface Used as Reference Datum





From Geotechnical Seepage Calculations with Cutoff Wall (2-27-2007)

Dist from toe FT	Ho FT
0	7
500	4

d=Landside

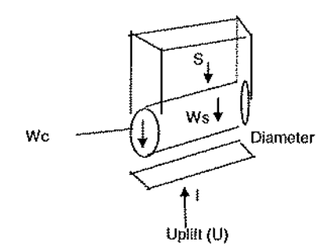
No Berm Calcs With WELLS

Distance from Toe Feet	Excess Head Feet, Ho'	Invert Elev of pipe 16 -in steel	Design Base Blanket Feet, MSL	Ground Elev Feet, MSL	H3 Feet	H2 Feet	H1 Feet	P3 Psf	Ws lb	Wc lb	S lb	U lb	Wg lb	SFf (Full)	SFf (Empty)
0	7.0	756.67	748	760	3.33	12	19.0	329.0	63	87	306	439	0	1.04	0.84
25	6.9	756.67	748	760	3.33	12	18.9	326.4	63	87	306	435	0	1.05	0.85
50	6.7	756.67	748	760	3.33	12	18.7	323.8	63	87	306	432	0	1.06	0.86
100	6.4	756.67	748	760	3.33	12	18.4	318.6	63	87	306	425	0	1.07	0.87
125	6.3	756.67	748	760	3.33	12	18.3	316.0	63	87	306	421	0	1.08	0.88
150	6.1	756.67	748	760	3.33	12	18.1	313.4	63	87	306	418	0	1.09	0.88
200	5.8	756.67	748	760	3.33	12	17.8	308.2	63	87	306	411	0	1.11	0.90
300	5.2	756.67	748	760	3.33	12	17.2	297.8	63	87	306	397	0	1.15	0.93
400	4.6	756.67	748	760	3.33	12	16.6	287.4	63	87	306	383	0	1.19	0.96
500	4.0	756.67	748	760	3.33	12	16.0	277.1	63	87	306	369	0	1.24	1.00

Ws Calc 16 -in steel 1lf
63
Wc Calc
87

See Sample Calculations for list of abbreviations and sample calculations
Ws = weight of structure per foot of length = 62.58 lb per ft (16-inch Diameter Steel Pipe, .375" thick)
Wc = weight of water contained in the structure = pi * r^2 * 1 = 3.1416*((8/12)^2) *1*62.4 = 49 plf
S = surcharge loads = weight of satuarted soils above = (H3-Pipe Diameter/12)*(Pipe Diameter/12)*1*γsoil
P3 = H3*(H1/H2)*γwater
U = Uplift force on the project area of structure = Area of pipe * P3 = (Pipe Diameter/12)*1*P3
Wg = weight of surcharge water above top surface of structure control by gravity flow
SFf = Flotation Safety Factor (Ws+Wc+S)/(U-Wg)

Conclusions
For levee stretch: 66+00 to 79+00
For pipe diam (in): 16
There is uplift concern at a depth of 40 inches (3.3 feet) and less within 500 feet of the levee



U = P3 * diameter * l
Using l = 1

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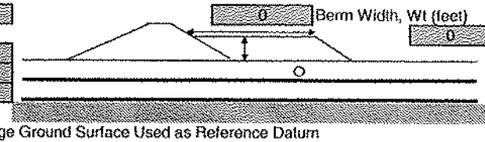
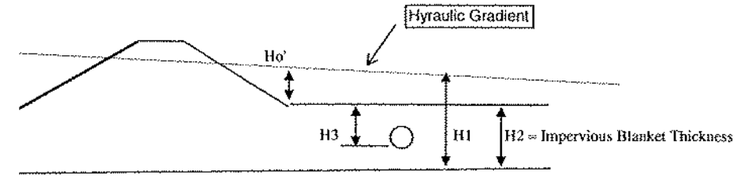
MARCH 8 ,2007

Armourdale Area
L2
Stationing Range
66+00
79+00
500-yr + 3ft

Levee Elev.	777	
Ground Elev.	760	
Blanket Base Elev.	748	
Bedrock Elev.	671	
	0	Berm Width, Wt (feet)
	0	Berm Height, t (feet)
	10	Pipe Depti (ft)
	750	Pipe Elev.
	16	Pipe Diameter (in)
	115	Soil Unit Weight, γsoil (pcf)
	10	Pipe Depth (Check)



Ground Elev = Landside Average Ground Surface Used as Reference Datum



From Geotechnical Seepage Calculations with Cutoff Wall (2-27-2007)

Dist from toe FT	Ho FT
0	7
500	4

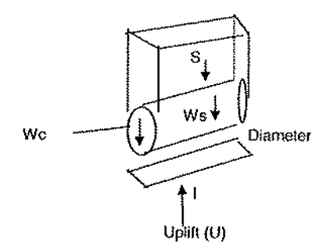
No Berm Calcs With WELLS

d=Landside Distance from Toe Feet	Excess Head Feet, Ho'	Invert Elev of pipe 16 -in steel	Design Base Blanket Feet, MSL	Ground Elev Feet, MSL	H3 Feet	H2 Feet	H1 Feet	P3 Psf	Ws lb	Wc lb	S lb	U lb	Wg lb	SFf (Full)	SFf (Empty)
0	7.0	750	748	760	10	12	19.0	988.0	63	87	1329	1317	0	1.12	1.06
25	6.9	750	748	760	10	12	18.9	980.2	63	87	1329	1307	0	1.13	1.07
50	6.7	750	748	760	10	12	18.7	972.4	63	87	1329	1297	0	1.14	1.07
100	6.4	750	748	760	10	12	18.4	956.8	63	87	1329	1276	0	1.16	1.09
125	6.3	750	748	760	10	12	18.3	949.0	63	87	1329	1265	0	1.17	1.10
150	6.1	750	748	760	10	12	18.1	941.2	63	87	1329	1255	0	1.18	1.11
200	5.8	750	748	760	10	12	17.8	925.6	63	87	1329	1234	0	1.20	1.13
300	5.2	750	748	760	10	12	17.2	894.4	63	87	1329	1193	0	1.24	1.17
400	4.6	750	748	760	10	12	16.6	863.2	63	87	1329	1151	0	1.29	1.21
500	4.0	750	748	760	10	12	16.0	832.0	63	87	1329	1109	0	1.39	1.25

Ws Calc 16 -in steel 1lf
63
Wc Calc 87

See Sample Calculations for list of abbreviations and sample calculations
Ws = weight of structure per foot of length = 62.58 lb per ft (16-inch Diameter Steel Pipe, .375" thick)
Wc = weight of water contained in the structure = pi * r^2 * 1 = 3.1416*((8/12)^2) *1*62.4 = 49 plf
S = surcharge loads = weight of satuarted soils above = (H3-Pipe Diameter/12)*(Pipe Diameter/12)*1*γsoil
P3 = H3*(H1/H2)*γwater
U = Uplift force on the project area of structure = Area of pipe * P3 = (Pipe Diameter/12)*1*P3
Wg = weight of surcharge water above top surface of structure control by gravity flow
SFf = Flotation Safety Factor (Ws+Wc+S)/(U-Wg)

Conclusions
For levee stretch: 66+00 to 79+00
For pipe diam (in): 16
There is uplift concern at a depth of 10 feet and less within 100 feet from the toe of the levee



U = P3 * diameter * l
Using l = 1

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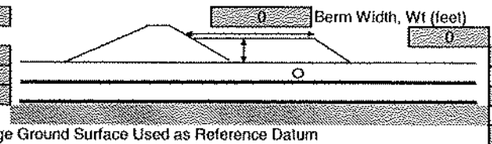
MARCH 8 ,2007

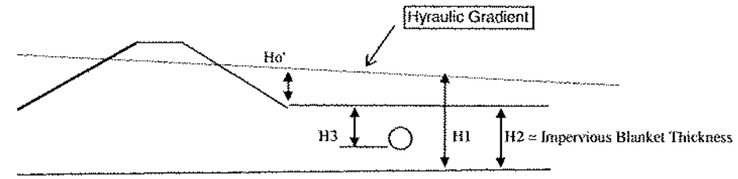
Armourdale Area
L2
Stationing Range
66+00
79+00
500-yr + 3ft

Levee Elev.	777
Ground Elev.	760
Blanket Base Elev.	748
Bedrock Elev.	671



0	Berm Width, Wt (feet)
0	Berm Height, t (feet)
15	Pipe Depth (ft)
745	Pipe Elev.
16	Pipe Diameter (in)
115	Soil Unit Weight, γsoil (pcf)
15	Pipe Depth (Check)

Ground Elev = Landside Average Ground Surface Used as Reference Datum



From Geotechnical Seepage Calculations with Cutoff Wall (2-27-2007)

Dist from toe FT	Ho FT
0	7
500	4

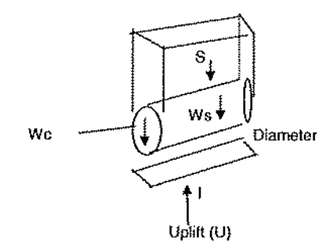
No Berm Calcs With WELLS

d=Landside Distance from Toe Feet	Excess Head Feet, Ho'	Invert Elev of pipe 16 -in steel	Design Base Blanket Feet, MSL	Ground Elev Feet, MSL	H3 Feet	H2 Feet	H1 Feet	P3 Psf	Ws lb	Wc lb	S lb	U lb	Wg lb	SFf (Full)	SFf (Empty)
0	7.0	745	748	760	15	12	19.0	1482.0	63	87	2096	1976	0	1.14	1.09
25	6.9	745	748	760	15	12	18.9	1470.3	63	87	2096	1960	0	1.15	1.10
50	6.7	745	748	760	15	12	18.7	1458.6	63	87	2096	1945	0	1.15	1.11
100	6.4	745	748	760	15	12	18.4	1435.2	63	87	2096	1914	0	1.17	1.13
125	6.3	745	748	760	15	12	18.3	1423.5	63	87	2096	1898	0	1.18	1.14
150	6.1	745	748	760	15	12	18.1	1411.8	63	87	2096	1882	0	1.19	1.15
200	5.8	745	748	760	15	12	17.8	1388.4	63	87	2096	1851	0	1.21	1.17
300	5.2	745	748	760	15	12	17.2	1341.6	63	87	2096	1789	0	1.26	1.21
400	4.6	745	748	760	15	12	16.6	1294.8	63	87	2096	1726	0	1.30	1.25
500	4.0	745	748	760	15	12	16.0	1248.0	63	87	2096	1664	0	1.35	1.30

Ws Calc 16 -in steel 1lf
63
Wc Calc
87

See Sample Calculations for list of abbreviations and sample calculations
Ws = weight of structure per foot of length = 62.58 lb per ft (16-inch Diameter Steel Pipe, .375" thick)
Wc = weight of water contained in the structure = pi * r^2 * 1 = 3.1416*((8/12)^2) *1*62.4 = 49 plf
S = surcharge loads = weight of satuarted soils above = (H3-Pipe Diameter/12)*(Pipe Diameter/12)*1*γsoil
P3 = H3*(H1/H2)*γwater
U = Uplift force on the project area of structure = Area of pipe * P3 = (Pipe Diameter/12)*1*P3
Wg = weight of surcharge water above top surface of structure control by gravity flow
SFf = Flotation Safety Factor (Ws+Wc+S)/(U-Wg)

Conclusions
For levee stretch: 66+00 to 79+00
For pipe diam (in): 16
There is uplift concern at a depth of 15 feet and less just at the toe of the levee



U = P3 * diameter * l
Using l = 1

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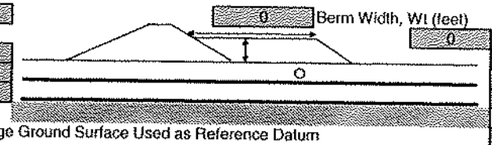
MARCH 8, 2007

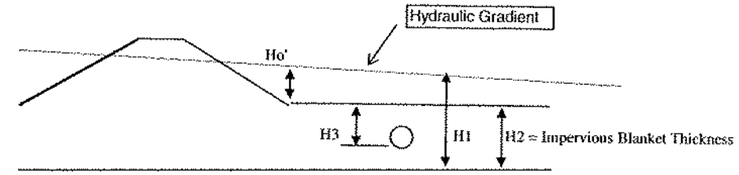
Armourdale Area
L2
Stationing Range
66+00
79+00
500-yr + 3ft

Levee Elev.	777
Ground Elev.	760
Blanket Base Elev.	748
Bedrock Elev.	671



0	Berm Width, Wt (feet)
0	Berm Height, t (feet)
3.3	Pipe Deptl (ft)
756.7	Pipe Elev.
24	Pipe Diameter (in)
115	Soil Unit Weight, γsoil (pcf)
3.3	Pipe Depth (Check)

Ground Elev = Landside Average Ground Surface Used as Reference Datum



From Geotechnical Seepage Calculations with Cutoff Wall (2-27-2007)

Dist from toe FT	Ho FT
0	7
500	4

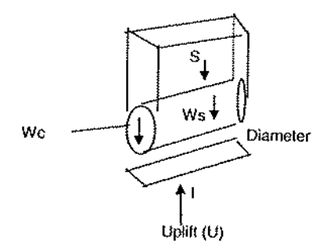
No Berm Calcs With WELLS

d=Landside Distance from Toe Feet	Excess Head Feet, Ho'	Invert Elev of pipe 24 -in steel	Design Base Blanket Feet, MSL	Ground Elev Feet, MSL	H3 Feet	H2 Feet	H1 Feet	P3 Psf	Ws lb	Wc lb	S lb	U lb	Wg lb	SFf (Full)	SFf (Empty)
0	7.0	756.7	748	760	3.3	12	19.0	326.0	95	196	299	652	0	0.90	0.60
25	6.9	756.7	748	760	3.3	12	18.9	323.5	95	196	299	647	0	0.91	0.61
50	6.7	756.7	748	760	3.3	12	18.7	320.9	95	196	299	642	0	0.92	0.61
100	6.4	756.7	748	760	3.3	12	18.4	315.7	95	196	299	631	0	0.93	0.62
125	6.3	756.7	748	760	3.3	12	18.3	313.2	95	196	299	626	0	0.94	0.63
150	6.1	756.7	748	760	3.3	12	18.1	310.6	95	196	299	621	0	0.95	0.63
200	5.8	756.7	748	760	3.3	12	17.8	305.4	95	196	299	611	0	0.97	0.64
300	5.2	756.7	748	760	3.3	12	17.2	295.2	95	196	299	590	0	1.00	0.67
400	4.6	756.7	748	760	3.3	12	16.6	284.9	95	196	299	570	0	1.04	0.69
500	4.0	756.7	748	760	3.3	12	16.0	274.6	95	196	299	549	0	1.07	0.72

Ws Calc 24 -in steel 1lf
95
Wc Calc
196

See Sample Calculations for list of abbreviations and sample calculations
Ws = weight of structure per foot of length = 94.62 lb per ft (24-inch Diameter Steel Pipe, .375" thick)
Wc = weight of water contained in the structure = pi * r^2 * 1 = 3.1416*((12/12)^2) *1*62.4 = 196 plf
S = surcharge loads = weight of satuarted soils above = (H3-Pipe Diameter/12)*(Pipe Diameter/12)*1*γsoil
P3 = H3*(H1/H2)*γwater
U = Uplift force on the project area of structure = Area of pipe * P3 = (Pipe Diameter/12)"1"P3
Wg = weight of surcharge water above top surface of structure control by gravity flow
SFf = Flotation Safety Factor (Ws+Wc+S)/(U-Wg)

Conclusions
For levee stretch: 66+00 to 79+00
For pipe diam (in): 24
There is uplift concern at a depth of 3.33 feet or less within 500 feet landward of the levee



U = P3 * diameter * I
Using I = 1

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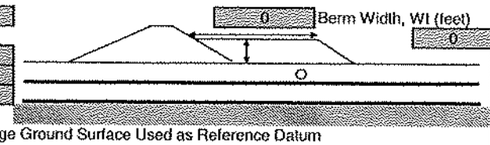
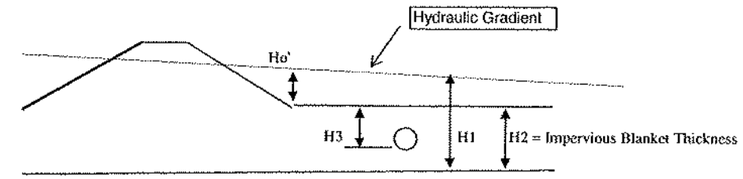
MARCH 8 ,2007

Armourdale Area
L2
Stationing Range
66+00
79+00
500-yr + 3ft

Levee Elev.	777	
Ground Elev.	760	
Blanket Base Elev.	748	
Bedrock Elev.	671	
	0	Berm Width, Wt (feet)
	0	Berm Height, t (feet)
	10	Pipe Depth (ft)
	750	Pipe Elev.
	24	Pipe Diameter (in)
	115	Soil Unit Weight, γsoil (pcf)
	10	Pipe Depth (Check)



Ground Elev = Landside Average Ground Surface Used as Reference Datum



From Geotechnical Seepage Calculations with Cutoff Wall (2-27-2007)

Dist from toe FT	Ho FT
0	7
500	4

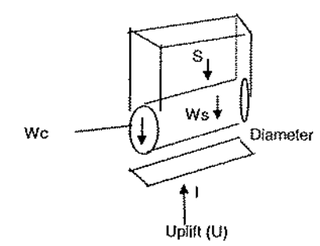
No Berm Calcs With WELLS

d=Landside Distance from Toe Feet	Excess Head Feet, Ho'	Invert Elev of pipe 24 -in steel	Design Base Blanket Feet, MSL	Ground Elev Feet, MSL	H3 Feet	H2 Feet	H1 Feet	P3 Psf	Ws lb	Wc lb	S lb	U lb	Wg lb	SFf (Full)	SFf (Empty)
0	7.0	750	748	760	10	12	19.0	988.0	95	196	1840	1976	0	1.08	0.98
25	6.9	750	748	760	10	12	18.9	980.2	95	196	1840	1960	0	1.09	0.99
50	6.7	750	748	760	10	12	18.7	972.4	95	196	1840	1945	0	1.10	0.99
100	6.4	750	748	760	10	12	18.4	956.8	95	196	1840	1914	0	1.11	1.01
125	6.3	750	748	760	10	12	18.3	949.0	95	196	1840	1898	0	1.12	1.02
150	6.1	750	748	760	10	12	18.1	941.2	95	196	1840	1882	0	1.13	1.03
200	5.8	750	748	760	10	12	17.8	925.6	95	196	1840	1851	0	1.15	1.05
300	5.2	750	748	760	10	12	17.2	894.4	95	196	1840	1789	0	1.19	1.08
400	4.6	750	748	760	10	12	16.6	863.2	95	196	1840	1726	0	1.23	1.12
500	4.0	750	748	760	10	12	16.0	832.0	95	196	1840	1664	0	1.28	1.16

Ws Calc 24 -in steel 1lf
95
Wc Calc
196

See Sample Calculations for list of abbreviations and sample calculations
Ws = weight of structure per foot of length = 94.62 lb per ft (24-inch Diameter Steel Pipe, .375" thick)
Wc = weight of water contained in the structure = pi * r^2 * 1 = 3.1416*((12/12)^2) *1*62.4 = 196 plf
S = surcharge loads = weight of saturated soils above = (H3-Pipe Diameter/12)*(Pipe Diameter/12)*1*γsoil
P3 = H3*(H1/H2)*γwater
U = Uplift force on the project area of structure = Area of pipe * P3 = (Pipe Diameter/12)*1*P3
Wg = weight of surcharge water above top surface of structure control by gravity flow
SFf = Flotation Safety Factor (Ws+Wc+S)/(U-Wg)

Conclusions
For levee stretch: 66+00 to 79+00
For pipe diam (in): 24
There is uplift concern at a depth of 10 feet or less within 300 feet landward of the levee



U = P3 * diameter * l
Using l = 1

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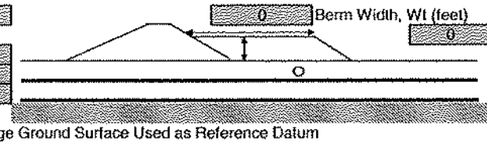
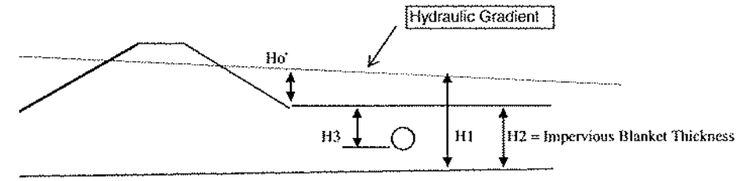
Armourdale Area
L2
Stationing Range
66+00
79+00
500-yr + 3ft

Levee Elev.	777
Ground Elev.	760
Blanket Base Elev.	748
Bedrock Elev.	671



0	Berm Width, Wt (feet)
0	Berm Height, t (feet)
15	Pipe Depth (ft)
745	Pipe Elev.
24	Pipe Diameter (in)
115	Soil Unit Weight, γsoil (pcf)
15	Pipe Depth (Check)

Ground Elev = Landside Average Ground Surface Used as Reference Datum



From Geotechnical Seepage Calculations with Cutoff Wall (2-27-2007)

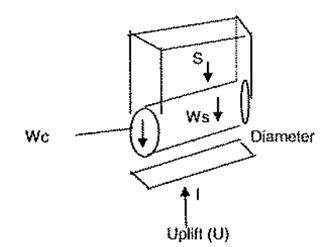
Dist from toe FT	Ho FT
0	7
500	4

d=Landside Distance from Toe Feet	No Berm Calcs With WELLS Excess Head Feet, Ho'	Invert Elev of pipe 24 -in steel	Design Base Blanket Feet, MSL	Ground Elev Feet, MSL	H3 Feet	H2 Feet	H1 Feet	P3 Psf	Ws lb	Wc lb	S lb	U lb	Wg lb	SFf (Full)	SFf (Empty)
0	7.0	745	748	760	15	12	19.0	1482.0	95	196	2990	2964	0	1.11	1.04
25	6.9	745	748	760	15	12	18.9	1470.3	95	196	2990	2941	0	1.12	1.05
50	6.7	745	748	760	15	12	18.7	1458.6	95	196	2990	2917	0	1.12	1.06
100	6.4	745	748	760	15	12	18.4	1435.2	95	196	2990	2870	0	1.14	1.07
125	6.3	745	748	760	15	12	18.3	1423.5	95	196	2990	2847	0	1.15	1.08
150	6.1	745	748	760	15	12	18.1	1411.8	95	196	2990	2824	0	1.16	1.09
200	5.8	745	748	760	15	12	17.8	1388.4	95	196	2990	2777	0	1.18	1.11
300	5.2	745	748	760	15	12	17.2	1341.6	95	196	2990	2683	0	1.22	1.15
400	4.6	745	748	760	15	12	16.6	1294.8	95	196	2990	2590	0	1.27	1.19
500	4.0	745	748	760	15	12	16.0	1248.0	95	196	2990	2496	0	1.31	1.24

Ws Calc 24 -in steel 1lf
95
Wc Calc
196

See Sample Calculations for list of abbreviations and sample calculations
Ws = weight of structure per foot of length = 94.62 lb per ft (24-inch Diameter Steel Pipe, .375" thick)
Wc = weight of water contained in the structure = pi * r^2 * 1 = 3.1416*((12/12)^2) *1*62.4 = 196 plf
S = surcharge loads = weight of satuarted soils above = (H3-Pipe Diameter/12)*(Pipe Diameter/12)*1*γsoil
P3 = H3*(H1/H2)*γwater
U = Uplift force on the project area of structure = Area of pipe * P3 = (Pipe Diameter/12)*1*P3
Wg = weight of surcharge water above top surface of structure control by gravity flow
SFf = Flotation Safety Factor (Ws+Wc+S)/(U-Wg)

Conclusions
For levee stretch: 66+00 to 79+00
For pipe diam (in): 24
There is uplift concern at a depth of 15 feet or less within 150 feet landward of the levee



U = P3 * diameter * l
Using l = 1

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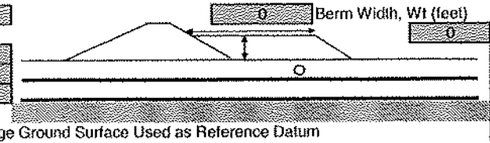
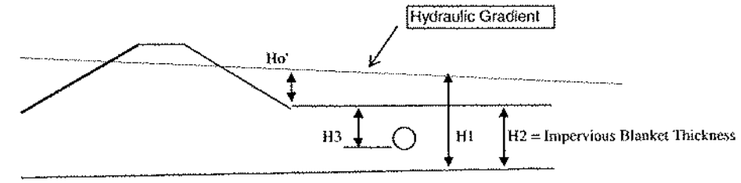
Armourdale Area
L2
Stationing Range
66+00
79+00
500-yr + 3ft

Levee Elev.	777	
Ground Elev.	760	
Blanket Base Elev.	748	
Bedrock Elev.	671	
	0	Berm Width, Wt (feet)
	0	Berm Height, t (feet)
	20	Pipe Depth (ft)
	740	Pipe Elev.
	24	Pipe Diameter (in)
	115	Soil Unit Weight, γsoil (pcf)
	20	Pipe Depth (Check)



Ground Elev = Landside Average Ground Surface Used as Reference Datum



From Geotechnical Seepage Calculations with Cutoff Wall (2-27-2007)

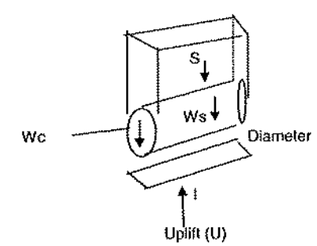
Dist from toe FT	Ho FT
0	7
500	4

No Berm Calcs With WELLS

d=Landside Distance from Toe Feet	Excess Head Feet, Ho'	Invert Elev of pipe 24 -in steel	Design Base Blanket Feet, MSL	Ground Elev Feet, MSL	H3 Feet	H2 Feet	H1 Feet	P3 Psf	Ws lb	Wc lb	S lb	U lb	Wg lb	SFf (Full)	SFf (Empty)
0	7.0	740	748	760	20	12	19.0	1976.0	95	196	4140	3952	0	1.12	1.07
25	6.9	740	748	760	20	12	18.9	1960.4	95	196	4140	3921	0	1.13	1.08
50	6.7	740	748	760	20	12	18.7	1944.8	95	196	4140	3890	0	1.14	1.09
100	6.4	740	748	760	20	12	18.4	1913.6	95	196	4140	3827	0	1.16	1.11
125	6.3	740	748	760	20	12	18.3	1898.0	95	196	4140	3796	0	1.17	1.12
150	6.1	740	748	760	20	12	18.1	1882.4	95	196	4140	3765	0	1.18	1.12
200	5.8	740	748	760	20	12	17.8	1851.2	95	196	4140	3702	0	1.20	1.14
300	5.2	740	748	760	20	12	17.2	1788.8	95	196	4140	3578	0	1.24	1.18
400	4.6	740	748	760	20	12	16.6	1726.4	95	196	4140	3453	0	1.28	1.23
500	4.0	740	748	760	20	12	16.0	1664.0	95	196	4140	3328	0	1.33	1.27

Ws Calc 24 -in steel 1lf
95
Wc Calc
196

See Sample Calculations for list of abbreviations and sample calculations
Ws = weight of structure per foot of length = 94.62 lb per ft (24-inch Diameter Steel Pipe, .375" thick)
Wc = weight of water contained in the structure = pi * r^2 * 1 = 3.1416*((12/12)^2) *1*62.4 = 196 plf
S = surcharge loads = weight of satuarted soils above = (H3-Pipe Diameter/12)*(Pipe Diameter/12)*1*γsoil
P3 = H3*(H1/H2)*γwater
U = Uplift force on the project area of structure = Area of pipe * P3 = (Pipe Diameter/12)*1*P3
Wg = weight of surcharge water above top surface of structure control by gravity flow
SFf = Flotation Safety Factor (Ws+Wc+S)/(U-Wg)



U = P3 * diameter * l
Using l = 1

Conclusions
For levee stretch: 66+00 to 79+00
For pipe diam (in): 24
There is uplift concern at a depth of 15 feet or less within 50 feet landward of the levee

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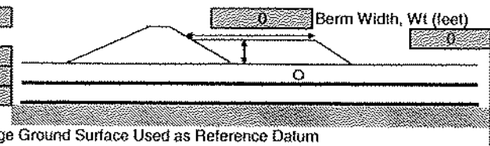
MARCH 8, 2007

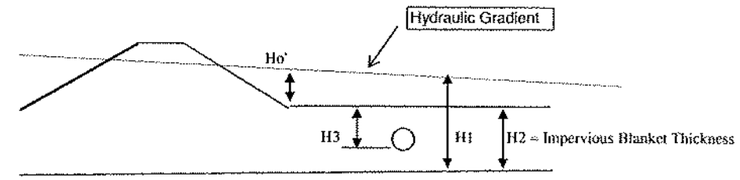
Armourdale Area
L2
Stationing Range
66+00
79+00
500-yr + 3ft

Levee Elev.	777
Ground Elev.	760
Blanket Base Elev.	748
Bedrock Elev.	673



0	Berm Width, Wt (feet)
0	Berm Height, t (feet)
25	Pipe Deptl (ft)
735	Pipe Elev.
24	Pipe Diameter (in)
115	Soil Unit Weight, γsoil (pcf)
25	Pipe Depth (Check)

Ground Elev = Landside Average Ground Surface Used as Reference Datum



From Geotechnical Seepage Calculations with Cutoff Wall (2-27-2007)

Dist from toe FT	Ho FT
0	7
500	4

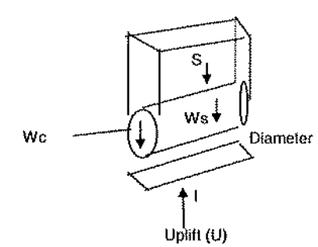
No Berm Calcs With WELLS

d=Landside Distance from Toe Feet	Excess Head Feet, Ho'	Invert Elev of pipe 24 -in steel	Design Base Blanket Feet, MSL	Ground Elev Feet, MSL	H3 Feet	H2 Feet	H1 Feet	P3 Psf	Ws lb	Wc lb	S lb	U lb	Wg lb	SFf (Full)	SFf (Empty)
0	7.0	735	748	760	25	12	19.0	2470.0	95	196	5290	4940	0	1.13	1.09
25	6.9	735	748	760	25	12	18.9	2450.5	95	196	5290	4901	0	1.14	1.10
50	6.7	735	748	760	25	12	18.7	2431.0	95	196	5290	4862	0	1.15	1.11
100	6.4	735	748	760	25	12	18.4	2392.0	95	196	5290	4784	0	1.17	1.13
125	6.3	735	748	760	25	12	18.3	2372.5	95	196	5290	4745	0	1.18	1.13
150	6.1	735	748	760	25	12	18.1	2353.0	95	196	5290	4706	0	1.19	1.14
200	5.8	735	748	760	25	12	17.8	2314.0	95	196	5290	4628	0	1.21	1.16
300	5.2	735	748	760	25	12	17.2	2236.0	95	196	5290	4472	0	1.25	1.20
400	4.6	735	748	760	25	12	16.6	2158.0	95	196	5290	4316	0	1.29	1.25
500	4.0	735	748	760	25	12	16.0	2080.0	95	196	5290	4160	0	1.34	1.29

Ws Calc
24 -in steel 1lf
95
Wc Calc
196

See Sample Calculations for list of abbreviations and sample calculations
Ws = weight of structure per foot of length = 94.62 lb per ft (24-inch Diameter Steel Pipe, .375" thick)
Wc = weight of water contained in the structure = pi * r^2 * 1 = 3.1416*((12/12)^2) *1*62.4 = 196 plf
S = surcharge loads = weight of satuarted soils above = (H3-Pipe Diameter/12)*(Pipe Diameter/12)*1*γsoil
P3 = H3*(H1/H2)*γwater
U = Uplift force on the project area of structure = Area of pipe * P3 = (Pipe Diameter/12)*1*P3
Wg = weight of surcharge water above top surface of structure control by gravity flow
SFf = Flotation Safety Factor (Ws+Wc+S)/(U-Wg)

Conclusions
For levee stretch: 66+00 to 79+00
For pipe diam (in): 24
There is uplift concern at a depth of 15 feet or less within 25 feet landward of the levee



U = P3 * diameter * l
Using l = 1

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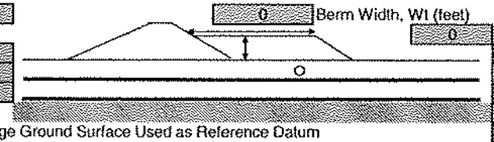
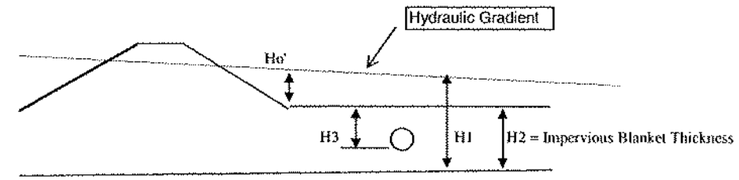
MARCH 8 ,2007

Armourdale Area
L2
Stationing Range
66+00
79+00
500-yr + 3ft

Levee Elev.	777	
	0	Berm Width, Wt (feet)
	0	Berm Height, t (feet)
Ground Elev.	760	
Blanket Base Elev.	748	
Bedrock Elev.	671	
	30	Pipe Deptl (ft)
	730	Pipe Elev.
	24	Pipe Diameter (in)
	115	Soil Unit Weight, γsoil (pcf)
	30	Pipe Depth (Check)



Ground Elev = Landside Average Ground Surface Used as Reference Datum



From Geotechnical Seepage Calculations with Cutoff Wall (2-27-2007)

Dist from toe FT	Ho FT
0	7
500	4

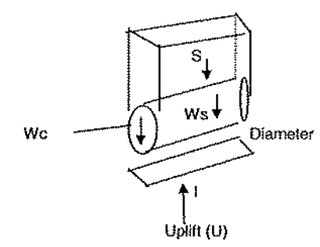
No Berm Calcs With WELLS

d=Landside Distance from Toe Feet	Excess Head Feet, Ho'	Invert Elev of pipe 24 -in steel	Design Base Blanket Feet, MSL	Ground Elev Feet, MSL	H3 Feet	H2 Feet	H1 Feet	P3 Psf	Ws lb	Wc lb	S lb	U lb	Wg lb	SFf (Full)	SFf (Empty)
0	7.0	730	748	760	30	12	19.0	2964.0	95	196	6440	5928	0	1.14	1.10
25	6.9	730	748	760	30	12	18.9	2940.6	95	196	6440	5881	0	1.14	1.11
50	6.7	730	748	760	30	12	18.7	2917.2	95	196	6440	5834	0	1.15	1.12
100	6.4	730	748	760	30	12	18.4	2870.4	95	196	6440	5741	0	1.17	1.14
125	6.3	730	748	760	30	12	18.3	2847.0	95	196	6440	5694	0	1.18	1.15
150	6.1	730	748	760	30	12	18.1	2823.6	95	196	6440	5647	0	1.19	1.16
200	5.8	730	748	760	30	12	17.8	2776.8	95	196	6440	5554	0	1.21	1.18
300	5.2	730	748	760	30	12	17.2	2683.2	95	196	6440	5366	0	1.25	1.22
400	4.6	730	748	760	30	12	16.6	2589.6	95	196	6440	5179	0	1.30	1.26
500	4.0	730	748	760	30	12	16.0	2496.0	95	196	6440	4992	0	1.35	1.31

Ws Calc 24 -in steel 1lf
95
Wc Calc
196

See Sample Calculations for list of abbreviations and sample calculations
Ws = weight of structure per foot of length = 94.62 lb per ft (24-inch Diameter Steel Pipe, .375" thick)
Wc = weight of water contained in the structure = pi * r^2 * 1 = 3.1416*((12/12)^2) *1*62.4 = 196 plf
S = surcharge loads = weight of satuarted soils above = (H3-Pipe Diameter/12)*(Pipe Diameter/12)*1*γsoil
P3 = H3*(H1/H2)*γwater
U = Uplift force on the project area of structure = Area of pipe * P3 = (Pipe Diameter/12)**1**P3
Wg = weight of surcharge water above top surface of structure control by gravity flow
SFf = Flotation Safety Factor (Ws+Wc+S)/(U-Wg)

Conclusions
For levee stretch: 66+00 to 79+00
For pipe diam (in): 24
There is no uplift concern at a depth of 30 feet or less within 500 feet landward of the levee



U = P3 * diameter * l
Using l = 1

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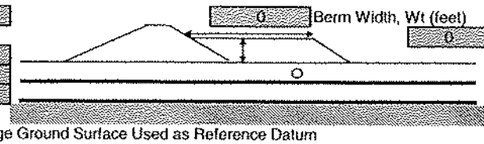
MARCH 8 ,2007

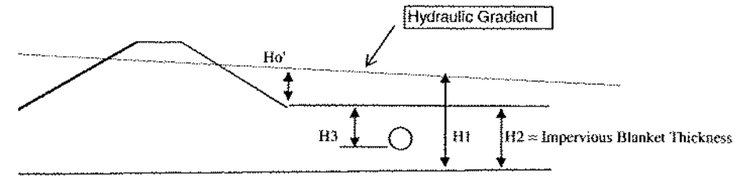
Armourdale Area
L2
Stationing Range
66+00
79+00
500-yr + 3ft

Levee Elev.	777
Ground Elev.	760
Blanket Base Elev.	748
Bedrock Elev.	671



0	Berm Width, Wt (feet)
0	Berm Height, t (feet)
15	Pipe Depth (ft)
745	Pipe Elev.
48	Pipe Diameter (in)
115	Soil Unit Weight, γsoil (pcf)
15	Pipe Depth (Check)

Ground Elev = Landside Average Ground Surface Used as Reference Datum



From Geotechnical Seepage Calculations with Cutoff Wall (2-27-2007)

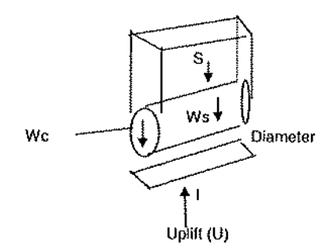
Dist from toe FT	Ho FT
0	7
500	4

No Berm Calcs With WELLS

d=Landside Distance from Toe Feet	Excess Head Feet, Ho'	Invert Elev of pipe 48 -in steel	Design Base Blanket Feet, MSL	Ground Elev Feet, MSL	H3 Feet	H2 Feet	H1 Feet	P3 Psf	Ws lb	Wc lb	S lb	U lb	Wg lb	SFf (Full)	SFf (Empty)
0	7.0	745	748	760	15	12	19.0	1482.0	191	784	5060	5928	0	1.02	0.89
25	6.9	745	748	760	15	12	18.9	1470.3	191	784	5060	5881	0	1.03	0.89
50	6.7	745	748	760	15	12	18.7	1458.6	191	784	5060	5834	0	1.03	0.90
100	6.4	745	748	760	15	12	18.4	1435.2	191	784	5060	5741	0	1.05	0.91
125	6.3	745	748	760	15	12	18.3	1423.5	191	784	5060	5694	0	1.06	0.92
150	6.1	745	748	760	15	12	18.1	1411.8	191	784	5060	5647	0	1.07	0.93
200	5.8	745	748	760	15	12	17.8	1388.4	191	784	5060	5554	0	1.09	0.95
300	5.2	745	748	760	15	12	17.2	1341.6	191	784	5060	5366	0	1.12	0.98
400	4.6	745	748	760	15	12	16.6	1294.8	191	784	5060	5179	0	1.17	1.01
500	4.0	745	748	760	15	12	16.0	1248.0	191	784	5060	4992	0	1.21	1.05

Ws Calc 48 -in steel llf
191
Wc Calc
784

See Sample Calculations for list of abbreviations and sample calculations
Ws = weight of structure per foot of length = 190.70 lb per ft (48-inch Diameter Steel Pipe, .375" thick)
Wc = weight of water contained in the structure = pi * r^2 * 1 = 3.1416*((24/12)^2) *1*62.4 = 780 plf
S = surcharge loads = weight of satuarted soils above = (H3-Pipe Diameter/12)*(Pipe Diameter/12)*1*γsoil
P3 = H3*(H1/H2)*γwater
U = Uplift force on the project area of structure = Area of pipe * P3 = (Pipe Diameter/12)**1**P3
Wg = weight of surcharge water above top surface of structure control by gravity flow
SFf = Flotation Safety Factor (Ws+Wc+S)/(U-Wg)



U = P3 * diameter * I
Using I = 1

Conclusions
For levee stretch: 66+00 to 79+00
For pipe diam (in): 48
There is uplift concern at a depth of 15 feet or less within 500 feet landward of the levee

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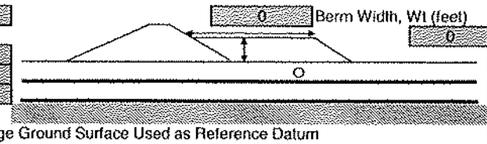
MARCH 8, 2007

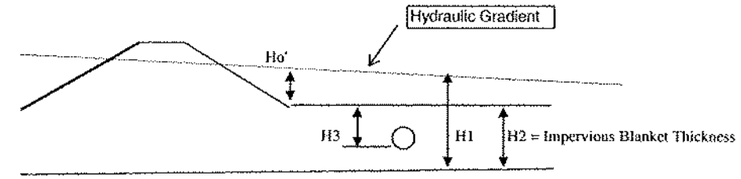
Armourdale Area
L2
Stationing Range
66+00
79+00
500-yr + 3ft

Levee Elev.	777
Ground Elev.	760
Blanket Base Elev.	748
Bedrock Elev.	671



0	Berm Width, Wt (feet)
0	Berm Height, t (feet)
25	Pipe Depth (ft)
735	Pipe Elev.
48	Pipe Diameter (in)
115	Soil Unit Weight, ysoil (pcf)
25	Pipe Depth (Check)

Ground Elev = Landside Average Ground Surface Used as Reference Datum



From Geotechnical Seepage Calculations with Cutoff Wall (2-27-2007)

Dist from toe FT	Ho FT
0	7
500	4

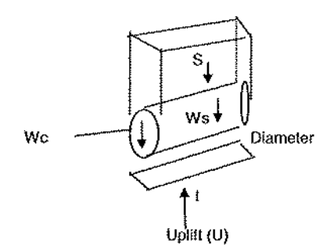
No Berm Calcs With WELLS

d=Landside Distance from Toe Feet	Excess Head Feet, Ho'	Invert Elev of pipe 48 -in steel	Design Base Blanket Feet, MSL	Ground Elev Feet, MSL	H3 Feet	H2 Feet	H1 Feet	P3 Psf	Ws lb	Wc lb	S lb	U lb	Wg lb	SFf (Full)	SFf (Empty)
0	7.0	735	748	760	25	12	19.0	2470.0	191	784	9660	9880	0	1.08	1.00
25	6.9	735	748	760	25	12	18.9	2450.5	191	784	9660	9802	0	1.08	1.00
50	6.7	735	748	760	25	12	18.7	2431.0	191	784	9660	9724	0	1.09	1.01
100	6.4	735	748	760	25	12	18.4	2392.0	191	784	9660	9568	0	1.11	1.03
125	6.3	735	748	760	25	12	18.3	2372.5	191	784	9660	9490	0	1.12	1.04
150	6.1	735	748	760	25	12	18.1	2353.0	191	784	9660	9412	0	1.13	1.05
200	5.8	735	748	760	25	12	17.8	2314.0	191	784	9660	9256	0	1.15	1.06
300	5.2	735	748	760	25	12	17.2	2236.0	191	784	9660	8944	0	1.19	1.10
400	4.6	735	748	760	25	12	16.6	2158.0	191	784	9660	8632	0	1.23	1.14
500	4.0	735	748	760	25	12	16.0	2080.0	191	784	9660	8320	0	1.28	1.18

Ws Calc
48 -in steel 1lf
191
Wc Calc
784

See Sample Calculations for list of abbreviations and sample calculations
Ws = weight of structure per foot of length = 190.70 lb per ft (48-inch Diameter Steel Pipe, .375" thick)
Wc = weight of water contained in the structure = pi * r^2 * 1 = 3.1416*((24/12)^2) *1*62.4 = 780 plf
S = surcharge loads = weight of satuarted soils above = (H3-Pipe Diameter/12)*(Pipe Diameter/12)*1*ysoil
P3 = H3*(H1/H2)*ywater
U = Uplift force on the project area of structure = Area of pipe * P3 = (Pipe Diameter/12)**1**P3
Wg = weight of surcharge water above top surface of structure control by gravity flow
SFf = Flotation Safety Factor (Ws+Wc+S)/(U-Wg)

Conclusions
For levee stretch: 66+00 to 79+00
For pipe diam (in): 48
There is uplift concern at a depth of 25 feet or less within 200 feet landward of the levee



U = P3 * diameter * l
Using l = 1

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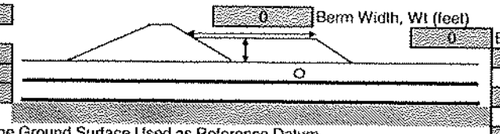
MARCH 8, 2007

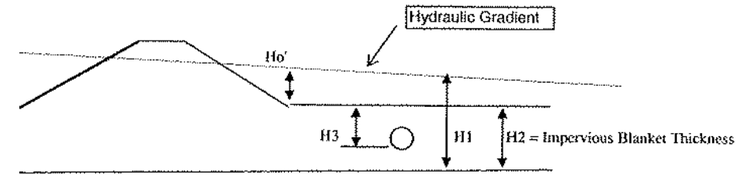
Armourdale Area
L2
Stationing Range
66+00
79+00
500-yr + 3ft

Levee Elev.	777
Ground Elev.	760
Blanket Base Elev.	748
Bedrock Elev.	671



0	Berm Width, Wt (feet)
0	Berm Height, t (feet)
35	Pipe Deptl (ft)
725	Pipe Elev.
48	Pipe Diameter (in)
115	Soil Unit Weight, γsoil (pcf)
35	Pipe Depth (Check)

Ground Elev = Landside Average Ground Surface Used as Reference Datum



From Geotechnical Seepage Calculations with Cutoff Wall (2-27-2007)

Dist from toe Ft	Ho Ft
0	7
500	4

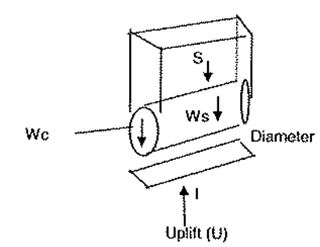
No Berm Calcs With WELLS

d=Landside Distance from Toe Feet	Excess Head Feet, Ho'	Invert Elev of pipe 48 -in steel	Design Base Blanket Feet, MSL	Ground Elev Feet, MSL	H3 Feet	H2 Feet	H1 Feet	P3 Psf	Ws lb	Wc lb	S lb	U lb	Wg lb	SFf (Full)	SFf (Empty)
0	7.0	725	748	760	35	12	19.0	3458.0	191	784	14260	13832	0	1.10	1.04
25	6.9	725	748	760	35	12	18.9	3430.7	191	784	14260	13723	0	1.11	1.05
50	6.7	725	748	760	35	12	18.7	3403.4	191	784	14260	13614	0	1.12	1.06
100	6.4	725	748	760	35	12	18.4	3348.8	191	784	14260	13395	0	1.14	1.08
125	6.3	725	748	760	35	12	18.3	3321.5	191	784	14260	13286	0	1.15	1.09
150	6.1	725	748	760	35	12	18.1	3294.2	191	784	14260	13177	0	1.16	1.10
200	5.8	725	748	760	35	12	17.8	3239.6	191	784	14260	12958	0	1.18	1.12
300	5.2	725	748	760	35	12	17.2	3130.4	191	784	14260	12522	0	1.22	1.15
400	4.6	725	748	760	35	12	16.6	3021.2	191	784	14260	12085	0	1.26	1.20
500	4.0	725	748	760	35	12	16.0	2912.0	191	784	14260	11648	0	1.31	1.24

Ws Calc 48 -in steel 1lf
191
Wc Calc 784

See Sample Calculations for list of abbreviations and sample calculations
Ws = weight of structure per foot of length = 190.70 lb per ft (48-inch Diameter Steel Pipe, .375" thick)
Wc = weight of water contained in the structure = pi * r^2 * 1 = 3.1416*((24/12)^2) *1*62.4 = 780 plf
S = surcharge loads = weight of satuarted soils above = (H3-Pipe Diameter/12)*(Pipe Diameter/12)*1*γsoil
P3 = H3*(H1/H2)*γwater
U = Uplift force on the project area of structure = Area of pipe * P3 = (Pipe Diameter/12)*1*P3
Wg = weight of surcharge water above top surface of structure control by gravity flow
SFf = Flotation Safety Factor (Ws+Wc+S)/(U-Wg)

Conclusions
For levee stretch: 66+00 to 79+00
For pipe diam (in): 48
There is uplift concern at a depth of 35 feet or less within 150 feet landward of the levee



U = P3 * diameter * l
Using l = 1

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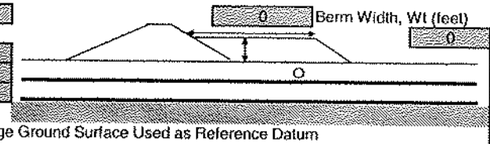
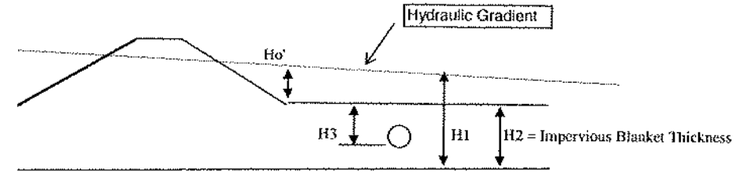
Armourdale Area
L2
Stationing Range
66+00
79+00
500-yr + 3ft

Levee Elev.	777
Ground Elev.	760
Blanket Base Elev.	748
Bedrock Elev.	671



0	Berm Width, Wt (feet)
0	Berm Height, t (feet)
45	Pipe Depti (ft)
715	Pipe Elev.
48	Pipe Diameter (in)
116	Soil Unit Weight, γsoil (pcf)
45	Pipe Depth (Check)

Ground Elev = Landside Average Ground Surface Used as Reference Datum



From Geotechnical Seepage Calculations with Cutoff Wall (2-27-2007)

Dist from toe FT	Ho FT
0	7
500	4

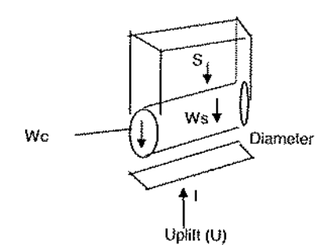
No Berm Calcs With WELLS

d=Landside Distance from Toe Feet	Excess Head Feet, Ho'	Invert Elev of pipe 48 -in steel	Design Base Blanket Feet, MSL	Ground Elev Feet, MSL	H3 Feet	H2 Feet	H1 Feet	P3 Psf	Ws lb	Wc lb	S lb	U lb	Wg lb	SFf (Full)	SFf (Empty)
0	7.0	715	748	760	45	12	19.0	4446.0	191	784	18860	17784	0	1.12	1.07
25	6.9	715	748	760	45	12	18.9	4410.9	191	784	18860	17644	0	1.12	1.08
50	6.7	715	748	760	45	12	18.7	4375.8	191	784	18860	17503	0	1.13	1.09
100	6.4	715	748	760	45	12	18.4	4305.6	191	784	18860	17222	0	1.15	1.11
125	6.3	715	748	760	45	12	18.3	4270.5	191	784	18860	17082	0	1.16	1.12
150	6.1	715	748	760	45	12	18.1	4235.4	191	784	18860	16942	0	1.17	1.12
200	5.8	715	748	760	45	12	17.8	4165.2	191	784	18860	16661	0	1.19	1.14
300	5.2	715	748	760	45	12	17.2	4024.8	191	784	18860	16099	0	1.23	1.18
400	4.6	715	748	760	45	12	16.6	3884.4	191	784	18860	15538	0	1.28	1.23
500	4.0	715	748	760	45	12	16.0	3744.0	191	784	18860	14976	0	1.32	1.27

Ws Calc 48 -in steel 1lf
191
Wc Calc 784

See Sample Calculations for list of abbreviations and sample calculations
Ws = weight of structure per foot of length = 190.70 lb per ft (48-inch Diameter Steel Pipe, .375" thick)
Wc = weight of water contained in the structure = pi * r^2 * 1 = 3.1416*((24/12)^2) *1*62.4 = 780 plf
S = surcharge loads = weight of satuarted soils above = (H3-Pipe Diameter/12)*(Pipe Diameter/12)*1*γsoil
P3 = H3*(H1/H2)*γwater
U = Uplift force on the project area of structure = Area of pipe * P3 = (Pipe Diameter/12)*1*P3
Wg = weight of surcharge water above top surface of structure control by gravity flow
SFf = Flotation Safety Factor (Ws+Wc+S)/(U-Wg)

Conclusions
For levee stretch: 66+00 to 79+00
For pipe diam (in): 48
There is uplift concern at a depth of 45 feet or less within 50 feet landward of the levee



U = P3 * diameter * l
Using l = 1

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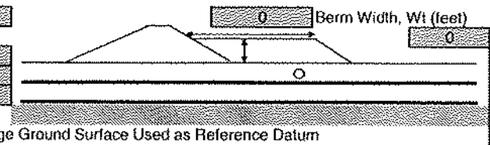
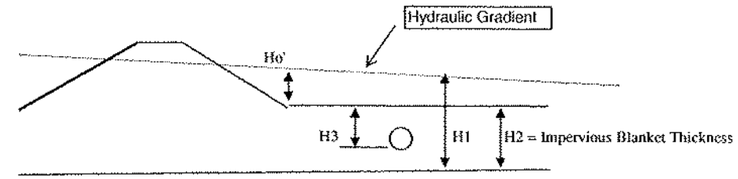
Armourdale Area
L2
Stationing Range
66+00
79+00
500-yr + 3ft

Levee Elev.	777
Ground Elev.	760
Blanket Base Elev.	748
Bedrock Elev.	671



0	Berm Width, Wt (feet)
0	Berm Height, t (feet)
55	Pipe Depth (ft)
705	Pipe Elev.
48	Pipe Diameter (in)
115	Soil Unit Weight, γsoil (pcf)
55	Pipe Depth (Check)

Ground Elev = Landside Average Ground Surface Used as Reference Datum



From Geotechnical Seepage Calculations with Cutoff Wall (2-27-2007)

Dist from toe FT	Ho FT
0	7
500	4

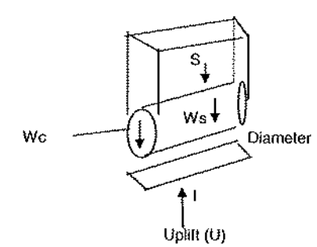
No Berm Calcs With WELLS

d=Landside Distance from Toe Feet	Excess Head Feet, Ho'	Invert Elev of pipe 48 -in steel	Design Base Blanket Feet, MSL	Ground Elev Feet, MSL	H3 Feet	H2 Feet	H1 Feet	P3 Psf	Ws lb	Wc lb	S lb	U lb	Wg lb	SFf (Full)	SFf (Empty)
0	7.0	705	748	760	55	12	19.0	5434.0	191	784	23460	21736	0	1.12	1.09
25	6.9	705	748	760	55	12	18.9	5391.1	191	784	23460	21564	0	1.13	1.10
50	6.7	705	748	760	55	12	18.7	5348.2	191	784	23460	21393	0	1.14	1.11
100	6.4	705	748	760	55	12	18.4	5262.4	191	784	23460	21050	0	1.16	1.12
125	6.3	705	748	760	55	12	18.3	5219.5	191	784	23460	20878	0	1.17	1.13
150	6.1	705	748	760	55	12	18.1	5176.6	191	784	23460	20706	0	1.18	1.14
200	5.8	705	748	760	55	12	17.8	5090.8	191	784	23460	20363	0	1.20	1.16
300	5.2	705	748	760	55	12	17.2	4919.2	191	784	23460	19677	0	1.24	1.20
400	4.6	705	748	760	55	12	16.6	4747.6	191	784	23460	18990	0	1.29	1.25
500	4.0	705	748	760	55	12	16.0	4576.0	191	784	23460	18304	0	1.33	1.29

Ws Calc 48 -in steel 1ft
191
Wc Calc 784

See Sample Calculations for list of abbreviations and sample calculations
Ws = weight of structure per foot of length = 190.70 lb per ft (48-inch Diameter Steel Pipe, .375" thick)
Wc = weight of water contained in the structure = pi * r^2 * 1 = 3.1416*((24/12)^2) *1*62.4 = 780 plf
S = surcharge loads = weight of saturated soils above = (H3-Pipe Diameter/12)*(Pipe Diameter/12)*1*γsoil
P3 = H3*(H1/H2)*γwater
U = Uplift force on the project area of structure = Area of pipe * P3 = (Pipe Diameter/12)*1*P3
Wg = weight of surcharge water above top surface of structure control by gravity flow
SFf = Flotation Safety Factor (Ws+Wc+S)/(U-Wg)

Conclusions
For levee stretch: 66+00 to 79+00
For pipe diam (in): 48
There is uplift concern at a depth of 55 feet or less within 25 feet landward of the levee



U = P3 * diameter * l
Using l = 1

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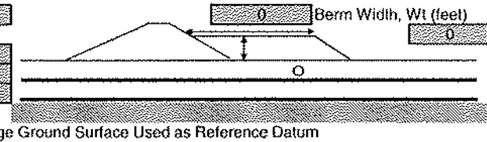
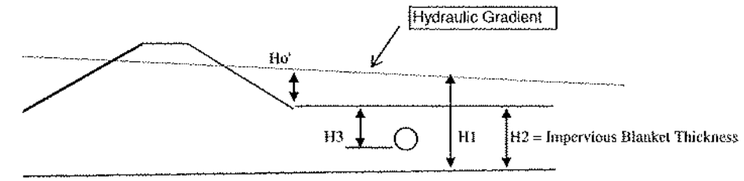
MARCH 8, 2007

Armourdale Area
L2
Stationing Range
66+00
79+00
500-yr + 3ft

Levee Elev.	777	
Ground Elev.	760	
Blanket Base Elev.	748	
Bedrock Elev.	671	
	0	Berm Width, Wt (feet)
	0	Berm Height, t (feet)
	15	Pipe Depth (ft)
	745	Pipe Elev.
	72	Pipe Diameter (in)
	115	Soil Unit Weight, ysoil (pcf)
	15	Pipe Depth (Check)



Ground Elev = Landside Average Ground Surface Used as Reference Datum



From Geotechnical Seepage Calculations with Cutoff Wall (2-27-2007)

Dist from toe FT	Ho FT
0	7
500	4

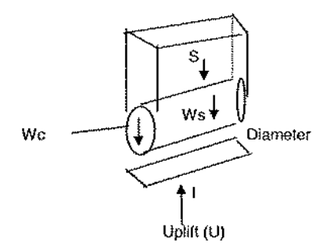
No Berm Calcs With WELLS

d=Landside Distance from Toe Feet	Excess Head Feet, Ho'	Invert Elev of pipe 72 -in steel	Design Base Blanket Feet, MSL	Ground Elev Feet, MSL	H3 Feet	H2 Feet	H1 Feet	P3 Psf	Ws lb	Wc lb	S lb	U lb	Wg lb	SFf (Full)	SFf (Empty)
0	7.0	745	748	760	15	12	19.0	1482.0	1532	1764	6210	8892	0	1.07	0.87
25	6.9	745	748	760	15	12	18.9	1470.3	1532	1764	6210	8822	0	1.08	0.88
50	6.7	745	748	760	15	12	18.7	1458.6	1532	1764	6210	8752	0	1.09	0.88
100	6.4	745	748	760	15	12	18.4	1435.2	1532	1764	6210	8611	0	1.10	0.90
125	6.3	745	748	760	15	12	18.3	1423.5	1532	1764	6210	8541	0	1.11	0.91
150	6.1	745	748	760	15	12	18.1	1411.8	1532	1764	6210	8471	0	1.12	0.91
200	5.8	745	748	760	15	12	17.8	1388.4	1532	1764	6210	8330	0	1.14	0.93
300	5.2	745	748	760	15	12	17.2	1341.6	1532	1764	6210	8050	0	1.18	0.96
400	4.6	745	748	760	15	12	16.6	1294.8	1532	1764	6210	7769	0	1.22	1.00
500	4.0	745	748	760	15	12	16.0	1248.0	1532	1764	6210	7488	0	1.27	1.03

Ws Calc 72 -in RCP 1lf
1532
Wc Calc
1764

See Sample Calculations for list of abbreviations and sample calculations
Ws = weight of structure per foot of length = 1532 lb per ft (72-inch Diameter RCP, 6" wall thick)
Wc = weight of water contained in the structure = pi * r^2 * 1 = 3.1416*((24/12)^2) *1*62.4 = 1764 plf
S = surcharge loads = weight of satuarted soils above = (H3-Pipe Diameter/12)*(Pipe Diameter/12)*1*ysoil
P3 = H3*(H1/H2)*ywater
U = Uplift force on the project area of structure = Area of pipe * P3 = (Pipe Diameter/12)*1*P3
Wg = weight of surcharge water above top surface of structure control by gravity flow
SFf = Flotation Safety Factor (Ws+Wc+S)/(U-Wg)

Conclusions
For levee stretch: 66+00 to 79+00
For pipe diam (in): 72
There is uplift concern at a depth of 15 feet or less within 500 feet landward of the levee



U = P3 * diameter * t
Using t = 1

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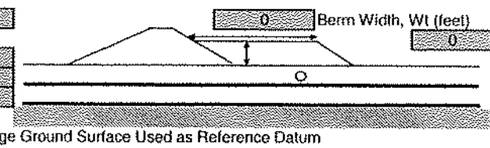
MARCH 8 ,2007

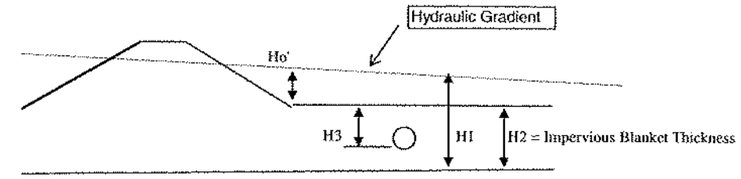
Armourdale Area
L2
Stationing Range
66+00
79+00
500-yr + 3ft

Levee Elev.	777
Ground Elev.	760
Blanket Base Elev.	748
Bedrock Elev.	671



0	Berm Width, Wt (feet)
0	Berm Height, t (feet)
25	Pipe Depth (ft)
735	Pipe Elev.
72	Pipe Diameter (in)
115	Soil Unit Weight, γsoil (pcf)
25	Pipe Depth (Check)

Ground Elev = Landside Average Ground Surface Used as Reference Datum



From Geotechnical Seepage Calculations with Cutoff Wall (2-27-2007)

Dist from toe FT	Ho FT
0	7
500	4

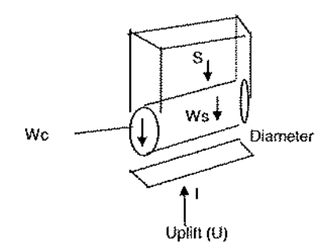
No Berm Calcs With WELLS

d=Landside Distance from Toe Feet	Excess Head Feet, Ho'	Invert Elev of pipe 72 -in steel	Design Base Blanket Feet, MSL	Ground Elev Feet, MSL	H3 Feet	H2 Feet	H1 Feet	P3 Psf	Ws lb	Wc lb	S lb	U lb	Wg lb	SFf (Full)	SFf (Empty)
0	7.0	735	748	760	25	12	19.0	2470.0	1532	1764	13110	14820	0	1.11	0.99
25	6.9	735	748	760	25	12	18.9	2450.5	1532	1764	13110	14703	0	1.12	1.00
50	6.7	735	748	760	25	12	18.7	2431.0	1532	1764	13110	14586	0	1.12	1.00
100	6.4	735	748	760	25	12	18.4	2392.0	1532	1764	13110	14352	0	1.14	1.02
125	6.3	735	748	760	25	12	18.3	2372.5	1532	1764	13110	14235	0	1.15	1.03
150	6.1	735	748	760	25	12	18.1	2353.0	1532	1764	13110	14118	0	1.16	1.04
200	5.8	735	748	760	25	12	17.8	2314.0	1532	1764	13110	13884	0	1.18	1.05
300	5.2	735	748	760	25	12	17.2	2236.0	1532	1764	13110	13416	0	1.22	1.09
400	4.6	735	748	760	25	12	16.6	2158.0	1532	1764	13110	12948	0	1.27	1.13
500	4.0	735	748	760	25	12	16.0	2080.0	1532	1764	13110	12480	0	1.31	1.17

Ws Calc 72 -in RCP 1lf
1532
Wc Calc 1764

See Sample Calculations for list of abbreviations and sample calculations
Ws = weight of structure per foot of length = 1532 lb per ft (72-inch Diameter RCP, 6" wall thick)
Wc = weight of water contained in the structure = pi * r^2 * 1 = 3.1416*((24/12)^2) *1*62.4 = 1764 plf
S = surcharge loads = weight of satuarted soils above = (H3-Pipe Diameter/12)*(Pipe Diameter/12)*1*γsoil
P3 = H3*(H1/H2)*γwater
U = Uplift force on the project area of structure = Area of pipe * P3 = (Pipe Diameter/12)*1*P3
Wg = weight of surcharge water above top surface of structure control by gravity flow
SFf = Flotation Safety Factor (Ws+Wc+S)/(U-Wg)

Conclusions
For levee stretch: 66+00 to 79+00
For pipe diam (in): 72
There is uplift concern at a depth of 25 feet or less within 300 feet landward of the levee



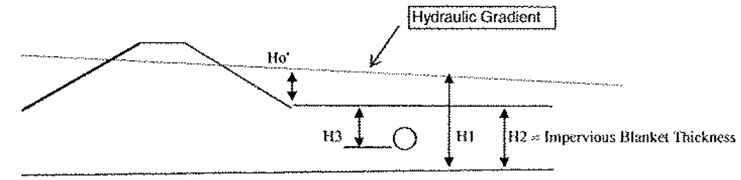
U = P3 * diameter * l
Using l = 1

DRAFT
MARCH 8 ,2007

Armourdale Area
L2
Stationing Range
66+00
79+00
500-yr + 3ft

Levee Elev.	777	0 Berm Width, Wt (feet)	
		0	Berm Height, t (feet)
Ground Elev.	760	35	Pipe Depth (ft)
Blanket Base Elev.	748	725	Pipe Elev.
Bedrock Elev.	671	72	Pipe Diameter (in)
		115	Soil Unit Weight, γsoil (pcf)
		35	Pipe Depth (Check)

Ground Elev = Landside Average Ground Surface Used as Reference Datum



From Geotechnical Seepage Calculations with Cutoff Wall (2-27-2007)

Dist from toe FT	Ho FT
0	7
500	4

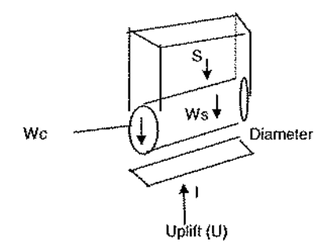
No Berm Calcs With WELLS

d=Landside Distance from Toe Feet	Excess Head Feet, Ho'	Invert Elev of pipe 72 -in steel	Design Base Blanket Feet, MSL	Ground Elev Feet, MSL	H3 Feet	H2 Feet	H1 Feet	P3 Psf	Ws lb	Wc lb	S lb	U lb	Wg lb	SFf (Full)	SFf (Empty)
0	7.0	725	748	760	35	12	19.0	3458.0	1532	1764	20010	20748	0	1.12	1.04
25	6.9	725	748	760	35	12	18.9	3430.7	1532	1764	20010	20584	0	1.13	1.05
50	6.7	725	748	760	35	12	18.7	3403.4	1532	1764	20010	20420	0	1.14	1.05
100	6.4	725	748	760	35	12	18.4	3348.8	1532	1764	20010	20093	0	1.16	1.07
125	6.3	725	748	760	35	12	18.3	3321.5	1532	1764	20010	19929	0	1.17	1.08
150	6.1	725	748	760	35	12	18.1	3294.2	1532	1764	20010	19765	0	1.18	1.09
200	5.8	725	748	760	35	12	17.8	3239.6	1532	1764	20010	19438	0	1.20	1.11
300	5.2	725	748	760	35	12	17.2	3130.4	1532	1764	20010	18782	0	1.24	1.15
400	4.6	725	748	760	35	12	16.6	3021.2	1532	1764	20010	18127	0	1.29	1.19
500	4.0	725	748	760	35	12	16.0	2912.0	1532	1764	20010	17472	0	1.33	1.23

Ws Calc 72 -in RCP 1lf
1532
Wc Calc 1764

See Sample Calculations for list of abbreviations and sample calculations
Ws = weight of structure per foot of length = 1532 lb per ft (72-inch Diameter RCP, 6" wall thick)
Wc = weight of water contained in the structure = pi * r^2 * 1 = 3.1416*((24/12)^2) *1*62.4 = 1764 plf
S = surcharge loads = weight of saturated soils above = (H3-Pipe Diameter/12)*(Pipe Diameter/12)*1*γsoil
P3 = H3*(H1/H2)*γwater
U = Uplift force on the project area of structure = Area of pipe * P3 = (Pipe Diameter/12)*1*P3
Wg = weight of surcharge water above top surface of structure control by gravity flow
SFf = Flotation Safety Factor (Ws+Wc+S)/(U-Wg)

Conclusions
For levee stretch: 66+00 to 79+00
For pipe diam (in): 72
There is uplift concern at a depth of 35 feet or less within 150 feet landward of the levee

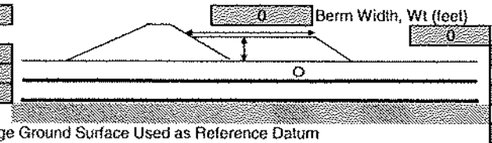


U = P3 * diameter * l
Using l = 1

DRAFT
MARCH 8, 2007

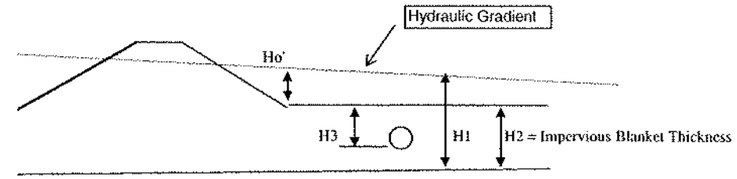
Armourdale Area
L2
Stationing Range
66+00
79+00
500-yr + 3ft

Levee Elev.	777
Ground Elev.	760
Blanket Base Elev.	748
Bedrock Elev.	671



0	Berm Width, Wt (feet)
0	Berm Height, t (feet)
45	Pipe Depth (ft)
715	Pipe Elev.
72	Pipe Diameter (in)
115	Soil Unit Weight, γsoil (pcf)
45	Pipe Depth (Check)

Ground Elev = Landside Average Ground Surface Used as Reference Datum



From Geotechnical Seepage Calculations with Cutoff Wall (2-27-2007)

Dist from toe FT	Ho FT
0	7
500	4

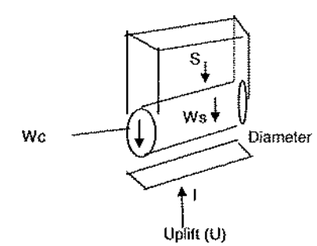
No Berm Calcs With WELLS

d=Landside Distance from Toe Feet	Excess Head Feet, Ho'	Invert Elev of pipe 72 -in RCP	Design Base Blanket Feet, MSL	Ground Elev Feet, MSL	H3 Feet	H2 Feet	H1 Feet	P3 Psf	Ws lb	Wc lb	S lb	U lb	Wg lb	SFf (Full)	SFf (Empty)
0	7.0	715	748	760	45	12	19.0	4446.0	1532	1764	26910	26676	0	1.13	1.07
25	6.9	715	748	760	45	12	18.9	4410.9	1532	1764	26910	26465	0	1.14	1.07
50	6.7	715	748	760	45	12	18.7	4375.8	1532	1764	26910	26255	0	1.15	1.08
100	6.4	715	748	760	45	12	18.4	4305.6	1532	1764	26910	25834	0	1.17	1.10
125	6.3	715	748	760	45	12	18.3	4270.5	1532	1764	26910	25623	0	1.18	1.11
150	6.1	715	748	760	45	12	18.1	4235.4	1532	1764	26910	25412	0	1.19	1.12
200	5.8	715	748	760	45	12	17.8	4165.2	1532	1764	26910	24991	0	1.21	1.14
300	5.2	715	748	760	45	12	17.2	4024.8	1532	1764	26910	24149	0	1.25	1.18
400	4.6	715	748	760	45	12	16.6	3884.4	1532	1764	26910	23306	0	1.30	1.22
500	4.0	715	748	760	45	12	16.0	3744.0	1532	1764	26910	22464	0	1.34	1.27

Ws Calc 72 -in RCP 1lf
1532
Wc Calc 1764

See Sample Calculations for list of abbreviations and sample calculations
Ws = weight of structure per foot of length = 1532 lb per ft (72-inch Diameter RCP, 6" wall thick) (Am. Conc. Pipe Ass.)
Wc = weight of water contained in the structure = pi * r^2 * 1 = 3.1416*((24/12)^2) *1*62.4 = 1764 plf
S = surcharge loads = weight of satuarted soils above = (H3-Pipe Diameter/12)*(Pipe Diameter/12)*1*γsoil
P3 = H3*(H1/H2)*γwater
U = Uplift force on the project area of structure = Area of pipe * P3 = (Pipe Diameter/12)**1**P3
Wg = weight of surcharge water above top surface of structure control by gravity flow
SFf = Flotation Safety Factor (Ws+Wc+S)/(U-Wg)

Conclusions
For levee stretch: 66+00 to 79+00
For pipe diam (in): 72
There is uplift concern at a depth of 45 feet or less within 50 feet landward of the levee



U = P3 * diameter * l
Using l = 1

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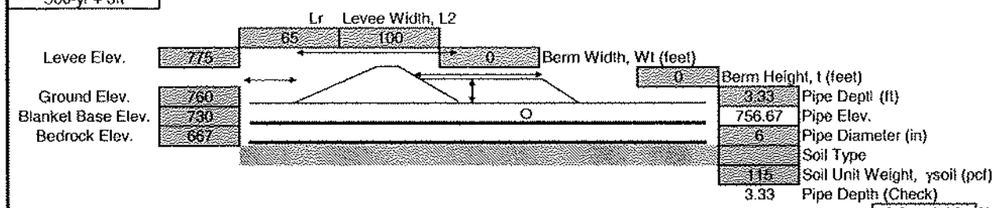
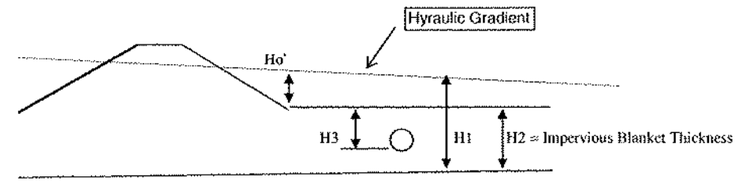
MARCH 8, 2007

Armourdale Area L3 Stationing Range	K-r	K-L	DbL	Dbo	Dbr	Df	H	i-c	Lr	Wt	Safety	L1	L2	Le	Lt	L't	Ho'	Hwt/2	Hwt	i-o	Cr	Cl	t	s
																							feet	
79+00	350	350	30	30	30	63	15	0.84	65	0	2.03	65	100	813	978	978	12.47	12.47	12.47	0.42	813	813	0	0.000
190+00	Geotechnical data (above) presented in this spreadsheet was provided by Geotechnical Engineers and is used to develop the Hydraulic Gradient at various distances from the toe.																							
500-yr + 3ft																								





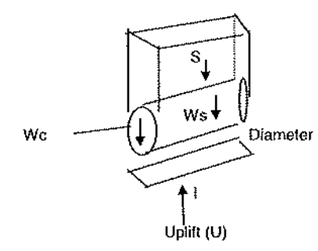
d=Landside Distance from Toe Feet	No Berm Calcs Excess Head Feet, Ho'	Invert Elev of pipe 6 -in steel	Design Base Blanket Feet, MSL	Ground Elev Feet, MSL	H3 Feet	H2 Feet	H1 Feet	P3 Psf	Ws lb	Wc lb	S lb	U lb	Wg lb	SFf (Full)	SFf (Empty)
0	12.47	756.67	730	760	3.33	30	42.5	294.2	19	12	163	147	0	1.32	1.24
25	12.09	756.67	730	760	3.33	30	42.1	291.6	19	12	163	146	0	1.33	1.25
50	11.73	756.67	730	760	3.33	30	41.7	289.0	19	12	163	145	0	1.34	1.26
100	11.03	756.67	730	760	3.33	30	41.0	284.2	19	12	163	142	0	1.36	1.28
125	10.70	756.67	730	760	3.33	30	40.7	281.9	19	12	163	141	0	1.38	1.29
150	10.37	756.67	730	760	3.33	30	40.4	279.6	19	12	163	140	0	1.39	1.30
200	9.75	756.67	730	760	3.33	30	39.8	275.3	19	12	163	138	0	1.41	1.32
300	8.62	756.67	730	760	3.33	30	38.6	267.5	19	12	163	134	0	1.45	1.36
400	7.63	756.67	730	760	3.33	30	37.6	260.6	19	12	163	130	0	1.49	1.39
500	6.74	756.67	730	760	3.33	30	36.7	254.5	19	12	163	127	0	1.52	1.43

Ws Calc 6 -in steel 1lf
19
Wc Calc
12

See Sample Calculations for list of abbreviations and sample calculations
Ws = weight of structure per foot of length = 18.97 lb per ft (6-inch Diameter Steel Pipe, .280" thick)
Wc = weight of water contained in the structure = pi * r^2 * 1 = 3.1416*((3/12)^2) *1*62.4 = 12 plf
S = surcharge loads = weight of satuarted soils above = (H3-Pipe Diameter/12)*(Pipe Diameter/12)*1*γsoil
P3 = H3*(H1/H2)*γwater
U = Uplift force on the project area of structure = Area of pipe * P3 = (Pipe Diameter/12)"1"P3
Wg = weight of surcharge water above top surface of structure control by gravity flow
SFf = Flotation Safety Factor (Ws+Wc+S)/(U-Wg)

Use this table to determine the distance from toe at which the Safety Factor is met
Enter the Distance from toe and change the value until the SFf is equal to that required

	Ground Elev 760		Distance from toe (ft) 0			Uplift Safety Extreme Case (1.1 REQ'D)	
		Ws = 19		Wc = 12 Full			
Depth Below Ground	Pipe Inv Elev, Ft	Surcharge Load, S, lbs/ft	Uplift (U) Force, lbs/ft	Pipe Weight, Lbs/ft	Full water Wt, Lbs / ft	SFf Full	SFf Empty
	760	0		19	12		
3.33	756.67	163	147	19	12	1.32	1.24
4.33	755.67	220	191	19	12	1.31	1.25
5.33	754.67	278	235	19	12	1.31	1.26
6.33	753.67	335	280	19	12	1.31	1.27
7.33	752.67	393	324	19	12	1.31	1.27
8.33	751.67	450	368	19	12	1.31	1.28
9.33	750.67	508	412	19	12	1.31	1.28
10.33	749.67	565	456	19	12	1.31	1.28
11.33	748.67	623	500	19	12	1.31	1.28



U = P3 * diameter * l
Using l = 1

Conclusions
For levee stretch: 79+00 to 190+00
For pipe diam (in): 6
There is no uplift concern at a depth of 3.33 feet or deeper within 500 feet landward of the levee

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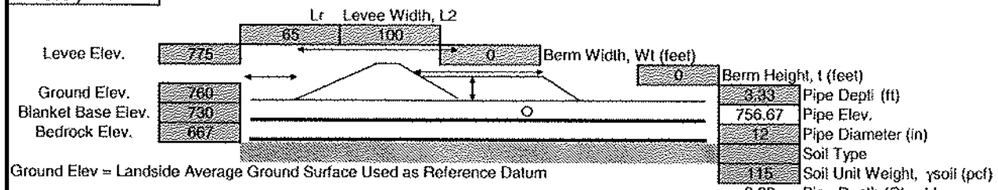
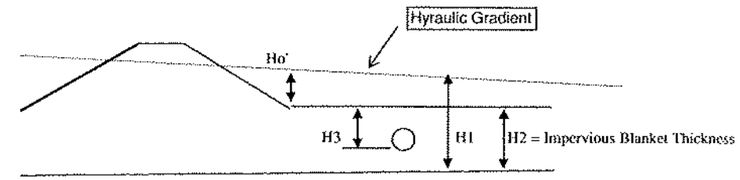
MARCH 8 ,2007

Armourdale Area L3 Stationing Range	K-r	K-L	DbL	Dbo	Dbr	Df	H	i-c	Lr	Wt	Safety	L1	L2	Lc	Lt	L't	Ho'	Hwt/2	Hwt	i-o	Cr	Cl	t	s
																							feet	
79+00	350	350	30	30	30	63	15	0.84	65	0	2.03	65	100	813	978	978	12.47	12.47	12.47	0.42	813	813	0	0.000
190+00	Geotechnical data (above) presented in this spreadsheet was provided by Geotechnical Engineers and is used to develop the Hydraulic Gradient at various distances from the toe.																							
500-yr + 3ft																								



Ground Elev = Landside Average Ground Surface Used as Reference Datum



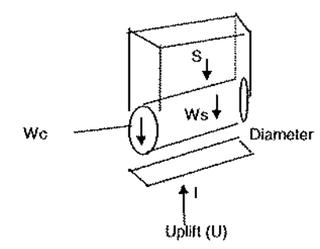
d=Landside Distance from Toe Feet	No Berm Calcs Excess Head Feet, Ho'	Invert Elev of pipe 12 -in steel	Design Base Blanket Feet, MSL	Ground Elev Feet, MSL	H3 Feet	H2 Feet	H1 Feet	P3 Psf	Ws lb	Wc lb	S lb	U lb	Wg lb	SFf (Full)	SFf (Empty)
0	12.47	756.67	730	760	3.33	30	42.5	294.2	50	49	268	294	0	1.25	1.08
25	12.09	756.67	730	760	3.33	30	42.1	291.6	50	49	268	292	0	1.26	1.09
50	11.73	756.67	730	760	3.33	30	41.7	289.0	50	49	268	289	0	1.27	1.10
100	11.03	756.67	730	760	3.33	30	41.0	284.2	50	49	268	284	0	1.29	1.12
125	10.70	756.67	730	760	3.33	30	40.7	281.9	50	49	268	282	0	1.30	1.13
150	10.37	756.67	730	760	3.33	30	40.4	279.6	50	49	268	280	0	1.31	1.14
200	9.75	756.67	730	760	3.33	30	39.8	275.3	50	49	268	275	0	1.33	1.15
300	8.62	756.67	730	760	3.33	30	38.6	267.5	50	49	268	268	0	1.37	1.19
400	7.63	756.67	730	760	3.33	30	37.6	260.6	50	49	268	261	0	1.41	1.22
500	6.74	756.67	730	760	3.33	30	36.7	254.5	50	49	268	255	0	1.44	1.25

Ws Calc 12 -in steel 1lf
50
Wc Calc
49

See Sample Calculations for list of abbreviations and sample calculations
Ws = weight of structure per foot of length = 50 lb per ft (12-inch Diameter Steel Pipe, .375" thick)
Wc = weight of water contained in the structure = pi * r^2 * 1 = 3.1416*((6/12)^2) *1*62.4 = 49 plf
S = surcharge loads = weight of satuarted soils above = (H3-Pipe Diameter/12)*(Pipe Diameter/12)*1*γsoil
P3 = H3*(H1/H2)*γwater
U = Uplift force on the project area of structure = Area of pipe * P3 = (Pipe Diameter/12)*1*P3
Wg = weight of surcharge water above top surface of structure control by gravity flow
SFf = Flotation Safety Factor (Ws+Wc+S)/(U-Wg)

Use this table to determine the distance from toe at which the Safety Factor is met
Enter the Distance from toe and change the value until the SFf is equal to that required

	Ground Elev 760		Distance from toe (ft) 0			Uplift Safety Extreme Case (1.1 REQ'D)	
		Ws = 50		Wc = 49 Full			
Depth Below Ground	Pipe Inv Elev, Ft	Surcharge Load, S, lbs/ft	Uplift (U) Force, lbs/ft	Pipe Weight, Lbs/ft	Full water Wt, Lbs / ft	SFf Full	SFf Empty
	760	0		50	49		
3.33	756.67	268	294	50	49	1.25	1.08
4.33	755.67	383	383	50	49	1.26	1.13
5.33	754.67	498	471	50	49	1.27	1.16
6.33	753.67	613	559	50	49	1.27	1.18
7.33	752.67	728	648	50	49	1.28	1.20
8.33	751.67	843	736	50	49	1.28	1.21
9.33	750.67	958	824	50	49	1.28	1.22
10.33	749.67	1073	913	50	49	1.28	1.23
11.33	748.67	1188	1001	50	49	1.29	1.24

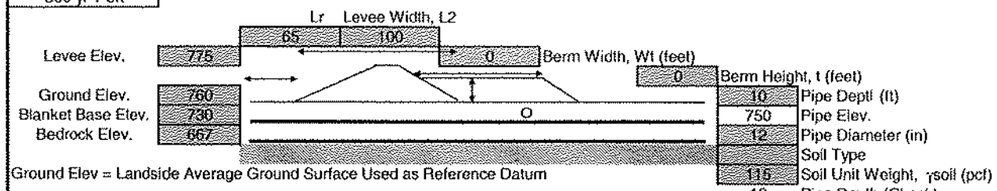


U = P3 * diameter * l
Using l = 1

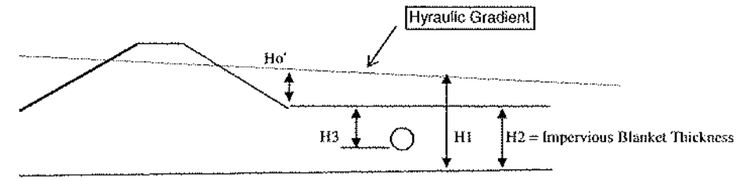
Conclusions
For levee stretch: 79+00 to 190+00
For pipe diam (in): 12
There is uplift concern at a depth of 40 inches (3.3 feet) and less within 50 feet landward of the levee
There is uplift concern at a depth of 3.33 feet and less at the landward toe

DRAFT
MARCH 8 ,2007

Armourdale Area L3 Stationing Range	K-r	K-L	DbL	Dbo	Dbr	Df	H	i-c	Lr	Wt	Safety	L1	L2	Le	Lt	L't	Ho'	Hwt/2	Hwt	i-o	Cr	Cl	t (feet)	s
79+00	350	350	30	30	30	63	15	0.84	65	0	2.03	65	100	813	978	978	12.47	12.47	12.47	0.42	813	813	0	0.000
190+00	Geotechnical data (above) presented in this spreadsheet was provided by Geotechnical Engineers and is used to develop the Hydraulic Gradient at various distances from the toe.																							
500-yr + 3ft																								



Ground Elev = Landside Average Ground Surface Used as Reference Datum



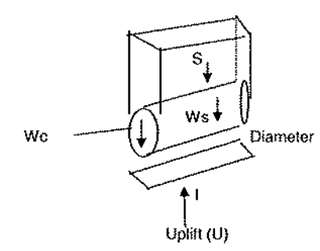
d=Landside Distance from Toe Feet	No Berm Calcs Excess Head Feet, Ho'	Invert Elev of pipe 12 -in steel	Design Base Blanket Feet, MSL	Ground Elev Feet, MSL	H3 Feet	H2 Feet	H1 Feet	P3 Psf	Ws lb	Wc lb	S lb	U lb	Wg lb	SFf (Full)	SFf (Empty)
0	12.47	750	730	760	10	30	42.5	883.4	50	49	1035	883	0	1.28	1.23
25	12.09	750	730	760	10	30	42.1	875.6	50	49	1035	876	0	1.29	1.24
50	11.73	750	730	760	10	30	41.7	867.9	50	49	1035	868	0	1.31	1.25
100	11.03	750	730	760	10	30	41.0	853.4	50	49	1035	853	0	1.33	1.27
125	10.70	750	730	760	10	30	40.7	846.5	50	49	1035	846	0	1.34	1.28
150	10.37	750	730	760	10	30	40.4	839.7	50	49	1035	840	0	1.35	1.29
200	9.75	750	730	760	10	30	39.8	826.9	50	49	1035	827	0	1.37	1.31
300	8.62	750	730	760	10	30	38.6	803.4	50	49	1035	803	0	1.41	1.35
400	7.63	750	730	760	10	30	37.6	782.6	50	49	1035	783	0	1.45	1.39
500	6.74	750	730	760	10	30	36.7	764.3	50	49	1035	764	0	1.48	1.42

Ws Calc 12 -in steel 1lf
50
Wc Calc
49

See Sample Calculations for list of abbreviations and sample calculations
Ws = weight of structure per foot of length = 50 lb per ft (12-inch Diameter Steel Pipe, .375" thick)
Wc = weight of water contained in the structure = pi * r^2 * 1 = 3.1416*((6/12)^2) *1*62.4 = 49 plf
S = surcharge loads = weight of satuarted soils above = (H3-Pipe Diameter/12)*(Pipe Diameter/12)*1*γsoil
P3 = H3*(H1/H2)*γwater
U = Uplift force on the project area of structure = Area of pipe * P3 = (Pipe Diameter/12)*1*P3
Wg = weight of surcharge water above top surface of structure control by gravity flow
SFf = Flotation Safety Factor (Ws+Wc+S)/(U-Wg)

Use this table to determine the distance from toe at which the Safety Factor is met
Enter the Distance from toe and change the value until the SFf is equal to that required

	Ground Elev 760		Distance from toe (ft) 0			Uplift Safety Extreme Case (1.1 REQ'D)	
		Ws = 50		Wc = 49 Full			
Depth Below Ground	Pipe Inv Elev, Ft	Surcharge Load, S, lbs/ft	Uplift (U) Force, lbs/ft	Pipe Weight, Lbs/ft	Full water Wt, Lbs / ft	SFf Full	SFf Empty
	760	0		50	49		
10	750	1035	883	50	49	1.28	1.23
11	749	1150	972	50	49	1.28	1.23
12	748	1265	1060	50	49	1.29	1.24
13	747	1380	1148	50	49	1.29	1.24
14	746	1495	1237	50	49	1.29	1.25
15	745	1610	1325	50	49	1.29	1.25
16	744	1725	1413	50	49	1.29	1.26
17	743	1840	1502	50	49	1.29	1.26
18	742	1955	1590	50	49	1.29	1.26

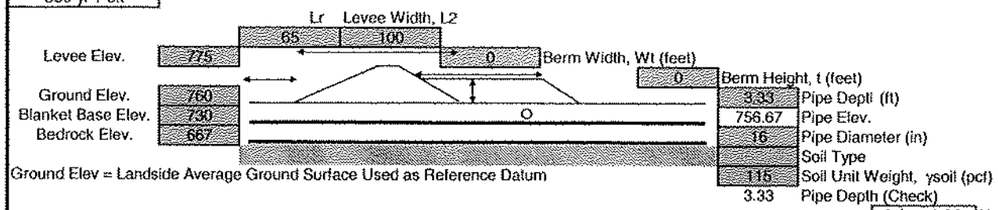


U = P3 * diameter * l
Using l = 1

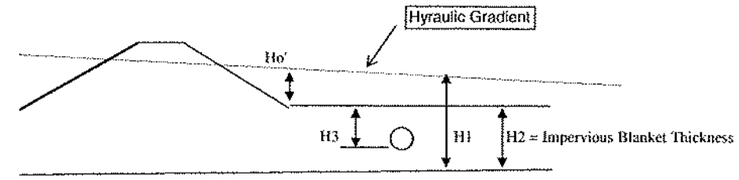
Conclusions
For levee stretch: 79+00 to 190+00
For pipe diam (in): 12
There is no uplift concern at a depth of 10 feet or deeper within 500 feet landward of the levee

DRAFT
MARCH 8 ,2007

Armourdale Area L3 Stationing Range	K-r	K-L	DbL	Dbo	Dbr	Df	H	i-c	Lr	Wt	Safety	L1	L2	Le	Lt	L't	Ho'	Hwt/2	Hwt	i-o	Cr	Cf	t	s
																							feet	
79+00	350	350	30	30	30	63	15	0.84	65	0	2.03	65	100	813	978	978	12.47	12.47	12.47	0.42	813	813	0	0.000
190+00	Geotechnical data (above) presented in this spreadsheet was provided by Geotechnical Engineers and is used to develop the Hydraulic Gradient at various distances from the toe.																							
500-yr + 3ft																								



Ground Elev = Landside Average Ground Surface Used as Reference Datum



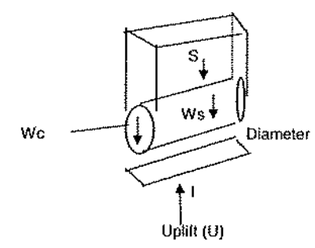
d=Landside Distance from Toe Feet	No Berm Calcs Excess Head Feet, Ho'	Invert Elev of pipe 16 -in steel	Design Base Blanket Feet, MSL	Ground Elev Feet, MSL	H3 Feet	H2 Feet	H1 Feet	P3 Psf	Ws lb	Wc lb	S lb	U lb	Wg lb	SFf (Full)	SFf (Empty)
0	12.47	756.67	730	760	3.33	30	42.5	294.2	63	87	306	392	0	1.16	0.94
25	12.09	756.67	730	760	3.33	30	42.1	291.6	63	87	306	389	0	1.17	0.95
50	11.73	756.67	730	760	3.33	30	41.7	289.0	63	87	306	385	0	1.18	0.96
100	11.03	756.67	730	760	3.33	30	41.0	284.2	63	87	306	379	0	1.20	0.97
125	10.70	756.67	730	760	3.33	30	40.7	281.9	63	87	306	376	0	1.21	0.98
150	10.37	756.67	730	760	3.33	30	40.4	279.6	63	87	306	373	0	1.22	0.99
200	9.75	756.67	730	760	3.33	30	39.8	275.3	63	87	306	367	0	1.24	1.01
300	8.62	756.67	730	760	3.33	30	38.6	267.5	63	87	306	357	0	1.28	1.03
400	7.63	756.67	730	760	3.33	30	37.6	260.6	63	87	306	347	0	1.31	1.06
500	6.74	756.67	730	760	3.33	30	36.7	254.5	63	87	306	339	0	1.34	1.09

Ws Calc 16 -in steel 1lf
63
Wc Calc 87

See Sample Calculations for list of abbreviations and sample calculations
Ws = weight of structure per foot of length = 62.58 lb per ft (16-inch Diameter Steel Pipe, .375" thick)
Wc = weight of water contained in the structure = pi * r^2 * 1 = 3.1416*((8/12)^2) *1*62.4 = 49 plf
S = surcharge loads = weight of satuarted soils above = (H3-Pipe Diameter/12)*(Pipe Diameter/12)*1*γsoil
P3 = H3*(H1/H2)*γwater
U = Uplift force on the project area of structure = Area of pipe * P3 = (Pipe Diameter/12)*1*P3
Wg = weight of surcharge water above top surface of structure control by gravity flow
SFf = Flotation Safety Factor (Ws+Wc+S)/(U-Wg)

Use this table to determine the distance from toe at which the Safety Factor is met
Enter the Distance from toe and change the value until the SFf is equal to that required

	Ground Elev 760		Distance from toe (ft) 0			Uplift Safety Extreme Case (1.1 REQ'D)	
		Ws = 63		Wc = 87 Full			
Depth Below Ground	Pipe Inv Elev, Ft	Surcharge Load, S, lbs/ft	Uplift (U) Force, lbs/ft	Pipe Weight, Lbs/ft	Full water Wt, Lbs / ft	SFf Full	SFf Empty
	760	0		63	87		
3.33	756.67	306	392	63	87	1.16	0.94
4.33	755.67	459	510	63	87	1.20	1.02
5.33	754.67	613	628	63	87	1.22	1.06
6.33	753.67	766	746	63	87	1.23	1.11
7.33	752.67	919	863	63	87	1.24	1.14
8.33	751.67	1073	981	63	87	1.25	1.16
9.33	750.67	1226	1099	63	87	1.25	1.17
10.33	749.67	1379	1217	63	87	1.26	1.19
11.33	748.67	1533	1335	63	87	1.26	1.20

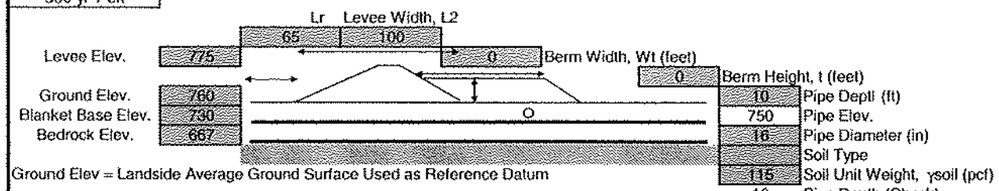


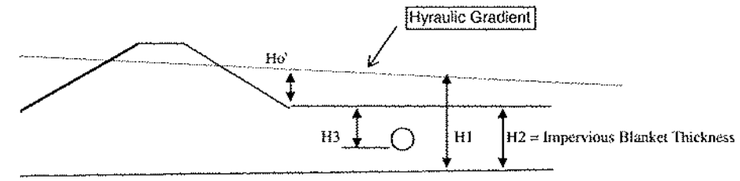
U = P3 * diameter * l
Using l = 1

Conclusions
For levee stretch: 79+00 to 190+00
For pipe diam (in): 16
There is uplift concern at a depth of 40 inches (3.3 feet) and less within 500 feet landward of the levee
There is uplift concern at a depth of 5.33 feet and less at the landward toe

DRAFT
MARCH 8, 2007

Armourdale Area L3 Stationing Range	K-r	K-L	DbL	Dbo	Dbr	Df	H	i-c	Lr	Wt	Safety	L1	L2	Lc	Lt	L't	Ho'	Hwt/2	Hwt	i-o	Cr	Cl	t (feet)	s
79+00	350	350	30	30	30	63	15	0.84	65	0	2.03	65	100	813	978	978	12.47	12.47	12.47	0.42	813	813	0	0.000
190+00	Geotechnical data (above) presented in this spreadsheet was provided by Geotechnical Engineers and is used to develop the Hydraulic Gradient at various distances from the toe.																							
500-yr + 3ft																								





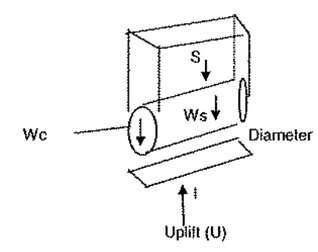
d=Landside Distance from Toe Feet	No Berm Calcs Excess Head Feet, Ho'	Invert Elev of pipe 16 -in steel	Design Base Blanket Feet, MSL	Ground Elev Feet, MSL	H3 Feet	H2 Feet	H1 Feet	P3 Psf	Ws lb	Wc lb	S lb	U lb	Wg lb	SFf (Full)	SFf (Empty)
0	12.47	750	730	760	10	30	42.5	883.4	63	87	1329	1178	0	1.26	1.18
25	12.09	750	730	760	10	30	42.1	875.6	63	87	1329	1167	0	1.27	1.19
50	11.73	750	730	760	10	30	41.7	867.9	63	87	1329	1157	0	1.28	1.20
100	11.03	750	730	760	10	30	41.0	853.4	63	87	1329	1138	0	1.30	1.22
125	10.70	750	730	760	10	30	40.7	846.5	63	87	1329	1129	0	1.31	1.23
150	10.37	750	730	760	10	30	40.4	839.7	63	87	1329	1120	0	1.32	1.24
200	9.75	750	730	760	10	30	39.8	826.9	63	87	1329	1102	0	1.34	1.26
300	8.62	750	730	760	10	30	38.6	803.4	63	87	1329	1071	0	1.38	1.30
400	7.63	750	730	760	10	30	37.6	782.6	63	87	1329	1044	0	1.42	1.33
500	6.74	750	730	760	10	30	36.7	764.3	63	87	1329	1019	0	1.45	1.37

Ws Calc 16 -in steel 1lf
63
Wc Calc
87

See Sample Calculations for list of abbreviations and sample calculations
Ws = weight of structure per foot of length = 62.58 lb per ft (16-inch Diameter Steel Pipe, .375" thick)
Wc = weight of water contained in the structure = pi * r^2 * 1 = 3.1416*((8/12)^2) *1*62.4 = 49 plf
S = surcharge loads = weight of satuarted soils above = (H3-Pipe Diameter/12)*(Pipe Diameter/12)*1*γsoil
P3 = H3*(H1/H2)*γwater
U = Uplift force on the project area of structure = Area of pipe * P3 = (Pipe Diameter/12)*1*P3
Wg = weight of surcharge water above top surface of structure control by gravity flow
SFf = Flotation Safety Factor (Ws+Wc+S)/(U-Wg)

Use this table to determine the distance from toe at which the Safety Factor is met
Enter the Distance from toe and change the value until the SFf is equal to that required

	Ground Elev 760		Distance from toe (ft) 0			Uplift Safety Extreme Case (1.1 REQ'D)	
		Ws = 63		Wc = 87 Full			
Depth Below Ground	Pipe Inv Elev, Ft	Surcharge Load, S, lbs/ft	Uplift (U) Force, lbs/ft	Pipe Weight, Lbs/ft	Full water Wt, Lbs / ft	SFf Full	SFf Empty
	760	0		63	87		
10	750	1329	1178	63	87	1.26	1.18
11	749	1482	1296	63	87	1.26	1.19
12	748	1636	1413	63	87	1.26	1.20
13	747	1789	1531	63	87	1.27	1.21
14	746	1942	1649	63	87	1.27	1.22
15	745	2096	1767	63	87	1.27	1.22
16	744	2249	1885	63	87	1.27	1.23
17	743	2402	2002	63	87	1.27	1.23
18	742	2556	2120	63	87	1.28	1.24

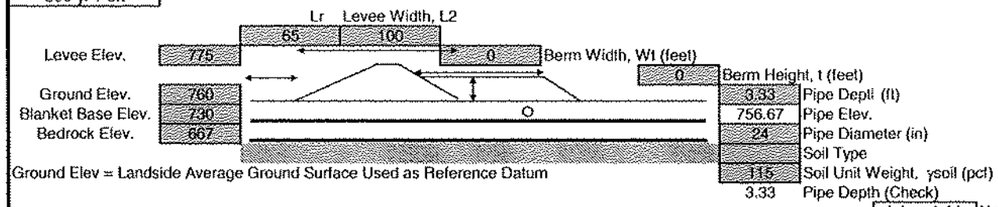


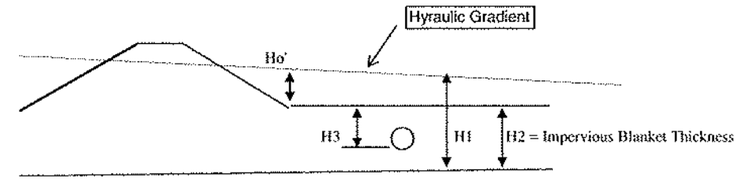
U = P3 * diameter * l
Using l = 1

Conclusions
For levee stretch: 79+00 to 190+00
For pipe diam (in): 16
There is no uplift concern at a depth of 3.33 feet or deeper within 500 feet landward of the levee

DRAFT
MARCH 8, 2007

Armourdale Area L3 Stationing Range	K-r	K-L	DbL	Dbo	Dbr	Df	H	i-c	Lr	Wt	Safety	L1	L2	Le	Lt	L't	Ho'	Hwt/2	Hwt	i-o	Cr	Cl	t	s
																							feet	
79+00	350	350	30	30	30	63	15	0.84	65	0	2.03	65	100	813	978	978	12.47	12.47	12.47	0.42	813	813	0	0.000
190+00	Geotechnical data (above) presented in this spreadsheet was provided by Geotechnical Engineers and is used to develop the Hydraulic Gradient at various distances from the toe.																							
500-yr + 3ft																								





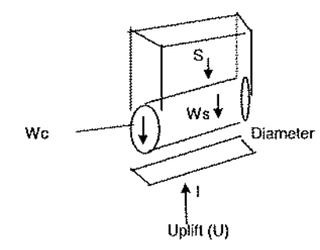
d=Landside Distance from Toe Feet	No Berm Calcs Excess Head Feet, Ho'	Invert Elev of pipe 24 -in steel	Design Base Blanket Feet, MSL	Ground Elev Feet, MSL	H3 Feet	H2 Feet	H1 Feet	P3 Psf	Ws lb	Wc lb	S lb	U lb	Wg lb	SFf (Full)	SFf (Empty)
0	12.47	756.67	730	760	3.33	30	42.5	294.2	95	196	306	588	0	1.01	0.68
25	12.09	756.67	730	760	3.33	30	42.1	291.6	95	196	306	583	0	1.02	0.69
50	11.73	756.67	730	760	3.33	30	41.7	289.0	95	196	306	578	0	1.03	0.69
100	11.03	756.67	730	760	3.33	30	41.0	284.2	95	196	306	568	0	1.05	0.71
125	10.70	756.67	730	760	3.33	30	40.7	281.9	95	196	306	564	0	1.06	0.71
150	10.37	756.67	730	760	3.33	30	40.4	279.6	95	196	306	559	0	1.07	0.72
200	9.75	756.67	730	760	3.33	30	39.8	275.3	95	196	306	551	0	1.08	0.73
300	8.62	756.67	730	760	3.33	30	38.6	267.5	95	196	306	535	0	1.12	0.75
400	7.63	756.67	730	760	3.33	30	37.6	260.6	95	196	306	521	0	1.15	0.77
500	6.74	756.67	730	760	3.33	30	36.7	254.5	95	196	306	509	0	1.17	0.79

Ws Calc 24 -in steel 1lf
95
Wc Calc
196

See Sample Calculations for list of abbreviations and sample calculations
Ws = weight of structure per foot of length = 94.62 lb per ft (24-inch Diameter Steel Pipe, .375" thick)
Wc = weight of water contained in the structure = pi * r^2 * 1 = 3.1416*((12/12)^2) *1*62.4 = 196 plf
S = surcharge loads = weight of satuarted soils above = (H3-Pipe Diameter/12)*(Pipe Diameter/12)*1*γsoil
P3 = H3*(H1/H2)*γwater
U = Uplift force on the project area of structure = Area of pipe * P3 = (Pipe Diameter/12)*1*P3
Wg = weight of surcharge water above top surface of structure control by gravity flow
SFf = Flotation Safety Factor (Ws+Wc+S)/(U-Wg)

Use this table to determine the distance from toe at which the Safety Factor is met
Enter the Distance from toe and change the value until the SFf is equal to that required

	Ground Elev 760		Distance from toe (ft) 0			Uplift Safety Extreme Case (1.1 REQ'D)	
		Ws = 95		Wc = 196 Full			
Depth Below Ground	Pipe Inv Elev, Ft	Surcharge Load, S, lbs/ft	Uplift (U) Force, lbs/ft	Pipe Weight, Lbs/ft	Full water Wt, Lbs / ft	SFf Full	SFf Empty
	760	0		95	196		
3.33	756.67	306	588	95	196	1.01	0.68
4.33	755.67	536	765	95	196	1.08	0.82
5.33	754.67	766	942	95	196	1.12	0.91
6.33	753.67	996	1118	95	196	1.15	0.98
7.33	752.67	1226	1295	95	196	1.17	1.02
8.33	751.67	1456	1472	95	196	1.19	1.05
9.33	750.67	1686	1648	95	196	1.20	1.08
10.33	749.67	1916	1825	95	196	1.21	1.10
11.33	748.67	2146	2002	95	196	1.22	1.12

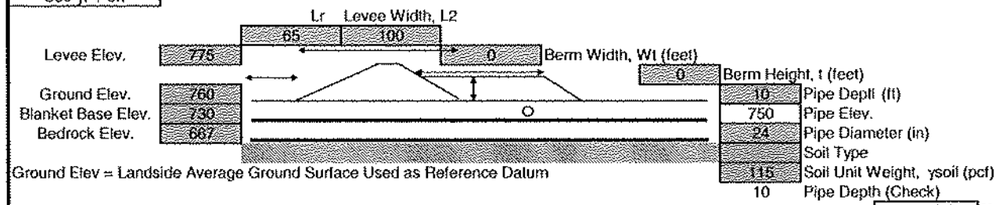


U = P3 * diameter * l
Using l = 1

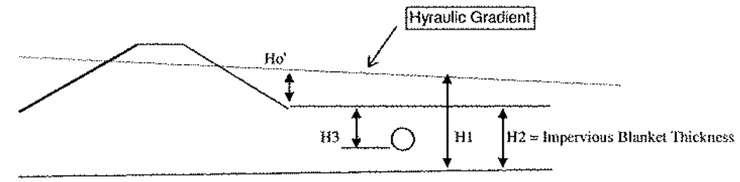
Conclusions
For levee stretch: 79+00 to 190+00
For pipe diam (in): 24
There is uplift concern at a depth of 40 inches (3.3 feet) and less within 500 feet landward of the levee
There is uplift concern at a depth of 9.33 feet and less at the landward toe

DRAFT
MARCH 8, 2007

Armourdale Area L3 Stationing Range	K-r	K-L	DbL	Dbo	Dbr	Df	H	i-c	Lr	Wt	Safety	L1	L2	Le	Lt	L't	Ho'	Hwt/2	Hwt	i-o	Cr	Cl	t	s
																							feet	
79+00	350	350	30	30	30	63	15	0.84	65	0	2.03	65	100	813	978	978	12.47	12.47	12.47	0.42	813	813	0	0.000
190+00	Geotechnical data (above) presented in this spreadsheet was provided by Geotechnical Engineers and is used to develop the Hydraulic Gradient at various distances from the toe.																							
500-yr + 3ft																								



Ground Elev = Landside Average Ground Surface Used as Reference Datum



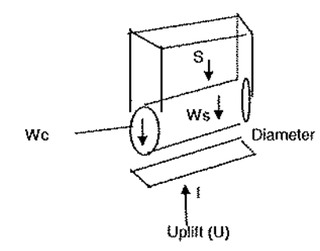
d=Landside Distance from Toe Feet	No Berm Calcs Excess Head Feet, Ho'	Invert Elev of pipe 24 -in steel	Design Base Blanket Feet, MSL	Ground Elev Feet, MSL	H3 Feet	H2 Feet	H1 Feet	P3 Psf	Ws lb	Wc lb	S lb	U lb	Wg lb	SFf (Full)	SFf (Empty)
0	12.47	750	730	760	10	30	42.5	883.4	95	196	1840	1767	0	1.21	1.10
25	12.09	750	730	760	10	30	42.1	875.6	95	196	1840	1751	0	1.22	1.11
50	11.73	750	730	760	10	30	41.7	867.9	95	196	1840	1736	0	1.23	1.11
100	11.03	750	730	760	10	30	41.0	853.4	95	196	1840	1707	0	1.25	1.13
125	10.70	750	730	760	10	30	40.7	846.5	95	196	1840	1693	0	1.26	1.14
150	10.37	750	730	760	10	30	40.4	839.7	95	196	1840	1679	0	1.27	1.15
200	9.75	750	730	760	10	30	39.8	826.9	95	196	1840	1654	0	1.29	1.17
300	8.62	750	730	760	10	30	38.6	803.4	95	196	1840	1607	0	1.33	1.20
400	7.63	750	730	760	10	30	37.6	782.6	95	196	1840	1565	0	1.36	1.24
500	6.74	750	730	760	10	30	36.7	764.3	95	196	1840	1529	0	1.39	1.27

Ws Calc 24 -in steel 1lf
95
Wc Calc
196

See Sample Calculations for list of abbreviations and sample calculations
Ws = weight of structure per foot of length = 94.62 lb per ft (24-inch Diameter Steel Pipe, .375" thick)
Wc = weight of water contained in the structure = pi * r^2 * 1 = 3.1416*((12/12)^2) *1*62.4 = 196 plf
S = surcharge loads = weight of satuarted soils above = (H3-Pipe Diameter/12)*(Pipe Diameter/12)*1*γsoil
P3 = H3*(H1/H2)*γwater
U = Uplift force on the project area of structure = Area of pipe * P3 = (Pipe Diameter/12)''1''P3
Wg = weight of surcharge water above top surface of structure control by gravity flow
SFf = Flotation Safety Factor (Ws+Wc+S)/(U-Wg)

Use this table to determine the distance from toe at which the Safety Factor is met
Enter the Distance from toe and change the value until the SFf is equal to that required

	Ground Elev 760		Distance from toe (ft) 0			Uplift Safety Extreme Case (1.1 REQ'D)	
		Ws = 95		Wc = 196 Full			
Depth Below Ground	Pipe Inv Elev, Ft	Surcharge Load, S, lbs/ft	Uplift (U) Force, lbs/ft	Pipe Weight, Lbs/ft	Full water Wt, Lbs / ft	SFf Full	SFf Empty
	760	0		95	196		
10	750	1840	1767	95	196	1.21	1.10
11	749	2070	1944	95	196	1.21	1.11
12	748	2300	2120	95	196	1.22	1.13
13	747	2530	2297	95	196	1.23	1.14
14	746	2760	2474	95	196	1.23	1.15
15	745	2990	2650	95	196	1.24	1.16
16	744	3220	2827	95	196	1.24	1.17
17	743	3450	3004	95	196	1.25	1.18
18	742	3680	3180	95	196	1.25	1.19



U = P3 * diameter * l
Using l = 1

Conclusions
For levee stretch: 79+00 to 190+00
For pipe diam (in): 24
There is uplift concern at a depth of 40 inches (3.3 feet) and less at the toe of the levee
There is uplift concern at a depth of 10 feet and less at the landward toe

DRAFT
MARCH 8, 2007