PANAMA CANAL CONCEPT DESIGN

Atlantic Locks Structure
Third Lane Lock
Final Report

Prepared for

ACP
AUTORIDAD DEL CANAL DE PANAMA

Canal Capacity Projects Office

By

US Army Corps of Engineers

Volume 3 –Appendices K through Q

23 July 2003

DOUBLE-LIFT CONFIGURATION QUANTITIES

QUANTITIES: PANAMA THIRD LANE ATLANTIC LOCKS, ENTRANCE WALLS

CASINGS: 50.8 mm WALL THICKNESS for 2.44 M						
			Lake Gatun Walls		TOTAL	UNITS
Number of shafts			69			
Caisson Length, l =			40			*meters*
Outside diameter of Caisson, d_o =			2.440			*meters*
Inside diameter of Caisson, d_i =			2.338			*meters*
Diameter of #18 (#57 metric) reinforcing bar, db=			57.3			*mm*
Number reinforcing bars, n_b=			47			
Caisson Wall Thickness, t=			50.8			*mm*
Volume of Steel in Caisson Wall, $v_s = \{[p(d_o^2 - d_i^2)]/4\} l$ =			15.25			*cubic meters*
Weight of Steel in Caisson Wall, $w_s = v_s$*7.8483 tonnes/m³ =			119.70			*metric tons*
Volume of Reinforcing in Caisson, $v_r = [(p(d_b)^2)/4] l n_b$=			4.85			*cubic meters*
Weight of Reinforcing Steel in Caisson Wall, $w_r = v_r$*7.8483 tonnes/m³ =			38.05			*metric tons*
Volume of Concrete in Caisson, $v_c = [(pdi^2)/4]l - v_r$ =			166.94			*cubic meters*
Weight of steel casing, total			8259.44		**8259.4432**	***metric tons***
Volume of Reinforced Concrete in Drilled Shafts			11518.72		**11518.718**	***cubic meters***
Weight of reinforcing steel, total			2625.32		**2625.3165**	***metric tons***

(63 shafts under Cap Beam, and 12 under the Lake Gatun Nose Pier)

FENDERS:	Quantity	Unit Cost	TOTAL COST	Comments and discussion
Metso/Trellex MV1450 x 1000A fender systems, with closed-box frontal frames ancillary hardware and UHMW pads; assumed to sized 6.10-m by 3.66 m by 37.5-cmm thick, with 51 mm gap between each frame.	112	$36,782.00	$4,119,584.00	*Price quote from John Rector and Tara Perry, Metso Minerals Trellex Fender, 3 October, 2002*
Wheel Fender Model # 290-110WF Wheel Fneder elements, including the heavy duty steel casing, sliding axle, idler rollers and protective "eyebrows". The Nose Piers each have 9 in plan view; the Lake Gatun Fenders are stacked two high; there is a single height of fenders on the Atlantic Nose Piers.	54	$80,000.00	$4,320,000.00	*Price quote from Fentek Americas, Apri2003*
TOTAL			**$8,439,584.00**	

CONVENTIONAL REINFORCED CONCRETE FOR CAP BEAMS:

	Lake Gatun Walls				
	Cross-Sectional Area (M²)	Length (M)	Volume (m³)	Reinforcing Steel, t	
11.800 M wide section	59.0	430	25370.00	201	
22.501 M wide section	112.5	131	14738.16	117	
Transitions	85.8	46	3944.62	31	
Transitions					
SUBTOTAL VOLUME (M³)			44052.77	349	44052.77 plus

Subtract for drilled shaft embedment into Cap Beams	Cross-Sectional Area (M²)	Height (M)	Number of Shafts	Volume (m³)	
2.44 M	4.68	2.5	69	806.60	
SUBTOTAL VOLUME (M³)				806.60	806.60 minus
Total Volume (M³) =					**43246.17 cubic meters**

CONVENTIONAL REINFORCED CONCRETE FOR NOSE PIERS:

	Lake Gatun, right bank Wall ("Cap Beam" wall mounted on drilled shafts)			
	Area (M²)	Height (M)	Volume (m³)	
	1350	5	6750.00	
SUBTOTAL VOLUME (M³)			6750.00	
Total Volume (M³) =				**6750.00 cubic meters**

TOTAL VOLUME of REINFORCED CONCRETE, Lake Gatun Entrance Wall (M³) = **61514.89 cubic meters**

US Army Corps
of Engineers
Pittsburgh District

Panama Canal Authority
Atlantic Locks
3rd Lane - Concept Design Study

COMPUTATION

Two Lift Lock, Gate Quantity Estimate
Material Estimates for Double Skin Plate Miter Gates

Computed By: WAH Date 8-Nov-02
Checked By: RAA Date

Material Quantity Summary

Component	Material	Total, lbs	Total, t*
Fabricated Steel (Welded Construction)	ASTM A572M Grade 345	33,730,495	**15,332**
Fabricated Steel (Welded Construction)	ASTM A572M Grade 450	5,012,830	**2,279**
Casting (Pintle and Pintle Base)	ASTM A27 Class 65-35 Annealed	184,294	**84**
Pintle Bushing	ASTM B148, Alloy 954	27,516	**13**
Quoin and Miter Blocks	ASTM XM-25	1,955,768	**889**
Embedded Anchorage Frames	ASTM A572M Grade 345	1,455,024	**661**
Embedments for Quoin Blocks	ASTM A572M Grade 345	542,700	**247**
Gate Sill Embedded Metals	ASTM 304 Stainless Stl.	83,718	**38**
		42,992,345	**19,542**

* - Metric Ton

34.5m Tall Miter Gate Leaf

Component	Material	Each, lbs	# Required	Total, lbs
Fabricated Steel (Welded Construction)	ASTM A572M Grade 345	2,968,652	8	23,749,215
Fabricated Steel (Welded Construction)	ASTM A572M Grade 450	626,604	8	5,012,830
Casting (Pintle and Pintle Base)	ASTM A27 Class 65-35 Annealed	19,019	8	152,154
Pintle Bushing	ASTM B148, Alloy 954	2,710	8	21,680
Quoin and Miter Blocks	ASTM XM-25	184,874	8	1,478,989
Embedded Anchorage Frames	ASTM A572M Grade 345	121,252	8	970,016
Embedments for Quoin Blocks	ASTM A572M Grade 345	51,300	8	410,400
		3,974,410		**31,795,284**

22.34m Tall Miter Gate Leaf

Component	Material	Each, lbs	# Required	Total, lbs
Fabricated Steel (Welded Construction)	ASTM A572M Grade 345	2,495,320	4	9,981,280
Casting (Pintle and Pintle Base)	ASTM A27 Class 65-35 Annealed	8,035	4	32,139
Pintle Bushing	ASTM B148, Alloy 954	1,459	4	5,837
Quoin and Miter Blocks	ASTM XM-25	119,195	4	476,779
Embedded Anchorage Frames	ASTM A572M Grade 345	121,252	4	485,008
Embedments for Quoin Blocks	ASTM A572M Grade 345	33,075	4	132,300
		2,778,336		**11,113,343**

Gate Sills

Component	Material	Each, lbs	# Required	Total, lbs
Gate Sill Embedded Metals	ASTM 304 Stainless Stl.	13,953	6	**83,718**

Total (lbs) = **42,992,345**

US Army Corps
of Engineers
Pittsburgh District

Panama Canal Authority
Atlantic Locks
3rd Lane - Concept Design Study

COMPUTATION
Lock Screening Study
Quantity Summary

Computed By: AHARKNESS Date 15-Mar-03
Checked By: RAALLWES Date 24-Mar-03

Alternative #2 - ICLC Gravity Monoliths with WSB to the West

							Concrete			*Type of Concrete*	
	Description	**Station**	**to**	**Station**	**Reinforcing Steel kg/m**	**Reinforcing Steel kg**	**Area m^2**	**Volume m^3**	**RCC %**	**RCC m^3**	**Cast-in-Place (CIP) m^3**
East Walls	***Atlantic East Entrance Wall***										
		11+611		11+837	2 500	565 000	500	113 000	95%	107 350	5 650
		11+837		11+883	2 500	115 000	447	20 539	95%	19 512	1 027
		11+883		12+400	2 500	1 292 500	393	203 181	95%	193 022	10 159
	Gatun East Entrance Wall	13+690		13+800	2 500	275 000	482	53 020	95%	50 369	2 651
		13+800		14+400			In the wet				
					Subtotal =	2 247 500			**Subtotal =**	370 253	19 487
	North Gate Bay Monoliths	12+491		12+582	10 000	910 000	811	73 801	40%	29 520	44 281
	Center Gate Bay Monoliths	13+006		13+097	10 000	910 000	1 146	104 286	40%	41 714	62 572
	South Gate Bay Monoliths	13+520		13+611	9 721	884 611	741	67 431	40%	26 972	40 459
					Subtotal =	2 704 611			**Subtotal =**	98 207	147 311
	Atlantic Outlet Structure - between entrance wall and lower gate monolith	12+400		12+491	5 400	491 400	500	45 500	50%	22 750	22 750
	Lower Chamber East Wall										
	Section 1	12+582		12+623	3 600	147 600	938	38 458	90%	34 612	3 846
	Section 2	12+623		12+873	3 600	900 000	825	206 250	90%	185 625	20 625
	Section 3	12+873		12+949	3 600	273 600	938	71 288	90%	64 159	7 129
	Section 4	12+949		13+006	3 600	205 200	1 051	59 907	90%	53 916	5 991
	Upper Chamber East Wall										
	Section 1	13+097		13+135	3 600	136 800	1 068	40 584	90%	36 526	4 058
	Section 2	13+135		13+414	3 600	1 004 400	900	251 100	90%	225 990	25 110
	Section 3	13+414		13+475	3 600	219 600	1 068	65 148	90%	58 633	6 515
	Section 4	13+475		13+520	3 600	162 000	1 235	55 575	90%	50 018	5 558
	Gatun Intake Structure - between entrance wall and upper gate monolith	13+611		13+690	5 400	426 600	500	39 500	50%	19 750	19 750
					Subtotal =	3 967 200			**Subtotal =**	751 979	121 331
West Walls	***Atlantic West Entrance Wall***	12+316		12+400	2 500	210 000	550	46 200	95%	43 890	2 310
	Gatun West Entrance Wall	13+690		13+775	2 500	212 500	660	56 100	95%	53 295	2 805
					Subtotal =	422 500			**Subtotal =**	97 185	5 115
	North Gate Bay Monoliths	12+490		12+580	10 000	910 000	811	72 990	50%	36 495	36 495
	Center Gate Bay Monoliths	13+006		13+095	10 000	910 000	1 146	101 994	50%	50 997	50 997
	South Gate Bay Monoliths	13+525		13+615	9 721	884 611	741	66 690	50%	33 345	33 345
					Subtotal =	2 704 611			**Subtotal =**	120 837	120 837
	Atlantic Outlet Structure - between entrance wall and lower gate monolith	12+400		12+490	5 400	486 000	500	45 000	50%	22 500	22 500
	Lower Chamber West Wall										
	Section 1	12+580		12+630	3 600	180 000	938	46 900	90%	42 210	4 690
	Section 2	12+630		12+875	3 600	882 000	825	202 125	90%	181 913	20 213
	Section 3	12+875		12+950	3 600	270 000	938	70 350	90%	63 315	7 035
	Section 4	12+950		13+006	3 600	201 600	1 051	58 856	90%	52 970	5 886
	Upper Chamber West Wall										
	Section 1	13+095		13+150	3 600	198 000	1 068	58 740	90%	52 866	5 874
	Section 2	13+150		13+420	3 600	972 000	900	243 000	90%	218 700	24 300
	Section 3	13+420		13+475	3 600	198 000	1 068	58 740	90%	52 866	5 874
	Section 4	13+475		13+525	3 600	180 000	1 235	61 750	90%	55 575	6 175
	Gatun Intake Structure - between entrance wall and upper gate monolith	13+615		13+690	5 400	405 000	500	37 500	50%	18 750	18 750
					Subtotal =	3 972 600			**Subtotal =**	761 665	121 296
Floor	***Outlet Paving***	12+354		12+491	2 882	366 014	54	7 398	100%	7 398	0
	Downstream Bulkhead Sill	12+466		12+476	4 102	41 020	270	2 700	90%	2 430	270
	North Gate Bay Sill	12+491		12+582	4 102	373 282	295	27 874	80%	22 299	5 575
	Lower Chamber Floor	12+582		13+006	2 837	1 202 888	41	17 172	100%	17 172	0
	Lower Chamber Culverts	12+582		13+006	2 585	1 095 938	34	14 416	0%	0	14 416
	Center Gate Bay Sill	13+006		13+052	4 102	188 692	528	24 787	80%	19 830	4 957
	Center Gate Bay Sill	13+052		13+097	4 102	184 590	355	16 452	80%	13 161	3 290
	Upper Chamber Floor	13+097		13+522	3 140	1 334 500	39	16 416	100%	16 416	0
	Upper Chamber Culverts	13+097		13+522	2 585	1 098 523	34	14 450	0%	0	14 450
	South Gate Bay Sill	13+522		13+568	3 140	144 440	636	30 221	80%	24 177	6 044
	South Gate Bay Sill	13+568		13+600	3 140	100 480	187	6 444	80%	5 155	1 289
	Upstream Bulkhead Sill	13+625		13+638	1 570	20 724	264	3 478	90%	3 130	348
	Inlet Paving	13+600		13+700	2 882	250 158	53	5 270	100%	5 270	0
	Connecting Culvert Runs										
					Subtotal =	6 401 249			**Subtotal =**	136 438	50 639

	Item	Total Length	Mass, kg/m	Mass	Length	Area	Volume
WSB 1A	***Exterior Wall Footing***	31,864.0	3.042	96.93	569.00	4.31	2 454
		26,713.0	2.235	59.70			
	Exterior Wall Stem	42,214.0	3.042	128.41	569.00	3.21	1 828
		27,141.0	2.235	60.66			
	Baffle Wall	6,073.0	1.552	9.43	80.50	1.68	135
	Floor Slab	260,400.0	2.235	581.99			15 500
WSB 1B	***Exterior Wall Footing***	9,310.0	3.042	28.32	166.25	4.31	717
		7,805.0	2.235	17.44			
	Exterior Wall Stem	12,263.0	3.042	37.30	166.25	3.16	526
		7,805.0	2.235	17.44			
	Baffle Wall	6,830.0	1.552	10.60	92.00	1.65	152
	Floor Slab	293,672.0	2.235	656.36			17 481
	Middle Wall Footing	23,393.0	3.042	71.16	406.00	7.44	3 021
		24,563.0	6.404	157.30			
	Middle Wall Stem	11,263.0	3.042	34.26	406.00	6.71	2 724
		20,794.0	2.235	46.47			
		18,778.0	6.404	120.25			
		20,300.0	3.973	80.65			
		7,335.0	3.973	29.14			
			Subtotal =	**2 243 847**		**Subtotal =**	**44 537**
WSB 2A	***Exterior Wall Footing***	31,864.0	3.042	96.93	569.00	4.31	2 454
		26,713.0	2.235	59.70			
	Exterior Wall Stem	41,207.0	3.042	125.35	569.00	3.01	1 713
		26,713.0	2.235	59.70			
	Baffle Wall	5,684.0	1.552	8.82	80.50	1.57	126
	Floor Slab	260,400.0	2.235	581.99			15 500
WSB 2B	***Exterior Wall Footing***	9,310.0	3.042	28.32	166.25	4.31	717
		7,805.0	2.235	17.44			
	Exterior Wall Stem	11,786.0	3.042	35.85	164.66	2.96	487
		7,225.0	2.235	16.15			
	Baffle Wall	6,830.0	1.552	10.60	92.00	1.65	152
	Floor Slab	293,672.0	2.235	656.36			17 481
	Middle Wall Footing	23,393.0	3.042	71.16	406.00	7.44	3 021
		24,563.0	6.404	157.30			
	Middle Wall Stem	11,263.0	3.042	34.26	406.00	6.71	2 724
		19,927.0	2.235	44.54			
		21,518.0	6.404	137.80			
		20,300.0	3.973	80.65			
		6,616.0	3.973	26.29			
			Subtotal =	**2,249,228**		**Subtotal =**	**44,374**

					Excavated Soil		***Structural Backfill***		***Random Backfill***	
	Description	**Station**	**to**	**Station**	**Area m^2**	**Volume m^3**	**Area m^2**	**Volume m^3**	**Area m^2**	**Volume m^3**
East Walls	***Atlantic East Entrance Wall***									
		11+682.		11+837.	320	72 320	96	21 696	224	50 624
		11+837.		11+883.	320	14 720	96	4 416	224	10 304
		11+883.		12+400.	716	370 172	215	111 052	501	259 120
	Gatun East Entrance Wall	13+690.		13+800.	326	35 860	98	10 758	228	25 102
		13+800.		14+400.	0	0	0	0	0	0
					Subtotal =	493 072	**Subtotal =**	147 922	**Subtotal =**	345 150
	North Gate Bay Monoliths	12+491.		12+582.	410	37 310	123	11 193	287	26 117
	Center Gate Bay Monoliths	13+006.		13+097.	0	0	0	0	0	0
	South Gate Bay Monoliths	13+520.		13+611.	271	24 661	81	7 398	190	17 263
					Subtotal =	61 971	**Subtotal =**	18 591	**Subtotal =**	43 380
	Atlantic Outlet Structure - between entrance wall and	12+400.		12+491.	626	56 966	188	17 090	438	39 876
	Lower Chamber East Wall									
	Section 1	12+582.		12+623.	245	10 045	74	3 014	172	7 032
	Section 2	12+623.		12+873.	192	48 000	58	14 400	134	33 600
	Section 3	12+873.		12+949.	207	15 732	62	4 720	145	11 012
	Section 4	12+949.		13+006.	140	7 980	42	2 394	98	5 586
	Upper Chamber East Wall									
	Section 1	13+097.		13+135.	262	9 956	262	9 956	0	0
	Section 2	13+135.		13+414.	459	128 061	138	38 418	321	89 643
	Section 3	13+414.		13+475.	152	9 272	46	2 782	106	6 490
	Section 4	13+475.		13+520.	185	8 325	56	2 498	130	5 828
	Gatun Intake Structure - between entrance wall and	13+611.		13+690.	343	27 097	103	8 129	240	18 968
					Subtotal =	321 434	**Subtotal =**	103 399	**Subtotal =**	218 035

West Walls	*Atlantic West Entrance Wall*	12+316.		12+400.	587	49 308	176	14 792	411	34 516
	Gatun West Entrance Wall	13+690.		13+775.	726	61 710	218	18 513	508	43 197
					Subtotal =	111 018	**Subtotal =**	33 305	**Subtotal =**	77 713
	North Gate Bay Monoliths	12+490.		12+580.	415	37 350	125	11 205	291	26 145
	Center Gate Bay Monoliths	13+006.		13+095.	0	0	0	0	0	0
	South Gate Bay Monoliths	13+525.		13+615.	708	63 720	212	19 116	496	44 604
					Subtotal =	101 070	**Subtotal =**	30 321	**Subtotal =**	70 749
	Atlantic Outlet Structure - between entrance wall and	12+400.		12+490.	446	40 140	134	12 042	312	28 098
	Lower Chamber West Wall									
	Section 1	12+580.		12+630.	313	15 650	94	4 695	219	10 955
	Section 2	12+630.		12+875.	419	102 655	419	102 655	0	0
	Section 3	12+875.		12+950.	163	12 225	163	12 225	0	0
	Section 4	12+950.		13+006.	0	0	0	0	0	0
	Upper Chamber West Wall									
	Section 1	13+095.		13+150.	0	0	0	0	0	0
	Section 2	13+150.		13+420.	144	38 880	0	0	0	0
	Section 3	13+420.		13+475.	49	2 695	49	2 695	0	0
	Section 4	13+475.		13+525.	264	13 200	264	13 200	0	0
	Gatun Intake Structure - between entrance wall and upper gate monolith	13+615.		13+690.	906	67950	272	20385	634	47565
					Subtotal =	293 395	**Subtotal =**	167 897	**Subtotal =**	86 618
					Total =	1 381 960	***Total =***	501 436	***Total =***	841 644

Main Features	RCC m^3	CIP m^3	Reinforcing Steel kg	Structural Backfill m^3	Random Backfill m^3
Gate Monolith Construction	219 044	268 148	5 409 222	48 912	114 129
Chamber Monolith Construction	1 513 644	242 627	7 939 800	271 296	304 653
Floor and Sill Construction	136 438	50 639	6 401 249	0	0
Entrance Wall Construction	467 438	24 602	2 670 000	181 227	422 863
Water Saving Basins	—	88 911	4 493 [illegible]75	—	—
Total	2 336 600	675 000	26 913 400	501 500	841 700

TRIPLE-LIFT CONFIGURATION QUANTITIES

US Army Corps
of Engineers
Pittsburgh District

Panama Canal Authority
Atlantic Locks
3rd Lane - Concept Design Study

COMPUTATION

Three Lift Lock - Gatun Entrance Wall (In the Wet Construction)
Quantity Summary

Computed By: AHARKNESS Date 15-Mar-03
Checked By: RAALLWES Date 24-Mar-03

CASINGS: 50.8 mm WALL THICKNESS for 2.44 M						
			Lake Gatun Walls		TOTAL	UNITS
Number of shafts			72			
Caisson Length, l =			40			*meters*
Outside diameter of Caisson, d_o =			2.440			*meters*
Inside diameter of Caisson, d_i =			2.338			*meters*
Diameter of #18 (#57 metric) reinforcing bar, db=			57.3			*mm*
Number reinforcing bars, n_b=			47			
Caisson Wall Thickness, t=			50.8			*mm*
Volume of Steel in Caisson Wall, $v_s = \{[p(d_o^2 - d_i^2)]/4\} l$ =			15.25			*cubic meters*
Weight of Steel in Caisson Wall, $w_s = v_s$*7.8483 tonnes/m³ =			119.70			*metric tons*
Volume of Reinforcing in Caisson, $v_r = [(p(d_b)^2)/4]\ l\ n_b$=			4.85			*cubic meters*
Weight of Reinforcing Steel in Caisson Wall, $w_r = v_r$*7.8483 tonnes/m³ =			38.05			*metric tons*
Volume of Concrete in Caisson, $v_c = [(pdi^2)/4]l - v_r$ =			166.94			*cubic meters*
Weight of steel casing, total			8618.55		**8618.5494**	***metric tons***
Volume of Reinforced Concrete in Drilled Shafts			12019.53		**12019.532**	***cubic meters***
Weight of reinforcing steel, total			2739.46		**2739.4606**	***metric tons***

(63 shafts under Cap Beam, and 12 under the Lake Gatun Nose Pier)

FENDERS:	Quantity	Unit Cost	TOTAL COST	Comments and discussion
Metso/Trellex MV1450 x 1000A fender systems, with closed-box frontal frames ancillary hardware and UHMW pads; assumed to sized 6.10-m by 3.66-m by 37.5-cmm thick, with 51 mm gap between each frame.	106	$36,782.00	$3,898,892.00	*Price quote from John Rector and Tara Perry, Metso Minerals Trellex Fender, 3 October, 2002*
Wheel Fender Model # 290-110WF Wheel Fneder elements, including the heavy duty steel casing, sliding axle, idler rollers and protective "eyebrows". The Nose Piers each have 9 in plan view; the Lake Gatun Fenders are stacked two high; there is a single height of fenders on the Atlantic Nose Piers.	54	$80,000.00	$4,320,000.00	*Price quote from Fentek Americas, April2003*
TOTAL			**$8,218,892.00**	

CONVENTIONAL REINFORCED CONCRETE FOR CAP BEAMS:

	Lake Gatun Walls				
	Cross-Sectional Area (M²)	Length (M)	Volume (m³)		
11.800 M wide section	59	432	25488.00		
22.501 M wide section	112.505	238	26776.19		
Transitions	85.7525	46	3944.62		
Transitions					
SUBTOTAL VOLUME (M³)			56208.81	56208.81	plus

Subtract for drilled shaft embedment into Cap Beams	Cross-Sectional Area (M²)	Height (M)	Number of Shafts	Volume (m³)		
2.44 M	4.68	2.5	72	841.67		
SUBTOTAL VOLUME (M³)				841.67	841.67	minus
Total Volume (M³) =					**55367.13 cubic meters**	

TOTAL VOLUME of REINFORCED CONCRETE, Lake Gatun Entrance Wall (M³) = **67386.67 cubic meters**

US Army Corps
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Pittsburgh District

Panama Canal Authority
Atlantic Locks
3rd Lane - Concept Design Study

COMPUTATION

Lock Gate Quanity Estimate
Contact Block Weight Take-off

Computed By: WAH Date 23-Aug-02
Checked By: Date

Quoin and Miter Blocks

	Steel	Stainless Steel	No. Req'd	LF	PLF	Extension
Upper Gates		XM-25	8	73.5	1210	711,480
	Str. Steel		8	73.5	200	117,600
Center gates		XM-25	8	100	1210	968,000
	Str. Steel		8	100	200	160,000
Lower Gates		XM-25	8	100	1210	968,000
	Str. Steel		8	100	200	160,000
			Total Stainless Steel			1,936,000
			Total Structural Steel			

Embedded Quoin Block

	Steel	Stainless Steel	No. Req'd	LF	PLF	Extension
Upper Gates		XM-25	4	73.5	412	121,039
	Str. Steel		4	73.5	450	132,300
Center gates		XM-25	4	100	412	164,679
	Str. Steel		4	100	450	180,000
Lower Gates		XM-25	4	100	412	164,679
	Str. Steel		4	100	450	180,000
			Total Stainless Steel			3,097,878
			Total Structural Steel			929,900

Gate Sill

	A36		6	210	12	15120
		304SS	6	210	54.4	68600

Summary of Quantities

Total Stainless Steel	3,166,478
Total Structural Steel	945,020

US Army Corps
of Engineers
Pittsburgh District

Panama Canal Authority
Atlantic Locks
3rd Lane - Concept Design Study

COMPUTATION
Three Lift Concept Design (Cost Estimate)
Quantity Summary

Computed By: AHARKNESS Date 20-Jun-03
Checked By: RAALLWES Date

Three Lift Lock - ICLC F&E System, Gravity Monoliths, WSB to the West

							Concrete			Type of Concrete	
	Description	Station	to	Station	Reinforcing Steel kg/m	Reinforcing Steel kg	Area m²	Volume m³	RCC %	RCC m³	Cast-in-Place (CIP) m³
East Walls	***Atlantic East Entrance Wall***										
		12+140		12+334	2 500	484 625	506	98 049	90%	88 244	9 805
		12+334		·12+381	2 500	119 100	463	22 076	90%	19 869	2 208
		12+381		12+877	2 500	1 238 578	421	208 576	90%	187 719	20 858
		12+877		12+935	2 500	144 450	463	26 775	90%	24 098	2 678
	Gatun East Entrance Wall	14+773		14+898	2 500	312 823	440	55 057	90%	49 551	5 506
		14+898		15+568	n the wet construction - see separate quantity take-o						
					Subtotal =	2 299 575			**Subtotal =**	369 481	41 053
	North Gate Bay Monoliths	13 043		13 134	10 000	908 000	1 078	97 882		39 153	58 729
	Gate Bay 2 Monoliths	13 558		13 649	10 000	908 000	1 078	97 882		39 153	58 729
	Gate Bay 3 Monoliths	14 074		14 165	10 000	908 000	1 078	97 882		39 153	58 729
	South Gate Bay Monoliths	14 590		14 680	9 721	882 667	796	72 277		28 911	43 366
					Subtotal =	3 606 667			**Subtotal =**	146 370	219 554
	Atlantic Outlet Structure - between entrance wall and lower gate monolith	12+935		13+043	5 400	584 550	580	62 785	50%	31 393	31 393
	Lower Chamber East Wall										
	Section 1	13+134		13+175	4 200	174 174	845	35 042	90%	31 538	3 504
	Section 2	13+175		13+428	4 200	1 063 650	741	187 658	90%	168 892	18 766
	Section 3	13+428		13+504	4 200	319 200	845	64 220	90%	57 798	6 422
	Section 4	13+504		13+558	4 200	226 842	947	51 164	90%	46 047	5 116
	Center Chamber East Wall										
	Section 1	13+649		13+691	4 200	174 174	876	36 328	90%	32 695	3 633
	Section 2	13+691		13+944	4 200	1 063 650	782	197 915	90%	178 123	19 791
	Section 3	13+944		14+020	4 200	319 200	876	66 576	90%	59 918	6 658
	Section 4	14+020		14+074	4 200	226 842	969	52 341	90%	47 107	5 234
	Upper Chamber East Wall										
	Section 1	14+165		14+206	4 200	174 174	945	39 189	90%	35 270	3 919
	Section 2	14+206		14+460	4 200	1 063 650	900	227 925	90%	205 133	22 793
	Section 3	14+460		14+536	4 200	319 200	945	71 820	90%	64 638	7 182
	Section 4	14+536		14+590	4 200	226 842	988	53 383	90%	48 045	5 338
	Gatun Intake Structure - between entrance wall and upper gate monolith	14+680		14+773	5 400	499 662	425	39 325	50%	19 663	19 663
					Subtotal =	6 435 810			**Subtotal =**	1 026 260	159 411
West Walls	***Atlantic West Entrance Wall***	12+780		12+935	2 500	387 750	506	78 450	90%	70 605	7 845
	Gatun West Entrance Wall	14+773		14+898	2 500	311 775	640	79 839	90%	71 855	7 984
					Subtotal =	699 525			**Subtotal =**	142 460	15 829
	North Gate Bay Monoliths	13+043		13+134	10 000	908 000	1 078	9[illegible]82	50%	48 941	48 941
	Gate Bay 2 Monoliths	13+558		13+649	10 000	908 000	1 078	9[illegible] 882	40%	39 153	58 729
	Gate Bay 3 Monoliths	14+074		14+165	10 000	908 000	1 078	97 882	40%	39 153	58 729
	South Gate Bay Monoliths	14+590		14+680	9 721	882 667	796	72 277	50%	36 138	36 138
					Subtotal =	3 606 667			**Subtotal =**	163 386	202 538
	Atlantic Outlet Structure - between entrance wall and lower gate monolith	12+935		13+043	5 400	584 550	580	62 785	50%	31 393	31 393
	Lower Chamber West Wall										
	Section 1	13+134		13+175	3 600	149 292	733	30 398	90%	27 358	3 040
	Section 2	13+175		13+428	3 600	911 700	661	167 297	90%	150 567	16 730
	Section 3	13+428		13+504	3 600	273 600	733	55 708	90%	50 137	5 571
	Section 4	13+504		13+558	3 600	194 436	804	43 424	90%	39 082	4 342
	Center Chamber West Wall										
	Section 1	13+649		13+691	5 400	223 938	722	29 941	90%	26 947	2 994
	Section 2	13+691		13+944	5 400	1 367 550	651	164 866	90%	148 379	16 487
	Section 3	13+944		14+020	5 400	410 400	722	54 872	90%	49 385	5 487
	Section 4	14+020		14+074	5 400	291 654	793	42 808	90%	38 527	4 281
	Upper Chamber West Wall										
	Section 1	14+165		14+206	3 600	149 292	726	30 107	90%	27 096	3 011
	Section 2	14+206		14+460	3 600	911 700	653	165 372	90%	148 835	16 537
	Section 3	14+460		14+536	3 600	273 600	726	55 176	90%	49 658	5 518
	Section 4	14+536		14+590	3 600	194 436	797	43 051	90%	38 746	4 305
	Gatun Intake Structure - between entrance wall and upper gate monolith	14+680		14+773	5 400	499 662	576	53 316	50%	26 658	26 658
					Subtotal =	6 435 810			**Subtotal =**	852 769	146 352

US Army Corps
of Engineers
Pittsburgh District

Panama Canal Authority
Atlantic Locks
3rd Lane - Concept Design Study

COMPUTATION
Three Lift Concept Design (Cost Estimate)
Quantity Summary

Computed By: AHARKNESS Date 20-Jun-03
Checked By: RAALLWES Date

Downstream Bulkhead Sill	12+927		12+935	4 102	32 816	270	2 160	90%	1 944	216
Downstream Paving	12+935		13+043	2 882	311 977	54	5 846	100%	5 846	
North Gate Bay Sill	13+043		13+134	4 102	372 462	295	27 815	80%	22 252	5 563
Lower Chamber Floor	13+134		13+558	2 837	1 204 959	41	17 202	100%	17 202	0
Lower Chamber Culverts	13+134		13+558	2 585	1 097 825	36	15 290	0%	0	15 290
Gate Bay 2 Sill	13+558		13+591	4 102	135 120	528	17 891	80%	14 313	3 578
Gate Bay 2 Sill	13+591		13+649	4 102	237 342	355	21 011	80%	16 809	4 202
Center Chamber Floor	13+649		14+074	2 837	1 204 959	41	17 202	100%	17 202	0
Center Chamber Culverts	13+649		14+074	2 585	1 097 825	36	15 290	0%	0	15 290
Gate Bay 3 Sill	14+074		14+107	4 102	135 120	528	17 891	80%	14 313	3 578
Gate Bay 3 Sill	14+107		14+165	4 102	237 342	355	21 011	80%	16 809	4 202
Upper Chamber Floor	14+165		14+590	3 140	1 333 652	38	15 927	100%	15 927	0
Upper Chamber Culverts	14+165		14+590	2 585	1 097 825	36	15 290	0%	0	15 290
South Gate Bay Sill	14+590		14+622	3 140	103 432	636	21 915	80%	17 532	4 383
South Gate Bay Sill	14+622		14+680	3 140	181 680	187	11 278	80%	9 023	2 256
Upstream Paving	14+680		14+765	2 882	243 558	53	4 454	100%	4 454	0
Upstream Bulkhead Sill	14+765		14+773	1 570	12 560	264	2 108	90%	1 897	211
Connecting Culvert Runs										
				Subtotal =	9 040 453			**Subtotal =**	175 521	74 060

	Item	*Total Length*	*Mass, kg/m*	*Mass*	*Length*	*Cross Sectional Area*	*Volume, m ^{3}*
WSB 1A	*Exterior Wall Footing*	31,864.0	3.042	96.93	569.00	4.31	2 454
		26,713.0	2.235	59.70			
	Exterior Wall Stem	42,214.0	3.042	128.41	569.00	2.81	1 601
		27,141.0	2.235	60.66			
	Baffle Wall	6,073.0	1.552	9.43	80.50	1.28	103
	Floor Slab	260,400.0	2.235	581.99			15 500
WSB 1B	*Exterior Wall Footing*	9,310.0	3.042	28.32	166.25	4.31	717
		7,805.0	2.235	17.44			
	Exterior Wall Stem	12,263.0	3.042	37.30	166.25	2.76	459
		7,805.0	2.235	17.44			
	Baffle Wall	6,830.0	1.552	10.60	92.00	1.25	115
	Floor Slab	293,672.0	2.235	656.36			17 481
	Middle Wall Footing	23,393.0	3.042	71.16	406.00	7.44	3 021
		24,563.0	6.404	157.30			
	Middle Wall Stem	11,263.0	3.042	34.26	406.00	6.31	2 561
		20,794.0	2.235	46.47			
		18,778.0	6.404	120.25			
		20,300.0	3.973	80.65			
		7,335.0	3.973	29.14			
			Subtotal =	**2 243 847**		**Subtotal =**	**44 011**

WSB 2A	*Exterior Wall Footing*	31,864.0	3.042	96.93	569.00	4.31	2 454
		26,713.0	2.235	59.70			
	Exterior Wall Stem	41,207.0	3.042	125.35	569.00	2.61	1 485
		26,713.0	2.235	59.70			
	Baffle Wall	5,684.0	1.552	8.82	80.50	1.17	94
	Floor Slab	260,400.0	2.235	581.99			15 500
WSB 2B	*Exterior Wall Footing*	9,310.0	3.042	28.32	166.25	4.31	717
		7,805.0	2.235	17.44			
	Exterior Wall Stem	11,786.0	3.042	35.85	164.66	2.56	422
		7,225.0	2.235	16.15			
	Baffle Wall	6,830.0	1.552	10.60	92.00	1.25	115
	Floor Slab	293,672.0	2.235	656.36			17 481
	Middle Wall Footing	23,393.0	3.042	71.16	406.00	7.44	3 021
		24,563.0	6.404	157.30			
	Middle Wall Stem	11,263.0	3.042	34.26	406.00	6.31	2 561
		19,927.0	2.235	44.54			
		21,518.0	6.404	137.80			
		20,300.0	3.973	80.65			
		6,616.0	3.973	26.29			
			Subtotal =	**2,249,228**		**Subtotal =**	**43,849**

US Army Corps
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Pittsburgh District

Panama Canal Authority
Atlantic Locks
3rd Lane - Concept Design Study

COMPUTATION

Three Lift Concept Design (Cost Estimate)

Quantity Summary

Computed By: AHARKNESS Date 20-Jun-03

Checked By: RAALLWES Date

WSB 3A	***Exterior Wall Footing***	31,864.0	3.042	96.93	569.00	4.31	2 454
		26,713.0	2.235	59.70			
	Exterior Wall Stem	41,207.0	3.042	125.35	569.00	2.61	1 485
		26,713.0	2.235	59.70			
	Baffle Wall	5,684.0	1.552	8.82	80.50	1.17	94
	Floor Slab	260,400.0	2.235	581.99			15 500
WSB 3B	***Exterior Wall Footing***	9,310.0	3.042	28.32	166.25	4.31	717
		7,805.0	2.235	17.44			
	Exterior Wall Stem	11,786.0	3.042	35.85	164.66	2.56	422
		7,225.0	2.235	16.15			
	Baffle Wall	6,830.0	1.552	10.60	92.00	1.25	115
	Floor Slab	293,672.0	2.235	656.36			17 481
	Middle Wall Footing	23,393.0	3.042	71.16	406.00	7.44	3 021
		24,563.0	6.404	157.30			
	Middle Wall Stem	11,263.0	3.042	34.26	406.00	6.31	2 561
		19,927.0	2.235	44.54			
		21,518.0	6.404	137.80			
		20,300.0	3.973	80.65			
		6,616.0	3.973	26.29			
			Subtotal =	**2,249,228**		**Subtotal =**	**43,849**

US Army Corps
of Engineers
Pittsburgh District

Panama Canal Authority
Atlantic Locks
3rd Lane - Concept Design Study

COMPUTATION

Three Lift Concept Design (Cost Estimate)
Quantity Summary

Computed By: AHARKNESS Date 20-Jun-03
Checked By: RAALLWES Date

	Main Features	RCC m^3	CIP m^3	Reinforcing Steel kg	Overburden Excavation, m^3	Rock Excavation, m^3	Structural Backfill, m^3	Random Fill, m^3
Summary Table	***Gate Monolith Construction***	309 755	422 093	7 213 334				
	Chamber Monolith Construction	1 879 029	305 764	12 871 620				
	Floor and Sill Construction	175 521	74 060	9 040 453				
	Entrance Wall Construction	511 941	56 882	2 999 100				
	Water Saving Basins	—	131 710	6 742 303				
	Total	2,876,300	990,600	38,866,900	5,934,619	8,407,642	724,628	1,155,989
				WSB Excavation	2,294,229	2,217,998	13,390	58,382

US Army Corps
of Engineers
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Panama Canal Authority
Atlantic Locks
3rd Lane - Concept Design Study

COMPUTATION

Triple Lift Concept Design
3 Lift Valve Quantity Estimate

Computed By: WAH 29-Apr-03
Checked By: RAA

Upper and Valves between Locks

	Two Lift Lock				Three Lift Lock				
Number	Width	Height	Hydrodynamic Head	Weight	Width	Height	Hydrodynamic Head	Proportioned Weight, Ea	Total Weight, kg
12	4.0	7.0	40.6	66,400	4.0	8.0	27.0	50,466	605,590

Lower Valves

	Two Lift Lock				Three Lift Lock				
Number	Width	Height	Hydrodynamic Head	Weight	Width	Height	Hydrodynamic Head	Proportioned Weight, Ea	Total Weight, kg
4	4.0	7.0	40.6	66,400	5.0	8.0	13.5	63,199	252,797

Water Saving Basins

	Two Lift Lock				Three Lift Lock				
Number	Width	Height	Hydrodynamic Head	Weight	Width	Height	Hydrodynamic Head	Proportioned Weight, Ea	Total Weight, kg
24	6.0	8.0	10.1	58,300	6.0	8.0	6.7	38,522	924,521

Total (kg) 1,782,908

PANAMA CANAL CONCEPT DESIGN

Atlantic Locks Structure

Third Lane Lock

Appendix L

Project Construction Schedules

Prepared for

Canal Capacity Projects Office

By

US Army Corps
of Engineers®

Final Report

23 July 2003

Table of Contents

Table of Contents

1. GENERAL

1.1. Scope

This appendix details construction plan and time schedules for the concept level design of the new third lane locks, Atlantic Ocean side of the Canal. It includes construction schedules for both options presented for the double-lift concept design with water saving basins. The construction schedules identify the major features of work, appropriate sequencing and expected duration of the various activities. A narrative description is included that corresponds with the schedule and presents expected construction methodologies and plan of construction activities upon which the cost estimates are based. This appendix also includes a work plan showing the land requirements for the various construction activities with appropriate land routings and interrelationship of activities indicated for the various activities. The Plan is specific as to the purpose of the various areas and generally shows how the construction contractor would manage the work activities. This includes staging area, work areas, materials storage and processing areas, offices, parking, and road relocations.

1.2. Criteria

The construction work plan and schedules were prepared with guidance from the design team as well as construction personnel from within the USACE. The schedule focuses on the main tasks associated with the construction of the locks structure and water saving basins. It has been prepared using Primavera Project Planner.

2. CONSTRUCTION WORK PLAN

2.1. Construction Contracts

The construction schedules included in this appendix are based upon the assumption that the work will all be included in one construction contract. This assumption was used so that the construction schedules are based upon the same criteria as the cost estimates. By awarding the work under one construction contract, the owner minimizes the amount of management required. However, other contracting strategies may result in both time and cost savings to the ACP if they are willing to accept more management responsibility during the construction process.

Multiple construction contracts, broken down by major features of work, could be used for this work to help assure that the project is completed in a cost effective, timely fashion. By splitting the work into smaller packages, the ACP would allow more companies the opportunity to bid on the work. This would effectively increase competition and should drive down costs. Also, once a contractor is on site, he is more likely to bid on subsequent packages. Therefore, more packages issued should translate into more available competition.

Another advantage of separating the work into several construction packages is that it would allow ACP to stagger the work to fit its budget and timeframe and possibly achieve an earlier finish date. By having several packages, individual packages can be awarded prior to overall final design being complete. This would essentially result in construction commencing at an earlier time frame. The splitting up of the work into packages would also allow ACP to potentially fund some of the work with its own monies, decreasing the amount borrowed from the bank.

Two of the more substantial potential cost and time saving alternatives for the ACP to consider, would be to perform site preparation work and lock excavation prior to finalizing the design, and purchasing the miter gates in advance with a separate procurement contract. By completing the lock excavation and site preparation work in an earlier contract, the ACP can shorten the overall project duration. The construction schedules show that the rock excavation is on the critical path. By completing or at least starting these tasks prior to final design being complete, the ACP can bring the construction completion date in as much as 1 year. By separating the fabrication and erection into a separate procurement package, the ACP could potentially add both a time saving, and a cost saving to the project. In talking with fabricators while preparing the cost estimate, it was determined that the fabrication of the miter gates would take between 2.5 to 3.5 years. Currently this is not on the critical path, but since it is a long lead-time item, there is an increased risk of it not being ready on time. By awarding early, prior to completion of final design, ACP can ensure that the gates will arrive on time. Also, by awarding the gates as a separate package, ACP can eliminate any additional markup associated with a prime contractor subcontractor this work out.

2.2. Land Requirements

The size and nature of this project would require a large project work area and significant land use. Drawings ACP-R-3/2 –3/5, 93/1, 93/2, 68/1, and 99/1 show breakdowns of the identified land needs and uses. The following section explains the purpose of this land use.

2.2.1. Work Area

The project work area would consist of most of the area between the 1939 lock excavation and the existing Gatun Locks. It also includes a disposal area approximately 6 km north of the new locks site. Other areas that the contractor would potentially use during construction are the inlet just north of the existing locks for an offloading dock facility, and a railroad loading dock south of Gatun at the location of the future bridge to be constructed over the canal. These areas plus areas set aside for haul roads and railroad lines connecting the work areas would makeup the land required by the contractor for this work.

2.2.2. Staging Areas

A large staging area would be located just east of the contractor's office location at the main lock construction work area. This area will allow access from both the haul roads and the rail line. Another potential staging area would be at the offloading dock facility. These staging areas are shown on drawings ACP-R-93/1 and 93/2.

2.2.3. Material Storage/Processing Areas

There are several areas for material storage and processing. The aggregate, cement and water for concrete would be stockpiled next to the batch plants on the east side of the new locks structure. This material would be delivered by truck or rail to these locations. It is important that the contractor has large areas set aside for the storage and processing of the concrete materials, as the high rates of concrete placement would require a large stockpile of ingredients. Other materials delivered to site can be stored either in the same location as the contractor's staging area or in the vicinity of the offloading dock. Drawings ACP-R-93/1 and 93/2 identify the storage and processing areas.

2.2.4. Batch Plants

For the purpose of this report, the assumption was made that the contractor would use a total of three batch plants for this project. The construction schedule is based on the use of these three batch plants. Two of the batch plants will be located on the east side of the new lock location. They are located approximately across from the outer miter gate locations. The third batch plant would be located on the west side of the new locks structure in between the two water saving basins. The location of these batch plants is important due to the amount of concrete to be placed during construction of the locks and entrance walls as well as the large distance covered by the locks structure. It was assumed that the concrete would be delivered to the placement areas by conveyor belts. The batch plants on the east side of the new locks structure would be used for lock concrete as well as the long entrance walls. The batch plant on the west side would mainly be used for lock concrete. The batch plants are identified on drawing ACP-R-93/1.

2.2.5. Roadways

There are several different roadway aspects associated with the locks construction. First of all, relocation and removal of various roadways would be required during the construction period. The road that crosses over the Canal on the northern end of the Gatun Locks would be temporarily relocated during construction. The relocated roadway would run along the banks on the approach to the locks and still cross over the canal at the same location. This is only a temporary relocation, and a permanent relocation will be required prior to the completion of the lock contract. The report does not discuss the options for permanent relocation of this roadway.

Other roadways within the work area would have to be removed and the roadway for access to the city of Gatun would be relocated to the east of its existing location. The roadway would also be used for access to the construction site. A construction haul road would also be required for this project. It will allow the contractor to transport the excavated material from the locks site to the disposal area. The road would also be used for transferring larger loads from the dock front area to the contractor staging/laydown area. The haul road can be seen on drawings ACP-R-93/1 and 93/2.

2.2.6. Railroad Siding

In additional to the roadway access to the construction site, a temporary railroad siding would be built, mostly along an existing right-of-way, to allow deliveries of aggregate and larger fabricated pieces to the storage/laydown areas. The rail line would extend from the locks location northward to a tie-in with the main line at approximately the location of the offloading docks. An additional siding would be located at the offloading dock. The temporary railroad tracks are shown on drawings ACP-R-93/1 and 93/2.

2.2.7. Offices

An area just east of the new locks location would be set-aside for the contractor's offices. There are several existing buildings at this location that can potentially be converted into office space. There is also a lot of room available for office trailers and parking. Other smaller offices would be located at the offloading dock area and next to the batch plants. This location is shown on drawing ACP-R-93/1.

2.3. Sequencing

As previously stated, the construction schedule is based upon the work being completed under one construction contract. The first items of work would consist of preparatory work readying the work site for the construction of the locks structure. This work consists of clearing and grubbing, building demolition, roadway removal/relocation, utilities relocation, haul road preparation, rail lines and loading docks, and an offloading dock facility. Most of this site preparation work would take place simultaneously, except the clearing and grubbing and building demolition work must be completed in the areas where the new roads and rail lines would be constructed. The other sequencing issues with this contract are the coordination with the railroad company on installing the connections to the main line. The construction of the off-loading dock facility could also offer the contractor some difficulty, depending on delivery of materials. Also, it was assumed that the ACP would perform any necessary dredging in the inlet area to allow access to the off-loading dock facility. This dredging would take place prior to award of this contract.

The sequencing involved with the actual construction of the locks is a little more complicated. The locks contract follows two separate paths until final completion. The first path is the construction of the lock chambers and the gravity entrance walls. It includes in the dry overburden and rock excavation, the placement of concrete for the lock walls and floor, and installation of the lock gates and valves. The construction of the water saving basins and the control building are spin-offs of this path. The second path includes the construction of the portion of the upstream approach that is in the wet. This portion of the entrance wall involves a more complicated construction method, walls founded on drilled shaft caissons, than the more conventional methods used in the lock chambers construction. Due to the complexity and potentially long duration involved in constructing the entrance walls, it was determined that they should be built simultaneously with the lock chambers.

The work sequence for the lock construction begins with overburden and rock excavation starting at the Gatun Lake (upstream) side and working downstream to the Atlantic Ocean side. The construction of the lock will begin with the upper and middle gate monoliths being constructed while excavation is still on going. Then the upper chamber will be completed. The lower chamber, beginning with the lower gate monoliths, will proceed upon completion of the rock excavation. The roller compacted concrete entrance walls will be constructed along with the chamber concrete and are not on the critical path.

The critical path for the construction of the double-lift locks is controlled by the rock excavation and concrete placement. The fabrication and delivery of Miter Gates is not on the critical path, but could become a critical item if the fabrication process takes longer than anticipated. The water saving basins are not on the critical path and whether or not they are included in the locks structure should not have an effect on the construction duration.

The overall construction duration ranged from approximately 4.75 years for Option 2 and 5 years for option 1. The 3-month difference is associated with the higher production rates associated with placing the lock walls for Option 2 since it consists of roller compacted concrete for the entire lock walls. At this level of design it is safe to assume a 5-year construction schedule for both options.

For more information on construction sequencing, please refer to the breakdown of the detailed construction schedule presented later in this appendix.

2.4. Batch Plants/Concrete Placement

There would be several different types of concrete applications required for the construction of the double-lift locks structure. The locks structure as designed includes mass concrete, roller compacted concrete, tremie concrete, and precast concrete. Due to the large quantity of concrete, as well as the varying types of concrete, several batch plants would be required. The batch plants used for concrete other than RCC should be equipped with rotating drums. For tremie, and other flowable concrete mixtures, a tilting rotating drum mixer is best suited. Various types of mixers are suitable for the production of RCC and conventional concrete. Horizontal shaft mixers, known as pugmills are suitable for both RCC and conventional concrete. Horizontal shaft mixers have become the preferred type of mixing plant for high production RCC.

For this job, the contractor would use a combination of horizontal shaft mixers and rotating tilt drum mixers. Each batch plant should be able to handle approximately 600 m^3 per hour.

This might require multiple mixers per batch plant. In order to support the RCC effort, the horizontal shaft mixer should be a continuous batch type system.

The cost estimate and construction schedule for this concept study were based on 3 batch plants. Two batch plants would be equipped with horizontal shaft mixer(s). The other two batch plants would be equipped with a tilting rotating drum mixer.

The concrete for this job will be transferred to its placement location using large concrete hopper trucks. Placement will be from a conveyor crane apparatus (creter crane), concrete pumps, and concrete buckets. A conveyor to transport the concrete from the batch plants to the placement sites is an option, but the length of this project makes large hopper trucks a more suitable option.

2.5. Miter Gates

The size and weight of the Miter Gates will require that they are delivered in sections and erected in place on the miter sill. The gates would be delivered by barge to the offloading dock and then be transferred by rail or truck to staging areas next to the lock walls. They will then be erected one section at a time. The size of the gates and the precision required for proper alignment make gate installation a difficult task with increased risk to the contractor.

3. CONSTRUCTION SCHEDULE

The attached construction schedules have been prepared for the Double-Lift concept level design. A different construction schedule is presented for each of the two design options. The construction schedule identifies the major features of work, appropriate sequencing, and expected duration for the various activities. This section outlines the construction schedule itself. It was prepared using Primavera Project Planner.

3.1. Schedule Set-up

The Locks Contract schedule is broken down into the various items of work. These items include; Site Preparation, General Items, Berms, Earthwork, Concrete, Electrical, Mechanical, Water Saving Basins, Entrance Walls, and Control Building.

3.2. Calendars

Three separate work calendars were used in the preparation of the construction schedule. These calendars represent workweeks from seven days a week down to five days a week. The calendar's used varies for each individual item of work, however, most of the contract utilized a six-day workweek. The five-day workweek was used sparingly, mostly for subcontracted work not on the critical path.

Weather delays are not specifically shown in the Primavera Schedule at this concept level, but were considered when preparing production rates and durations, especially the concrete production rates.

3.3. Durations

The assigned durations were calculated using production rates, information provided by suppliers, and estimator/designer judgment based upon production rates on similar Corps projects. When determining the durations for the Locks Construction contract it was assumed that the contractor will work 6 days a week, 20 hours a day for all the activities on the critical path. The durations with their basis are expressed in the activity breakdown.

3.4. Activities

The following activities are those that comprise the construction schedule for Option #1 of the double-lift concept design. Option #2 is basically the same activity wise, except that it does not include activities for CIP concrete for the lock walls, as the walls are comprised of all roller compacted concrete.

3.4.1. Locks Contract

3.4.1.1. Site Prep Work

0330	Award Locks Contract (NTP)	Start of construction activities for the project.
0340	Mobilization	Contractor mobilization for the Locks Contract. International contractor – 4 months allotted. Total Duration – 120 calendar days

0050	Roadway Relocations (Temp)	Relocation of approximately 11 000 m^2 of the roadway that crosses over the Canal in front of the Gatun Locks. Total of 3 five-day weeks allotted. Total Duration – 15 workdays. Pred – Mobilization (0340)
0010	Site Clearing/Building Demolition	Demolition of 118 structures. 2 crews, total of 2.0 buildings per day. Assume 10 hr shifts, 6-day workweek. Total duration – 80 work days. Pred – Mobilization (0340)
0700	Clearing and Grubbing	Clearing the work site of trees/vegetation. 2 crews, total of 10 000 m^2 per day. 10 hr shifts, 6-day workweek. Duration – 100 workdays. Pred – Mobilization (0340)
0740	Construct Offloading Dock	Construction of the offloading dock. Duration of 180 workdays based upon estimator judgment. 6 day work week. Pred – Mobilization (0340)
0760	Utilities Relocation (Temp)	Temporary relocation of utilities to Gatun Locks. Duration based upon estimator judgment. 150 workdays, 6 workdays per week. Pred – Mobilization (0340)
0730	Construct Rail Sidings	Placing railroad tracks and switches. Duration of 140 workdays based upon 2 crews total 40 m per day. 10 hr shifts, 6-day workweek. Pred – Clearing and Grubbing (0700) w/overlap, Bldg Demolition (0010) w/overlap
0710	Permanent Roadway Relocation	Permanent replacement of the access road to the city of Gatun. 11 700 m^2 of roadway at 1400 m^2 per 8 hr shift. Total 10 work days, 5-day workweek. Pred – Clearing and Grubbing (0700)
0020	Build Construction Haul Road	Constructing the haul road from the lock site to the disposal site. 5 600 m total at 100 m per 10 hr shift. Total of 60 workdays, 6 work days per week. Pred – Site Clearing/Building Demolition (0010), Clearing and Grubbing (0700) w/overlap

0720	Remove Existing Roadways	Removal of 7200 m^2 of existing roadway. 600 m^2 / 10 hr shift. Total of 15 work days, 5-day workweek. Pred – Perm Roadway Relocation (0710)
0750	Construct Railroad Loading Dock	Construct a loading dock for railroad access. 1-month duration based upon estimator judgment. 6 days per week. Pred – Construct Rail Sidings (0730)

3.4.1.2. General

0370	Award Locks Contract	Start of construction activities for the Locks Construction contract. Pred – Site Preparation Contract Complete (0360)
0770	Award Fabrication/Supply Subcontracts	Arranging and awarding subcontracts to perform gate and valve fabrications as well as caisson steel and any other large procurement items. Pred – Award Locks Contract (0330)
0400	Punchlist Items	Final items for contractor to take care of. Duration of 48 days (estimator judgment), 6-day workweek Pred – All main features of construction
0310	Demobilization	Demobilization of the Locks Construction contractor's equipment. Allow 60 days to demobilize, 7-day workweek. Pred – All of the activities associated with the Locks Contract
0410	Locks Contract Complete	Milestone

3.4.1.3. Water Diversion

0030	Construct Perm/Temp Berms	Construction of Berm on the lakeside approach to the new locks. Duration – 60 days (Based upon rock excavation), 6-day workweek. Pred – Rock Excavation (0070) w/overlap

0270	Flood Chamber	Flood the lock chamber. Duration – 7 calendar days Pred – Final Test Adjust Gates/Valves (0420)
0290	Remove Upstream Temporary Berm	Remove the temporary portion of the construction berm. Includes sheetpile removal as well as rock removal. Duration – 50 days, 6-day workweek. Pred – Flood Chamber (0270)

3.4.1.4. Earthwork

0060	Common Excavation	Includes dry excavation for the lock chambers and water saving basins. Duration of 240 days. Six-day workweek, 20 hrs per day. 25,360 m^3 / day. 240 days. Pred – Build Construction Haul Road (0020)
0070	Rock Excavation	Dry rock excavation for the lock chambers and water saving basins. Duration of 520 days based on 12 720 m^3 per day. Six-day workweek, 20 hrs per day. Pred – Common Excavation (0060) with an overlap
0150	Structural Backfill D/S Chamber	Placement of structural backfill behind the downstream lock walls. Duration – of 50 days, based on qty of approx 250 000 m^3 @ 5000 m^3/day Pred – Downstream Chamber Concrete RCC (0550)
0360	Structural Backfill U/S Chamber	Placement of structural backfill behind the upstream lock walls. Duration – of 50 days, based on qty of approx 250 000 m^3@ 5000 m^3/day Pred – Upstream Chamber Concrete RCC (0380)
0180	Backfill/Grading (Lock Chamber)	Placement of backfill material above structural backfill, and the final grading behind the lock walls. Duration – 60 days Pred – Structural Backfill D/S Chamber (0150)

0430	Install Parking Lots	Installation of 2 parking lots. Duration of 30 days, 5-day workweek. Pred – Backfill/Grading (0180)
0500	Permanent Access Roads	Permanent Roadways accessing parking lots. Duration – 5 days, 5-day workweek. Approx 6000 m^2. Pred – Backfill/Grading (0180)
0520	Seeding	Seeding of work area upon completion of construction. 600 000 m^2. Allow 45 days for this activity. This allows time for grass to come in ensure completion. 6-day workweek. Pred – Install Parking Lots (0430)
0300	Site Cleanup	Final Cleanup of work site. Duration – 45 days. 6-day workweek. Pred – Punchlist Items (0400)

3.4.1.5. Lock Concrete

0090	Set-up Batch Plants	Include delivery and set-up of the three batch plants. Duration 120 calendar days. Use 7 day per week calendar. Pred – Construct Railroad Loading Dock (0750)
0080	Foundation Prep (Upper Chamber)	Readying the foundation rock for concrete placement. Duration 60 work days, 6-day workweek. (Estimators judgment) Pred – Rock Excavation (0070), Set-up Batch Plants (0090)
0120	Place Miter U/S and Middle Gate/Valve/Sill Monolith Concrete	Place concrete (CIP&RCC) for the monoliths feature the miter gates, and valves. CIP Concrete placed at 2 000 m^3/day. Total of 130 workdays, 6-day workweek. Pred – Foundation Prep (Upper Chamber) (0080)
0130	U/S Chamber Concrete (CIP)	Place concrete (CIP, conventional) for the lower portion of the lock walls in the U/S chamber. Concrete placed at 2000 m^3/day. Total of 145 days, 6-day workweek. Pred – Place U/S and Middle Miter Gate/Valve/Sill Monolith Concrete (0120)

0160	Foundation Prep (Lower Chamber)	Readying the foundation rock for concrete placement. Duration 48 work days, 6-day workweek. (Estimators judgment) Pred – Rock Excavation (0070), Set-up Batch Plants (0090)
0170	Place Miter D/S Gate/Valve/Sill Monolith Concrete	Place concrete (CIP&RCC) for the monoliths feature the miter gates, and valves. CIP Concrete placed at 2000 m^3/day. Total of 90 workdays, 6-day workweek. Pred – Foundation Prep (Lower Chamber) (0160)
0380	Upstream Chamber Concrete (RCC)	Place roller compacted concrete for the upper chamber lock walls. Concrete placed at 4,660 m^3/day. Total of 85 days, 6-day workweek. Pred – Lockside Chamber Concrete (Conv) (0130)
0590	Downstream Chamber Concrete (CIP)	Place concrete (CIP, conventional) for the lower portion of the lock walls of the D/S Chamber. Concrete placed at 2000 m^3/day. Total of 145 days, 6-day workweek. Pred – Place D/S Miter Gate/Valve/Sill Monolith Concrete (0170)
0100	Place U/S Concrete Chamber Floors	Place concrete (CIP, conventional) for the chamber floors. Concrete place at 1000 m^3/day. Total of 45 workdays, 6-day workweek. Pred – Place U/S Chamber Concrete RCC (0380)
0550	Downstream Chamber Concrete (RCC)	Place roller compacted concrete for the downstream chamber lock walls. Concrete placed at 4660 m^3/day. Total of 85 days, 6-day workweek. Pred – Downstream Chamber Concrete (CIP) (0590)
0320	Place Downstream Chamber Floor	Place concrete (CIP, conventional) for the chamber floors. Concrete place at 1000 m^3/day. Total of 45 workdays, 6-day workweek. Pred – Place D/S Chamber Concrete RCC (0550)

0390	Final Concrete Placements (Top of walls)	Include the final placement of concrete (conventional, CIP) on the top of the lock walls. Duration – 45 workdays, 6-day workweek. Pred – Place D/S Chamber Floor (0320)

3.4.1.6. Electrical Work

0240	Install Lighting	Installing the lighting for the locks. Duration – 88 days, 6-day workweek. Pred – Final Concrete Placements (Top of walls) (0390)
0250	Supply Power (U/S Chamber)	Electrical items and power supply for the lock operating machinery. Duration – 150 days, 6-day workweek. Pred – Upstream Chamber Concrete RCC (0380)
0350	Supply Power (D/S Chamber)	Electrical items and power supply for the lock operating machinery. Duration – 150 days, 6-day workweek. Pred – Downstream Chamber Concrete RCC (0550)

3.4.1.7. Mechanical

0190	Fabricate/Delivery Miter Gates 1st set	Fabrication and delivery of the 1st set of Miter Gates. Duration of 400 calendar days. Duration based upon information provided by fabricators. Pred – Award Fabrication/Supply Subcontracts (0770)
0540	Fabricate/Delivery Gate Operating Equipment	Fabrication and delivery of the gate operating equipment. Duration of 400 calendar days based on quote information from manufacturer. Pred – Award Fabrication/Supply Subcontracts (0770)
0580	Fabricate/Delivery Filling/Emptying Valve Operating Equipment	Fabrication of Filling/Emptying Valves operating equipment. Duration of 400 calendar days based on information from manufacturer. Pred – Award Fabrication/Supply Subcontracts (0770)

0440	Fabricate/Delivery Filling/Emptying Valves	Fabrication and delivery of the filling and emptying valves. Duration of 400 calendar days. Based upon estimators judgment. Pred – Award Fabrication/Supply Subcontracts (0770)
0600	Fabricate/Delivery Miter Gates 2nd set	Fabrication and delivery of the 2nd set of Miter Gates. Duration of 210 calendar days. Duration based upon information provided by fabricators. Pred – Fabricate/Delivery Miter Gates 1st set (0190)
0610	Fabricate/Delivery Miter Gates 3rd set	Fabrication and delivery of the 3rd set of Miter Gates. Duration of 210 calendar days. Duration based upon information provided by fabricators. Pred – Fabricate/Delivery Miter Gates 2nd set (0600)
0620	Fabricate/Delivery Miter Gates 4th set	Fabrication and delivery of the 4th set of Miter Gates. Duration of 210 calendar days. Duration based upon information provided by fabricators. Pred – Fabricate/Delivery Miter Gates 3rd set (0610)
0630	Fabricate/Delivery Miter Gates 5th set	Fabrication and delivery of the 5th set of Miter Gates. Duration of 200 calendar days. Duration based upon information provided by fabricators. Pred – Fabricate/Delivery Miter Gates 4th set (0620)
0640	Farbricate/Delivery Miter Gates 6th set	Fabrication and delivery of the 6th set of Miter Gates. Duration of 200 calendar days. Duration based upon information provided by fabricators. Pred – Fabricate/Delivery Miter Gates 5th set (0630)
0210	Install Gate Operating Equipment 1st set	Installation of the gate operating equipment for the 1st set of miter gates. Duration of 30 days, 6-day workweek. Pred – Place U/S and Middle Miter Gate/Valve/Sill Monolith Concrete (0120), Fabricate/Del Gate Operating Equipment (0540)

0280	Install Gate Operating Equipment 2nd set	Installation of the gate operating equipment for the 2nd set of miter gates. Duration of 30 days, 6-day workweek. Pred – Install Gate Operating Equipment 1st set (0210)
0200	Install Miter Gates 1st set	Installation of the 1st set of Miter Gates. Duration of 70 days, 6-day workweek. Pred – Fabricate/Del Miter Gates 1st set (0190), Install Gate Operating Equipment 1st set (0210)
0450	Install Gate Operating Equipment 3rd set	Installation of the gate operating equipment for the 3rd set of miter gates. Duration of 30 days, 6-day workweek. Pred – Install Gate Operating Equipment 2nd set (0280)
0510	Install Gate Operating Equipment 4th set	Installation of the gate operating equipment for the 4th set of miter gates. Duration of 30 days, 6-day workweek. Pred – Install Gate Operating Equipment 3rd set (0450)
0650	Install Miter Gates 2nd set	Installation of the 2nd set of Miter Gates. Duration of 70 days, 6-day workweek. Pred – Fabricate/Del Miter Gates 2nd set (0600), Install Gate Operating Equipment 2nd set (0280) Install Miter Gates 1st set (0200)
0660	Install Miter Gates 3rd set	Installation of the 3rd set of Miter Gates. Duration of 70 days, 6-day workweek. Pred – Fabricate/Del Miter Gates 3rd set (0610), Install Gate Operating Equipment 3rd set (0450), Install Miter Gates 2nd set (0650)
0530	Install Gate Operating Equipment 5th set	Installation of the gate operating equipment for the 5th set of miter gates. Duration of 30 days, 6-day workweek. Pred – Install Gate Operating Equipment 4th set (0510), D/S Gate/Valve/Sill Concrete (0170)

0570	Install Gate Operating Equipment 6th set	Installation of the gate operating equipment for the 6th set of miter gates. Duration of 30 days, 6-day workweek. Pred – Install Gate Operating Equipment 5th set (0530)
0670	Install Miter Gates 4th set	Installation of the 4th set of Miter Gates. Duration of 70 days, 6-day workweek. Pred – Fabricate/Del Miter Gates 4th set (0620), Install Gate Operating Equipment 4th set (0510), Install Miter Gates 3rd set (0660),
0680	Install Miter Gates 5th set	Installation of the 5th set of Miter Gates. Duration of 70 days, 6-day workweek. Pred – Fabricate/Del Miter Gates 5th set (0630), Install Gate Operating Equipment 5th set (0530), Install Miter Gates 4th set (0670) D/S Gate/Valve/Sill Concrete (0170)
0690	Install Miter Gates 6th set	Installation of the 6th set of Miter Gates. Duration of 70 days, 6-day workweek. Pred – Fabricate/Del Miter Gates 6th set (0640), Install Gate Operating Equipment 6th set (0570), Install Miter Gates 5th set (0680)
0230	Install Filling/Emptying Valve Operating Equipment	Installation of the Filling and Emptying Valves Operating Equipment. Duration of 96 days, 6-day workweek. Pred – Downstream Chamber Concrete RCC (0550), Fab/Delv F/E Valve Oper Equip (0580)
0220	Install Filling/Emptying Valves	Installation of the Filling and Emptying Valves. Duration of 72 days, 6-day workweek. Pred – Install F/E Valve Oper Equipment (0230), Fabricate/Deliver F/E Valves (0440)
0420	Final Test Adjust Gates/Valves	Final test to assure that everything is operating correctly. Duration 30 calendar days. Pred – Supply Power (0350,0250), Install Miter Gates 6th set (0690), Install Filling/Emptying Valves (0220), Install Valves (WSB's) (0490)

3.4.1.8. Water Saving Basins

0460	Fabricate Valves (WSB's)	Fabrication and Delivery of Valves for the Water Saving Basins. Duration of 210 calendar days. Pred – Award Fabrication/Supply Subcontracts (0770)
0480	Fabricate/Delivery Valve Operating Equipment (WSB's)	Fabrication and Delivery of Valve Operating Equipment for the Water Saving Basins. Duration of 210 calendar days. Pred – Award Fabrication/Supply Subcontracts (0770)
0110	Place WSB Conduits	Placing concrete conduits for transferring water back and forth between the WSB's and the lock chambers. Duration of 90 days. 6-day workweek. 1000 m^3/day Pred – D/S Gate/Valve/Sill Monoliths (0170)
0140	Water Saving Basins	Construction of the Water Saving Basins. Duration of 120 days. 6-day workweek. 88,911 m^3@ 1000 m^3/day + resteel placement. Pred – Place WSB conduits (0110)
0470	Install Valve Operating Equipment	Installation of the Valve Operating Equipment for the WSB's. Duration of 60 days, 6-day workweek. Pred – Water Saving Basins (0140), Fab/Delv Valve Oper Equip (WSB's) (0480)
0490	Install Valves (WSB's)	Installation of the Valves for the WSB's. Duration of 48 days, 6-day workweek. Pred – Install Valve Operating Equipment (0470), Fabricate Valves (0460)

3.4.1.9. Entrance Walls

0560	Fabricate/Delivery Caisson Steel	Includes the fabrication and delivery of structural steel piping for the drilled shaft caissons. 365 calendar days. Pred – Award Fabrication/Supply Subcontracts (0770)

0850	Place Upstream Caisson Steel	Placement of steel casings for the Upstream entrance wall. Duration – 240 days, 6-day work week Pred – Fabricate/Delivery Caisson Steel (0560)
0860	Excavate Inside Upstream Caissons	Removal of earth and rock inside the upstream steel casings. Duration – 240 days. 6-day workweek. Duration dependent on activity 0850. Work will commence 45 days after activity 0850 begins and will end 45 days after 0850. Pred – Place Upstream Caisson Steel (0850) (Lag relationship)
0870	Place Upstream Caisson Concrete	Placement of tremie concrete inside the upstream steel casings. Duration dependent on activity 0860. This activity can't start until 60 days after the start of 0860 and then runs 60 days after the conclusion of 0860. Pred – Excavate Inside Upstream Caissons (0860) (Lag relationship)
0800	Upstream Entrance Walls (Gravity Walls)	Placement of RCC concrete entrance walls. Duration of 42 days, 6-day workweek. Production rate of 5,000 m^3day. Pred – U/S Chamber Foundation Prep (0080)
0880	Place Upstream Concrete Cap Wall	Placement of concrete cap wall/mass on top of the structural caissons. Duration dependent on activity 0870. This activity can't start until 120 days after the start of 0870 and then runs 120 days after the conclusion of 0870. Pred – Place Upstream Caisson Concrete (0870) (lag relationship)
0840	Downstream Approach Concrete (Gravity Walls)	Placement of RCC concrete entrance walls. Duration of 84 days, 6-day workweek. Production rate of 5,000 m^3day. Pred – D/S Chamber Foundation Prep (0160)
0920	Excavate Upstream Approach (wet)	Excavation of overburden and rock for the upstream approach. Duration – approximately 120 calendar days. Pred – Place Upstream Concrete Wall Boxes (0880), Excavate Downstream Approach (Wet) (0910)

0820	Add Downstream Fenders	Installation of fenders on the entrance walls. Pred – D/S Entrance Concrete Walls (0840)
0900	Add Upstream Fenders	Installation of fenders on the entrance walls. Pred – Place Upstream Concrete Cap Wall (0880)

3.4.1.10. Control Building

0260	Control Building	Construction of the control building for the locks project. Allow 300 calendar days to complete this work. Pred – U/S Chamber Concrete RCC (0380)

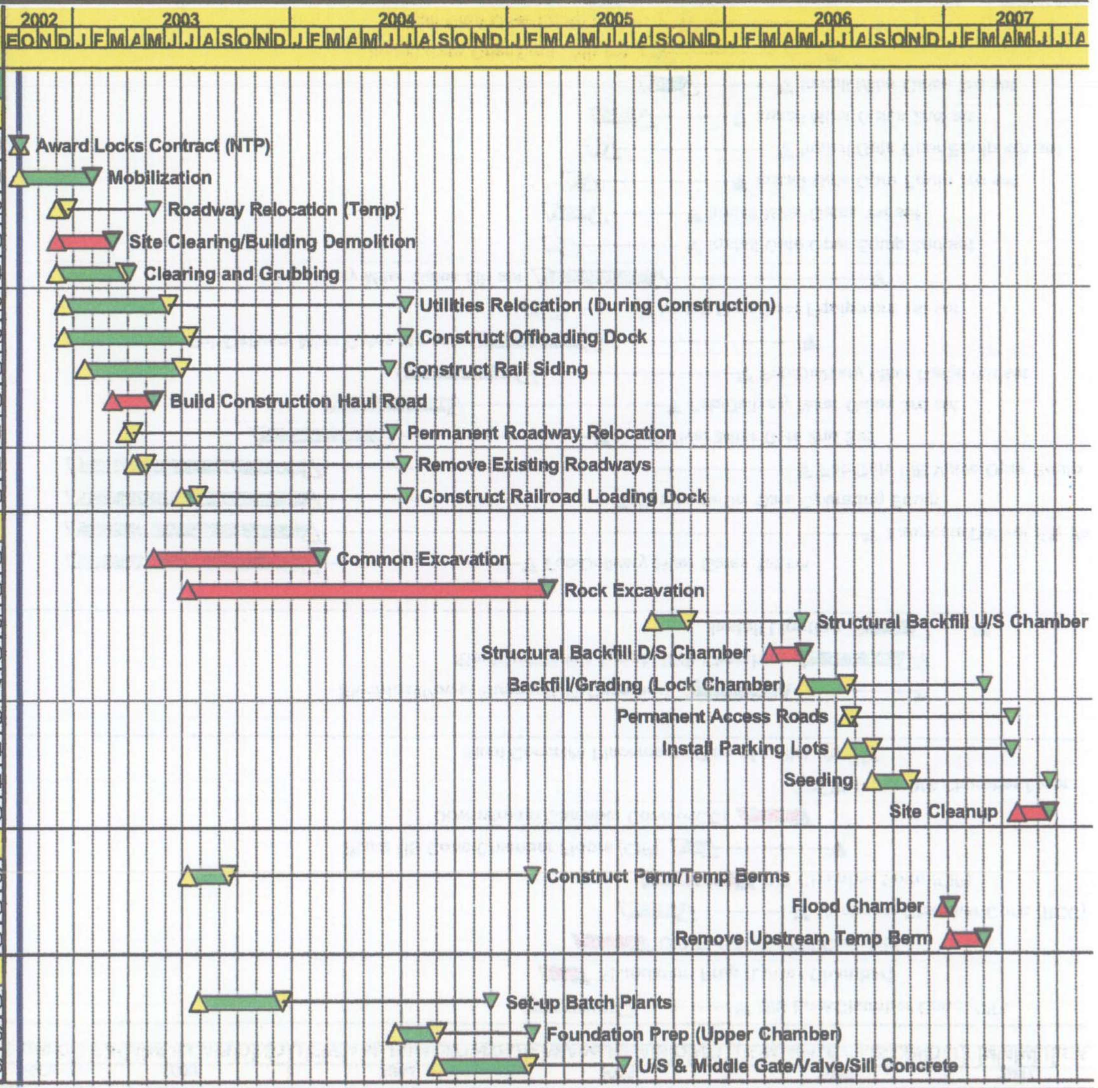
4. SUMMARY

Construction of the concept level designs for the double-lift locks structure would have a length of approximately 5.0 years. The critical path is dependent on the rock excavation and concrete placement. Fabrication and delivery of the Miter Gates is not on the critical path, but due to its long lead-time a higher risk is associated with this item. The water saving basins are not on the critical path and eliminating them from the project would probably not result in a time saving.

The construction schedule for Option #2 ends approximately 3 months prior to that of Option #1. This is due to the fact that the culverts in Option #2 are located within the chamber floor and not in the lock walls, allowing roller compacted concrete to be used for the entire lock walls. Roller compacted concrete can be placed at a higher rate than cast-in-place concrete thus reducing the amount of time required for placing the lock walls. At this level of design and construction duration, a 3-month difference in schedule length is not significant and should not be a deciding factor in selecting between the two options. It is safe to assume that the construction duration of either option will be approximately 5 years.

PANAMA CANAL CONCEPT DESIGN
ATLANTIC LOCKS STRUCTURE
DOUBLE-LIFT
OPTION #1

Activity ID	Activity Description	Orig Dur	Early Start	Early Finish	Total Float
Locks Contract					
Site Prep Work					
0330	Award Locks Contract (NTP)	1	01OCT02	01OCT02	1
0340	Mobilization	120	02OCT02	29JAN03	1
0050	Roadway Relocation (Temp)	15	02DEC02	20DEC02	102
0010	Site Clearing/Building Demolition	80	02DEC02	04MAR03	0
0700	Clearing and Grubbing	100	02DEC02	27MAR03	4
0760	Utilities Relocation (During Construction)	150	16DEC02	07JUN03	342
0740	Construct Offloading Dock	180	16DEC02	12JUL03	312
0730	Construct Rail Siding	140	17JAN03	28JUN03	300
0020	Build Construction Haul Road	60	05MAR03	13MAY03	0
0710	Permanent Roadway Relocation	10	28MAR03	10APR03	311
0720	Remove Existing Roadways	15	11APR03	01MAY03	311
0750	Construct Railroad Loading Dock	24	30JUN03	26JUL03	300
Earthwork					
0060	Common Excavation	240	14MAY03	17FEB04	0
0070	Rock Excavation	520	09JUL03	05MAR05	0
0360	Structural Backfill U/S Chamber	50	29AUG05	25OCT05	165
0150	Structural Backfill D/S Chamber	50	13MAR06	09MAY06	0
0180	Backfill/Grading (Lock Chamber)	60	10MAY06	18JUL06	197
0500	Permanent Access Roads	5	19JUL06	25JUL06	189
0430	Install Parking Lots	30	19JUL06	29AUG06	164
0520	Seeding	45	30AUG06	31OCT06	164
0300	Site Cleanup	45	27APR07	18JUN07	0
Water Diversion					
0030	Construct Perm/Temp Berms	60	09JUL03	16SEP03	436
0270	Flood Chamber	7	27DEC06	02JAN07	0
0290	Remove Upstream Temp Berm	50	03JAN07	01MAR07	0
Lock Concrete					
0090	Set-up Batch Plants	120	28JUL03	13DEC03	300
0080	Foundation Prep (Upper Chamber)	60	23JUN04	31AUG04	136
0120	U/S & Middle Gate/Valve/Sill Concrete	130	01SEP04	29JAN05	136



Start Date	01OCT02
Finish Date	18AUG07
Data Date	01OCT02
Run Date	31MAR03 13:28

🟩 Early Bar
▽ Float Bar
🟦 Progress Bar
🟥 Critical Activity

PANA

Sheet 1 of 3

USACE

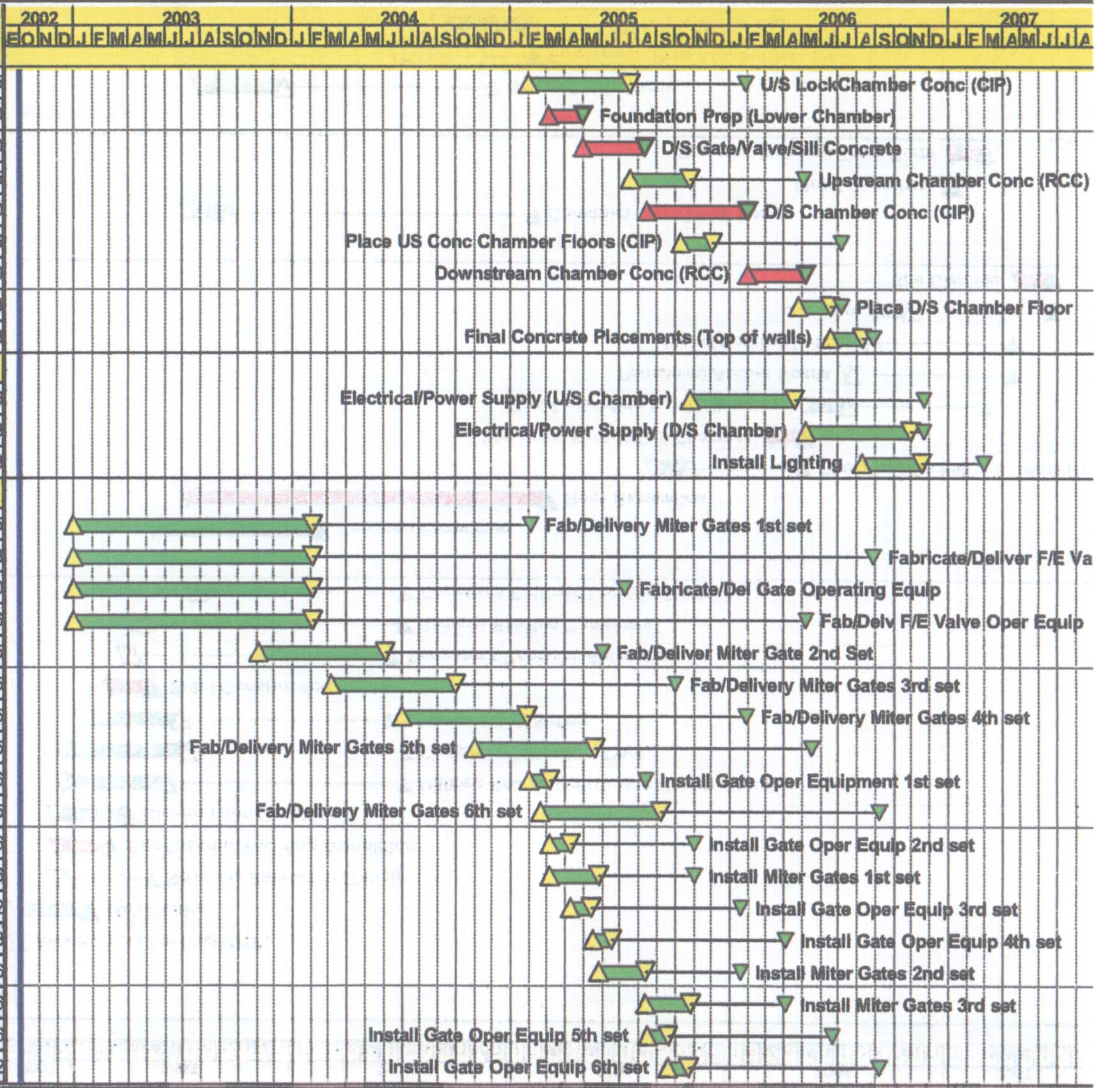
Panama Locks Study, 2 Lift, Option 1

Classic Schedule Layout

Date	Revision	Checked	Approved

PANAMA CANAL CONCEPT DESIGN
ATLANTIC LOCKS STRUCTURE
DOUBLE-LIFT
OPTION #1

Activity ID	Activity Description	Orig Dur	Early Start	Early Finish	Total Float
0130	U/S LockChamber Conc (CIP)	145	31JAN05	18JUL05	165
0160	Foundation Prep (Lower Chamber)	48	07MAR05	30APR05	0
0170	D/S Gate/Valve/Sill Concrete	90	02MAY05	13AUG05	0
0380	Upstream Chamber Conc (RCC)	85	19JUL05	25OCT05	165
0590	D/S Chamber Conc (CIP)	145	15AUG05	30JAN06	0
0100	Place US Conc Chamber Floors (CIP)	45	12OCT05	02DEC05	186
0550	Downstream Chamber Conc (RCC)	85	31JAN06	09MAY06	0
0320	Place D/S Chamber Floor	45	26APR06	16JUN06	18
0390	Final Concrete Placements (Top of walls)	45	17JUN06	08AUG06	18
Electrical Work					
0250	Electrical/Power Supply (U/S Chamber)	150	26OCT05	18APR06	186
0350	Electrical/Power Supply (D/S Chamber)	150	10MAY06	31OCT06	18
0240	Install Lighting	88	09AUG06	18NOV06	88
Mechanical					
0190	Fab/Delivery Miter Gates 1st set	400	31DEC02	03FEB04	365
0440	Fabricate/Deliver F/E Valves	400	31DEC02	03FEB04	938
0540	Fabricate/Del Gate Operating Equip	400	31DEC02	03FEB04	520
0580	Fab/Delv F/E Valve Oper Equip	400	31DEC02	03FEB04	826
0600	Fab/Deliver Miter Gate 2nd Set	210	06NOV03	02JUN04	365
0610	Fab/Delivery Miter Gates 3rd set	210	05MAR04	30SEP04	365
0620	Fab/Delivery Miter Gates 4th set	210	03JUL04	28JAN05	365
0630	Fab/Delivery Miter Gates 5th set	200	31OCT04	18MAY05	365
0210	Install Gate Oper Equipment 1st set	30	31JAN05	05MAR05	136
0640	Fab/Delivery Miter Gates 6th set	200	18FEB05	05SEP05	365
0280	Install Gate Oper Equip 2nd set	30	07MAR05	09APR05	176
0200	Install Miter Gates 1st set	70	07MAR05	26MAY05	136
0450	Install Gate Oper Equip 3rd set	30	11APR05	14MAY05	212
0510	Install Gate Oper Equip 4th set	30	16MAY05	18JUN05	248
0650	Install Miter Gates 2nd set	66	27MAY05	11AUG05	136
0660	Install Miter Gates 3rd set	66	12AUG05	27OCT05	136
0530	Install Gate Oper Equip 5th set	30	15AUG05	17SEP05	236
0570	Install Gate Oper Equip 6th set	30	19SEP05	22OCT05	272



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Panama Locks Study, 2 Lift, Option 1

Classic Schedule Layout

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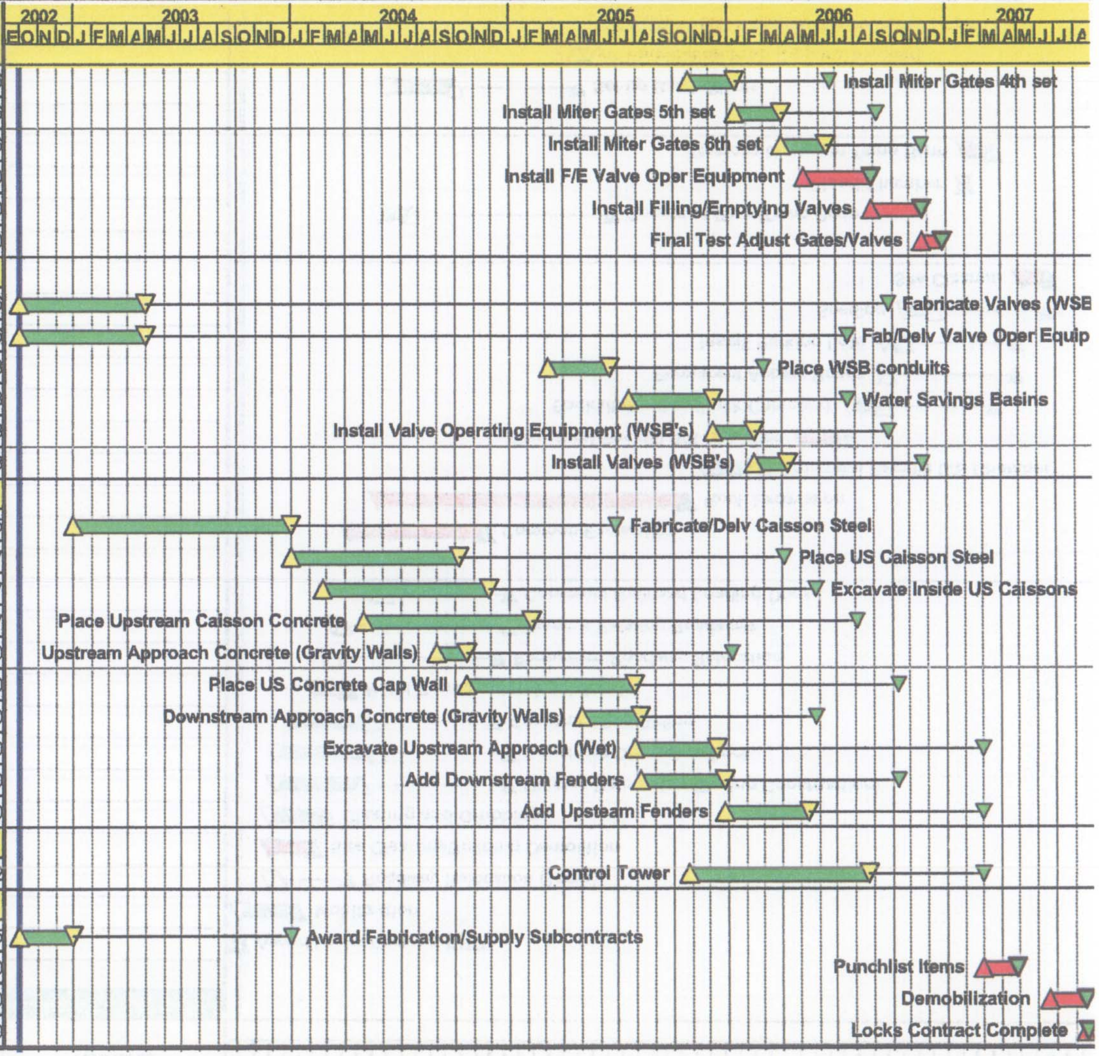
PANAMA CANAL CONCEPT DESIGN
ATLANTIC LOCKS STRUCTURE
DOUBLE-LIFT
OPTION #1

Activity ID	Activity Description	Orig Dur	Early Start	Early Finish	Total Float
0670	Install Miter Gates 4th set	66	28OCT05	12JAN06	136
0680	Install Miter Gates 5th set	66	13JAN06	30MAR06	136
0690	Install Miter Gates 6th set	66	31MAR06	15JUN06	136
0230	Install F/E Valve Oper Equipment	96	10MAY06	29AUG06	0
0220	Install Filling/Emptying Valves	72	30AUG06	21NOV06	0
0420	Final Test Adjust Gates/Valves	30	22NOV06	26DEC06	0
Water Savings Basins					
0460	Fabricate Valves (WSB's)	210	02OCT02	29APR03	1,246
0480	Fab/Delv Valve Oper Equip (WSB's)	210	02OCT02	29APR03	1,176
0110	Place WSB conduits	90	07MAR05	18JUN05	218
0140	Water Savings Basins	120	19JUL05	05DEC05	193
0470	Install Valve Operating Equipment (WSB's)	60	06DEC05	13FEB06	193
0490	Install Valves (WSB's)	48	14FEB06	10APR06	193
Approach Walls					
0560	Fabricate/Delv Caisson Steel	365	31DEC02	30DEC03	545
0850	Place US Caisson Steel	240	31DEC03	05OCT04	467
0860	Excavate Inside US Caissons	240	21FEB04	26NOV04	467
0870	Place Upstream Caisson Concrete	240	01MAY04	04FEB05	467
0800	Upstream Approach Concrete (Gravity Walls)	42	01SEP04	19OCT04	380
0880	Place US Concrete Cap Wall	240	20OCT04	26JUL05	380
0840	Downstream Approach Concrete (Gravity Walls)	84	02MAY05	06AUG05	250
0920	Excavate Upstream Approach (Wet)	120	27JUL05	13DEC05	380
0820	Add Downstream Fenders	120	08AUG05	24DEC05	250
0900	Add Upsteam Fenders	120	26DEC05	13MAY06	250
Control Building					
0260	Control Tower	300	26OCT05	21AUG06	192
General Work Locks Contract					
0770	Award Fabrication/Supply Subcontracts	90	02OCT02	30DEC02	365
0400	Punchlist Items	48	02MAR07	26APR07	0
0310	Demobilization	60	19JUN07	17AUG07	0
0410	Locks Contract Complete	1	18AUG07	18AUG07	0



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Panama Locks Study, 2 Lift, Option 1

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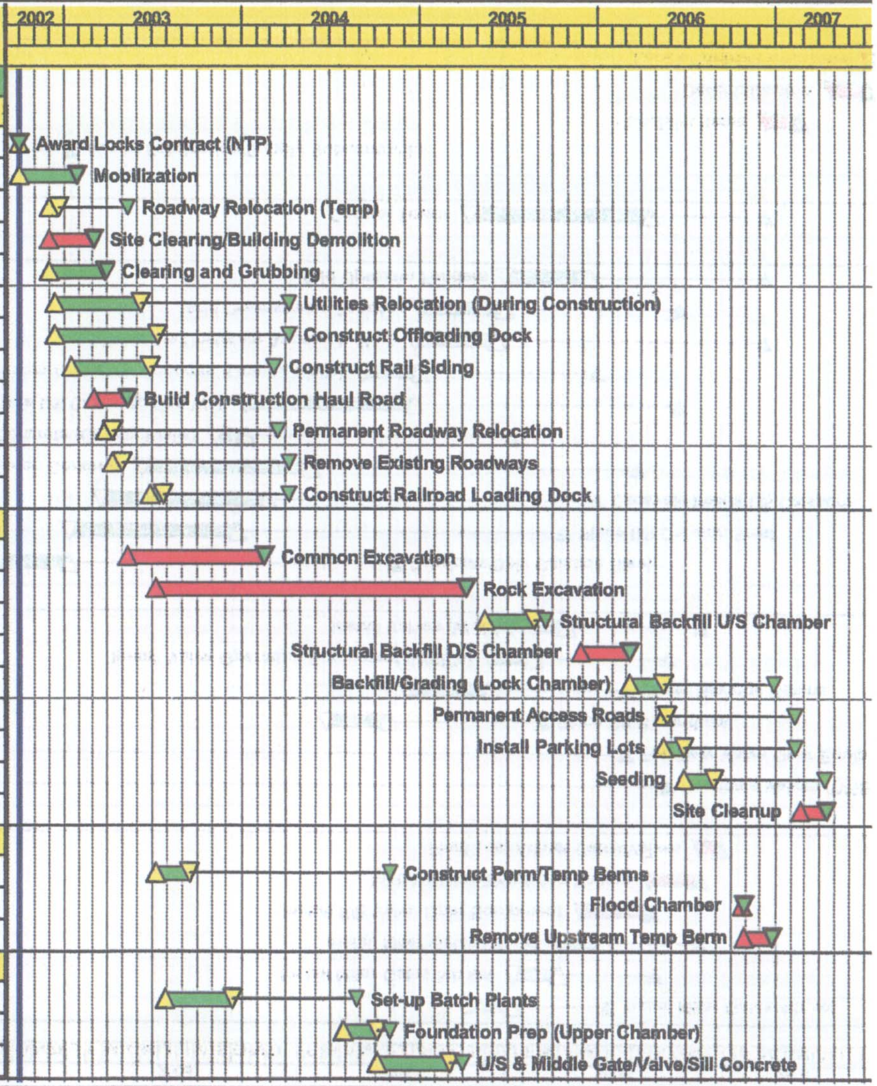
PANAMA CANAL CONCEPT DESIGN
ATLANTIC LOCKS STRUCTURE
DOUBLE-LIFT
CONSTRUCTION SCHEDULE

Activity ID	Activity Description	Orig Dur	Early Start	Early Finish	Total Float	Resource
Locks Contract						
Site Prep Work						
0330	Award Locks Contract (NTP)	1	01OCT02	01OCT02	1	
0340	Mobilization	120	02OCT02	29JAN03	1	
0050	Roadway Relocation (Temp)	15	02DEC02	20DEC02	102	
0010	Site Clearing/Building Demolition	80	02DEC02	04MAR03	0	
0700	Clearing and Grubbing	100	02DEC02	27MAR03	4	
0760	Utilities Relocation (During Construction)	150	16DEC02	07JUN03	259	
0740	Construct Offloading Dock	180	16DEC02	12JUL03	229	
0730	Construct Rail Siding	140	17JAN03	28JUN03	217	
0020	Build Construction Haul Road	60	05MAR03	13MAY03	0	
0710	Permanent Roadway Relocation	10	28MAR03	10APR03	242	
0720	Remove Existing Roadways	15	11APR03	01MAY03	242	
0750	Construct Railroad Loading Dock	24	30JUN03	28JUL03	217	
Earthwork						
0060	Common Excavation	240	14MAY03	17FEB04	0	
0070	Rock Excavation	550	09JUL03	09APR05	0	
0360	Structural Backfill U/S Chamber	85	16MAY05	22AUG05	23	
0150	Structural Backfill D/S Chamber	85	28NOV05	06MAR06	0	
0180	Backfill/Grading (Lock Chamber)	60	07MAR06	15MAY06	197	
0600	Permanent Access Roads	5	16MAY06	22MAY06	189	
0430	Install Parking Lots	30	16MAY06	26JUN06	164	
0520	Seeding	45	27JUN06	28AUG06	164	
0300	Site Cleanup	45	22FEB07	14APR07	0	
Water Diversion						
0030	Construct Perm/Temp Berms	60	09JUL03	16SEP03	353	
0270	Flood Chamber	7	24OCT06	30OCT06	0	
0290	Remove Upstream Temp Berm	50	31OCT06	27DEC06	0	
Lock Concrete						
0090	Set-up Batch Plants	120	28JUL03	13DEC03	217	
0080	Foundation Prep (Upper Chamber)	60	28JUL04	05OCT04	23	
0120	U/S & Middle Gate/Valve/Sill Concrete	130	06OCT04	05MAR05	23	



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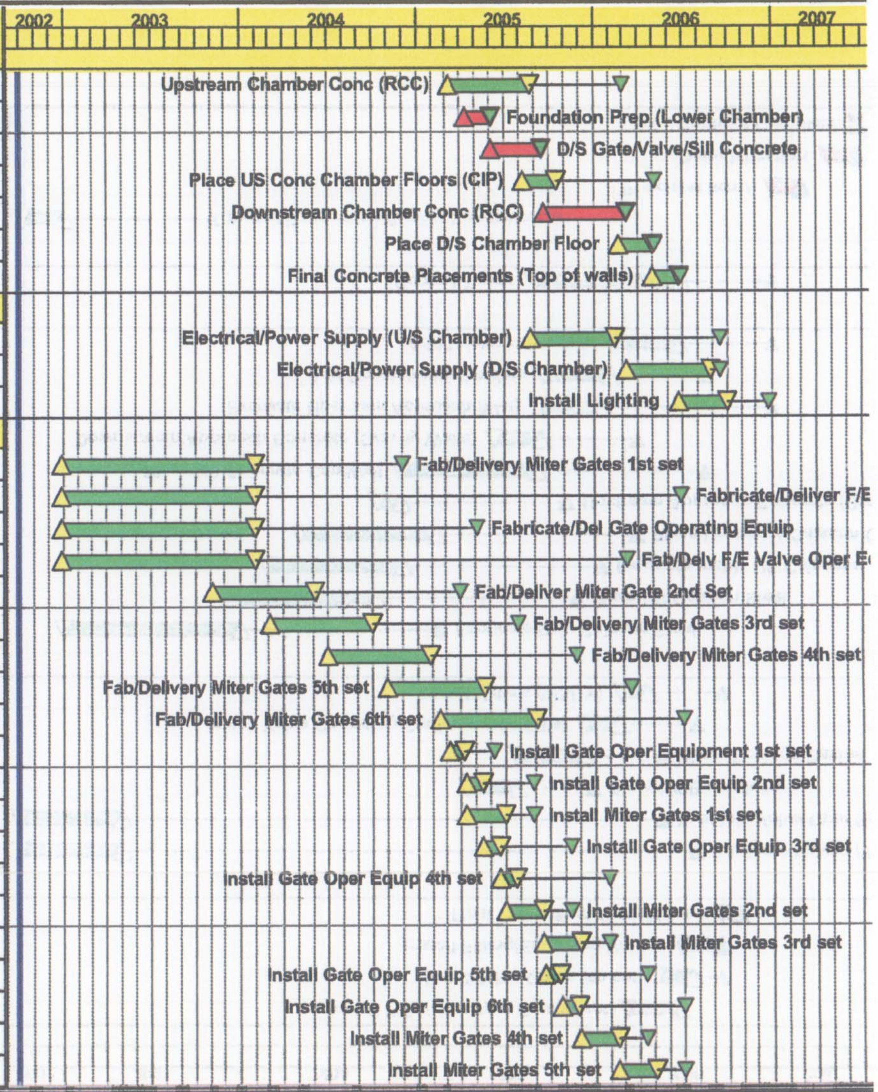
Panama Locks Study, 2 Lift, Option 2

Classic Schedule Layout

Date	Revision	Checked	Approved

PANAMA CANAL CONCEPT DESIGN
ATLANTIC LOCKS STRUCTURE
DOUBLE-LIFT
CONSTRUCTION SCHEDULE

Activity ID	Activity Description	Orig Dur	Early Start	Early Finish	Total Float	Resource
0380	Upstream Chamber Conc (RCC)	145	07MAR05	22AUG05	165	
0160	Foundation Prep (Lower Chamber)	48	11APR05	04JUN05	0	
0170	D/S Gate/Valve/Sill Concrete	90	06JUN05	17SEP05	0	
0100	Place US Conc Chamber Floors (CIP)	60	09AUG05	17OCT05	171	
0550	Downstream Chamber Conc (RCC)	145	19SEP05	06MAR06	0	
0320	Place D/S Chamber Floor	60	21FEB06	01MAY06	3	
0390	Final Concrete Placements (Top of walls)	45	02MAY06	22JUN06	3	
Electrical Work						
0250	Electrical/Power Supply (U/S Chamber)	150	23AUG05	13FEB06	186	
0350	Electrical/Power Supply (D/S Chamber)	150	07MAR06	28AUG06	18	
0240	Install Lighting	88	23JUN06	03OCT06	73	
Mechanical						
0190	Fab/Delivery Miter Gates 1st set	400	31DEC02	03FEB04	301	
0440	Fabricate/Deliver F/E Valves	400	31DEC02	03FEB04	874	
0540	Fabricate/Del Gate Operating Equip	400	31DEC02	03FEB04	456	
0580	Fab/Delv F/E Valve Oper Equip	400	31DEC02	03FEB04	762	
0600	Fab/Deliver Miter Gate 2nd Set	210	06NOV03	02JUN04	301	
0610	Fab/Delivery Miter Gates 3rd set	210	05MAR04	30SEP04	301	
0620	Fab/Delivery Miter Gates 4th set	210	03JUL04	28JAN05	301	
0630	Fab/Delivery Miter Gates 5th set	200	31OCT04	18MAY05	301	
0640	Fab/Delivery Miter Gates 6th set	200	18FEB05	06SEP05	301	
0210	Install Gate Oper Equipment 1st set	30	07MAR05	09APR05	51	
0280	Install Gate Oper Equip 2nd set	30	11APR05	14MAY05	91	
0200	Install Miter Gates 1st set	70	11APR05	30JUN05	51	
0450	Install Gate Oper Equip 3rd set	30	16MAY05	18JUN05	127	
0510	Install Gate Oper Equip 4th set	30	20JUN05	23JUL05	163	
0650	Install Miter Gates 2nd set	66	01JUL05	15SEP05	51	
0660	Install Miter Gates 3rd set	66	16SEP05	01DEC05	51	
0530	Install Gate Oper Equip 5th set	30	19SEP05	22OCT05	151	
0570	Install Gate Oper Equip 6th set	30	24OCT05	26NOV05	187	
0670	Install Miter Gates 4th set	66	02DEC05	16FEB06	51	
0680	Install Miter Gates 5th set	66	17FEB06	04MAY06	51	



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Panama Locks Study, 2 Lift, Option 2

Classic Schedule Layout

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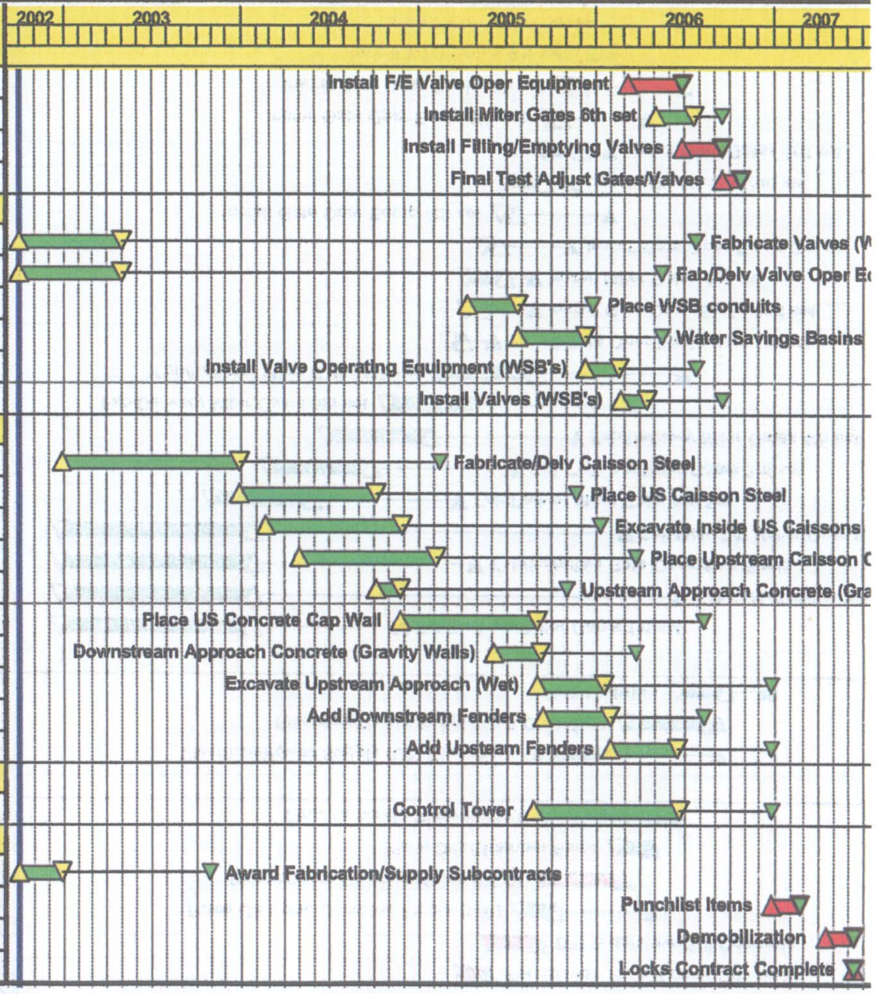
PANAMA CANAL CONCEPT DESIGN
ATLANTIC LOCKS STRUCTURE
DOUBLE-LIFT
CONSTRUCTION SCHEDULE

Activity ID	Activity Description	Orig Dur	Early Start	Early Finish	Total Float	Resource
0230	Install F/E Valve Oper Equipment	96	07MAR06	26JUN06	0	
0690	Install Miter Gates 6th set	66	05MAY06	20JUL06	51	
0220	Install Filling/Emptying Valves	72	27JUN06	18SEP06	0	
0420	Final Test Adjust Gates/Valves	30	19SEP06	23OCT06	0	
Water Savings Basins						
0460	Fabricate Valves (WSB's)	210	02OCT02	29APR03	1,182	
0480	Fab/Delv Valve Oper Equip (WSB's)	210	02OCT02	29APR03	1,112	
0110	Place WSB conduits	90	11APR05	23JUL05	133	
0140	Water Savings Basins	120	25JUL05	10DEC05	133	
0470	Install Valve Operating Equipment (WSB's)	60	12DEC05	18FEB06	133	
0490	Install Valves (WSB's)	48	20FEB06	15APR06	133	
Approach Walls						
0560	Fabricate/Delv Caisson Steel	365	31DEC02	30DEC03	411	
0850	Place US Caisson Steel	240	31DEC03	05OCT04	352	
0860	Excavate Inside US Caissons	240	21FEB04	26NOV04	352	
0870	Place Upstream Caisson Concrete	240	01MAY04	04FEB05	352	
0800	Upstream Approach Concrete (Gravity Walls)	42	06OCT04	23NOV04	295	
0880	Place US Concrete Cap Wall	240	24NOV04	30AUG05	295	
0840	Downstream Approach Concrete (Gravity Walls)	84	06JUN05	10SEP05	165	
0920	Excavate Upstream Approach (Wet)	120	31AUG05	17JAN06	295	
0820	Add Downstream Fenders	120	12SEP05	28JAN06	165	
0900	Add Upsteam Fenders	120	30JAN06	17JUN06	165	
Control Building						
0260	Control Tower	300	23AUG05	18JUN06	192	
General Work Locks Contract						
0590	Award Fabrication/Supply Subcontracts	90	02OCT02	30DEC02	301	
0400	Punchlist Items	48	28DEC06	21FEB07	0	
0310	Demobilization	60	15APR07	13JUN07	0	
0410	Locks Contract Complete	1	14JUN07	14JUN07	0	



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Panama Locks Study, 2 Lift, Option 2

Classic Schedule Layout

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PANAMA CANAL CONCEPT DESIGN

Atlantic Lock Structures
Third Lane Lock
Appendix M
Cost Estimates

Prepared for

Canal Capacity Projects Office

By

US Army Corps
of Engineers®

Final Report
23 July 2003

Table of Contents

List of Tables

1. GENERAL

1.1. Scope

This appendix details the total project cost preparations for the concept design of the new third lane, Atlantic Ocean side. It includes a breakdown of the construction costs for two separate double-lift lock designs. The designs differ in their filling and emptying system make-up. In addition, separate estimates are included for the differences in cost that would exist if the water depth over the sills was 1.5 m less (16.8 m instead of 18.3 m) and if the lock width was 6 m less (55 m instead of 61 m). It also includes cost estimates for final design, construction management and engineering support during construction.

These estimates are at the concept level of detail and therefore include contingencies assigned to individual line items.

1.2. Criteria

The concept design level total project cost estimates each include construction cost (broken down into various items of work), anticipated design cost, construction management cost, and engineering support during construction. Relevant notes on construction methods, and other assumptions are included to assist in review.

1.2.1. Construction Cost & Contingencies

The estimates of construction cost are presented in unit price format. They are based upon historical information (from ACP and USACE), quotes, unit price books, previous studies furnished by the ACP, and the development of detailed estimates. An appropriate level of contingency, as determined by the cost engineer in conjunction with the design team, was applied to each item on a case-by-case basis. Contingencies are assigned to cover cost increases due to design incompleteness at this level, detail changes, alternative design changes, potential quantity increases, unknowns, and associated costing inaccuracy. The contingency rate applied to each line item is related to the uncertainty associated with that individual item. For this estimate, normal design variances are expected thus normal contingency values ranging from 10%-20% were used for most items or work. Any items that have a contingency rate differing from this above range will include an explanation within the descriptions of the item presented below.

1.2.2. Total Project Cost

The design, engineering support during construction, and construction management costs are derived by applying percentages to the construction cost. The cost engineer developed these percentages with support from the design team and Pittsburgh District Construction personnel, based upon experience with similar USACE projects.

1.2.3. Comparison Estimates

Estimates were prepared for the differences in cost based upon the water depth over the sills being 1.5 m less and the lock width being 6 m less. These estimates are based upon the original quantities being adjusted where appropriate, to account for these changes. This appendix will address which items are affected by these changes, and how they are affected in more detail.

using RS Means and includes the above plus a 30 cm deep crushed stone base. The direct unit cost from Means was adjusted for work in Panama (local labor and equipment).

2.1.5.5. Storm Drainage

This item consists of a 15 cm diameter perforated PVC pipe running the length of the lock walls and around the perimeter of the Water Saving Basins. The unit cost was developed using RS Means. The direct unit costs from Means were adjusted for work in Panama (assumed local labor, material, and equipment), and combined to form one unit cost for this work.

2.1.5.6. Project Signage

This item of work includes signs identifying the project and its various features. It does not include navigation signs. A lump sum cost was included in the estimate for this item. The cost is based upon the cost estimator's judgment.

2.1.6. Entrance Walls, Upper and Lower

The Guard and Guide Walls consist of RCC walls as well as a section of drilled caissons with a concrete cap. The development of the cost for RCC concrete is explained in section 2.1.7.3. (Concrete for Lock Walls, Roller Compacted Concrete). The cost for the upper entrance wall (caisson portion) includes driving caissons and sheet piling, placing tremie concrete, reinforcing steel, and also the concrete cap wall. The cost development for this portion of the wall set on drilled caissons was developed using both detailed crew preparation as well as some previously prepared costs. This work is water-based work and thus the labor rates that were used are higher than the land based rates. Also, it was assumed that a subcontractor would perform the caisson work and sheet pile driving, while the prime contractor would place the concrete cap wall. A discussion of construction methods is included in the design appendix for these walls.

2.1.7. Lock Structure

This group of items includes the concrete in place for the lock structure. Several different mixes of concrete will be used for the lock structure. The cost estimate is based upon two separate mixes for the conventional cast in place concrete. The miter gate monoliths, sills and lock walls use one mix, while a mix with a higher cement content is used for the lock floors (laterals and culverts). Mix designs were also prepared for both roller compacted concrete and tremie concrete to assist in the costing of those items. TABLE M-2-3 shows a breakdown of the makeup of the different mixes.

Table M-2-3 Concrete Mixes

[illegible]	RCC	Conv CIP	Gate Monolith	Floors	Tremie
Cement (kg/m^3)	140	180	180	205	200
Pozzolan (kg/m^3)	40	40	40	35	190

[illegible]	RCC	Conv CIP	Gate Monolith	Floors	Tremie
Water (kg/m^3)	125	125	125	100	310
Sand (kg/m^3)	865	650	650	500	745
¾" Aggregate (kg/m^3)		386	386	550	
1.5" Aggregate (kg/m^3)	1285	386	386	550	
3" Aggregate (kg/m^3)		773	773		
#57 Stone (kg/m^3)					890
Silica Fume (kg/m^3)					24
Limestone Powder (kg/m^3)					119
Water Reducing Admixture (liters)					3.8
Anti-Washout Admixture (liters)					1.7

The mixture designs are based on Type II cement, Class F fly ash as the pozzolan; sand from Charges River alluvium, or Pacific or Atlantic dredge, with a specific gravity of 2.65; and basalt coarse aggregate from the Pacific Lock excavation with a specific gravity of 2.70. Cement meeting the requirements of ASTM C150, Type II, low heat and low alkali will be required. There are sources in Mexico, Columbia, and Venezuela that supply Panama. One or a combination of these sources would be used.

2.1.7.1. Concrete for Lock Walls, Conventional CIP

This item accounts for placement of concrete for the lock walls up to the top of the culverts. It also includes the chamber face concrete placed along side of the RCC concrete. The quantities for concrete and formwork were developed based upon an average cross section for each chamber. The formwork associated with this item includes the formwork associated with the concrete around the culverts, but does not include the forming associated with the cast in place concrete used for the chamber facing. This formwork cost is included in the RCC cost. The two options differ in the fact that Option 1 includes culverts within the lock walls while the design for Option 2 calls for the culverts to be within the lock floor.

The unit cost prepared for the conventional cast in place concrete was based upon a detailed breakdown of the individual costs associated with placing the concrete. The cast-in-place concrete cost includes costs associated with furnishing and operating batch plants, delivering concrete to placement area, formwork, placement, curing and finishing. The cost for batch plants is based upon three batch plants being required and includes cost for furnishing, set-up and operating for the duration of the project. The cost has been divided by the amount of concrete for the entire project to develop a constant unit cost per cubic meter. The delivery cost is associated with the cost of a conveyor system to deliver the concrete from the batch plants to placement areas. This cost was also divided evenly among the concrete items. The cost associated with the concrete mix was based upon current local market prices for material, except for the aggregate which is based upon using rock from the Pacific Lock excavation. The other main costs include the forming and placing of the concrete. For these items, detailed crews and corresponding production rates were developed to establish the unit costs. All of the unit costs were combined to form the unit cost for conventional cast in place concrete for the lock walls.

2.1.7.2. Cast in Place Concrete for Miter Gate Monoliths

This work includes the placement of concrete for the Miter Gate monoliths as well as the gate sills. The unit cost for the Miter Gate Monolith Concrete was prepared the same way as the conventional cast in place concrete. The only difference between the two was the concrete mix makeup, formwork, and the finishing and curing required. For more information on this unit cost preparation see 2.1.7.1 Concrete for Lock Walls, Conventional CIP.

2.1.7.3. Concrete for Lock Walls, Roller Compacted Concrete

This work involves the placement of concrete using the roller compacted method on the lock walls above the culverts. The unit cost for Roller Compacted Concrete was prepared with the same steps used to compute the conventional and Miter Gate monolith concrete unit prices. The only differences were the mix designs, the labor and equipment cost breakdowns associated with placement, formwork cost, as well as finishing and curing. Roller Compacted Concrete placement requires a different crew than conventional concrete placement. RCC can be placed at a faster rate than conventional, but involves use of heavy equipment (dozers) to spread the concrete. Rain can greatly effect the production rates associated with RCC placement and was a major factor in the development of the production rates for this item. In order to deal with the rain, the contractor will place RCC in several smaller runs instead of doing the length of the walls all at once. This will make it easier to cover the concrete with plastic during rain events. The unit cost developed for RCC coincides with the historic cost tables of RCC developed by the Portland Cement Association. These tables are included with the cost backup. For more information on the unit cost preparation see 2.1.7.1 Concrete for Lock Walls, Conventional CIP. Also, more information on RCC is presented in the main report.

2.1.7.4. Reinforcing Steel

A singular unit cost was prepared for the furnishing and placement of reinforcing steel. This unit cost is used for all of the reinforcing steel line items. The unit cost for reinforcing steel was prepared using crew development with the average international market price for reinforcing steel.

2.1.8. Lock Gates & Operating Machinery

This group of line items covers all of the work associated with furnishing and installing the Miter Gates and their operating machinery. A separate report has been previously prepared on lock gate selection. This report should be referred to for details on the Miter Gates.

2.1.8.1. Furnish and Install Miter Gates

This item includes the cost of fabricating, delivering, and installing the lock gates. Four different quotes were received for fabricating and delivering the miter gates. The quotes were from 2 Brazilian companies, 1 Japanese company, 1 Korean company, as well as feedback from an American fabricator. It was assumed that the gates would be fabricated outside of the United States, as international pricing for fabricated steel structures is a lot more economical than U.S. pricing. The quotes are listed in the computation sheets for the miter gates. One of the quotes included a cost for erection along with the cost of fabrication and delivery. This cost matched previous estimates prepared by the USACE for the erection of the gates and thus was determined to be feasible. Although the geographical proximity of Brazil provides an advantage for delivery, at this concept level it was determined to be more reasonable to use an average of the four quotes for the unit cost of fabrication.

The fabricators were also asked to provide information on the time required for fabrication of the gates. The responses from the companies all fell in the range of 3 to 5 years for fabrication and delivery of all of the gates for the double-lift concept design.

2.1.8.2. Furnish and Install Miter Gate Operating Machinery

This work includes furnishing and installing the gate operating machinery. It includes the hydraulic power units, local control cabinets, hydraulic cylinders, cardanic rings, mounting brackets, and gate attachments. Equipment manufacturers have furnished information on cost of the machinery as well as fabrication time. The installation cost was developed through preparing a crew for this work. The fabrication and installation cost were added together and a location adjustment factors were applied to account for work in Panama. The final result was a unit cost per gate for the operating machinery.

2.1.8.3. Embedded Metals (Stainless Steel)

This item accounts for any embedded stainless steel required for the miter gates sills and quoins. The unit cost for material was derived from the average international pricing for stainless steel. The installation cost is based upon historical cost in the United States updated to October 2002 price level and then adjusted for location. The location adjustment factor was based upon the assumption that installation will be performed with locally available equipment and labor.

2.1.8.4. Gate Anchorage (Structural Steel)

This work consists of furnishing and installing the gate anchorages for the miter gates. The unit cost for material was derived from the average international pricing for structural steel. The installation unit cost per weight of structural steel was developed through the use of historic cost information. The historic unit cost was updated to October 2002 price level and then adjusted for location. The location adjustment factor was based upon the assumptions that the material would be imported and installed with locally available equipment and labor.

2.1.8.5. Recess Bridges (Structural Steel)

This item includes the fabrication and installation of bridges over the Miter Gate recesses. These bridges must support the weight of the locomotive system used to assist the ships during lockage. The unit cost is based on the cost of structural steel included in the bridges.

2.1.8.6. Emergency Closure System

This item encompasses the cost associated with a lift-up wicket emergency closure system. It involves fabricating and installing structural steel wickets (approximately 20) to span the width of the lock chamber, a recess in the sill to accommodate the wickets and an operating system. A lump sum cost has been prepared for this item based on a recent similar project at Olmstead Locks and Dam (Louisville District). The size increase of the system versus that at Olmstead, as well as the cost reduction associated with using international pricing have been accounted for in preparing the lump sum cost.

2.1.9. Culvert Valves and Operating Machinery

This section includes the cost of the culvert valves and associated items used for the filling and emptying system. There are two separate design options presented for the filling and emptying system. The two concepts are an interlaced bottom lateral filling and emptying system and an in-chamber longitudinal filling and emptying system. In the interlaced bottom lateral system, the culverts are in the lock walls with an upstream intake and downstream outlet manifold. Instead of connecting directly to the lock chamber, the ports themselves connect to transverse culverts that extend across the lock chamber. The in-chamber longitudinal system consists of culverts within the floors of the locks. A bifurcation of valves has been included for the in-chamber longitudinal system. Separate quantities have been developed for the line items that differ under these two concepts. However, the unit costs used for similar features of work are the same for both concepts.

2.1.9.1. Valves

This cost includes the fabrication, delivery, and installation of the filling and emptying valves. For Option 1 (Interlaced Bottom Lateral) three separate line items are used for this cost since there are three separate sizes of valves for the filling and emptying system. The Upper Lock Filling Valves and Lower Lock Emptying Valves are the same size, and the Valve Between Locks are slightly heavier. The valves for Option 2 (ILCS) are all the same size and weight. Three quotes from international companies were received for the fabrication of the valves. One of the quotes also included erection cost. The three quotes included a large variance in cost. It was determined to use a value slightly above the lower quote, but below the cost per tonne for fabricating and erecting the Miter Gates. Since the weights are smaller, it was assumed that more competition might be available to fabricate the valves, thus lowering the cost per tonne versus the Miter Gates. The unit cost was applied to the weight of each valve, resulting in a unit cost per valve.

2.1.9.2. Furnish and Install Valve Operating Machinery

This work includes furnishing and installing the valve operating machinery. It includes the (cylinders, etc.). The unit cost for the valve operating machinery is based upon the Miter Gate Operating Machinery quote received. The quote was reduced to account for the smaller size of the valves versus the miter gates.

2.1.9.3. Embedded Metals (Stainless Steel)

This item accounts for any embedded stainless steel required for the miter gates sills and quoins. The unit cost for material was derived from the average international pricing for stainless steel. The installation cost is based upon historical cost in the United States updated to October 2002 price level and then adjusted for location. The location adjustment factor was based upon the assumption that installation will be performed with locally available equipment and labor.

2.1.9.4. Valve Anchorage (Structural Steel)

This work consists of furnishing and installing the gate anchorages for the miter gates. The unit cost for material was derived from the average international pricing for structural steel. The installation unit cost per weight of structural steel was developed through the use of historic cost information. The historic unit cost was updated to October 2002 price level and then adjusted for location. The location adjustment factor was based upon the assumptions that the material would be imported and installed with locally available equipment and labor.

2.1.10. Piping System

This section accounts for the cost of tying in the Operations/Control Building with existing water, gas, and sanitary sewage systems.

2.1.10.1. Water/Gas/Sanitary Sewage Systems

This item consists of furnishing the new locks structure with water, gas, electric, and sewage systems. Not much information was available on the existing utilities in the area. Therefore, a lump sum cost based upon estimator judgment, was used for this item. A 30% contingency was placed on this lump sum due to the amount of unknowns.

2.1.11. Power and Lighting Systems

2.1.11.1. Electrical Systems/Lighting

This item of work consists of the cost associated with supplying the necessary power to run the locks operating machinery. It also includes the cost for lighting the chamber. The lump sum cost is based upon material data from RS Means, previous estimates, and industry contacts.

2.1.11.2. Standby Generator Unit

A lump sum cost was prepared for this item. The cost was based upon estimator's judgment.

2.1.11.3. Temporary Power Supply During Construction

This cost accounts for power used by the construction contractor during construction of the locks. A lump sum cost was prepared for this item. The cost was based upon estimator's judgment.

2.1.12. Associated General Items

This section of items specific items not covered under other categories.

2.1.12.1. Stainless Steel Planking, Cover Plates, Rabbet Angles

These items consist of the cost associated with covering the recesses, culvert access points, and machinery trenches on top of the lock walls. The unit costs for these items were developed using RS Means. The unit prices derived from RS Means was then factored for work in Panama as well as international steel pricing. The location adjustment factor was based upon the assumption the material would be imported but that locally supplied labor and equipment would be used for installation.

2.1.13. Building, Project Operations

This cost is associated with building the operations building for the new locks structure. A lump sum cost was prepared by factoring the cost of a control building recently awarded for the Charleroi Locks Project (Pittsburgh District). A contingency of 30% was used for this item since there were still a lot of unknowns.

2.1.14. Miscellaneous Items

2.1.14.1. Erosion and Sediment Control

This item of work accounts for the cost associated with the erosion and sediment control required during the construction of the locks structure. This includes but is not limited to sedimentation traps, silt fence, diversion ditches, channels, temporary seeding, and erosion control material. This item is difficult to quantify at this level of detail. The cost was developed as a lump sum cost using historic cost information from the Grays Landing Lock Project (Pittsburgh District, February 1990). In order to prepare the lump sum cost, all of the bid items relating to erosion and sediment control were summed and then compared to the average total of the excavation costs. This yielded a percentage of total cost related to erosion and sediment control. This percentage was calculated at 19.90%. Since this project is on a larger scale, the cost for this project will be based on 15% of the total excavation cost including markups. This number is a lump sum cost as there are a lot of unknowns associated with it. A higher contingency rate (25%) is used for this item to account for the unknowns.

2.1.14.2. Permanent/Temporary Instrumentation

This item of work includes both the cost of installing and monitoring during construction, and also the installation of permanent instrumentation. This includes but is not limited to observation wells, open standpipe piezometers, inclinometers, data management systems, an instrumentation coordinator, alignment pins, and control monuments in soil and concrete. This cost was developed as a lump sum cost using historic cost information from the Grays Landing Lock Project (Pittsburgh District, February 1990). Quantities were developed for this project and then multiplied by the updated average unit prices. This yielded a total cost for temporary and permanent instrumentation.

2.1.15. Maintenance Facility (Gates)

This work comprises of building a maintenance facility for repair and maintenance of the Miter Gates. The unit costs for this maintenance facility were developed for the gate study report and do not always correspond to similar unit costs developed for the overall locks estimate. It is assumed that this work will be performed under a separate contract and thus the unit costs used will be higher in comparison to the unit costs of the larger lock contract. For more information on the Maintenance Facility see the Gate Selection Report.

2.1.16. Water Saving Basins

All of the unit prices used to calculate the cost of the water saving basins have been already developed for use in the construction of the locks structure. The concrete cost was interpolated from the conventional cast in place concrete cost used for the lock walls and the lock floors.

Table M-2-4 expresses the cost associated with the Water Saving Basins.

Table M-2-4 Water Saving Basins Cost

	Water Saving Basins Cost	Contingency	Total Cost
Option 1, Interlaced Bottom Lateral F/E System	$62,190,000	$9,905,000	$72,095,000
Option 2, In-Chamber Longitudinal F/E System	$62,190,000	$9,905,000	$72,095,000

2.2. Comparison Cost Estimates

This section deals with the differences in cost based upon the water depth over the sills being 1.5 m less and the lock width being 6 m less. These cost differences are based upon the original quantities being adjusted where appropriate, to account for these changes. The quantities and cost reductions are based upon Option 1. The cost reduction associated with Option 2 would be similar to that of Option 1.

2.2.1. Water Depth 1.5 Meters Less Over Sills

The cost reduction associated with the water depth over the sills being 5 m less is based upon the assumption that the locks structure could be raised 5 m. The changes associated with the scenario are a reduction in wall concrete, a reduction in gate size, and a reduction in the excavation quantity. The size of the components for the filling and emptying system would not change with this reduction.

The reduction in wall concrete was calculated using a ratio of the reduction in cross-sectional area. The results are a 6% reduction in the lockwall concrete. The lock gates reduction was based upon a ration of the (new height/old height)^2. This resulted in an approximate 8% reduction. The excavation reduction was calculated at 3.1% of the rock excavation required for the lock chambers.

Table M-2-5, Cost Reduction 1.5 Meter Less Water Depth

	Qty Reduction	U/C	Total	Cont %	Total with Contingency
Concrete Reduction	79,000 m^3	$100/m^3	$7,900,000	20%	$9,480,000
Miter Gate Reduction	1496 tonne	$6,500/mton	$9,724,000	15%	$11,183,000
Rock Excavation Reduction	173,000 m^3	$7.80/m^3	$1,349,400	20%	$1,619,300
				Total	$22,282,300

The total cost reduction based upon a 1.5 m reduction in water depth over the sill is estimated at $22,282,300.

2.2.2. Six Meter Reduction in Lock Width

The cost reduction associated with a 6 m reduction in lock width is based upon the assumption that the lock walls would have the same cross section, but would be 6 m closer to each other, thus reducing the concrete floor width. The changes associated with this scenario include a reduction in excavation, a reduction in gate size (15%), and a reduction in the concrete for the chamber floors. Also, the size of the components for the Filling and Emptying system would also be reduced. This includes the culverts, valves, laterals, and the water saving basins.

The reduction in floor concrete was calculated using a ratio of the reduction in cross-sectional area. The result is a 9% reduction in the concrete for the chamber floors. The lock gate reduction was estimated at 15%. The reduction in rock excavation was calculated to be 7.5% of the rock excavation for the lock chambers. The reduction in overburden excavation was calculated to be 3.6% of the overburden excavation for the lock chambers. A 10% reduction in valve weight was estimated as well as a reduction in the water saving basins floor volumes of 10%.

Table M-2-6, Cost Reduction 6-Meter Reduction in Width

	Qty Reduction	U/C	Total	Cont %	Total with Contingency
Chamber Concrete Reduction	14,800 m^3	$100/m^3	$1,480,000	20%	$1,776,000
Miter Gate Reduction	2,800 tonne	$6,500/mton	$18,200,000	15%	$20,930,000
Overburden Excavation Reduction	189,000 m^3	$3.75/m^3	$708,750	20%	$850,500
Rock Excavation Reduction	418,500 m^3	$7.80/m^3	$3,264,300	20%	$3,917,200
WSB Concrete Reduction	6570 m^3	$150/m^3	$985,500	15%	$1,133,300
Valve Reduction	10%	LS	$300,000	15%	$345,000
				Total	$28,952,000

The total cost reduction based upon a 6 m reduction in width is estimated at $28,952,000.

3. TOTAL PROJECT COST ESTIMATE

3.1. Engineering and Design

This includes all estimated costs of engineering & design to take this project from concept through construction. In proceeding with the design process, it is recommended that Feature Design Memorandum Reports be prepared for the major features of work before proceeding into the design-for-construction and preparation of the construction plans and specifications. Additional design would provide a final evaluation of the options available for the specific site conditions, select the most appropriate feature, optimize its design and establish the design parameters. Additional recommended items of work needed to proceed into the final design have also been identified and costs developed. The Waterways Experiment Station estimates the cost for building and testing a physical hydraulic model of the new locks by contract would be $2,250,000 and take 26 months. Miter gate and gate valve physical models are recommended and would cost an additional $3,000,000. Subsurface investigations that must be completed prior to awarding the locks contract are estimated to cost $1,750,000. Engineering and design costs have been developed based upon USACE experience with similar features of work for our projects and consideration given to the immense size of this construction project. An estimated 2000 drawings would be required for the final design at an average cost of $10,000 per drawing, which includes all costs for engineering design and computations required for a total of $20,000,000.

Table M-3-1 Engineering and Design Cost

Description	Cost
Subsurface Investigations	$1,750,000
Physical Models	$5,250,000
Feature Design Memorandum Reports	$10,000,000
Plans and Specifications	$20,000,000
Total	$37,000,000

3.2. Construction Management

Costs for construction management were developed based upon USACE experience with similar work with consideration for the immense size of the construction project. Costs are estimated to be approximately 1 3/4 percent of the total construction cost. This assumes that a process similar to the USACE Quality Management system will be used where the construction contractor is responsible for quality control including planning, procedures, testing and inspections. The construction contractor's costs for quality control were included in the overhead for each line item of the construction estimate. The 1 3/4 percent included here is for a construction management firm hired by the ACP to oversee the project. This includes contract administration, management, and quality assurance inspection and testing, contract modification and change order negotiations, and dispute mediation. The costs for the design firm to provide engineering services during construction are included here also and estimated as an additional 3/4 percent of the total construction cost.

Table M-3-2 Construction Management Cost

Item	Percentage of Construction Cost	Total Cost (Rounded)
Construction Management	1.75%	$14,350,000
Engineering During Construction	0.75%	$6,150,000
Total Construction Management	2.50%	$20,500,000

3.3. Summary of Total Project Costs

Table M-3-3 Total Project Cost, Option 1, Interlaced Bottom Lateral F/E System

Cost Level October 2002	Cost	Cont. %	Contingency	Total Cost
Construction Cost	$692,000,000	N/A	$128,000,000	$820,000,000
Design Cost	$37,000,000	15%	$5,550,000	$42,550,000
Construction Mgmt	$14,350,000	15%	$2,150,000	$16,500,000
Engineering During Construction	$6,150,000	15%	$925,000	$7,075,000
Total Project Cost	$749,500,000	N/A	$136,625,000	$886,125,000

Table M-3-4 Total Project Cost, Option 2, In-Chamber Longitudinal F/E System

Cost Level October 2002	Cost	Cont. %	Contingency	Total Cost
Construction Cost	$688,000,000	N/A	$128,000,000	$816,000,000
Design Cost	$37,000,000	15%	$5,550,000	$42,550,000
Construction Mgmt	$14,350,000	15%	$2,150,000	$16,500,000
Engineering During Construction	$6,150,000	15%	$925,000	$7,075,000
Total Project Cost	$745,500,000	N/A	$136,625,000	$882,125,000

Table M-3-5 Total Project Costs

Cost Level October 2002	Option 1 Interlaced Bottom Lateral Filling and Emptying System	Option 2 In-Chamber Longitudinal Filling and Emptying System
Construction Cost	$820,000,000	$816,000,000
Design Cost	$42,550,000	$42,550,000
Construction Management	$16,500,000	$16,500,000
Engineering During Construction	$7,075,000	$7,075,000
Total Project Cost	$886,125,000	$882,125,000

4. SUMMARY

The total first construction cost including contingencies for Option 1, Interlaced Bottom Lateral Filling and Emptying System is estimated to be $820,000,000 (October 2002 price level) and the total project cost for this option, including engineering, design and construction management is estimated to be $886,125,000. The total first construction cost including contingencies for Option 2, In-Chamber Longitudinal Filling and Emptying System is estimated to be $816,000,000 and the total project cost for this option, including engineering, design and construction management is estimated to be $882,125,000. These estimates contain the costs for preparing separate Feature Design Memorandum reports, hydraulic and physical modeling, subsurface investigations, preparation of plans and specifications and construction management.

The cost difference between the two different options appears to be negligible. The difference of $4 million between the two estimates works out to be approximately ½ of a percent. At this level of design the costs are not in enough detail to ensure accuracy down to this small of a percentage. As a result, cost should not be considered a deciding factor when choosing which of these two options to proceed with.

Appendix L contains a detailed project schedule for this contract and some recommendations for breaking this work into separate contracts that would potentially reduce construction costs and time.

Panama Canal Concept Design
Atlantic Locks Structure
Third Lane
Double-Lift Lock Screening Study
Construction Cost Estimate (Option 1 - Interlaced Bottom Lateral Filling System)

Price Level: October 2002

ITEM #	Description	Quantity	Unit	Unit Price	Amount	Contin-gencies	Total
	Mobilization & Demobilization (4%)	1	ls	$27,000,000.00	$27,000,000.00	10.0%	$29,700,000.00
01-01	**Preparatory Work**				$9,048,000.00	20.0%	$10,858,000.00
01-02	**Relocations**				$923,000.00	25.0%	$1,154,000.00
01-03	**Care & Diversion of Water**				$8,944,000.00	20.0%	$10,733,000.00
01-04	**Earthwork for Structures**						
01-04001	Exploratory Drilling	1	ls	$1,320,000.00	$1,320,000.00	20.0%	$1,584,000.00
01-04002	Common Excavation (Dry)	4341117	m^3	$3.75	$16,279,188.75	20.0%	$19,535,027.00
01-04003	Rock Excavation (Dry)	4789875	m^3	$7.80	$37,361,025.00	20.0%	$44,833,230.00
01-04004	Common Excavation (In the Wet)	910000	m^3	$6.50	$5,915,000.00	20.0%	$7,098,000.00
01-04005	Rock Excavation (In the Wet)	790000	m^3	$23.00	$18,170,000.00	20.0%	$21,804,000.00
01-04006	Pervious (Structural) Backfill	321190	m^3	$18.00	$5,781,420.00	25.0%	$7,226,775.00
01-04007	Random Backfill	416847	m^3	$3.00	$1,250,541.00	20.0%	$1,500,649.00
01-04008	Foundation Prep	125000	m^2	$75.00	$9,375,000.00	20.0%	$11,250,000.00
				Subtotals	**$95,452,000.00**		**$114,832,000.00**
01-05	**Sitework**				$1,403,000.00		$1,686,000.00

Panama Canal Concept Design
Atlantic Locks Structure
Third Lane
Double-Lift Lock Screening Study
Construction Cost Estimate (Option 1 - Interlaced Bottom Lateral Filling System)

Price Level: October 2002

ITEM #	Description	Quantity	Unit	Unit Price	Amount	Contin-gencies	Total
01-06	**Entrance Walls, Upper & Lower**						
01-06001	Soil Excavation (Caissons)	1930	m^3	$260.00	$501,800.00	30.0%	$652,340.00
01-06002	Rock Excavation (Caissons)	3550	m^3	$775.00	$2,751,250.00	30.0%	$3,576,625.00
01-06003	Caissons	2760	m	$3,000.00	$8,280,000.00	30.0%	$10,764,000.00
01-06004	Reinforcing Steel (Caissons)	2625316	kg	$0.90	$2,362,784.40	30.0%	$3,071,620.00
01-06005	Tremie Concrete	11520	m^3	$150.00	$1,728,000.00	30.0%	$2,246,400.00
01-06006	Testing/Monitoring Caissons	69	ea	$25,000.00	$1,725,000.00	30.0%	$2,242,500.00
01-06007	Concrete (Cap Wall)	43250	m^3	$335.00	$14,488,750.00	30.0%	$18,835,375.00
01-06008	Reinforcing Steel (Cap Wall)	349000	kg	$0.90	$314,100.00	30.0%	$408,330.00
01-06009	Sheet Piling (Cap Wall)	24680	m^2	$310.00	$7,650,800.00	30.0%	$9,946,040.00
01-06010	Conventional CIP (Gravity Walls)	24602	m^3	$93.00	$2,287,986.00	[illegible]	$2,745,583.00
01-06011	RCC (Gravity Walls)	467438	m^3	$65.00	$30,383,470.00	20.0%	$36,460,164.00
01-06012	Reinforcing Steel (Dry Section)	2670000	kg	$0.90	$2,403,000.00	20.0%	$2,883,600.00
01-06013	Pervious (Structural) Backfill	179798	m^3	$18.00	$3,236,364.00	25.0%	$4,045,455.00
01-06014	Random Backfill	419528	m^3	$3.00	$1,258,584.00	20.0%	$1,510,301.00
01-06015	Fenders	1	Job	$11,500,000.00	$11,500,000.00	20.0%	$13,800,000.00
				Subtotals	**$90,872,000.00**		**$113,188,000.00**
01-07	**Lock Structure**						
01-07001	Concrete for Lock Walls, (Conv)	541971	M3	$127.00	$68,830,317.00	20.0%	$82,596,380.00
01-07002	Concrete for Lock Walls, (RCC)	773889	M3	$59.00	$45,659,451.00	20.0%	$54,791,341.00
01-07003	Concrete in Place, Gate Monoliths, (Conv)	268148	M3	$110.00	$29,496,280.00	20.0%	$35,395,536.00
01-07004	Concrete for Lock Gate Monoliths, (RCC)	219044	M3	$51.00	$11,171,244.00	20.0%	$13,405,493.00
01-07005	Concrete for Lock Floors/Sills, (Conv)	41270	M3	$198.00	$8,171,460.00	20.0%	$9,805,752.00
01-07006	Concrete for Lock Floors, (RCC)	123144	M3	$46.00	$5,664,624.00	20.0%	$6,797,549.00
01-07007	Reinforcing Steel, Wall Monoliths	9661804	kg	$0.90	$8,695,623.60	20.0%	$10,434,748.00
01-07008	Reinforcing Steel, Floor/Sills	8638655	kg	$0.90	$7,774,789.50	20.0%	$9,329,747.00
01-07009	Reinforcing Steel, Gate Monoliths	5369501	kg	$0.90	$4,832,550.90	20.0%	$5,799,061.00
				Subtotals	**$190,296,000.00**		**$228,356,000.00**

Panama Canal Concept Design
Atlantic Locks Structure
Third Lane
Double-Lift Lock Screening Study
Construction Cost Estimate (Option 1 - Interlaced Bottom Lateral Filling System)
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ITEM #	Description	Quantity	Unit	Unit Price	Amount	Contin- gencies	Total
01-08	**Lock Gates & Operating Machinery**						
01-08001	Furnish & Install Lower Miter Gates	2	sets	$22,490,000.00	$44,980,000.00	15.0%	$51,727,000.00
01-08002	Furnish & Install Center Miter Gates	2	sets	$22,490,000.00	$44,980,000.00	15.0%	$51,727,000.00
01-08003	Furnish & Install Upper Miter Gates	2	sets	$15,502,500.00	$31,005,000.00	15.0%	$35,655,750.00
01-08004	Furnish and Install Operating Machinery	12	ea	$715,000.00	$8,580,000.00	15.0%	$9,867,000.00
01-08005	Embedded Metals (Stainless Steel)	38000	kg	$6.50	$247,000.00	15.0%	$284,050.00
01-08006	Gate Anchorage (Structural steel)	908000	kg	$2.50	$2,270,000.00	15.0%	$2,610,500.00
01-08007	Bridges over recesses	12	ea	$300,000.00	$3,600,000.00	20.0%	$4,320,000.00
01-08008	Emergency Closure	1	LS	$20,000,000.00	$20,000,000.00	15.0%	$23,000,000.00
				Subtotals	**$155,662,000.00**		**$179,191,000.00**
01-09	**Culvert Valves and Operating Machinery**						
01-09001	Upper Lock Filling Valves	2	ea	$465,520.00	$931,040.00	15.0%	$1,070,696.00
01-09002	Valves Between Locks	2	ea	$509,300.00	$1,018,600.00	15.0%	$1,171,390.00
01-09003	Lower Lock Emptying Valves	2	ea	$465,520.00	$931,040.00	15.0%	$1,070,696.00
01-09004	Embedded Metals (Stainless Steel)	1900	kg	$6.50	$12,350.00	15.0%	$14,203.00
01-09005	Valve Anchorage	19580	kg	$2.50	$48,950.00	15.0%	$56,293.00
01-09006	Bulkheads	1	LS	$1,120,000.00	$1,120,000.00	15.0%	$1,288,000.00
01-09007	Valves Operating Machinery	6	ea	$500,000.00	$3,000,000.00	15.0%	$3,450,000.00
				Subtotals	**$7,062,000.00**		**$8,121,000.00**
01-10	**Piping System**				$1,500,000.00	30.0%	$1,950,000.00
01-11	**Power and Lighting Systems**				$22,500,000.00	17.8%	$26,500,000.00
01-12	**Associated General Items**				$2,748,000.00	15.0%	$3,160,000.00
01-13	**Building, Project Operations**				$1,000,000.00	25.0%	$1,250,000.00
01-14	**Miscellaneous Items**				$12,210,000.00	15.9%	$14,152,000.00
01-15	**Maintenance Facility (Gates)**				$2,781,000.00	25.0%	$3,476,000.00

Panama Canal Concept Design
Atlantic Locks Structure
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Double-Lift Lock Screening Study
Construction Cost Estimate (Option 1 - Interlaced Bottom Lateral Filling System)
Price Level: October 2002

ITEM #	Description	Quantity	Unit	Unit Price	Amount	Contin-gencies	Total
01-16	**Water Savings Basins**						
01-16001	Overburden Excavation	1250943	m^3	$3.75	$4,691,036.25	15.0%	$5,394,692.00
01-16002	Rock Excavation	1048947	m^3	$7.80	$8,181,786.60	15.0%	$9,409,055.00
01-16003	Concrete (Conventional)	88911	m^3	$150.00	$13,336,650.00	15.0%	$15,337,148.00
01-16004	Reinforcing Steel	4493075	kg	$0.90	$4,043,767.50	20.0%	$4,852,521.00
01-16005	Handrailing	1370	LM	$50.00	$68,500.00	20.0%	$82,200.00
				Subtotals	**$30,322,000.00**		**$35,076,000.00**
01-17	**Conduits**						
01-17001	Overburden Excavation	11700	M3	$3.75	$43,875.00	15.0%	$50,456.00
01-17002	Rock Excavation	23400	M3	$7.80	$182,520.00	15.0%	$209,898.00
01-17003	Concrete (Conventional CIP)	60000	M3	$210.00	$12,600,000.00	15.0%	$14,490,000.00
01-17004	Reinforcing Steel	6540000	kg	$0.90	$5,886,000.00	20.0%	$7,063,200.00
				Subtotals	**$18,712,000.00**		**$21,814,000.00**
01-18	**Crossovers (Including with Lock Floor Costs)**						
01-19	**Conduit Valves and Operating Mach.**						
01-19001	Valves	16	ea	$320,650.00	$5,130,400.00	15.0%	$5,899,960.00
01-19002	Embedded Metals (Stainless Steel)	4000	kg	$6.50	$26,000.00	15.0%	$29,900.00
01-19003	Valve Anchorage (Structural Steel)	40000	kg	$2.50	$100,000.00	15.0%	$115,000.00
01-19004	[illegible]perating Machinery	16	ea	$400,000.00	$6,400,000.00	15.0%	$7,360,000.00
01-19005	Electrical System/Controls	1	job	$1,500,000.00	$1,500,000.00	20.0%	$1,800,000.00
				Subtotals	**$13,156,000.00**		**$15,205,000.00**

Totals	**$691,591,000.00**	**$820,402,000.00**
Rounded	**$692,000,000.00**	**$820,000,000.00**

Panama Canal Concept Design
Atlantic Locks Structure
Third Lane
Double-Lift Lock Screening Study
Construction Cost Estimate (Option 2 - ILCS Gravity Monoliths)
Price Level: October 2002

ITEM #	Description	Quantity	Unit	Unit Price	Amount	Contin-gencies	Total
	Mobilization & Demobilization (4%)	1	ls	$27,000,000.00	$27,000,000.00	10.0%	$29,700,000.00
01-01	**Preparatory Work**				$9,048,000.00	20.0%	$10,858,000.00
01-02	**Relocations**				$923,000.00	25.0%	$1,154,000.00
01-03	**Care & Diversion of Water**				$8,944,000.00	20.0%	$10,733,000.00
01-04	**Earthwork for Structures**						
01-04001	Exploratory Drilling	1	ls	$1,320,000.00	$1,320,000.00	20.0%	$1,584,000.00
01-04002	Common Excavation (Dry)	4188633	m^3	$3.75	$15,707,373.75	20.0%	$18,848,849.00
01-04003	Rock Excavation (Dry)	5112502	m^3	$7.80	$39,877,515.60	20.0%	$47,853,019.00
01-04004	Common Excavation (In the Wet)	910000	m^3	$6.50	$5,915,000.00	20.0%	$7,098,000.00
01-04005	Rock Excavation (In the Wet)	790000	m^3	$23.00	$18,170,000.00	20.0%	$21,804,000.00
01-04006	Pervious (Structural) Backfill	320208	m^3	$18.00	$5,763,744.00	25.0%	$7,204,680.00
01-04007	Random Backfill	418782	m^3	$3.00	$1,256,346.00	20.0%	$1,507,615.00
01-04008	Foundation Prep	125000	m^2	$75.00	$9,375,000.00	20.0%	$11,250,000.00
				Subtotals	**$97,385,000.00**		**$117,150,000.00**
01-05	**Sitework**				$1,403,000.00		$1,686,000.00

Panama Canal Concept Design
Atlantic Locks Structure
Third Lane
Double-Lift Lock Screening Study
Construction Cost Estimate (Option 2 - ILCS Gravity Monoliths)

Price Level: October 2002

ITEM #	Description	Quantity	Unit	Unit Price	Amount	Contin-gencies	Total
01-06	**Entrance Walls, Upper & Lower**						
01-06001	Soil Excavation (Caissons)	1930	m^3	$260.00	$501,800.00	30.0%	$652,340.00
01-06002	Rock Excavation (Caissons)	3550	m^3	$775.00	$2,751,250.00	30.0%	$3,576,625.00
01-06003	Caissons	2760	m	$3,000.00	$8,280,000.00	30.0%	$10,764,000.00
01-06004	Reinforcing Steel (Caissons)	2625316	kg	$0.90	$2,362,784.40	30.0%	$3,071,620.00
01-06005	Tremie Concrete	11520	m^3	$150.00	$1,728,000.00	30.0%	$2,246,400.00
01-06006	Testing/Monitoring Caissons	69	ea	$25,000.00	$1,725,000.00	30.0%	$2,242,500.00
01-06007	Concrete (Cap Wall)	43250	m^3	$335.00	$14,488,750.00	30.0%	$18,835,375.00
01-06008	Reinforcing Steel (Cap Wall)	349000	kg	$0.90	$314,100.00	30.0%	$408,330.00
01-06009	Sheet Piling (Cap Wall)	24680	m^2	$310.00	$7,650,800.00	30.0%	$9,946,040.00
01-06009	Conventional CIP	24602	m^3	$91.00	$2,238,782.00	20.0%	$2,686,538.00
01-06010	RCC	467438	m^3	$63.00	$29,448,594.00	20.0%	$35,338,313.00
01-06011	Reinforcing Steel (Dry Section)	2670000	kg	$0.90	$2,403,000.00	20.0%	$2,883,600.00
01-06012	Pervious (Structural) Backfill	181227	m^3	$18.00	$3,262,086.00	25.0%	$4,077,608.00
01-06013	Random Backfill	422863	m^3	$3.00	$1,268,589.00	20.0%	$1,522,307.00
01-06014	Fenders	1	Job	$11,500,000.00	$11,500,000.00	20.0%	$13,800,000.00
				Subtotals	**$89,924,000.00**		**$112,052,000.00**
01-07	**Lock Structure**						
01-07001	Concrete for Lock Walls, (Conv)	242627	M3	$90.00	$21,836,430.00	20.0%	$26,203,716.00
01-07002	Concrete for Lock Walls, (RCC)	1513644	M3	$56.00	$84,764,064.00	20.0%	$101,716,877.00
01-07003	Concrete in Place, Gate Monoliths	268148	M3	$111.00	$29,764,428.00	20.0%	$35,717,314.00
01-07004	Concrete for Lock Gate Monoliths, RCC	219044	M3	$49.00	$10,733,156.00	20.0%	$12,879,787.00
01-07005	Concrete for Lock Floors/Sills, (Conv)	50639	M3	$203.00	$10,279,717.00	20.0%	$12,335,660.00
01-07006	Concrete for Lock Floors, (RCC)	136438	M3	$45.00	$6,139,710.00	20.0%	$7,367,652.00
01-07007	Reinforcing Steel, Wall Monoliths	7939800	kg	$0.90	$7,145,820.00	20.0%	$8,574,984.00
01-07008	Reinforcing Steel, Floor/Sills	6401249	kg	$0.90	$5,761,124.10	20.0%	$6,913,349.00
01-07009	Reinforcing Steel, Gate Monoliths	5409222	kg	$0.90	$4,868,299.80	20.0%	$5,841,960.00
				Subtotals	**$181,293,000.00**		**$217,551,000.00**

Panama Canal Concept Design
Atlantic Locks Structure
Third Lane
Double-Lift Lock Screening Study
Construction Cost Estimate (Option 2 - ILCS Gravity Monoliths)

Price Level: October 2002

ITEM #	Description	Quantity	Unit	Unit Price	Amount	Contin-gencies	Total
01-08	**Lock Gates & Operating Machinery**						
01-08001	Furnish & Install Lower Miter Gates	2	sets	$22,490,000.00	$44,980,000.00	15.0%	$51,727,000.00
01-08002	Furnish & Install Center Miter Gates	2	sets	$22,490,000.00	$44,980,000.00	15.0%	$51,727,000.00
01-08003	Furnish & Install Upper Miter Gates	2	sets	$15,502,500.00	$31,005,000.00	15.0%	$35,655,750.00
01-08004	Furnish and Install Operating Machinery	12	ea	$715,000.00	$8,580,000.00	15.0%	$9,867,000.00
01-08005	Embedded Metals (Stainless Steel)	38000	kg	$6.50	$247,000.00	15.0%	$284,050.00
01-08006	Gate Anchorage (Structural steel)	908000	kg	$2.50	$2,270,000.00	15.0%	$2,610,500.00
01-08007	Bridges over recesses	12	ea	$300,000.00	$3,600,000.00	20.0%	$4,320,000.00
01-08008	Emergency Closure	1	LS	$20,000,000.00	$20,000,000.00	15.0%	$23,000,000.00
				Subtotals	**$155,662,000.00**		**$179,191,000.00**
01-09	**Culvert Valves and Operating Machinery**						
01-09001	Upper Lock Filling Valves	4	ea	$365,200.00	$1,460,800.00	15.0%	$1,679,920.00
01-09002	Valves Between Locks	4	ea	$365,200.00	$1,460,800.00	15.0%	$1,679,920.00
01-09003	Lower Lock Emptying Valves	4	ea	$365,200.00	$1,460,800.00	15.0%	$1,679,920.00
01-09004	Embedded Metals (Stainless Steel)	3800	kg	$6.50	$24,700.00	15.0%	$28,405.00
01-09005	Valve Anchorage	39160	kg	$2.50	$97,900.00	15.0%	$112,585.00
01-09006	Bulkheads	1	ls	$920,000.00	$920,000.00	15.0%	$1,058,000.00
01-09007	Valves Operating Machinery	12	ea	$500,000.00	$6,000,000.00	15.0%	$6,900,000.00
				Subtotals	**$11,425,000.00**		**$13,139,000.00**
01-10	**Piping System**				$1,500,000.00	30.0%	$1,950,000.00
01-11	**Power and Lighting Systems**				$22,500,000.00	17.8%	$26,500,000.00
01-12	**Associated General Items**				$2,748,000.00	15.0%	$3,160,000.00
01-13	**Building, Project Operations**				$1,000,000.00	25.0%	$1,250,000.00
01-14	**Miscellaneous Items**				$12,510,000.00	15.9%	$14,497,000.00
01-15	**Maintenance Facility (Gates)**				$2,781,000.00	25.0%	$3,476,000.00

Panama Canal Concept Design
Atlantic Locks Structure
Third Lane
Double-Lift Lock Screening Study
Construction Cost Estimate (Option 2 - ILCS Gravity Monoliths)
Price Level: October 2002

ITEM #	Description	Quantity	Unit	Unit Price	Amount	Contin-gencies	Total
01-16	**Water Savings Basins**						
01-16001	Overburden Excavation	1250943	m^3	$3.75	$4,691,036.25	15.0%	$5,394,692.00
01-16002	Rock Excavation	1048947	m^3	$7.80	$8,181,786.60	15.0%	$9,409,055.00
01-16003	Concrete (Conventional)	88911	m^3	$150.00	$13,336,650.00	15.0%	$15,337,148.00
01-16004	Reinforcing Steel	4493075	kg	$0.90	$4,043,767.50	20.0%	$4,852,521.00
01-16005	Handrailing	1370	LM	$50.00	$68,500.00	20.0%	$82,200.00
				Subtotals	**$30,322,000.00**		**$35,076,000.00**
01-17	**Conduits**						
01-17001	Overburden Excavation	11700	M3	$3.75	$43,875.00	15.0%	$50,456.00
01-17002	Rock Excavation	23400	M3	$7.80	$182,520.00	15.0%	$209,898.00
01-17003	Concrete	60000	M3	$210.00	$12,600,000.00	15.0%	$14,490,000.00
01-17004	Reinforcing Steel	6540000	kg	$0.90	$5,886,000.00	20.0%	$7,063,200.00
				Subtotals	**$18,712,000.00**		**$21,814,000.00**
01-18	**Crossovers (Including with Lock Floor Costs)**						
01-19	**Conduit Valves and Operating Mach.**						
01-19001	Valves	16	ea	$320,650.00	$5,130,400.00	15.0%	$5,899,960.00
01-19002	Embedded Metals (Stainless Steel)	4000	kg	$6.50	$26,000.00	15.0%	$29,900.00
01-19003	Valve Anchorage (Structural Steel)	40000	kg	$2.50	$100,000.00	15.0%	$115,000.00
01-19004	Valve Operating Machinery	16	ea	$400,000.00	$6,400,000.00	15.0%	$7,360,000.00
01-19005	Electrical System/Controls	1	job	$1,500,000.00	$1,500,000.00	20.0%	$1,800,000.00
				Subtotals	**$13,156,000.00**		**$15,205,000.00**

Totals	**$688,236,000.00**	**$816,142,000.00**
Rounded	**$688,000,000.00**	**$816,000,000.00**

COMPUTATION SHEET

Preparatory Work - Building Demolition
Double-Lift Concept

Price Level: Oct 02

Sheet 1 of 1

Filename: ____________
Tab: ____________

Computed By: CRC Date 3/14/03
Checked By: PGB Date 3/26/2003

Preparatory Work

Building Demolition

The contractor will have to demolish and dispose of several buildings within the construction work area. Assume that this work will be subcontracted.

		qty	$/hr	Total $/hr
Labor				
	Hvy Equipment Operator	2	$9.40	$18.80
	Equipment Operator	2	$8.40	$16.80
	Truck Driver	3	$7.30	$21.90
	Laborer	2	$5.00	$10.00
	Total			$67.50
Equipment				
	Dozer (CAT D6)	1	$40.00	$40.00
	Hyd Excavator (CAT 325 BL)	1	$45.00	$45.00
	Loader w/ Backhoe (1.15 m^3	2	$24.00	$48.00
	Truck 23 Tonne Rear Dump	3	$31.00	$93.00
				$226.00

Production Rate	20 hrs/building	
Direct Cost per building	$5,870.00	
Subcontractor's Markup	$1,174.00	20.00%
Subtotal	$7,044.00	
Contractor's Markup	$704.40	10.00%
Total Unit Costs w/ Markup	$7,748.40 /Building	
Rounded	**$7,750.00** /Building	

US Army Corps
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Pittsburgh District

Panama Canal Authority
Atlantic Locks
3rd Lane - Concept Design Study

COMPUTATION SHEET

Preparatory Work - Clearing and Grubbing
Double-Lift Concept

Price Level: Oct 02 Sheet 1 of 1

Filename: ________ Computed By: CRC Date 3/14/2003
Tab: ________ Checked By: PGB Date 3/26/2003

Preparatory Work

Clearing and Grubbing

The contractor will have to clear and grub the construction work area. Assume medium trees and brush (medium density). Burning allowed. Assume that this work will be subcontracted.

Labor		qty	$/hr	Total $/hr
	Supervisor	0.33	$50.00	$16.50
	Labor Foreman	1	$5.30	$5.30
	Laborer	6	$5.00	$30.00
	Equipment Oper Hvy	2	$9.40	$18.80
	Truck Drivers	3	$7.30	$21.90
Equipment	Loader w/bh Cat 446-B	1	24	$24.00
	Cat 325 Excavator	1	$45.00	$45.00
	23 tonne Rear Dump Truck	3	$31.00	$93.00
	Chain Saws	4	$1.00	$4.00
	Chipper	2	$13.00	$26.00
	Small Tools (2% Labor)	1	$1.85	$1.85

Production Rate	500	m^2/hr		
Direct Cost		$0.57		
Subcontractor's Markup		$0.11	20.00%	
Subtotal		$0.69		
Prime Contractor's Markup		$0.07	10.00%	
Total Unit Costs w/ Markup		$0.76	m^2	
Clearing and Grubbing				**$0.76 /m^2**
			Rounded	**$75.00 /csm**

csm - 100 square meters

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Atlantic Locks
3rd Lane - Concept Design Study

COMPUTATION SHEET

Preparatory Work - Access Roads
Double-Lift Concept

Price Level: Oct 02

Sheet 1 of 1

Filename: ________
Tab: ________

Computed By: CRC Date 3/14/2003
Checked By: PGB Date 3/26/2003

Preparatory Work
Access Roads

The contractor will build 7.5 meter wide access roads. These roads will require continuous upkeep.

Materials

Subbase - 10 cm thick		$15.00 /m		
Base - 5 cm thick		$8.00 /m		
	Total	$23.00 /m		

Labor/Equipment

Grading		$1.30 /m		
Subbase/Base		$26.00 /m		
	Total	$27.30 /m		
	Total	$50.30 /m		
Prime Contractor's Markup		$10.06	20%	
Total with Markup		$60.36 /m		
Installation		$60.36 /m		**$60,400.00 /km**
Upkeep		$30.18 /m		**$30,200.00 /km**

Haul Roads

The contractor will have to build approximately 7 km's of 12m wide haul roads. These roads will require continous upkeep.

Materials

Subbase - 30 cm thick		$45.00 /m	
Base - 15 cm thick		$24.00 /m	
Bituminous Paving (Incl installatior		$10.00 /m	
	Total	$79.00 /m	

Labor/Equipment

Grading		$2.50 /m	
Subbase/Base		$55.00 /m	
	Total	$57.50 /m	
	Total	$136.50 /m	
Contractor's Markup		20.00%	
Total Unit Costs w/ Markup			
Installation		$163.80 /m	**$163,800.00 /km**
Upkeep		$81.90 /m	**$81,900.00 /km**

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Panama Canal Authority
Atlantic Locks
3rd Lane - Concept Design Study

COMPUTATION SHEET

Preparatory Work - Temporary Railroad Access/Offloading Dock
Double-Lift Concept

Price Level: Oct 02

Sheet 1 of 1

Filename: ________

Tab: ________

Computed By: CRC Date 3/14/03

Checked By: PGB Date 3/26/2003

Preparatory Work

Temporary Railroad Tracks

The contractor will build a single track Railroad siding to use to supply aggregate to the batch plants.

Materials			
Track/Ties/Ballast/etc.		$200.00	/m
Assume Salvage		$40.00	/m
	Total	$160.00	/m
Labor/Equipment			
Installation		$25.00	/m
Removal		$40.00	/m
	Total	$65.00	/m
	Total	$225.00	/m
Contractor's Markup		20.00%	
Total Unit Costs w/ Markup		$270.00	/m
		$270,000.00	/km
Miscellaneous			
Switches		$15,000	Each
Loading Dock (not including track)		$50,000.00	Each

Temporary Offloading Dock	$3,000,000.00

An offloading facility for unloading construction items delivered by water. This cost does not include dredging out an approach channel as it is assumed that any dredging required will be performed by the ACP prior to the start of construction.

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Pittsburgh District

Panama Canal Authority
Atlantic Locks
3rd Lane - Concept Design Study

COMPUTATION SHEET

Relocations - Temporary Roads / Removal of Roadways
Double-Lift Concept

Price Level: Oct 02

Sheet 1 of 1

Filename: __________
Tab: __________

Computed By: CRC Date 3/14/03
Checked By: PGB Date 3/26/2003

Relocations

Temporary Roads

The contractor will have to build an approximately 1400 M long, 7.5 meter wide temporary roadway.

Graded Crushed Aggregate		$6.00	/m^2
Bituminous		$7.00	/m^2
	Total	$13.00	/m^2

Unit price base upon bids received for the cut widening program.
Unit prices already contain markups.

Removal of temporary roadway after construction is complete. Unit cost development shown below.

Total	$6.00	/m^2
Total including removing	$19.00	/m^2
Rounded	**$20.00**	/m^2

Remove Roadways

The contractor will have to remove approximately 1200 meters of 6 meter wide roadway.

Equipment				
	Removal		$3.00 /m^2	
		Total	$3.00 /m^2	
Labor				
	Removal		$2.00 /m^2	
		Total	$2.00 /m^2	
	Contractor's Markup		20.00%	
	Total Unit Costs w/ Markup Installation/Removal		$6.00 /m^2	**$6.00 /m^2**

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Pittsburgh District

Panama Canal Authority
Atlantic Locks
3rd Lane - Concept Design Study

COMPUTATION SHEET

Relocations - Temporary Utilities for Existing Gatun Locks
Double-Lift Concept

Price Level: Oct 02

Sheet 1 of 1

Filename: ____________
Tab: ____________

Computed By: RJB/CRC Date 3/14/2003
Checked By: PGB Date 3/26/2003

Relocations

Temporary Power Line

The contractor will build a single run (3500 m) Power Line to supply the existing locks with power during construction.

Materials, Equipment, and Labor		qty.	total cost
Utility Pole, 18.5m Pine Installed	$800.00 /ea	58	$46,400.00
Remove Utility Pole and Backfill	$175.00 /ea	58	$10,150.00
Electric Line Installed	$15.00 /m	3500	$52,500.00
Total			$109,050.00
Assume Salvagable	15% Salvage Value	Total	$92,692.50

Temporary Water Line 8cm

The contractor will build a single run (3500 m) water line to supply the existing locks with water during construction. Line will also be used for construction purposes.

Materials, Equipment, and Labor		qty.	total cost
Water Line, 8cm Dia. PVC	$115.00 /m	3500	$402,500.00

Temporary Telephone Line

The contractor will build a single run (3500 m) telephone line to supply the construction site with telephone communications. Line will also supply the construction site.

Materials, Equipment, and Labor		qty.	total cost
Fiber Optic Line Installed	$15.00 /m	3500	$52,500.00
		Total	$547,692.50

Contractor's Markup	20.00%
Total Unit Costs w/ Markup Installation/Removal	$657,231.00
Rounded Total	**$660,000.00**

Panama Canal Authority
Atlantic Locks
3rd Lane - Concept Design Study

COMPUTATION SHEET

Care and Diversion of Water - Sheet Piling
Double-Lift Concept

Price Level: Oct 02

Sheet 1 of 1

Filename: ___________
Tab: ___________

Computed By: RJB/CRC Date 3/14/2003
Checked By: PGB Date 3/26/2003

Care and Diversion of Water

Sheet Piling Installation

The sheet piling will be installed for temporary/permanent berm. Piling Cost based upon international steel pricing.

Temporary Berm		kg/m^2	$/kg	Unit Cost	
	PS 23 Sheet Piling	112.5	$0.60	$67.50	/m^2
	Installation / Removal	112.5	$0.30	$33.75	/m^2
	Salvage	112.5	-$0.15	-$16.88	/m^2
			Total	$84.38	/m^2
			Markup	20%	
			Rounded Total	**$100.00**	/m^2

Permanent Berm		kg/m^2	$/kg	Unit Cost	
	PS 23 Sheet Piling	112.5	$0.60	$67.50	/m^2
	Installation	112.5	$0.18	$20.25	/m^2
			Total	$87.75	/m^2
			Markup	20%	
			Total	$105.30	/m^2
			Rounded	**$105.00**	/m^2

Steel Prices

MEPS (International) Ltd. - Steel Industry and Market Analysis
Average World Steel Transaction Prices

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Pittsburgh District

Panama Canal Authority
Atlantic Locks
3rd Lane - Concept Design Study

COMPUTATION SHEET

Earthwork for Structures - Exploratory Drilling
Double-Lift Concept

Price Level: Oct 02

Sheet 1 of 1

Filename: _______
Tab: _______

Computed By: CRC Date 6/30/2003
Checked By: PGB Date 6/30/2003

Earthwork for Structures

Exploratory Drilling

The contractor will perform exploratory drilling prior to starting the excavation for the job. Assume 2 holes per monolith location. Approximately 300 monoliths, yielding 600 holes. Holes will consist of drilling without coring until 1.5 meter above the base of the foundation and 4 meters below the foundation depth. The holes will be sealed with cement upon completion of this task.

Item	Qty	Unit	Unit Cost	Total Cost	
Exploratory Drilling	600	holes	$2,000.00	$1,200,000.00	
			Markup	$120,000.00	10%
			Total	$1,320,000.00	
			Rounded Total	**$1,320,000.00**	

The cost per hole developed was based upon historic cost data from USACE projects factored for work in Panama.

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COMPUTATION SHEET

Earthwork for Structures - Overburden Excavation
Double-Lift Concept

Price Level: Oct 02

Sheet 1 of 2

Filename: ________
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Computed By: CRC Date 6/30/2003
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Earthwork for Structures

Overburden Excavation

Equipment

For the purpose of this estimate it was assumed that the contractor will use 2 CAT 5130B excavators with 10.5 m^3 buckets in combination with CAT 777D trucks. Production rate calculations to determine the # of trucks are included in the following sheets along with the cost estimate.

			Qty
Excavator	CAT 5130B	10.5 m^3 bucket	2
Trucks	CAT 777D	53.5 m^3 capacity	20

Production Rate 1585 lcm/hr

Equipment Rates		Location Factors	Factored Cost	
Excavator	$275.00 /hr	1	$275.00	/hr
Trucks	$125.00 /hr	1	$125.00	/hr
Dozer D-6 (2 @ $40)	$80.00 /hr	1	$80.00	/hr
Water Truck	$24.00 /hr	1	$24.00	/hr
Labor Rates (Higher rates used to account for operation of large equipment)				
Supervisor	$50.00 /hr	1	$50.00	/hr
Hvy Equip Oper	$10.00 /hr	1	$10.00	/hr
Truck Driver	$10.00 /hr	1	$10.00	/hr
Laborer (3 @$5.00	$15.00 /hr	1	$15.00	/hr
Dozer Oper (2 @ $9.40)	$18.80 /hr	1	$18.80	/hr
Truck Driver	$6.30 /hr	1	$6.30	/hr
Total cost per hour for crew consisting of 2 excavators, 20 trucks, and 3 laborers.			$3,464.10	/hr

Unit cost

$2.19 /lcm
$2.73 /bcm

Add for spreading material at the disposal area.	$0.35 /bm^3
Subtotal	$3.08 /bm^3
Contractor's Markup	20.00%
Total	$3.70 /bm^3
Rounded	**$3.75** /bm^3

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COMPUTATION SHEET

Earthwork for Structures - Overburden Excavation
Double-Lift Concept

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Earthwork for Structures - Overburden
Production Rate Calculations

5251117 BM^3

Conversion Factor	1.3074	cy/m^3
Load Factor	0.80	
Bucket Fill Factor	85%	
One way distance	6.0	km
Top speed loaded	61	kph

Equipment

Excavator	CAT 5130B	
Equip $/hr	275	
Labor $/hr	10	lcm
Qty	2	
Bucket Size	10.50	min
Efficiency	0.8	min
Cycle Time	0.45	
Min/hr	50	

Production Rate 1586.667 lcm/hr
Final

Truck	CAT 777D	
Capacity	53.5	lcm
Equip $/hr	125	
Labor $/hr	10	
Qty	20	
Loading Time	2.6975	min
Dumping Time	1.25	min
Manuevering	3.5	min
Cycle Time	32.932	min
Min/hr	50	

Production Rate 81.2284 lcm/hr per truck
Total 1624.568 lcm/hr

Rounded 1585 lcm/hr

Production Rate

1268	bm^3/hr	20 hrs per day
25360	bm^3/day	6 days per week
152160	bm^3/week	

US Army Corps of Engineers
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COMPUTATION SHEET

Earthwork for Structures - Rock Excavation
Double-Lift Concept

Price Level: Oct 02

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Earthwork for Structures

Rock Excavation

Equipment

For the purpose of this estimate it was assumed that that rock will be drilled and blasted. Unit cost for drilling and blasting based upon cost data furnished by ACP for past work in Panama. Loading and hauling cost developed in more detail based upon a 6 km one way haul distance.

Drilling and Blasting

ACP Cost	$2.17 /m^3
Local Contractor Rates	$1.85 /m^3
Use	$1.80 /m^3

Loading and Hauling			Qty
Excavator	CAT 5130B	10.5 m^3 bucket	2.00
Trucks	CAT 777D	53.5 m^3 capacity	15.00

Equipment Rates		Factor	Factored Cost	
Excavator	$275.00 /hr	1	$275.00	/hr
Truck	$125.00 /hr	1	$125.00	/hr
Dozer D-6 (2 @ $40)	$80.00 /hr	1	$80.00	/hr
Labor Rates (Higher rates used to account for operation of large equipment)				
Supervisor	$50.00 /hr	1	$50.00	/hr
Excavator Oper	$10.00 /hr	1	$10.00	/hr
Truck Driver	$10.00 /hr	1	$10.00	/hr
Laborer (3 @$5.00)	$15.00 /hr	1	$15.00	/hr
Dozer Operator (2@$9.40)	$18.80 /hr	1	$18.80	/hr
Total cost per hour for crew consisting of 2 excavators, 15 trucks, and 3 laborers.			$2,758.80	/hr
	Production Rate		1060	lcm/hr

Unit cost

$2.60 /lcm
$4.34 /bcm

Add for spreading material at the disposal area.	$0.35 /bm^3
Drilling and Blasting	$1.80 /bm^3
Subtotal	$6.49 /bm^3
Contractor's Markup	20.00%
Total	$7.79 /bm^3
Rounded	**$8.00** /bm^3

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COMPUTATION SHEET

Earthwork for Structures - Rock Excavation
Double-Lift Concept

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6/30/2003

Earthwork for Structures
Production Rate Calculations
Rock Excavation

6/30/2003

Conversion Factor	1.3074	cy/m^3
Load Factor	60%	
Bucket Fill Factor	70%	
One way distance	6.0	KM
Top speed loaded	61	Kph

Excavator		
5130B	$275.00	/hr
Operator	$10.00	/hr
Bucket Size	10.50	lcm
qty	2	
cycle time	0.5	min
min/hr	45	min
Efficiency	0.8	
Production	1058.4	lcm/hr
Limited Rate	1060	lcm/hr

Truck	CAT 777D	
Capacity	53.5	m^3
Equip $/hr	125	
Labor $/hr	10	
Qty	15	
Loading Time	3.639456	min
Dumping Time	1.25	min
Manuevering	3.5	min
Cycle Time	33.87381	min
Min/hr	45	
Production	71.07261	lcm per truck/hour
Total	1066.089	lcm/hr
Limited Rate	1060	lcm/hr

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COMPUTATION SHEET

Earthwork for Structures - Rock Excavation
Double-Lift Concept

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Earthwork for Structures
Production Rate Calculations
Rock Excavation - Disposal at Disposal Area

Production Rates

636 bm^3 / hr	
12720 bm^3 / day	20 hrs per day
76320 bm^3 / week	6 days per week

Removal of Berm Material

Item included under Care and Diversion of Water

Trucking + excavation		$4.34 /bcm
	Markup	20.00%
	Subtotal	$5.21
	Total	$5.25 /bm^3

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COMPUTATION SHEET

Earthwork for Structures - In The Wet Excavation
Double-Lift Concept

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Earthwork for Structures

In the Wet Excavation

The In-the Wet Excavation will be required for a portion of the upstream approach wall and the upstream approach channel.

The unit cost for Overburden In the Wet Excavation was taken from Harza's Evaluation of Lock Channel Alignments report (August 2000). The number being used was developed for Hydraulic Wet Excavation. This unit price can be found in Attachment A-1, pg 5 of the Harza report.

The unit cost for In the Wet Rock Excavation was furnished by the ACP.

Excavation Type	Daily Production m^3 / day	Daily Cost	Unit Cost	Rounded Updated Unit Cost (2002)
Overburden - Long Pump	25565	$152,574.00	$5.97	$6.50
Rock (Furnished by ACP)				$23.00

For the purpose of this estimate it was assumed that all of the rock could be excavated using a cutter suction dredge. There will be minimal blasting required.

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COMPUTATION SHEET

Earthwork for Structures - Foundation Preparation
Double-Lift Option

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Earthwork for Structures

Foundation Preparation

The contractor will be required to prepare the foundation rock prior to placement of concrete. This includes cleaning the rock, and filling and crack and voids with mortar/concrete. The unit cost for this work was developed from the average of bids associated with the Grays Landing Lock project (Feb 1990).

The following bid items were included in the unit cost preparation.

Bid Item	Qty	Unit	Unit Cost	Total Cost
Preliminary Cleanup	12380	SY	$16.00	$198,080.00
Final Cleanup	10800	SY	30.00	$324,000.00
Protective Coating for Rock Surfaces	109000	SF	0.75	$81,750.00
Temporary Earth Cover	10800	SY	10.00	$108,000.00
Dental Treatment, Mortar	20	CY	2,000.00	$40,000.00
Dental Treatment, Concrete	200	CY	600.00	$120,000.00

Total		$871,830.00	
Unit Cost		$70.42	/sy
Subtract Markup (22.5 %)		$57.49	/sy
ENR Inflation	1.40640342	$80.85	/sy
Panama Factor	0.65	$52.55	/sy
Contractor Markup	20.00%	$10.51	/sy
Total		$63.06	/sy
Total		$75.42	/m^2
Rounded Total		**$75.00**	**/m^2**

Panama Factor - This work is very labor intensive. Local laborers will be used.
Conversion Factor 1.196 sy/m2

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COMPUTATION SHEET

Earthwork for Structures - Structural Backfill
Double-Lift Concept

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Earthwork for Structures

Structural Backfill

Description

Labor

		Qty	$/hr	Total $/hr
	Supervisor	1	$50.00	$50.00
	Dozer Operator	2	$9.40	$18.80
	Loader Operator	1	$8.40	$8.40
	Truck Driver	5	$7.30	$36.50
	Laborer	2	$5.00	$10.00
			Total	$123.70
Equipment				
	D-6 Dozer	2	$40.00	$80.00
	Loader 4 m^3 articulated	1	$60.00	$60.00
	23 tonne Trucks	5	$31.00	$155.00
			Total	$295.00

Production Rate	250	m^3/hr	
Labor/Equipment			$1.67 /m^3
Material			$13.13 /m^3
Subtotal			$14.80 /m^3
Contractor's Markup			20.00%

Total Unit Costs w/ Markup Structural Backfill	$17.76 /m^3	**$18.00 /m^3**

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COMPUTATION SHEET

Earthwork for Structures - Structural Backfill
Double-Lift Concept

Price Level: Oct 02

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Earthwork for Structures

Structural Backfill

Backfill Material

Material From Pacific Excavation (Approximate Cost to Process Rock)		$4.00 /ton
Rail Freight		$3.00 /ton
Unload and stockpile		$0.50 /ton
	Total	$7.50 /ton
Tons to cubic meters	1.75	$13.13 /m^3

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COMPUTATION SHEET

Sitework - Fencing / Gates/Seeding
Double-Lift Option

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Sitework

Fencing Chain Link Industrial

The contractor will place chain link fence around the parking lots. Unit price based upon bids received for the cut widening program.

	Unit	Unit Cost	
Fencing	LM	$75.00	
Security Gates (Electrically Operated)		$15,000.00	/ea

Seeding Assume that seeding will be performed by a local contractor.

Seeding

	Unit	Unit Cost	
Unit Cost	MSM	$150.00	
Subcontractor's Markup		18.0%	
Subtotal		$177.00	
Prime Contractor's Markup		10.00%	
Total		$194.70	
Rounded		**$200.00**	/MSM

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COMPUTATION SHEET

Sitework - Parking Lots
Double-Lift Concept

Price Level: Oct 02

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Sitework
Parking Lots 60m x 25m per lot, 100 spaces each, 2 lots total

The contractor will build two parking lots adjacent to the new lock. The unit cost is based on an aggregate base with a bituminous surface course. Parking lot lines and concrete parking barriers are also included in the unit price. The unit prices used for the base and surface courses are based upon bid results from the cut widening program.

	Unit	Unit Cost	
Graded Crushed Aggregate	m^2	$6.00	
Bituminous Paving	m^2	$8.00	
Subtotal	m^2	$14.00	
Painting Stalls (100 stalls per lot: 1486 m^:	Stall	$6.00	
	m^2	$0.40	
Concrete Parking Bars	Stall	$45.00	
	m^2	$3.03	
Total		$17.43	/m^2
Rounded Total		**$17.50**	/m^2

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COMPUTATION SHEET

Sitework - Concrete Roads
Double-Lift Concept

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Sitework
Concrete Roads 7.5m roadway width.

The contractor will build various access roadways to the lock facility. The unit cost was based upon a 30 cm crushed stone base, and 30 cm thick reinforced concrete pavement. Unit price developed using RS Means while factoring in the lower cost of labor, materials and equipment in Panama.

Crushed Stone Base 30cm Deep

	Unit	Unit Cost	
Materials	m^2	$12.00	
Labor/Equipment	m^2	$1.20	
Equipment	m^2	$0.00	
Unit Cost Subtotal		$13.20	/m^2

Concrete Pavement

	Unit	Unit Cost	
Materials	m^2	$30.00	
Labor/Equipment	m^2	$2.25	
Equipment	m^2	$0.00	
Unit Cost Subtotal		$32.25	/m^2

Reinforcing Steel	$3.00	/m^2
Total Unit Cost	$48.45	/m^2
Contractor's Markup	20.0%	
Total	**$58.14**	/m^2
Rounded	**$60.00**	/m^2

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COMPUTATION SHEET

Sitework - Storm Drainage
Double-Lift Concept

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Sitework
Storm Drainage 15cm Perforated PVC

The contractor will place a 15cm diameter perforated PVC pipe adjacent to the back side of the lock walls and on the perimeter of the Water Savings Basins. Unit price developed using RS Means.

Excavate Trench/Backfill (0.6m x 0.6m)

	Unit	Unit Cost	
Labor/Equipment	m	$3.15	

Perforated PVC

	Unit	Unit Cost	
Materials	m	$9.00	
Labor	m	$9.00	
Unit Cost Subtotal		$18.00	m

Gravel Fill

	Unit	Unit Cost	
Materials	m	$3.50	
Labor	m	$1.00	
Unit Cost Subtotal		$4.50	/m

Total Unit Cost	$25.65	/m
Contractor's Markup	20.0%	
Total	**$30.78**	/m
Rounded	**$31.00**	/m

COMPUTATION SHEET

Entrance Walls - Soil Excavation (Caissons)
Double-Lift Option

Price Level: Oct 02

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Soil Excavation inside Caissons

Caissons	69	
Diam	2.44 meters	
Soil Depth	6 meters	Assumed depth of soil over rock
Volume	1930 m^3	

Production Rate 3 m^3/hr

CREW

LABOR	Qty	$/hr	Total $/hr
Supervisor	1	$50.00	$50.00
Towboat Operator	1	$25.00	$25.00
Deckhand	3	$6.00	$18.00
Crane Operator (floating)	1	$25.00	$25.00
Oiler	2	$7.00	$14.00
Drill Operator	1	$12.50	$12.50
Laborer	2	$7.50	$15.00
Pump Operatpr	1	$7.50	$7.50
EQUIPMENT			
Floating Crane	1	$200.00	$200.00
Tug Boat	1	$100.00	$100.00
Barges	2	$20.00	$40.00
Work Float	1	$3.50	$3.50
Drill Auger, Hyd	1	$65.00	$65.00
Pump, Submersible	1	$2.50	$2.50
Small Tools	4	$1.50	$6.00

Crew Total		$584.00 /hr
Subs Markup	20%	$700.80 /hr
Primes Markup	10%	$770.88 /hr
Rounded Unit Cost		$257.00 /m^3
Disposal Cost		$2.00 /m^3
Total		$259.00 /m^3

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COMPUTATION SHEET

Entrance Walls - Rock Excavation (Caissons)
Double-Lift Option

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Rock Excavation inside Caissons

Caissons	69
Diam	2.44 meters
Rock Depth	11 meters
Volume	3550 m^3

Production Rate 1 m^3/hr

CREW			
LABOR	Qty	$/hr	Total $/hr
Supervisor	1	$50.00	$50.00
Towboat Operator	1	$25.00	$25.00
Deckhand	3	$6.00	$18.00
Crane Operator (floating)	1	$25.00	$25.00
Oiler	2	$7.00	$14.00
Drill Operator	1	$12.50	$12.50
Laborer	2	$7.50	$15.00
Pump Operatpr	1	$7.50	$7.50
EQUIPMENT			
Floating Crane	1	$200.00	$200.00
Tug Boat	1	$100.00	$100.00
Barges	2	$20.00	$40.00
Work Float	1	$3.50	$3.50
Drill Auger, Hyd	1	$65.00	$65.00
Pump, Submersible	1	$2.50	$2.50
Small Tools	4	$1.50	$6.00

Crew Total		$584.00 /hr
Subs Markup	20%	$700.80 /hr
Primes Markup	10%	$770.88 /hr
Rounded Unit Cost		$771.00 /m^3
Disposal Cost		$2.00 /m^3
Total		$773.00 /m^3

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COMPUTATION SHEET

Entrance Walls - Steel Casings
Double-Lift Option

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Caissons Steel Casing (Including Driving)

Caissons	69		
Diam	2.44 meters		
Length	40 meters/each	Total Length	2760 meters
Weight	120 tonnes/each		

Production Rate 1 m/hr

CREW

LABOR	Qty	$/hr	Total $/hr
Supervisor	1	$50.00	$50.00
Towboat Operator	1	$25.00	$25.00
Deckhand	3	$6.00	$18.00
Crane Operator (floating)	1	$25.00	$25.00
Oiler	2	$7.00	$14.00
Pile Driverman	1	$12.50	$12.50
Laborer	2	$7.50	$15.00
Pileman	1	$10.00	$10.00
EQUIPMENT			
Floating Crane	2	$200.00	$400.00
Tug Boat	1	$100.00	$100.00
Barges	2	$20.00	$40.00
Work Float	1	$3.50	$3.50
Pile Hammer, VIB	1	$75.00	$75.00
Leads	1	$10.00	$10.00
Small Tools	4	$1.50	$6.00
		Crew Total	$804.00 /hr
	Subs Markup	20%	$964.80 /hr
	Primes Markup	10%	$1,061.28 /hr
		Rounded Unit Cost	$1,060.00 /m

	Qty	$/tonne	Total
Pile Cost (w/ 10% spoil)	9108	$400.00	$3,643,200.00
			$1,320.00 /m
	Subs Markup	20%	$1,584.00 /m
	Primes Markup	10%	$1,742.40 /m
		Rounded Unit Cost	$1,742.00 /m

Total $2,802.00 /m

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COMPUTATION SHEET

Entrance Walls - Steel Casings
Double+Lift Option

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Caissons Steel Casing (Including Driving)
Continued

Caissons	69		
Diam	2.44 meters		
Length	40 meters/each	Total Length	2760 meters
Weight	120 tonnes/each		

Remove Excess Casing		$2,500	/caisson
Prep Caissons		$1,000.00	/caisson
Drilling Template		$150,000.00	lump sum
Total		$391,500.00	
Subs Markup	20%	$469,800.00	
Primes Markup	10%	$516,780.00	
Unit Cost		$187.24	/m

Total Cost to furnish and Install Caissons $2,990.00 /m

Reinforcing Steel Use previously developed unit price $0.90 /kg

Tremie Concrete Cost based on other concrete costs developed for this estimate.
$150 /m^3

Testing/Monitoring Caissons $25,000.00 /ea

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COMPUTATION SHEET

Entrance Walls - Concrete Cap Wall
Double-Lift Option

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Concrete Cap Wall

	$/m^3
Batch Plant Cost	$6.73
Mix Cost	$31.24
Transport Cost	$7.50
Placement Cost	$38.86
Formcost	$186.36
Cleaning Lifts / Curing / Finishing / Misc	$5.35
Subtotal	$276.03
Total With Markup	$331.00

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COMPUTATION SHEET

Entrance Walls - Concrete Cap Wall
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Forming Quantities

	Wall Height	Base Width	Length	Monolith Joints	Lifts
Dimensions	5	11.8	430	29	2
	5	22.5	131	9	2
	5	17.15	46	3	2

Bottom Surface Area	8810.4	smca
Walls Surface Area (Front and Back)	6070	smca
Walls, Side Forms	2980.75	smca
Forming Total	17861.15	smca
Finishing	14880.4	m^2
Curing	26671.55	m^2
Surface Prep	8810.4	m^2

COMPUTATION SHEET

Entrance Walls - Concrete Cap Wall
Double-Lift Option

Price Level: Oct 02

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Computed By: CRC Date 3/28/2003
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Concrete Cap Wall CIP 43,250 m^3
Placement Cost

Installation Backup Production Rate 20 m^3/hr

Labor	$/mh	Qty	Total $/hr
Supervisor/Foreman	$50.00	1	$50.00
Tug Operator	$25.00	2	$50.00
Crane Operator	$25.00	1	$25.00
Deckhand	$6.00	3	$18.00
Oiler	$7.00	2	$14.00
Cement Finisher	$8.00	4	$32.00
Cement Finisher	$7.50	2	$15.00
Laborer	$7.50	2	$15.00
Laborer	$7.50	12	$90.00
		Subtotal	$309.00
Equipment			
Floating Crane	$200.00	1	$200.00
Tug Boat	$100.00	2	$200.00
Work Float	$3.50	4	$14.00
Bucket Concrete	$3.00	2	$6.00
Air Comp 250 CFM	$9.00	3	$27.00
Air Hose	$0.50	6	$3.00
Conc Vibrator	$2.00	6	$12.00
Small Tools	2.00%		$6.18
		Subtotal	$468.18
		Total	$777.18
		Unit Cost	$38.86

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COMPUTATION SHEET

Entrance Walls - Concrete Cap Wall
Double-Lift Option

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Computed By: CRC Date 3/28/2003
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Quantity 17,861 m^2
Forming Cost

CIP 43,250 m^3
Production 2 m^2 / hr

Labor	$/mh	Qty	Total $/hr
Supervisor/Foreman	$50.00	1	$50.00
Crane Operator (Floating)	$25.00	1	$25.00
Tugboat Operator	$25.00	1	$25.00
Formworker	$8.00	7	$56.00
Formworker helper	$7.00	3	$21.00
Carpenter	$8.00	3	$24.00
Oiler	$7.00	2	$14.00
Laborer	$7.50	2	$15.00
		Subtotal	$230.00
Equipment			
Floating Crane	$200.00	1	$200.00
Tug Boat	$100.00	1	$100.00
Power Tools	$5.00	4	$20.00
Work Float	$3.50	3	$10.50
Small Tools	$1.50	4	$6.00
		Subtotal	$336.50
		Total	$566.50 / hr
			$283.25 / m^2

Formwork Cost
Assume 3 uses + 10% waste for walls and 1 use for the floor forms.

Wall Forms	3318.6083 m^2	$85.00 /m^2	$282,081.71
Floor Forms	9691.44 m^2	$275.00 /m^2	$2,665,146.00
Scaffolding/Man lifts		$3.00 /m^2	$53,583.45
			$3,000,811.16
			$168.01 /m^2
		Total	$451.26 /m^2
		Total	$186.36 /m^3
Finishing	14,880.40	$6.00 /m^2	$89,282.40
			$2.06 /m^3
Curing	26,671.55	$4.00 /m^2	$106,686.20
			$2.47 /m^3
Surface Prep	8,810.40	$4.00 /m^2	$35,241.60
			$0.81 /m^3

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COMPUTATION SHEET

Entrance Walls - Sheet Pile Cut-off Wall
Double-Lift Option

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Steel Sheet Piling

Assume PZ 40 Piling will be used.

Depth	40	meters
Width	617	meters
	24680	m^2

	kg/m^2	$/kg	Unit Cost	
PZ40 w/connections	195.6	$0.80	$156.48	/m^2
Installation	195.6	$0.40	$78.24	/m^2
		Total	$234.72	/m^2
		Subcontractor's Markup	20%	
		Rounded Total	$280.00	/m^2
		Prime Contractor's Markup	10.00%	
		Rounded Total	$310.00	/m^2

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COMPUTATION SHEET

Entrance Walls - Fender System
Double-Lift Option

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Fender System

Quotes from Fentek Americas and Metso Minerals Trellex Fender

Metso/Trellex MV1450x1000A Fender Systems

Qty	U/C	Total
112.00	$36,800.00	$4,121,600.00

Fentek Americas Wheel Fender Elements

Qty	U/C	Total
54.00	$80,000.00	$4,320,000.00

Total	$8,441,600.00
Delivery to Panama	10%
Subtotal	$9,285,760.00
Prime's Markup	10%
Subtotal	$10,214,000.00
Installation	$1,272,000.00
Rounded Total	$11,500,000.00

Installation	$1,060.00	/hr	Crew cost with markkups (from caisson installation)
Installation Time	1200	hours	
Installation Total	$1,272,000.00		

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Atlantic Locks
3rd Lane - Concept Design Study

COMPUTATION SHEET

Summary of Concrete Costs - Interlaced Bottom Lateral
Double-Lift Concept

Price Level: Oct 02

Sheet 1 of 3

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Computed By: CRC Date 6/30/2003

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Roller Compacted Concrete

Lock Walls		Quantity	773889 m^3
		$/m^3	
	Batch Plant Cost	$6.73	
	Mix Cost	$22.45	
	Transport Cost	$5.00	
	Placement Cost	$1.89	
	Formcost	$10.34	
	Cleaning Lifts / Curing / Finishing / Misc	$3.00	
	Subtotal	$49.41	
	Total With Markup	$59.00	

Gate Monoliths		Quantity	219044 m^3
		$/m^3	
	Batch Plant Cost	$6.73	
	Mix Cost	$22.45	
	Transport Cost	$5.00	
	Placement Cost	$1.80	
	Formcost	$3.33	
	Cleaning Lifts / Curing / Finishing / Misc	$3.00	
	Subtotal	$42.31	
	Total With Markup	$51.00	

Approach Walls		Quantity	467438 m^3
		$/m^3	
	Batch Plant Cost	$6.73	
	Mix Cost	$22.45	
	Transport Cost	$5.00	
	Placement Cost	$2.15	
	Formcost	$14.48	
	Cleaning Lifts / Curing /	$3.00	
	Subtotal	$53.81	
	Total With Markup	$65.00	

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3rd Lane - Concept Design Study

COMPUTATION SHEET

Summary of Concrete Costs - Interlaced Bottom Lateral
Double-Lift Concept

Price Level: Oct 02

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Computed By: CRC Date 6/30/2003
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Floor		Quantity	123144 m^3
		$/m^3	
	Batch Plant Cost	$6.73	
	Mix Cost	$22.45	
	Transport Cost	$5.00	
	Placement Cost	$1.49	
	Formcost	$0.00	
	Cleaning Lifts / Curing /	$3.00	
	Subtotal	$38.67	
	Total With Markup	$46.00	
CAST IN PLACE Monolith Concrete		Quantity	541971 m^3
		$/m^3	
	Batch Plant Cost	$6.73	
	Mix Cost	$25.82	
	Transport Cost	$5.00	
	Placement Cost	$12.45	
	Formcost	$51.98	
	Cleaning Lifts / Curing / Finishing / Misc	$4.11	
	Subtotal	$106.09	
	Total With Markup	$127.00	
Miter Gate Bays		Quantity	268148 m^3
		$/m^3	
	Batch Plant Cost	$6.73	
	Mix Cost	$25.82	
	Transport Cost	$5.00	
	Placement Cost	$12.08	
	Formcost	$38.42	
	Cleaning Lifts / Curing / Finishing / Misc	$4.00	
	Subtotal	$92.05	
	Total With Markup	$110.00	

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COMPUTATION SHEET

Summary of Concrete Costs - Interlaced Bottom Lateral
Double-Lift Concept

Price Level: Oct 02

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Computed By: CRC Date 6/30/2003

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Approach Wall CIP		Quantity	24602 m^3
		$/m^3	
	Batch Plant Cost	$6.73	
	Mix Cost	$25.82	
	Transport Cost	$5.00	
	Placement Cost	$16.10	
	Formcost	$0.00	
	Cleaning Lifts / Curing / Finishing / Misc	$23.43	
	Subtotal	$77.09	
	Total With Markup	$93.00	

Floor Concrete		Quantity	41270 m^3
		$/m^3	
	Batch Plant Cost	$6.73	
	Mix Cost	$23.12	
	Transport Cost	$5.00	
	Placement Cost	$13.80	
	Formcost	$110.81	
	Cleaning Lifts / Curing /	$5.82	
	Subtotal	$165.28	
	Total With Markup	$198.00	

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COMPUTATION SHEET

Batch Plant Cost - Interlaced Bottom Lateral
Double-Lift Concept

Price Level: Oct 02

Sheet 1 of 2

Filename: ______		Computed By:	CRC	Date	6/30/2003
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Batch Plants

Cost of Batch Plant Delivered to Panama (Includes cost of Ice Plant)	$1,500,000
Spare Parts	$150,000
Set-up cost	$200,000
Total Cost	$1,850,000
Number of batch plants required	3
Total	$5,550,000
Concrete Quantity	2600000 m3
Unit Cost	$2.13 / m3

Cost to Run Batch Plant

Labor	$/mh	Qty	Total $/hr
Supervisor/Foreman	$50.00	1	$50.00
Technician	$45.00	2	$90.00
Laborer	$5.00	3	$15.00
Mechanic	$8.40	2	$16.80
Equipment Operator	$8.40	2	$16.80
			$188.60 /hr

Allow Operating Staff to be on site for 3.0 years

Approximately 18,720 hrs

Total	$3,530,592 / Plant
Total	$10,591,776
Unit Cost	$4.07 / m3

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COMPUTATION SHEET

Batch Plant Cost - Interlaced Bottom Lateral
Double-Lift Concept

Price Level: Oct 02
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Batch Plant continued

Yearly Maintenance Allowance per plant		$100,000.00
	Total	$300,000.00 /Plant
	Total	$900,000.00
	Unit Cost	$0.35 / m3
Yearly Power Consumption		$50,000 /Plant
	Total	$150,000.00 /Plant
	Total	$450,000.00
	Unit Cost	$0.17 / m3
Total Unit Cost of Batch Plants		$6.73 / m3

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3rd Lane - Concept Design Study

COMPUTATION SHEET

Concrete Delivery System - Interlaced Bottom Lateral
Double-Lift Concept

Price Level: Oct 02

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Computed By: CRC Date 6/30/2003

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Concrete Delivery System

Cost based upon data furnished by ROTEC.

	Qty	Purchase Cost	Total Cost
Creter Crane	3	$1,600,000.00	$4,800,000.00
Auger Max	3	$160,700.00	$482,100.00
Big Dog (Concrete Hauler)	15	$200,000.00	$3,000,000.00
		Total	$8,282,100.00

Assume that salvage value of machinery after 3 years is equal to the cost of 3 years of O&M

Concrete Quantity 2600000 m3

Unit Cost $3.19 / m3

Cost to Run Batch Plant

Labor	$/mh	Qty	Total $/hr
Supervisor/Foreman	$50.00	1	$50.00
Laborer	$5.00	3	$15.00
Mechanic	$8.40	2	$16.80
Equipment Operator	$8.40	6	$50.40
Truck Driver	$7.30	15	$109.50
			$241.70 /hr

Allow Operating Staff to be on site for 3.0 years

Approximately 18,720 hrs

Total $4,524,624

Unit Cost $1.74 / m3

Total Unit Cost $4.93 /m^3

Rounded Unit Cost $5.00 /m^3

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COMPUTATION SHEET

Roller Compacted Concrete - Concrete Mix Cost
Double-Lift Concept

Price Level: Oct 02

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Computed By: CRC Date 6/30/2003

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RCC Mix Cost

Design	Cement	140	kg/m^3
	Pozzolan	40	kg/m^3
	Sand	865	kg/m^3
	Aggregate	1285	kg/m^3

Mixes are for cost proposes only

Cement

$60.00 /tonne	$25/t (Thailand) + $35/t (Shipping Cost)
$3.00 /tonne	Delivery Cost
$63.00 /tonne	

Quantity of cement per cubic meter of concrete	0.14 tonne
Cost per cubic meter of concrete	$8.82 /m^3

Sand

$7.00 /m^3	Delivered to site
1.5 tonnes/m^3 (Sand weight)	
$4.67 / tonne	

Quantity of Sand per cubic meter of concrete	0.865 tonne
Cost per cubic meter of concrete	$4.04 /m^3

Aggregate

$7.00 / tonne	See aggregate cost backup sheet

Quantity of Aggregate per cubic meter of concrete	1.285 tonne
Cost per cubic meter of concrete	$9.00 /m^3

Pozzolan

$15.00 /tonne	Delivered to site

Quantity of Pozzolan per cubic meter of concrete	0.04 tonne
Cost per cubic meter of concrete	$0.60 /m^3
Total	$22.45 /m^3

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COMPUTATION SHEET

Conventional CIP - Concrete Mix Cost
Double-Lift Concept

Price Level: Oct 02

Sheet 2 of 5

Filename: ________
Tab: ________

Computed By: CRC Date 6/30/2003
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Lock Walls/Miter Gate CIP

Design	Cement	180 kg/m^3
	Pozzolan	40 kg/m^3
	Sand	650 kg/m^3
	Aggregate	1550 kg/m^3

Mixes are for cost proposes only

Cement

$60.00	/tonne	$25/t (Thailand) + $35/t (Shipping Cost)
$3.00	/tonne	Delivery Cost
$63.00	/tonne	

Quantity of cement per cubic meter of concrete	0.18 tonne
Cost per cubic meter of concrete	$11.34 /m^3

Sand

$7.00	/m^3	Delivered to site
1.5	tonnes/m^3 (Sand weight)	
$4.67	/ tonne	

Quantity of Sand per cubic meter of concrete	0.65 tonne
Cost per cubic meter of concrete	$3.03 /m^3

Aggregate

$7.00	/ tonne	See aggregate cost backup sheet

Quantity of Aggregate per cubic meter of concrete	1.55 tonne
Cost per cubic meter of concrete	$10.85 /m^3

Pozzolan

$15.00	/tonne	Delivered to site

Quantity of Pozzolan per cubic meter of concrete	0.04 tonne
Cost per cubic meter of concrete	$0.60 /m^3
Total	$25.82 /m^3

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COMPUTATION SHEET

Conventional CIP - Concrete Mix Cost
Double-Lift Concept

Price Level: Oct 02

Sheet 3 of 5

Filename: ________
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Computed By:	CRC	Date	6/30/2003
Checked By:	PGB	Date	6/30/2003

Chamber Floor

Design	Cement	205	kg/m^3
	Pozzolan	35	kg/m^3
	Sand	500	kg/m^3
	Aggregate	1050	kg/m^3

Mixes are for cost proposes only

Cement

$60.00	/tonne	$25/t (Thailand) + $35/t (Shipping Cost)
$3.00	/tonne	Delivery Cost
$63.00	/tonne	

Quantity of cement per cubic meter of concrete	0.205	tonne
Cost per cubic meter of concrete	$12.92	/m^3

Sand

$7.00	/m^3	Delivered to site
1.5	tonnes/m^3 (Sand weight)	
$4.67	/ tonne	

Quantity of Sand per cubic meter of concrete	0.5	tonne
Cost per cubic meter of concrete	$2.33	/m^3

Aggregate

$7.00 / tonne See aggregate cost backup sheet

Quantity of Aggregate per cubic meter of concrete	1.05	tonne
Cost per cubic meter of concrete	$7.35	/m^3

Pozzolan

$15.00 /tonne Delivered to site

Quantity of Pozzolan per cubic meter of concrete	0.035	tonne
Cost per cubic meter of concrete	$0.53	/m^3
Total	$23.12	/m^3

Panama Canal Authority
Atlantic Locks
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COMPUTATION SHEET

Tremie Concrete - Concrete Mix Cost
Double-Lift Concept

Price Level: Oct 02

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Computed By: CRC Date 6/30/2003
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Tremie Mix

Design	Cement	200	kg/m^3
	Pozzolan	190	kg/m^3
	Sand	745	kg/m^3
	Aggregate	890	kg/m^3

Mixes are for cost proposes only

Cement

$60.00 /tonne	$25/t (Thailand) + $35/t (Shipping Cost)
$3.00 /tonne	Delivery Cost
$63.00 /tonne	

Quantity of cement per cubic meter of concrete	0.2 tonne
Cost per cubic meter of concrete	$12.60 /m^3

Sand

$7.00 /m^3	Delivered to site
1.5 tonnes/m^3 (Sand weight)	
$4.67 / tonne	

Quantity of Sand per cubic meter of concrete	0.745 tonne
Cost per cubic meter of concrete	$3.48 /m^3

Aggregate

$7.00 / tonne See aggregate cost backup sheet

Quantity of Aggregate per cubic meter of concrete	0.89 tonne
Cost per cubic meter of concrete	$6.23 /m^3

Pozzolan

$15.00 /tonne Delivered to site

Quantity of Pozzolan per cubic meter of concrete	0.19 tonne
Cost per cubic meter of concrete	$2.85 /m^3
Total	$25.16 /m^3

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COMPUTATION SHEET

Aggregate Cost Backup -Concrete Mix Cost
Double-Lift Concept

Price Level: Oct 02

Sheet 5 of 5

Filename: ________
Tab: ________

Computed By: CRC Date 6/30/2003
Checked By: PGB Date 6/30/2003

Aggregate Cost
Source: Pacific Lock excavation

	Unit Cost	Qtu	Unit	Total
Rock Crusher	$550,000.00	2	Each	$1,100,000.00
Conveyors	$300,000.00	1	LS	$300,000.00
Screening Plant	$150,000.00	3	Each	$450,000.00
			Total	$1,850,000.00
			Delivery	$185,000.00
			Total	$2,035,000.00
Setup				$150,000.00
Operation cost (Allow $1,000,000/year for three years)				$3,000,000.00
Maintenance Cost (Allow $200,000/year for three years)				$600,000.00
			Total	$5,785,000.00

Delivery of Aggregate (to Gatun by Rail, $/m^3 furnished by ACP) $3.00 /tonne

	U/C	Qty	Unit		
Grading/Ballast	$125,000.00	10	km	$1,250,000.00	
Track/Switches/Misc	$3,500,000.00	1	LS	$3,500,000.00	(ACP furnished cost)
Railroad Bridge Repairs	$2,500,000.00	1	LS	$2,500,000.00	

Option 1 aggregate required 3372000 tonne

Unit Costs	Plant	$1.72	/tonne
	Delivery	$3.00	/tonne
	Railwork	$2.15	/tonne
	Total	$6.87	/tonne
	Rounded Total	$7.00	/tonne

Note: The cost of drilling, blasting and excavating the rock is not included with this estimate. It should be included with the Pacific Lock estimate. Also, the cost for the railroad bridge repairs should be updated, as no information was available at the time of this estimate.

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COMPUTATION SHEET

RCC Placement/Forming Costs - Interlaced Bottom Lateral
Double-Lift Concept

Price Level: Oct 02

Sheet 1 of 7

Filename: ________
Tab: ________

Computed By: CRC Date 6/30/2003
Checked By: PGB Date 6/30/2003

Roller Compacted Concrete
Chamber Monolith Construction RCC 773,889 m^3
Placement Cost

Installation Backup Production Rate 233 m^3/hr

Labor	$/mh	Qty	Total $/hr
Supervisor/Foreman	$50.00	1	$50.00
Dozer Operator	$8.40	2	$16.80
Roller Operator	$8.40	2	$16.80
Truck Driver	$6.50	1	$6.50
Backhoe Operator	$8.40	1	$8.40
Equipment Operator	$8.40	1	$8.40
Concrete Worker	$5.00	4	$20.00
Laborer	$5.00	3	$15.00
Oiler	$5.00	2	$10.00
		Subtotal	$151.90
Equipment			
Dozer D-5	$25.00	1	$25.00
Dozer D-3	$20.00	1	$20.00
Vibratory Roller 10T	$35.00	1	$35.00
Vibratory Roller 2.7T	$12.00	1	$12.00
Truck Hwy 43k GVW	$20.00	1	$20.00
Water Tank (3000 Gal)	$4.00	1	$4.00
Truck F250	$7.00	1	$7.00
Hyd Excavator	$32.00	1	$32.00
Water Jet	$1.50	3	$4.50
Tampers	$2.00	3	$6.00
Small Tools	2.00%		$3.04
		Subtotal	$168.54
		Total	$320.44

	U/P	Qty	Cost
Joint Metal (m^2)	$10.00	40,110.00	$401,100.00
			$0.52 /m3
		Unit Cost	$1.89 / m3

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COMPUTATION SHEET

RCC Placement/Forming Costs - Interlaced Bottom Lateral
Double-Lift Concept

Price Level: Oct 02

Sheet 2 of 7

Filename: ________
Tab: ________

Computed By:	CRC	Date	6/30/2003
Checked By:	PGB	Date	6/30/2003

Chamber Monolith Construction

Quantity	104,100 m^2	RCC	773,889 m^3
Forming Cost		Production	6 m^2 / hr

Labor	$/mh	Qty	Total $/hr
Supervisor/Foreman	$50.00	1	$50.00
Crane Operator	$6.90	2	$13.80
Formworker	$5.60	6	$33.60
Formworker helper	$4.90	3	$14.70
Carpenter	$6.10	2	$12.20
Oiler	$5.00	1	$5.00
Laborer	$5.00	2	$10.00
		Subtotal	$139.30
Equipment			
75 Ton Crane	$85.00	2	$170.00
Small Tools	2.00%		$2.79
Power Tools	$5.00	4	$20.00
		Subtotal	$192.79
		Total	$332.09 / hr
			$55.35 / m^2

Formwork Cost
Slipforming (steel forms, 10% waste)

114510 m^2	$15.00 /m^2	$1,717,650.00
Scaffolding	$5.00 /m^2	$520,500.00
		$2,238,150.00
		$21.50 /m^2

Total	$76.85 /m^2
Total	$10.34 /m^3

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Panama Canal Authority
Atlantic Locks
3rd Lane - Concept Design Study

COMPUTATION SHEET

RCC Placement/Forming Costs - Interlaced Bottom Lateral
Double-Lift Concept

Price Level: Oct 02

Sheet 3 of 7

Filename: ________

Tab: ________

Computed By: CRC Date 6/30/2003

Checked By: PGB Date 6/30/2003

Gate Monolith Construction

RCC 219,044 m^3

Placement Cost

Installation Backup

Production Rate 233 m^3/hr

Labor	$/mh	Qty	Total $/hr
Supervisor/Foreman	$50.00	1	$50.00
Dozer Operator	$8.40	2	$16.80
Roller Operator	$8.40	2	$16.80
Truck Driver	$6.50	1	$6.50
Backhoe Operator	$8.40	1	$8.40
Equipment Operator	$8.40	1	$8.40
Concrete Worker	$5.00	4	$20.00
Laborer	$5.00	3	$15.00
Oiler	$5.00	2	$10.00
		Subtotal	$151.90
Equipment			
Dozer D-5	$25.00	1	$25.00
Dozer D-3	$20.00	1	$20.00
Vibratory Roller 10T	$35.00	1	$35.00
Vibratory Roller 2.7T	$12.00	1	$12.00
Truck Hwy 43k GVW	$20.00	1	$20.00
Water Tank (3000 Gal)	$4.00	1	$4.00
Truck F250	$7.00	1	$7.00
Hyd Excavator	$32.00	1	$32.00
Water Jet	$1.50	3	$4.50
Tampers	$2.00	3	$6.00
Small Tools	2.00%		$3.04
		Subtotal	$168.54
		Total	$320.44

	U/P	Qty	Cost
Joint Metal (m^2)	$10.00	9,210.00	$92,100.00
			$0.42 /m3
		Unit Cost	$1.80 / m3

US Army Corps
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3rd Lane - Concept Design Study

COMPUTATION SHEET

RCC Placement/Forming Costs - Interlaced Bottom Lateral
Double-Lift Concept

Price Level: Oct 02

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Filename: ________
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Computed By: CRC Date 6/30/2003
Checked By: PGB Date 6/30/2003

Gate Monolith Construction

Quantity	9,500 m^2	RCC	219,044 m^3
Forming Cost		Production	6 m^2 / hr

Labor	$/mh	Qty	Total $/hr
Supervisor/Foreman	$50.00	1	$50.00
Crane Operator	$6.90	2	$13.80
Formworker	$5.60	6	$33.60
Formworker helper	$4.90	3	$14.70
Carpenter	$6.10	2	$12.20
Oiler	$5.00	1	$5.00
Laborer	$5.00	2	$10.00
		Subtotal	$139.30
Equipment			
75 Ton Crane	$85.00	2	$170.00
Small Tools	2.00%		$2.79
Power Tools	$5.00	4	$20.00
		Subtotal	$192.79
		Total	$332.09 / hr
			$55.35 / m^2

Formwork Cost			
Slipforming (steel forms, 10% waste)			
10450 m^2	$15.00 /m^2		$156,750.00
Scaffolding	$5.00 /m^2		$47,500.00
			$204,250.00
			$21.50 /m^2
		Total	$76.85 /m^2
		Total	$3.33 /m^3

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3rd Lane - Concept Design Study

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RCC Placement/Forming Costs - Interlaced Bottom Lateral
Double-Lift Concept

Price Level: Oct 02

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Computed By: CRC Date 6/30/2003
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Approach Wall Construction

RCC 467,438 m^3

Placement Cost

Installation Backup

Production Rate 267 m^3/hr

Labor	$/mh	Qty	Total $/hr
Supervisor/Foreman	$50.00	1	$50.00
Dozer Operator	$8.40	2	$16.80
Roller Operator	$8.40	2	$16.80
Truck Driver	$6.50	1	$6.50
Backhoe Operator	$8.40	1	$8.40
Equipment Operator	$8.40	1	$8.40
Concrete Worker	$5.00	4	$20.00
Laborer	$5.00	3	$15.00
Oiler	$5.00	2	$10.00
		Subtotal	$151.90

Equipment			
Dozer D-5	$25.00	1	$25.00
Dozer D-3	$20.00	1	$20.00
Vibratory Roller 10T	$35.00	1	$35.00
Vibratory Roller 2.7T	$12.00	1	$12.00
Truck Hwy 43k GVW	$20.00	1	$20.00
Water Tank (3000 Gal)	$4.00	1	$4.00
Truck F250	$7.00	1	$7.00
Hyd Excavator	$32.00	1	$32.00
Water Jet	$1.50	3	$4.50
Tampers	$2.00	3	$6.00
Small Tools	2.00%		$3.04
		Subtotal	$168.54
		Total	$320.44

	U/P	Qty	Cost
Joint Metal (m^2)	$10.00	44,370.00	$443,700.00
			$0.95 /m3
		Unit Cost	$2.15 / m3

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Atlantic Locks
3rd Lane - Concept Design Study

COMPUTATION SHEET

RCC Placement/Forming Costs - Interlaced Bottom Lateral
Double-Lift Concept

Price Level: Oct 02

Sheet 6 of 7

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Computed By: CRC Date 6/30/2003
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Approach Wall Construction

Quantity	88,100 m^2	RCC	467,438 m^3
Forming Cost		Production	6 m^2 / hr

Labor	$/mh	Qty	Total $/hr
Supervisor/Foreman	$50.00	1	$50.00
Crane Operator	$6.90	2	$13.80
Formworker	$5.60	6	$33.60
Formworker helper	$4.90	3	$14.70
Carpenter	$6.10	2	$12.20
Oiler	$5.00	1	$5.00
Laborer	$5.00	2	$10.00
		Subtotal	$139.30
Equipment			
75 Ton Crane	$85.00	2	$170.00
Small Tools	2.00%		$2.79
Power Tools	$5.00	4	$20.00
		Subtotal	$192.79
		Total	$332.09 / hr
			$55.35 / m^2

Formwork Cost		
Slipforming (steel forms, 10% waste)		
96910 m^2	$15.00 /m^2	$1,453,650.00
Scaffolding	$5.00 /m^2	$440,500.00
		$1,894,150.00
		$21.50 /m^2
	Total	$76.85 /m^2
	Total	$14.48 /m^3

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3rd Lane - Concept Design Study

COMPUTATION SHEET

RCC Placement/Forming Costs - Interlaced Bottom Lateral
Double-Lift Concept

Price Level: Oct 02

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Filename: ________
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Computed By: CRC Date 6/30/2003
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Chamber Floor

RCC 123,144 m^3

Placement Cost

Installation Backup

Production Rate 233 m^3/hr

Labor	$/mh	Qty	Total $/hr
Supervisor/Foreman	$50.00	1	$50.00
Dozer Operator	$8.40	2	$16.80
Roller Operator	$8.40	2	$16.80
Truck Driver	$6.50	1	$6.50
Backhoe Operator	$8.40	1	$8.40
Equipment Operator	$8.40	1	$8.40
Concrete Worker	$5.00	4	$20.00
Laborer	$5.00	3	$15.00
Oiler	$5.00	2	$10.00
		Subtotal	$151.90
Equipment			
Dozer D-5	$25.00	1	$25.00
Dozer D-3	$20.00	1	$20.00
Vibratory Roller 10T	$35.00	1	$35.00
Vibratory Roller 2.7T	$12.00	1	$12.00
Truck Hwy 43k GVW	$20.00	1	$20.00
Water Tank (3000 Gal)	$4.00	1	$4.00
Truck F250	$7.00	1	$7.00
Hyd Excavator	$32.00	1	$32.00
Water Jet	$1.50	3	$4.50
Tampers	$2.00	3	$6.00
Small Tools	2.00%		$3.04
		Subtotal	$168.54
		Total	$320.44

	U/P	Qty	Cost
Joint Metal (m^2)	$10.00	1,440.00	$14,400.00
			$0.12 /m3
		Unit Cost	$1.49 / m3

US Army Corps
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Atlantic Locks
3rd Lane - Concept Design Study

COMPUTATION SHEET

CIP Concrete Placement/Forming Costs - Interlaced Bottom Lateral
Double-Lift Concept

Price Level: Oct 02

Sheet 1 of 7

Filename: ________
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Computed By: CRC Date 6/30/2003
Checked By: PGB Date 6/30/2003

Cast in Place Concrete

Chamber Monolith Construction CIP 541,971 m^3

Placement Cost

Installation Backup Production Rate 40 m^3/hr

Labor	$/mh	Qty	Total $/hr
Supervisor/Foreman	$50.00	1	$50.00
Cement Finisher	$6.10	4	$24.40
Cement Finisher	$5.00	2	$10.00
Laborer	$5.00	2	$10.00
Crane Operator	$6.90	2	$13.80
Laborer	$5.00	12	$60.00
Concrete Pump Oper	$8.40	1	$8.40
		Subtotal	$176.60
Equipment			
Crane	$85.00	2	$170.00
Bucket Concrete	$3.00	2	$6.00
Air Comp 250 CFM	$9.00	3	$27.00
Air Hose	$0.50	6	$3.00
Conc Vibrator	$2.00	6	$12.00
Conc Pump Truck	$85.00	1	$85.00
Small Tools	2.00%		$3.53
		Subtotal	$306.53
		Total	$483.13

	U/P	Qty	Cost
Joint Metal (meters)	$50.00	4000	$200,000.00
			$0.37 /m3

Unit Cost $12.45 / m3

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3rd Lane - Concept Design Study

COMPUTATION SHEET

CIP Concrete Placement/Forming Costs - Interlaced Bottom Lateral
Double-Lift Concept

Price Level: Oct 02

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Computed By: CRC Date 6/30/2003

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Chamber Monolith Construction

Quantity	193,900 m^2	CIP	541,971 m^3
Forming Cost		Production	3 m^2 / hr

Labor	$/mh	Qty	Total $/hr
Supervisor/Foreman	$50.00	1	$50.00
Crane Operator	$6.90	2	$13.80
Formworker	$5.60	7	$39.20
Formworker helper	$4.90	3	$14.70
Carpenter	$6.10	3	$18.30
Oiler	$5.00	1	$5.00
Laborer	$5.00	2	$10.00
		Subtotal	$151.00
Equipment			
75 Ton Crane	$85.00	2	$170.00
Small Tools	2.00%		$3.02
Power Tools	$5.00	4	$20.00
		Subtotal	$193.02
		Total	$344.02 / hr
			$114.67 / m^2
Formwork Cost			
Assume 4 uses + 10% waste			
53322.5 m^2		$75.00 /m^2	$3,999,187.50
Scaffolding/Man lifts		$10.00 /m^2	$1,939,000.00
			$5,938,187.50
			$30.63 /m^2
		Total	$145.30 /m^2
		Total	$51.98 /m^3
Finishing	202,500.00	$4.50 /m^2	$911,250.00
			$1.68 /m^3
Curing	349,380.00	$2.50 /m^2	$873,450.00
			$1.61 /m^3
Surface Prep	146,880.00	$3.00 /m^2	$440,640.00
			$0.81 /m^3

US Army Corps
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Atlantic Locks
3rd Lane - Concept Design Study

COMPUTATION SHEET

CIP Concrete Placement/Forming Costs - Interlaced Bottom Lateral
Double-Lift Concept

Price Level: Oct 02

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Filename: ________
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Computed By: CRC Date 6/30/2003
Checked By: PGB Date 6/30/2003

Gate Monolith Construction

Cast in Place Concrete
Gate Monolith Construction CIP 268,148 m^3
Placement Cost

Installation Backup Production Rate 40 m^3/hr

Labor	$/mh	Qty	Total $/hr
Supervisor/Foreman	$50.00	1	$50.00
Cement Finisher	$6.10	4	$24.40
Cement Finisher	$5.00	2	$10.00
Laborer	$5.00	2	$10.00
Crane Operator	$6.90	2	$13.80
Laborer	$5.00	12	$60.00
Concrete Pump Oper	$8.40	1	$8.40
		Subtotal	$176.60
Equipment			
Crane	$85.00	2	$170.00
Bucket Concrete	$3.00	2	$6.00
Air Comp 250 CFM	$9.00	3	$27.00
Air Hose	$0.50	6	$3.00
Conc Vibrator	$2.00	6	$12.00
Conc Pump Truck	$85.00	1	$85.00
Small Tools	2.00%		$3.53
		Subtotal	$306.53
		Total	$483.13

	U/P	Qty	Cost
Joint Metal (meters)	$0.00	100000	$0.00
			$0.00 /m3
		Unit Cost	$12.08 / m3

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Atlantic Locks
3rd Lane - Concept Design Study

COMPUTATION SHEET

CIP Concrete Placement/Forming Costs - Interlaced Bottom Lateral
Double-Lift Concept

Price Level: Oct 02

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Computed By: CRC Date 6/30/2003
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Gate Monolith Construction

Quantity	70,900 m^2	CIP	268,148 m^3
Forming Cost		Production	3 m^2 / hr

Labor	$/mh	Qty	Total $/hr
Supervisor/Foreman	$50.00	1	$50.00
Crane Operator	$6.90	2	$13.80
Formworker	$5.60	7	$39.20
Formworker helper	$4.90	3	$14.70
Carpenter	$6.10	3	$18.30
Oiler	$5.00	1	$5.00
Laborer	$5.00	2	$10.00
		Subtotal	$151.00

Equipment			
75 Ton Crane	$85.00	2	$170.00
Small Tools	2.00%		$3.02
Power Tools	$5.00	4	$20.00
		Subtotal	$193.02
		Total	$344.02 / hr
			$114.67 / m^2

Formwork Cost
Assume 4 uses + 10% waste

19497.5 m^2	$75.00 /m^2	$1,462,312.50
Scaffolding	$10.00 /m^2	$709,000.00
		$2,171,312.50
		$30.63 /m^2
	Total	$145.30 /m^2
	Total	$38.42 /m^3

Finishing	61,874.00	$4.50 /m^2	$278,433.00
			$1.04 /m^3
Curing	178,172.00	$2.50 /m^2	$445,430.00
			$1.66 /m^3
Surface Prep	116,298.00	$3.00 /m^2	$348,894.00
			$1.30 /m^3

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COMPUTATION SHEET

CIP Concrete Placement/Forming Costs - Interlaced Bottom Lateral
Double-Lift Concept

Price Level: Oct 02

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Filename: _________
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Computed By: CRC Date 6/30/2003
Checked By: PGB Date 6/30/2003

Approach Wall Construction

CIP 24,602 m^3

Placement Cost

Installation Backup

Production Rate 30 m^3/hr

Labor	$/mh	Qty	Total $/hr
Supervisor/Foreman	$50.00	1	$50.00
Cement Finisher	$6.10	4	$24.40
Cement Finisher	$5.00	2	$10.00
Laborer	$5.00	2	$10.00
Crane Operator	$6.90	2	$13.80
Laborer	$5.00	12	$60.00
Concrete Pump Oper	$8.40	1	$8.40
		Subtotal	$176.60
Equipment			
Crane	$85.00	2	$170.00
Bucket Concrete	$3.00	2	$6.00
Air Comp 250 CFM	$9.00	3	$27.00
Air Hose	$0.50	6	$3.00
Conc Vibrator	$2.00	6	$12.00
Conc Pump Truck	$85.00	1	$85.00
Small Tools	2.00%		$3.53
		Subtotal	$306.53
		Total	$483.13
		Unit Cost	$16.10 /m^3

Finishing	82,362.00	$4.50 /m^2	$370,629.00
			$15.06 /m^3
Curing	82,362.00	$2.50 /m^2	$205,905.00
			$8.37 /m^3

COMPUTATION SHEET

CIP Concrete Placement/Forming Costs - Interlaced Bottom Lateral
Double-Lift Concept

Price Level: Oct 02 Sheet 6 of 7

Filename: __________ Computed By: CRC Date 6/30/2003
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Chamber Floor Construction

Chamber Floor Construction CIP 41,270 m^3
Placement Cost

Installation Backup Production Rate 35 m^3/hr

Labor	$/mh	Qty	Total $/hr
Supervisor/Foreman	$50.00	1	$50.00
Cement Finisher	$6.10	4	$24.40
Cement Finisher	$5.00	2	$10.00
Laborer	$5.00	2	$10.00
Crane Operator	$6.90	2	$13.80
Laborer	$5.00	12	$60.00
Concrete Pump Oper	$8.40	1	$8.40
		Subtotal	$176.60
Equipment			
Crane	$85.00	2	$170.00
Bucket Concrete	$3.00	2	$6.00
Air Comp 250 CFM	$9.00	3	$27.00
Air Hose	$0.50	6	$3.00
Conc Vibrator	$2.00	6	$12.00
Conc Pump Truck	$85.00	1	$85.00
Small Tools	2.00%		$3.53
		Subtotal	$306.53
		Total	$483.13

	U/P	Qty	Cost
Joint Metal (meters)	$0.00	100000	$0.00
			$0.00 /m3

Unit Cost $13.80 / m3

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COMPUTATION SHEET

CIP Concrete Placement/Forming Costs - Interlaced Bottom Lateral
Double-Lift Concept

Price Level: Oct 02

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Computed By: CRC Date 6/30/2003

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Chamber Floor

Quantity	33,800 m^2	CIP	41,270 m^3
Forming Cost		Production	3 m^2 / hr

Labor	$/mh	Qty	Total $/hr
Supervisor/Foreman	$50.00	1	$50.00
Crane Operator	$6.90	2	$13.80
Formworker	$5.60	7	$39.20
Formworker helper	$4.90	3	$14.70
Carpenter	$6.10	3	$18.30
Oiler	$5.00	1	$5.00
Laborer	$5.00	2	$10.00
		Subtotal	$151.00
Equipment			
75 Ton Crane	$85.00	2	$170.00
Small Tools	2.00%		$3.02
Power Tools	$5.00	4	$20.00
		Subtotal	$193.02
		Total	$344.02 / hr
			$114.67 / m^2

Formwork Cost

Assume 4 uses + 10% waste

	9295 m^2	$75.00 /m^2		$697,125.00
Scaffolding		$0.00 /m^2		$0.00
				$697,125.00
				$20.63 /m^2
			Total	$135.30 /m^2
			Total	$110.81 /m^3
Finishing	34,320.00	$4.50 /m^2		$154,440.00
				$3.74 /m^3
Curing	34,320.00	$2.50 /m^2		$85,800.00
				$2.08 /m^3

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Atlantic Locks
3rd Lane - Concept Design Study

COMPUTATION SHEET

Forming Quantities - Interlaced Bottom Lateral
Double-Lift Concept

Price Level: Oct 02

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Computed By: CRC Date 3/26/2003
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Alternative No.1
Formwork Quantities

Chamber Monolith Concrete

East Walls		Lower Chamber Section			Stationing			
		Top EL	Base EL	Height (m)	Start	End	Length	SMCA
RCC	Face	18.55	-6	24.55	12+582	13+006	424.00	10409.2
CIP	Face	-6	-24.28	18.28	12+582	13+006	424.00	7750.72
RCC	Rear	18.55	-3.00	21.55	12+582	13+006	424.00	9137.2
CIP	Rear	-6	-24.28	18.28	12+582	13+006	424.00	7750.72
					Width (m)	# of Sides		SMCA
CIP	Sides	-6	-24.28	18.28	11.67	31.00		6613.156
RCC	Sides	18.55	-6.00	24.55	11.67	3.00		859.4955

East Walls		Upper Chamber Section			Stationing			
		Top EL	Base EL	Height (m)	Start	End	Length	SMCA
RCC	Face	31.601	7	24.60	13+097	13+520	423.00	10406.22
CIP	Face	7	-11.517	18.52	13+097	13+520	423.00	7832.691
RCC	Rear	31.601	10.00	21.60	13+097	13+520	423.00	9137.223
CIP	Rear	7	-11.517	18.52	13+097	13+520	423.00	7832.691
					Width (m)	# of Sides		SMCA
CIP	Sides	7	-11.52	18.52	11.67	31.00		6698.895
RCC	Sides	31.601	7.00	24.60	11.67	3.00		861.281

West Walls		Lower Chamber Section			Stationing			
		Top EL	Base EL	Height (m)	Start	End	Length	SMCA
RCC	Face	18.55	-6	24.55	12+582	13+006	424.00	10409.2
CIP	Face	-6	-24.28	18.28	12+582	13+006	424.00	7750.72
RCC	Rear	18.55	0.00	18.55	12+582	13+006	424.00	7865.2
CIP	Rear	-6	-14	8.00	12+582	13+006	424.00	3392
					Width (m)	# of Sides		SMCA
CIP	Sides	-6	-24.28	18.28	11.67	31.00		6613.156
RCC	Sides	18.55	-6.00	24.55	11.67	3.00		859.4955

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3rd Lane - Concept Design Study

COMPUTATION SHEET

Forming Quantities - Interlaced Bottom Lateral
Double-Lift Concept

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Filename: ____________ Computed By: CRC Date 3/26/2003
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West Walls		Upper Chamber Section			Stationing			
		Top EL	Base EL	Height (m)	Start	End	Length	SMCA
RCC	Face	31.601	7	24.60	13+097	13+520	423.00	10406.22
CIP	Face	7	-11.517	18.52	13+097	13+520	423.00	7832.691
RCC	Rear	31.601	13.60	18.00	13+097	13+520	423.00	7614.423
CIP	Rear	7	3	4.00	13+097	13+520	423.00	1692
					Width (m)	# of Sides		SMCA
CIP	Sides	7	-11.52	18.52	11.67	31.00		6698.895
RCC	Sides	31.601	7.00	24.60	11.67	3.00		861.281

Total Walls	RCC	78826.45 smca
	CIP	78458.33 smca

Use these coverage areas for the outlet and intake structure

	Start	End	Distance (m)	RCC (m^2/m)	CIP (m^2/m)	RCC (smca)	CIP (smca)
Atlantic Outlet Structure	12+400	12+491	91	46.5327302	46.315428	8468.957	8429.407826
Gatun Intake Structure	13+611	13+690	79	46.5327302	46.315428	7352.171	7317.837563
					Totals	15821.13	15747.24539

Total Walls	RCC	94647.57 smca
	w/ 10%	**104100** smca
	CIP	94205.58 smca
	w/ 10%	**103600** smca

Gate Monoliths
North Gate Bay Monoliths

					Stationing			
		Top EL	Base EL	Height (m)	Start	End	Length	SMCA
RCC	Face	4	-6	10.00	12+491	12+582	91.00	1820
CIP	Face	-6	-25.18	19.18	12+582	13+006	91.00	3490.76
CIP	Face	18.5	4.00	14.50	12+582	13+006	91.00	2639
CIP	Rear	18.5	4	14.50	12+582	13+006	91.00	2639
					Width (m)	# of Sides		SMCA
CIP	Sides	-6	-25.18	19.18	22.5	6		5178.6
CIP	Sides	18.5	4.00	14.50	22.50	6.00		3915

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Center Gate Bay

					Stationing			
		Top EL	Base EL	Height (m)	Start	End	Length	SMCA
RCC	Face	23	4	19.00	13+006	13+097	91.00	3458
CIP	Face	31.601	23	8.60	13+006	13+097	91.00	1565.382
CIP	Face	4	-16.39	20.39	13+006	13+097	91.00	3711.162
CIP	Rear	31.601	23	8.60	13+006	13+097	91.00	1565.382
					Width (m)	# of Sides		SMCA
CIP	Sides	31.601	23.00	8.60	22.5	6		2322.27
CIP	Sides	4	-16.39	20.39	22.50	6.00		5505.3

Southern Gate Bay

					Stationing			
		Top EL	Base EL	Height (m)	Start	End	Length	SMCA
RCC	Face	26.669	8	18.67	13+520	13+611	91.00	3397.758
CIP	Face	31.601	26.669	4.93	13+520	13+611	91.00	897.624
CIP	Face	8	-6.97	14.97	13+520	13+611	91.00	2724.54
CIP	Rear	31.601	26.669	4.93	13+520	13+611	91.00	897.624
					Width (m)	# of Sides		SMCA
CIP	Sides	31.601	26.67	4.93	22.5	6		1331.64
CIP	Sides	8	-6.97	14.97	22.50	6.00		4041.9

Totals	RCC	8675.758	smca
	w/ 10%	**9500**	smca
	CIP	42425.184	smca
	w/ 10%	**46700**	smca

Chamber Floors

Lower Chamber		Length	Heigth / Width	Number	Sides	SMCA
Laterals	Walls	65	2.5	22	2.00	7150
CIP	Top	65	3.5	22	1.00	5005
					Total	12155
Upper Chamber		(Same features)				18590
					Totals	30745 smca
					w/ 10%	**33800** smca

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Approach Walls					Stationing			
Atlantic Approach		Top EL	Base EL	Height (m)	Start	End	Length	SMCA
RCC	East Face	3.5	-23.67	27.17	11+682	12+400	718.00	19508.06
RCC	West Face	3.5	-23.67	27.17	12+316	12+400	84.00	2282.28
RCC	East Rear	3.5	-8.00	11.50	11+682	12+400	718.00	8257
RCC	West Rear	3.5	-8	11.50	12+316	12+400	84.00	966
							Total	31013.34
					Width	Area	#	
RCC	Sides	3.5	-23.67	27.17	22.00	597.74	6.00	3586.44
					Stationing			
Gatun Approach		Top EL	Base EL	Height (m)	Start	End	Length	SMCA
RCC	East Face	31.6	0.64	30.96	13+690	14+400	710.00	21981.6
RCC	West Face	31.6	0.64	30.96	13+690	13+775	85.00	2631.6
RCC	East Rear	31.6	10.00	21.60	13+690	14+400	718.00	15508.8
RCC	West Rear	31.6	16	15.60	13+690	13+775	85.00	1326
							Total	41448
					Width	Area	#	
RCC	Sides	31.6	0.64	30.96	22.00	681.12	6.00	4086.72
							Totals	80134.5 smca
							w/ 10%	**88100** smca

Culverts						
	Dimensions	8m x 6m		Forming Perimeter	22	meters
			In Chambers	Length	2040	meters
					44880	smca
				w/ 15%	**51600**	smca
			Gate Monoliths	Length	546	meters
					12012	smca
				w/ 15%	**13800**	smca
Galleries						
	Dimensions	3m x 3m	Forming Perimeter		9	meters
		1.5m x 3m	Forming Perimeter		7.5	meters
					16.5	meters
				Length	2040	meters
					33660	smca
				w/ 15%	**38700**	smca
			Gate Monoliths	Length	546	meters
					9009	smca
				w/ 15%	**10400**	smca

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RCC Joint Materials

Lock Chamber		Depth (m)	Height (m)	Surface Area	Monolith Jts	surface area	
Lower Chamber	East Wall	12	24.55	294.60	31	9,132.60	
	West Wall	12.00	24.55	294.60	31	9,132.60	
Upper Chamber	East Wall	12	24.60	295.20	31	9,151.20	
	West Wall	12.00	24.60	295.20	31	9,151.20	
Intake/Outlet Structures	East Wall	12	24.60	295.20	6	1,771.20	
	West Wall	12.00	24.60	295.20	6	1,771.20	
						40,110.00	m^2

Gate Monoliths		Depth (m)	Height (m)	Surface Area	Monolith Jts	Total surface area	
Lower Gate Bays	East Walls	15	10.00	150.00	6	900.00	
	West Walls	15	10.00	150.00	6	900.00	
Middle Gate Bays	East Walls	10	19.00	190.00	6	1,140.00	
Middle Gate Bays	West Walls	10	19.00	190.00	6	1,140.00	
Upper Gate Bay	East Wall	22.50	19.00	427.50	6	2,565.00	
Lower Gate Bay	West Wall	22.50	19.00	427.50	6.00	2,565.00	
						9,210.00	m^2

Approach Walls		Depth (m)	Height (m)	Surface Area	Monolith Jts	surface area	
Atlantic	East Wall	15	27.00	405.00	45	18,225.00	
	West Wall	15.00	27.00	405.00	6	2,430.00	
Gatun	East Wall	15	31.00	465.00	45	20,925.00	
	West Wall	15.00	31.00	465.00	6	2,790.00	
						44,370.00	m^2

Chamber Floors		Depth (m)	Height (m)	Surface Area	Joints	Total surface area	
	Lower Chamber	15	1.00	15.00	48	720.00	m^2
	Upper Chamber	15	1.00	15.00	48	720.00	m^2
						1,440.00	m^2

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Finishing

Lock Chamber	Length	Height (m)	Surface Area	# of walls	Total surface area
Lower Chamber walls	425	43.00	18,275.00	2	36,550.00
Upper Chamber walls	425.00	43.00	18,275.00	2	36,550.00
Intake/Outlet Structures	170	43.00	7,310.00	2	14,620.00
Top of Walls (heigth is width)	425	12.00	5,100.00	4	20,400.00
Top of Intake/Outlet Struct. (Ht is width)	170	12.00	2,040.00	2	4,080.00
Culverts			11,900.00	4	51,600.00
Galleries			8,925.00	4	38,700.00
				Total	202,500.00

	Length (m)	Height (m)	Surface Area	# of walls	Total surface area
Northern Gate Monoliths	91	44.00	4,004.00	2	8,008.00
Middle Gate Monoliths	91.00	48.00	4,368.00	2	8,736.00
Southern Gate Monoliths	91	40.00	3,640.00	2	7,280.00
Top of Gate Monoliths	91	25.00	2,275.00	6	13,650.00
Galleries			1,911.00	6	10,400.00
Culverts			2,548.00	6	13,800.00
				Totals	61,874.00

Approach Walls	Length (m)	Height (m)	Surface Area	# of walls	Total surface area
Atlantic East	718	28.00	20,104.00	1	20,104.00
Atlantic West	84	28.00	2,352.00	1	2,352.00
Gatun East	718	31.00	22,258.00	1	22,258.00
Gatun West	84	31.00	2,604.00	1	2,604.00
Top of East Walls	718	23.00	16,514.00	2	33,028.00
Top of West Walls	84	12.00	1,008.00	2	2,016.00
					82,362.00

Chamber Floors		Surface Area	# of cross	Total
Laterals	Lower Chamber	780.00	22	17,160.00
Laterals	Upper Chamber	780.00	22	17,160.00
			Total	34,320.00

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Curing/Surface Prep	Length	Width	Surface Area	# of lifts	Total surface area	
Lower Chamber	425.00	12.00	5,100.00	6	30,600.00	
Upper Chamber	425.00	12.00	5,100.00	6	30,600.00	
Intake/Outlet Structures	170.00	12.00	2,040.00	6	12,240.00	
				Subtotal	73,440.00	/wall
				Subtotal	146,880.00	
		Incl finished surfaces		Total	349,380.00	

Gate Monoliths		Length	Width	Surface Area	# of lifts	Total surface area	
Norhern Gate Bays	East Walls	91	23.00	2,093.00	11	23,023.00	
	West Walls	91	23.00	2,093.00	11	23,023.00	
Middle Gate Bays	East Walls	91	25.00	2,275.00	9	20,475.00	
Middle Gate Bays	West Walls	91	25.00	2,275.00	9	20,475.00	
Southern Gate Bay	East Wall	91.00	23.00	2,093.00	7	14,651.00	
Southern Gate Bay	West Wall	91.00	23.00	2,093.00	7.00	14,651.00	
						116,298.00	m^2
			Incl finished surfaces		Total	178,172.00	m^2

Chamber Floors		Surface Area	# of cross	Total
Laterals	Lower Chamber	780.00	22	17,160.00
Laterals	Upper Chamber	780.00	22	17,160.00
			Total	34,320.00

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COMPUTATION SHEET

Concrete RCC Placement Production Rates
Double-Lift Concept

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Computed By: CRC Date 3/26/2003

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Roller Compacted Concrete

Production Rate Calculations

Assume 4 months of 16 hrs/day 6 days a week placement and 8 months of 8 hrs/day placement 6 days a week.

	Months	m^3/day	m^3/month	m^3/hour
Lock Walls	4	7000	168000	437.50
	8	3500	84000	437.50

Average m^3/month	112,000.00
Average m^3/day	4,666.67
Average m^3/hour	233.33

	Months	m^3/day	m^3/month	m^3/hour
Approach Walls	4	8000	192000	500.00
	8	4000	96000	500.00

Average m^3/month	128,000.00
Average m^3/day	5,333.33
Average m^3/hour	266.67

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COMPUTATION SHEET

Summary of Concrete Costs - ILCS Alternative
Double-Lift Concept

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Roller Compacted Concrete

Lock Walls		Quantity	1513644 m^3
		$/m^3	
	Batch Plant Cost	$6.25	
	Mix Cost	$21.74	
	Transport Cost	$5.00	
	Placement Cost	$2.09	
	Formcost	$8.41	
	Cleaning Lifts / Curing / Finishing / Misc	$3.00	
	Subtotal	$46.48	
	Total With Markup	$56.00	

Gate Monoliths		Quantity	219044 m^3
		$/m^3	
	Batch Plant Cost	$6.25	
	Mix Cost	$21.74	
	Transport Cost	$5.00	
	Placement Cost	$1.80	
	Formcost	$3.33	
	Cleaning Lifts / Curing /	$3.00	
	Subtotal	$41.11	
	Total With Markup	$49.00	

Approach Walls		Quantity	467438 m^3
		$/m^3	
	Batch Plant Cost	$6.25	
	Mix Cost	$21.74	
	Transport Cost	$5.00	
	Placement Cost	$2.15	
	Formcost	$14.48	
	Cleaning Lifts / Curing /	$3.00	
	Subtotal	$52.62	
	Total With Markup	$63.00	

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COMPUTATION SHEET

Summary of Concrete Costs - ILCS Alternative
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Floor		Quantity	136438 m^3
		$/m^3	
	Batch Plant Cost	$6.25	
	Mix Cost	$21.74	
	Transport Cost	$5.00	
	Placement Cost	$1.51	
	Formcost	$0.00	
	Cleaning Lifts / Curing /	$3.00	
	Subtotal	$37.50	
	Total With Markup	$45.00	
CAST IN PLACE			
Monolith Concrete		Quantity	242627 m^3
		$/m^3	
	Batch Plant Cost	$6.25	
	Mix Cost	$24.96	
	Transport Cost	$5.00	
	Placement Cost	$12.90	
	Formcost	$23.18	
	Cleaning Lifts / Curing / Finishing / Misc	$2.99	
	Subtotal	$75.27	
	Total With Markup	$90.00	
Miter Gate Bays		Quantity	268148 m^3
		$/m^3	
	Batch Plant Cost	$6.25	
	Mix Cost	$24.96	
	Transport Cost	$5.00	
	Placement Cost	$12.08	
	Formcost	$40.69	
	Cleaning Lifts / Curing / Finishing / Misc	$3.42	
	Subtotal	$92.40	
	Total With Markup	$111.00	

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Approach Wall CIP		Quantity	24602 m^3
		$/m^3	
	Batch Plant Cost	$6.25	
	Mix Cost	$24.96	
	Transport Cost	$5.00	
	Placement Cost	$16.10	
	Formcost	$0.00	
	Cleaning Lifts / Curing / Finishing / Misc	$23.43	
	Subtotal	$75.74	
	Total With Markup	$91.00	

Floor Concrete		Quantity	50639 m^3
		$/m^3	
	Batch Plant Cost	$6.25	
	Mix Cost	$22.50	
	Transport Cost	$5.00	
	Placement Cost	$13.80	
	Formcost	$114.89	
	Cleaning Lifts / Curing / Finishing / Misc	$7.05	
	Subtotal	$169.48	
	Total With Markup	$203.00	

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COMPUTATION SHEET

Concrete - Batch Plants - ILCS Alternative
Double-Lift Concept

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Batch Plants

Cost of Batch Plant Delivered to Panama (Includes cost of Ice Plant)	$1,500,000	
Spare Parts	$150,000	
Set-up cost	$200,000	
Total Cost	$1,850,000	
Number of batch plants required	3	
Total	$5,550,000	
Concrete Quantity		2800000 m3
Unit Cost		$1.98 / m3

Cost to Run Batch Plant

Labor	$/mh	Qty	Total $/hr
Supervisor/Foreman	$50.00	1	$50.00
Technician	$45.00	2	$90.00
Laborer	$5.00	3	$15.00
Mechanic	$8.40	2	$16.80
Equipment Operator	$8.40	2	$16.80
			$188.60 /hr

Allow Operating Staff to be on site for 3.0 years

Approximately 18,720 hrs

Total	$3,530,592 / Plant
Total	$10,591,776
Unit Cost	$3.78 / m3

COMPUTATION SHEET

Concrete - Batch Plants - ILCS Alternative
Double-Lift Concept

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Batch Plant continued

Yearly Maintenance Allowance per plant		$100,000.00
	Total	$300,000.00 /Plant
	Total	$900,000.00
	Unit Cost	$0.32 / m3
Yearly Power Consumption		$50,000 /Plant
	Total	$150,000.00 /Plant
	Total	$450,000.00
	Unit Cost	$0.16 / m3
Total Unit Cost of Batch Plants		$6.25 / m3

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COMPUTATION SHEET

Concrete Delivery System - ILCS Alternative
Double-Lift Concept

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Concrete Delivery Sy

Cost based upon data furnished by ROTEC.

	Qty	Purchase Cost	Total Cost
Creter Crane	3	$1,600,000.00	$4,800,000.00
Auger Max	3	$160,700.00	$482,100.00
Big Dog (Concrete Hauler)	15	$200,000.00	$3,000,000.00
		Total	$8,282,100.00

Assume that salvage value of machinery after 3 years is equal to the cost of 3 years of O&M

Concrete Quantity 2800000 m3

Unit Cost $2.96 / m3

Cost to Run Batch Plant

Labor	$/mh	Qty	Total $/hr
Supervisor/Foreman	$50.00	1	$50.00
Laborer	$5.00	3	$15.00
Mechanic	$8.40	2	$16.80
Equipment Operator	$8.40	6	$50.40
Truck Driver	$7.30	15	$109.50
			$241.70 /hr

Allow Operating Staff to be on site for 3.0 years

Approximately 18,720 hrs

Total $4,524,624

Unit Cost $1.62 / m3

Total Unit Cost $4.57 /m^3

Rounded Unit Cost $5.00 /m^3

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COMPUTATION SHEET

Roller Compacted Concrete - Concrete Mix Cost
Double-Lift Concept

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RCC Mix Cost

Design

Cement	140 kg/m^3
Pozzolan	40 kg/m^3
Sand	865 kg/m^3
Aggregate	1285 kg/m^3

Mixes are for cost proposes only

Cement

$60.00 /tonne	$25/t (Thailand) + $35/t (Shipping Cost)
$2.50 /tonne	Delivery Cost
$62.50 /tonne	

Quantity of cement per cubic meter of concrete 0.14 tonne

Cost per cubic meter of concrete $8.75 /m^3

Sand

$7.00 /m^3 Delivered to site

1.5 tonnes/m^3 (Sand weight)

$4.67 / tonne

Quantity of Sand per cubic meter of concrete 0.865 tonne

Cost per cubic meter of concrete $4.04 /m^3

Aggregate

$6.50 / tonne See aggregate cost backup sheet

Quantity of Aggregate per cubic meter of concrete 1.285 tonne

Cost per cubic meter of concrete $8.35 /m^3

Pozzolan

$15.00 /tonne Delivered to site

Quantity of Pozzolan per cubic meter of concrete 0.04 tonne

Cost per cubic meter of concrete $0.60 /m^3

Total $21.74 /m^3

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COMPUTATION SHEET

Conventional CIP - Concrete Mix Cost
Double-Lift Concept

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Lock Walls/Miter Gate CIP

Design	Cement	180 kg/m^3
	Pozzolan	40 kg/m^3
	Sand	650 kg/m^3
	Aggregate	1550 kg/m^3

Mixes are for cost proposes only

Cement

$60.00	/tonne	$25/t (Thailand) + $35/t (Shipping Cost)
$2.50	/tonne	Delivery Cost
$62.50	/tonne	

Quantity of cement per cubic meter of concrete	0.18	tonne
Cost per cubic meter of concrete	$11.25	/m^3

Sand

$7.00	/m^3	Delivered to site
1.5	tonnes/m^3 (Sand weight)	
$4.67	/ tonne	

Quantity of Sand per cubic meter of concrete	0.65	tonne
Cost per cubic meter of concrete	$3.03	/m^3

Aggregate

$6.50 / tonne See aggregate cost backup sheet

Quantity of Aggregate per cubic meter of concrete	1.55	tonne
Cost per cubic meter of concrete	$10.08	/m^3

Pozzolan

$15.00 /tonne Delivered to site

Quantity of Pozzolan per cubic meter of concrete	0.04	tonne
Cost per cubic meter of concrete	$0.60	/m^3
Total	$24.96	/m^3

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Chamber Floor

Design	Cement	205 kg/m^3
	Pozzolan	35 kg/m^3
	Sand	500 kg/m^3
	Aggregate	1050 kg/m^3

Mixes are for cost proposes only

Cement

$60.00 /tonne	$25/t (Thailand) + $35/t (Shipping Cost)
$2.50 /tonne	Delivery Cost
$62.50 /tonne	

Quantity of cement per cubic meter of concrete	0.205 tonne
Cost per cubic meter of concrete	$12.81 /m^3

Sand

$7.00 /m^3	Delivered to site
1.5 tonnes/m^3 (Sand weight)	
$4.67 / tonne	

Quantity of Sand per cubic meter of concrete	0.5 tonne
Cost per cubic meter of concrete	$2.33 /m^3

Aggregate

$6.50 / tonne	See aggregate cost backup sheet

Quantity of Aggregate per cubic meter of concrete	1.05 tonne
Cost per cubic meter of concrete	$6.83 /m^3

Pozzolan

$15.00 /tonne	Delivered to site

Quantity of Pozzolan per cubic meter of concrete	0.035 tonne
Cost per cubic meter of concrete	$0.53 /m^3
Total	$22.50 /m^3

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COMPUTATION SHEET

Tremie Concrete - Concrete Mix Cost
Double-Lift Concept

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Tremie Mix

Design	Cement	200	kg/m^3
	Pozzolan	190	kg/m^3
	Sand	745	kg/m^3
	Aggregate	890	kg/m^3

Mixes are for cost proposes only

Cement

$60.00	/tonne	$25/t (Thailand) + $35/t (Shipping Cost)
$2.50	/tonne	Delivery Cost
$62.50	/tonne	

Quantity of cement per cubic meter of concrete	0.2	tonne
Cost per cubic meter of concrete	$12.50	/m^3

Sand

$7.00	/m^3	Delivered to site
1.5	tonnes/m^3 (Sand weight)	
$4.67	/ tonne	

Quantity of Sand per cubic meter of concrete	0.745	tonne
Cost per cubic meter of concrete	$3.48	/m^3

Aggregate

$6.50 / tonne See aggregate cost backup sheet

Quantity of Aggregate per cubic meter of concrete	0.89	tonne
Cost per cubic meter of concrete	$5.79	/m^3

Pozzolan

$15.00 /tonne Delivered to site

Quantity of Pozzolan per cubic meter of concrete	0.19	tonne
Cost per cubic meter of concrete	$2.85	/m^3
Total	$24.61	/m^3

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COMPUTATION SHEET

Aggregate Cost Backup -Concrete Mix Cost
Double-Lift Concept

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Aggregate Cost
Source: Pacific Lock excavation

	Unit Cost	Qtu	Unit	Total
Rock Crusher	$550,000.00	2	Each	$1,100,000.00
Conveyors	$300,000.00	1	LS	$300,000.00
Screening Plant	$150,000.00	3	Each	$450,000.00
			Total	$1,850,000.00
			Delivery	$185,000.00
			Total	$2,035,000.00

Setup	$150,000.00
Operation cost (Allow $1,000,000/year for three years)	$3,000,000.00
Maintenance Cost (Allow $200,000/year for three years)	$600,000.00
Total	$5,785,000.00

Delivery of Aggregate (to Gatun by Rail, $/m^3 furnished by ACP) $3.00 /tonne

	U/C	Qty	Unit		
Grading/Ballast	$125,000.00	10	km	$1,250,000.00	
Track/Switches/Misc	$3,500,000.00	1	LS	$3,500,000.00	(ACP furnished cost)
Railroad Bridge Repairs	$2,500,000.00	1	LS	$2,500,000.00	

Option 2 aggregate required		3885000	tonne
Unit Costs	Plant	$1.49	/tonne
	Delivery	$3.00	/tonne
	Railwork	$1.87	/tonne
	Total	$6.36	/tonne
	Rounded Total	$6.50	/tonne

Note: The cost of drilling, blasting and excavating the rock is not included with this estimate. It should be included with the Pacific Lock estimate. Also, the cost for the railroad bridge repairs should be updated, as no information was available at the time of

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COMPUTATION SHEET

RCC Placement/Forming Costs - ILCS Alternative
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Roller Compacted Concrete

Chamber Monolith Construction RCC 1,513,644 m^3

Placement Cost

Installation Backup Production Rate 233 m^3/hr

Labor	$/mh	Qty	Total $/hr
Supervisor/Foreman	$50.00	1	$50.00
Dozer Operator	$8.40	2	$16.80
Roller Operator	$8.40	2	$16.80
Truck Driver	$6.50	1	$6.50
Backhoe Operator	$8.40	1	$8.40
Equipment Operator	$8.40	1	$8.40
Concrete Worker	$5.00	4	$20.00
Laborer	$5.00	3	$15.00
Oiler	$5.00	2	$10.00
		Subtotal	$151.90
Equipment			
Dozer D-5	$25.00	1	$25.00
Dozer D-3	$20.00	1	$20.00
Vibratory Roller 10T	$35.00	1	$35.00
Vibratory Roller 2.7T	$12.00	1	$12.00
Truck Hwy 43k GVW	$20.00	1	$20.00
Water Tank (3000 Gal)	$4.00	1	$4.00
Truck F250	$7.00	1	$7.00
Hyd Excavator	$32.00	1	$32.00
Water Jet	$1.50	3	$4.50
Tampers	$2.00	3	$6.00
Small Tools	2.00%		$3.04
		Subtotal	$168.54
		Total	$320.44

	U/P	Qty	Cost
Joint Metal (m^2)	$10.00	107,712.00	$1,077,120.00
			$0.71 /m3

Unit Cost $2.09 / m3

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COMPUTATION SHEET

RCC Placement/Forming Costs - ILCS Alternative
Double-Lift Concept

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Chamber Monolith Construction

Quantity	165,600 m^2	RCC	1,513,644 m^3
Forming Cost		Production	6 m^2 / hr

Labor	$/mh	Qty	Total $/hr
Supervisor/Foreman	$50.00	1	$50.00
Crane Operator	$6.90	2	$13.80
Formworker	$5.60	6	$33.60
Formworker helper	$4.90	3	$14.70
Carpenter	$6.10	2	$12.20
Oiler	$5.00	1	$5.00
Laborer	$5.00	2	$10.00
		Subtotal	$139.30
Equipment			
75 Ton Crane	$85.00	2	$170.00
Small Tools	2.00%		$2.79
Power Tools	$5.00	4	$20.00
		Subtotal	$192.79
		Total	$332.09 / hr
			$55.35 / m^2

Formwork Cost
Slipforming (Steel forms, 10% waste)

182160 m^2	$15.00 /m^2		$2,732,400.00
Scaffolding	$5.00 /m^2		$828,000.00
			$3,560,400.00
			$21.50 /m^2
		Total	$76.85 /m^2
		Total	$8.41 /m^3

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COMPUTATION SHEET

RCC Placement/Forming Costs - ILCS Alternative
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Gate Monolith Construction

RCC 219,044 m^3

Placement Cost

Installation Backup

Production Rate 233 m^3/hr

Labor	$/mh	Qty	Total $/hr
Supervisor/Foreman	$50.00	1	$50.00
Dozer Operator	$8.40	2	$16.80
Roller Operator	$8.40	2	$16.80
Truck Driver	$6.50	1	$6.50
Backhoe Operator	$8.40	1	$8.40
Equipment Operator	$8.40	1	$8.40
Concrete Worker	$5.00	4	$20.00
Laborer	$5.00	3	$15.00
Oiler	$5.00	2	$10.00
		Subtotal	$151.90
Equipment			
Dozer D-5	$25.00	1	$25.00
Dozer D-3	$20.00	1	$20.00
Vibratory Roller 10T	$35.00	1	$35.00
Vibratory Roller 2.7T	$12.00	1	$12.00
Truck Hwy 43k GVW	$20.00	1	$20.00
Water Tank (3000 Gal)	$4.00	1	$4.00
Truck F250	$7.00	1	$7.00
Hyd Excavator	$32.00	1	$32.00
Water Jet	$1.50	3	$4.50
Tampers	$2.00	3	$6.00
Small Tools	2.00%		$3.04
		Subtotal	$168.54
		Total	$320.44

	U/P	Qty	Cost
Joint Metal (m^2)	$10.00	9,210.00	$92,100.00
			$0.42 /m3

Unit Cost $1.80 / m3

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RCC Placement/Forming Costs - ILCS Alternative
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Gate Monolith Construction

Quantity	9,500 m^2	RCC	219,044 m^3
Forming Cost		Production	6 m^2 / hr

Labor	$/mh	Qty	Total $/hr
Supervisor/Foreman	$50.00	1	$50.00
Crane Operator	$6.90	2	$13.80
Formworker	$5.60	6	$33.60
Formworker helper	$4.90	3	$14.70
Carpenter	$6.10	2	$12.20
Oiler	$5.00	1	$5.00
Laborer	$5.00	2	$10.00
		Subtotal	$139.30
Equipment			
75 Ton Crane	$85.00	2	$170.00
Small Tools	2.00%		$2.79
Power Tools	$5.00	4	$20.00
		Subtotal	$192.79
		Total	$332.09 / hr
			$55.35 / m^2

Formwork Cost			
Slipforming (Steel forms, 10% waste)			
10450 m^2	$15.00 /m^2		$156,750.00
Scaffolding	$5.00 /m^2		$47,500.00
			$204,250.00
			$21.50 /m^2
		Total	$76.85 /m^2
		Total	$3.33 /m^3

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RCC Placement/Forming Costs - ILCS Alternative
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Approach Wall Construction

RCC 467,438 m^3

Placement Cost

Installation Backup

Production Rate 267 m^3/hr

Labor	$/mh	Qty	Total $/hr
Supervisor/Foreman	$50.00	1	$50.00
Dozer Operator	$8.40	2	$16.80
Roller Operator	$8.40	2	$16.80
Truck Driver	$6.50	1	$6.50
Backhoe Operator	$8.40	1	$8.40
Equipment Operator	$8.40	1	$8.40
Concrete Worker	$5.00	4	$20.00
Laborer	$5.00	3	$15.00
Oiler	$5.00	2	$10.00
		Subtotal	$151.90
Equipment			
Dozer D-5	$25.00	1	$25.00
Dozer D-3	$20.00	1	$20.00
Vibratory Roller 10T	$35.00	1	$35.00
Vibratory Roller 2.7T	$12.00	1	$12.00
Truck Hwy 43k GVW	$20.00	1	$20.00
Water Tank (3000 Gal)	$4.00	1	$4.00
Truck F250	$7.00	1	$7.00
Hyd Excavator	$32.00	1	$32.00
Water Jet	$1.50	3	$4.50
Tampers	$2.00	3	$6.00
Small Tools	2.00%		$3.04
		Subtotal	$168.54
		Total	$320.44

	U/P	Qty	Cost
Joint Metal (m^2)	$10.00	44,370.00	$443,700.00
			$0.95 /m3

Unit Cost $2.15 / m3

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COMPUTATION SHEET

RCC Placement/Forming Costs - ILCS Alternative
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Approach Wall Construction

Quantity	88,100 m^2	RCC	467,438 m^3
Forming Cost		Production	6 m^2 / hr

Labor	$/mh	Qty	Total $/hr
Supervisor/Foreman	$50.00	1	$50.00
Crane Operator	$6.90	2	$13.80
Formworker	$5.60	6	$33.60
Formworker helper	$4.90	3	$14.70
Carpenter	$6.10	2	$12.20
Oiler	$5.00	1	$5.00
Laborer	$5.00	2	$10.00
		Subtotal	$139.30
Equipment			
75 Ton Crane	$85.00	2	$170.00
Small Tools	2.00%		$2.79
Power Tools	$5.00	4	$20.00
		Subtotal	$192.79
		Total	$332.09 / hr
			$55.35 / m^2

Formwork Cost			
Slipforming (Steel forms, 10% waste)			
96910 m^2	$15.00 /m^2		$1,453,650.00
Scaffolding	$5.00 /m^2		$440,500.00
			$1,894,150.00
			$21.50 /m^2
		Total	$76.85 /m^2
		Total	$14.48 /m^3

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RCC Placement/Forming Costs - ILCS Alternative
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Chamber Floor

RCC 136,438 m^3

Placement Cost

Installation Backup

Production Rate 233 m^3/hr

Labor	$/mh	Qty	Total $/hr
Supervisor/Foreman	$50.00	1	$50.00
Dozer Operator	$8.40	2	$16.80
Roller Operator	$8.40	2	$16.80
Truck Driver	$6.50	1	$6.50
Backhoe Operator	$8.40	1	$8.40
Equipment Operator	$8.40	1	$8.40
Concrete Worker	$5.00	4	$20.00
Laborer	$5.00	3	$15.00
Oiler	$5.00	2	$10.00
		Subtotal	$151.90

Equipment			
Dozer D-5	$25.00	1	$25.00
Dozer D-3	$20.00	1	$20.00
Vibratory Roller 10T	$35.00	1	$35.00
Vibratory Roller 2.7T	$12.00	1	$12.00
Truck Hwy 43k GVW	$20.00	1	$20.00
Water Tank (3000 Gal)	$4.00	1	$4.00
Truck F250	$7.00	1	$7.00
Hyd Excavator	$32.00	1	$32.00
Water Jet	$1.50	3	$4.50
Tampers	$2.00	3	$6.00
Small Tools	2.00%		$3.04
		Subtotal	$168.54
		Total	$320.44

	U/P	Qty	Cost
Joint Metal (m^2)	$10.00	1,860.00	$18,600.00
			$0.14 /m3

Unit Cost $1.51 / m3

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COMPUTATION SHEET

CIP Concrete Placement/Forming Costs - ILCS Alternative
Double-Lift Concept

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Cast in Place Concrete
Chamber Monolith Construction CIP 242,627 m^3
Placement Cost

Installation Backup — Production Rate 40 m^3/hr

Labor	$/mh	Qty	Total $/hr
Supervisor/Foreman	$50.00	1	$50.00
Cement Finisher	$5.00	2	$10.00
Cement Finisher	$6.10	4	$24.40
Laborer	$5.00	2	$10.00
Crane Operator	$6.90	2	$13.80
Laborer	$5.00	12	$60.00
Concrete Pump Oper	$8.40	1	$8.40
		Subtotal	$176.60
Equipment			
Crane	$85.00	2	$170.00
Bucket Concrete	$3.00	2	$6.00
Air Comp 250 CFM	$9.00	3	$27.00
Air Hose	$0.50	6	$3.00
Conc Vibrator	$2.00	6	$12.00
Conc Pump Truck	$85.00	1	$85.00
Small Tools	2.00%		$3.53
		Subtotal	$306.53
		Total	$483.13

	U/P	Qty	Cost
Joint Metal (meters)	$50.00	4000	$200,000.00
			$0.82 /m3

Unit Cost $12.90 / m3

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COMPUTATION SHEET

CIP Concrete Placement/Forming Costs - ILCS Alternative
Double-Lift Concept

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Chamber Monolith Construction

Quantity	38,700 m^2	CIP	242,627 m^3
Forming Cost		Production	3 m^2 / hr

Labor	$/mh	Qty	Total $/hr
Supervisor/Foreman	$50.00	1	$50.00
Crane Operator	$6.90	2	$13.80
Formworker	$5.60	7	$39.20
Formworker helper	$4.90	3	$14.70
Carpenter	$6.10	3	$18.30
Oiler	$5.00	1	$5.00
Laborer	$5.00	2	$10.00
		Subtotal	$151.00
Equipment			
75 Ton Crane	$85.00	2	$170.00
Small Tools	2.00%		$3.02
Power Tools	$5.00	4	$20.00
		Subtotal	$193.02
		Total	$344.02 / hr
			$114.67 / m^2

Formwork Cost
Assume 4 uses + 10% waste

10642.5 m^2	$75.00 /m^2		$798,187.50
Scaffolding	$10.00 /m^2		$387,000.00
			$1,185,187.50
			$30.63 /m^2
		Total	$145.30 /m^2
		Total	$23.18 /m^3

Finishing	161,100.00	$4.50 /m^2	$724,950.00
			$2.99 /m^3
Curing	0	$2.50 /m^2	$0.00
			$0.00 /m^3

COMPUTATION SHEET

CIP Concrete Placement/Forming Costs - ILCS Alternative
Double-Lift Concept

Price Level: Oct 02

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Gate Monolith Construction

Cast in Place Concrete
Gate Monolith Construction CIP 268,148 m^3
Placement Cost

Installation Backup Production Rate 40 m^3/hr

Labor	$/mh	Qty	Total $/hr
Supervisor/Foreman	$50.00	1	$50.00
Cement Finisher	$5.00	2	$10.00
Cement Finisher	$6.10	4	$24.40
Laborer	$5.00	2	$10.00
Crane Operator	$6.90	2	$13.80
Laborer	$5.00	12	$60.00
Concrete Pump Oper	$8.40	1	$8.40
		Subtotal	$176.60
Equipment			
Crane	$85.00	2	$170.00
Bucket Concrete	$3.00	2	$6.00
Air Comp 250 CFM	$9.00	3	$27.00
Air Hose	$0.50	6	$3.00
Conc Vibrator	$2.00	6	$12.00
Conc Pump Truck	$85.00	1	$85.00
Small Tools	2.00%		$3.53
		Subtotal	$306.53
		Total	$483.13

	U/P	Qty	Cost
Joint Metal (meters)	$0.00	100000	$0.00
			$0.00 /m3
		Unit Cost	$12.08 / m3

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CIP Concrete Placement/Forming Costs - ILCS Alternative
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Gate Monolith Construction

Quantity	75,100 m^2	CIP	268,148 m^3
Forming Cost		Production	3 m^2 / hr

Labor	$/mh	Qty	Total $/hr
Supervisor/Foreman	$50.00	1	$50.00
Crane Operator	$6.90	2	$13.80
Formworker	$5.60	7	$39.20
Formworker helper	$4.90	3	$14.70
Carpenter	$6.10	3	$18.30
Oiler	$5.00	1	$5.00
Laborer	$5.00	2	$10.00
		Subtotal	$151.00
Equipment			
75 Ton Crane	$85.00	2	$170.00
Small Tools	2.00%		$3.02
Power Tools	$5.00	4	$20.00
		Subtotal	$193.02
		Total	$344.02 / hr
			$114.67 / m^2

Formwork Cost			
Assume 4 uses + 10% waste			
20652.5 m^2		$75.00 /m^2	$1,548,937.50
Scaffolding		$10.00 /m^2	$751,000.00
			$2,299,937.50
			$30.63 /m^2
		Total	$145.30 /m^2
		Total	$40.69 /m^3
Finishing	61,874.00	$4.50 /m^2	$278,433.00
			$1.04 /m^3
Curing	116,298.00	$2.50 /m^2	$290,745.00
			$1.08 /m^3
Surface Prep	116,298.00	$3.00 /m^2	$348,894.00
			$1.30 /m^3

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CIP Concrete Placement/Forming Costs - ILCS Alternative
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Approach Wall Construction

CIP 24,602 m^3

Placement Cost

Installation Backup

Production Rate 30 m^3/hr

Labor	$/mh	Qty	Total $/hr
Supervisor/Foreman	$50.00	1	$50.00
Cement Finisher	$5.00	2	$10.00
Cement Finisher	$6.10	4	$24.40
Laborer	$5.00	2	$10.00
Crane Operator	$6.90	2	$13.80
Laborer	$5.00	12	$60.00
Concrete Pump Oper	$8.40	1	$8.40
		Subtotal	$176.60
Equipment			
Crane	$85.00	2	$170.00
Bucket Concrete	$3.00	2	$6.00
Air Comp 250 CFM	$9.00	3	$27.00
Air Hose	$0.50	6	$3.00
Conc Vibrator	$2.00	6	$12.00
Conc Pump Truck	$85.00	1	$85.00
Small Tools	2.00%		$3.53
		Subtotal	$306.53
		Total	$483.13
		Unit Cost	$16.10 /m^3

Finishing	82,362.00	$4.50 /m^2	$370,629.00
			$15.06 /m^3
Curing	82,362.00	$2.50 /m^2	$205,905.00
			$8.37 /m^3

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CIP Concrete Placement/Forming Costs - ILCS Alternative
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Chamber Floor Construction

Chamber Floor Construction CIP 50,639 m^3
Placement Cost

Installation Backup Production Rate 35 m^3/hr

Labor	$/mh	Qty	Total $/hr
Supervisor/Foreman	$50.00	1	$50.00
Cement Finisher	$5.00	2	$10.00
Cement Finisher	$6.10	4	$24.40
Laborer	$5.00	2	$10.00
Crane Operator	$6.90	2	$13.80
Laborer	$5.00	12	$60.00
Concrete Pump Oper	$8.40	1	$8.40
		Subtotal	$176.60
Equipment			
Crane	$85.00	2	$170.00
Bucket Concrete	$3.00	2	$6.00
Air Comp 250 CFM	$9.00	3	$27.00
Air Hose	$0.50	6	$3.00
Conc Vibrator	$2.00	6	$12.00
Conc Pump Truck	$85.00	1	$85.00
Small Tools	2.00%		$3.53
		Subtotal	$306.53
		Total	$483.13

	U/P	Qty	Cost
Joint Metal (meters)	$0.00	100000	$0.00
			$0.00 /m3
		Unit Cost	$13.80 / m3

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COMPUTATION SHEET

CIP Concrete Placement/Forming Costs - ILCS Alternative
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Chamber Floor

Quantity	43,000 m^2	CIP	50,639 m^3
Forming Cost		Production	3 m^2 / hr

Labor	$/mh	Qty	Total $/hr
Supervisor/Foreman	$50.00	1	$50.00
Crane Operator	$6.90	2	$13.80
Formworker	$5.60	7	$39.20
Formworker helper	$4.90	3	$14.70
Carpenter	$6.10	3	$18.30
Oiler	$5.00	1	$5.00
Laborer	$5.00	2	$10.00
		Subtotal	$151.00
Equipment			
75 Ton Crane	$85.00	2	$170.00
Small Tools	2.00%		$3.02
Power Tools	$5.00	4	$20.00
		Subtotal	$193.02
		Total	$344.02 / hr
			$114.67 / m^2

Formwork Cost
Assume 4 uses + 10% waste

11825 m^2	$75.00 /m^2	$886,875.00
Scaffolding	$0.00 /m^2	$0.00
		$886,875.00
		$20.63 /m^2
	Total	$135.30 /m^2
	Total	$114.89 /m^3

Finishing	51,000.00	$4.50 /m^2	$229,500.00
			$4.53 /m^3
Curing	51,000.00	$2.50 /m^2	$127,500.00
			$2.52 /m^3

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Forming Quantities - ILCS Alternative
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Alternative No.4a
Formwork Quantities

Chamber Monolith Concrete

East Walls		Lower Chamber Section			Stationing			
		Top EL	Base EL	Height (m)	Start	End	Length	SMCA
RCC	Face	18.55	-29.28	47.83	12+582	13+006	424.00	20279.92
RCC	Rear	18.55	-3	21.55	12+582	13+006	424.00	9137.2
					Width	Area	#	
RCC	Sides	18.55	-29.28	47.83	18.00	860.94	3.00	2582.82

East Walls		Upper Chamber Section			Stationing			
		Top EL	Base EL	Height (m)	Start	End	Length	SMCA
RCC	Face	31.601	-16.517	48.12	13+097	13+520	423.00	20353.91
RCC	Rear	31.601	10	21.60	13+097	13+520	423.00	9137.223
					Width	Area	#	
RCC	Sides	31.601	-16.517	48.12	18.00	866.124	3.00	2598.372

West Walls		Lower Chamber Section			Stationing			
		Top EL	Base EL	Height (m)	Start	End	Length	SMCA
RCC	Face	18.55	-29.28	47.83	12+582	13+006	424.00	20279.92
RCC	Rear	18.55	-2	20.55	12+582	13+006	424.00	8713.2
					Width	Area	#	
RCC	Sides	18.55	-29.28	47.83	15.00	717.45	3.00	2152.35

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West Walls		Upper Chamber Section			Stationing			
		Top EL	Base EL	Height (m)	Start	End	Length	SMCA
RCC	Face	31.601	-16.517	48.12	13+097	13+520	423.00	20353.91
RCC	Rear	31.601	13.617	17.98	13+097	13+520	423.00	7607.232
					Width	Area	#	
RCC	Sides	31.601	-16.517	48.12	15.00	721.77	3.00	2165.31

Total Walls RCC 125361.4 smca

Use these coverage areas for the outlet and intake structure

	Start	End	Distance (m)	RCC (m^2/m)	CIP (m^2/m)	RCC (smca)	CIP (smca)
Atlantic Outlet Structure	12+400	12+491	91	74.003173	0	13468.58	0
Gatun Intake Structure	13+611	13+690	79	74.003173	0	11692.5	0
					Totals	25161.08	0

Total Walls	RCC	150522.5	smca
	w/ 10%	**165600**	smca
	CIP	0	smca
	w/ 10%	**0**	smca

Gate Monoliths
North Gate Bay Monoliths

					Stationing			
		Top EL	Base EL	Height (m)	Start	End	Length	SMCA
RCC	Face	4	-6	10.00	12+491	12+582	91.00	1820
CIP	Face	-6	-25.18	19.18	12+582	13+006	91.00	3490.76
CIP	Face	18.5	4.00	14.50	12+582	13+006	91.00	2639
CIP	Rear	18.5	4	14.50	12+582	13+006	91.00	2639
					Width (m)	# of Sides		SMCA
CIP	Sides	-6	-25.18	19.18	22.5	6		5178.6
CIP	Sides	18.5	4.00	14.50	22.50	6.00		3915

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Center Gate Bay					Stationing			
		Top EL	Base EL	Height (m)	Start	End	Length	SMCA
RCC	Face	23	4	19.00	13+006	13+097	91.00	3458
CIP	Face	31.601	23	8.60	13+006	13+097	91.00	1565.382
CIP	Face	4	-16.39	20.39	13+006	13+097	91.00	3711.162
CIP	Rear	31.601	23	8.60	13+006	13+097	91.00	1565.382
					Width (m)	# of Sides		SMCA
CIP	Sides	31.601	23.00	8.60	22.5	6		2322.27
CIP	Sides	4	-16.39	20.39	22.50	6.00		5505.3

Southern Gate Bay					Stationing			
		Top EL	Base EL	Height (m)	Start	End	Length	SMCA
RCC	Face	26.669	8	18.67	13+520	13+611	91.00	3397.758
CIP	Face	31.601	26.669	4.93	13+520	13+611	91.00	897.624
CIP	Face	8	-6.97	14.97	13+520	13+611	91.00	2724.54
CIP	Rear	31.601	26.669	4.93	13+520	13+611	91.00	897.624
					Width (m)	# of Sides		SMCA
CIP	Sides	31.601	26.67	4.93	22.5	6		1331.64
CIP	Sides	8	-6.97	14.97	22.50	6.00		4041.9
					Totals	RCC	8675.758	smca
						w/ 10%	**9500**	smca
		Length	SMCA	Total				
Culverts		546	30	16380				
						CIP	58805.184	smca
						w/ 10%	**64700**	smca

Chamber Floors							
Lower Chamber		Length	Heigth / Width	Number	Sides	SMCA	
CIP	Walls	425	7	2	2.00	11900	
Culverts	Top	425	8	2	1.00	6800	
					Total	18700	
Upper Chamber		(Same features)				18700	
					Totals	37400	smca
					w/ 15%	**43000**	smca

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Approach Walls

					Stationing			
Atlantic Approach		Top EL	Base EL	Height (m)	Start	End	Length	SMCA
RCC	East Face	3.5	-23.67	27.17	11+682	12+400	718.00	19508.06
RCC	West Face	3.5	-23.67	27.17	12+316	12+400	84.00	2282.28
RCC	East Rear	3.5	-8.00	11.50	11+682	12+400	718.00	8257
RCC	West Rear	3.5	-8	11.50	12+316	12+400	84.00	966
							Total	31013.34
		Top EL	Base EL	Height (m)	Width	Area	#	
RCC	Sides	3.5	-23.67	27.17	22.00	597.74	6.00	3586.44

					Stationing			
Gatun Approach		Top EL	Base EL	Height (m)	Start	End	Length	SMCA
RCC	East Face	31.6	0.64	30.96	13+690	14+400	710.00	21981.6
RCC	West Face	31.6	0.64	30.96	13+690	13+775	85.00	2631.6
RCC	East Rear	31.6	10.00	21.60	13+690	14+400	718.00	15508.8
RCC	West Rear	31.6	16	15.60	13+690	13+775	85.00	1326
							Total	41448
		Top EL	Base EL	Height (m)	Width	Area	#	
RCC	Sides	31.6	0.64	30.96	22.00	681.12	6.00	4086.72
							Totals	80134.5 smca
							w/ 10%	**88100** smca

Galleries

Dimensions	3m x 3m	Forming Perimeter	9 meters
	1.5m x 3m	Forming Perimeter	7.5 meters
			16.5 meters
		Length	2040 meters
			33660 smca
		w/ 15%	**38700** smca
	Gate Monoliths	Length	546 meters
			9009 smca
		w/ 15%	**10400** smca

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RCC Joint Materials

Lock Chamber		Depth (m)	Height (m)	Surface Area	Monolith Jts	Total surface	
Lower Chamber	East Wall	18	48.00	864.00	31	26,784.00	
	West Wall	15.00	48.00	720.00	31	22,320.00	
Upper Chamber	East Wall	18	48.00	864.00	31	26,784.00	
	West Wall	15.00	48.00	720.00	31	22,320.00	
Intake/Outlet Structures	East Wall	18	48.00	864.00	6	5,184.00	
	West Wall	15.00	48.00	720.00	6	4,320.00	
						107,712.00	m^2

Gate Monoliths		Depth (m)	Height (m)	Surface Area	Monolith Jts	Total surface area	
Lower Gate Bays	East Walls	15	10.00	150.00	6	900.00	
	West Walls	15	10.00	150.00	6	900.00	
Middle Gate Bays	East Walls	10	19.00	190.00	6	1,140.00	
Middle Gate Bays	West Walls	10	19.00	190.00	6	1,140.00	
Upper Gate Bay	East Wall	22.50	19.00	427.50	6	2,565.00	
Lower Gate Bay	West Wall	22.50	19.00	427.50	6.00	2,565.00	
						9,210.00	m^2

Approach Walls		Depth (m)	Height (m)	Surface Area	Monolith Jts	Total surface	
Atlantic	East Wall	15	27.00	405.00	45	18,225.00	
	West Wall	15.00	27.00	405.00	6	2,430.00	
Gatun	East Wall	15	31.00	465.00	45	20,925.00	
	West Wall	15.00	31.00	465.00	6	2,790.00	
						44,370.00	m^2

Chamber Floors		Depth (m)	Height (m)	Surface Area	Joints	Total surface area	
	Lower Chamber	30	1.00	30.00	31	930.00	m^2
	Upper Chamber	30	1.00	30.00	31	930.00	m^2
						1,860.00	m^2

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Finishing

Lock Chamber	Length	Height (m)	Surface Area	# of walls	Total surface area
Lower Chamber walls	425	48.00	20,400.00	2	40,800.00
Upper Chamber walls	425.00	48.00	20,400.00	2	40,800.00
Intake/Outlet Structures	170	48.00	8,160.00	2	16,320.00
Top of Walls (heigth is width)	425	12.00	5,100.00	4	20,400.00
Top of Intake/Outlet Struct. (Ht is width)	170	12.00	2,040.00	2	4,080.00
Galleries					38,700.00
				Total	161,100.00

	Length (m)	Height (m)	Surface Area	# of walls	Total surface area
Northern Gate Monoliths	91	44.00	4,004.00	2	8,008.00
Middle Gate Monoliths	91.00	48.00	4,368.00	2	8,736.00
Southern Gate Monoliths	91	40.00	3,640.00	2	7,280.00
Top of Gate Monoliths	91	25.00	2,275.00	6	13,650.00
Galleries					10,400.00
Culverts					13,800.00
				Totals	61,874.00

Approach Walls	Length (m)	Height (m)	Surface Area	# of walls	Total surface area
Atlantic East	718	28.00	20,104.00	1	20,104.00
Atlantic West	84	28.00	2,352.00	1	2,352.00
Gatun East	718	31.00	22,258.00	1	22,258.00
Gatun West	84	31.00	2,604.00	1	2,604.00
Top of East Walls	718	23.00	16,514.00	2	33,028.00
Top of West Walls	84	12.00	1,008.00	2	2,016.00
				Total	82,362.00

Chamber Floors	Surface Area	Length	# of culverts	Total surface area
Lower Chamber	30	425.00	2.00	25,500.00
Upper Chamber	30	425.00	2.00	25,500.00
			Total	51,000.00

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Curing/Surface Prep	Length	Width	Surface Area	# of lifts	Total surface area	
Lower Chamber	425.00	12.00	5,100.00	0	0.00	
Upper Chamber	425.00	12.00	5,100.00	0	0.00	
Intake/Outlet Structures	170.00	12.00	2,040.00	0	0.00	
				Total	0.00	/wall
				Total	0.00	

Gate Monoliths		Length	Width	Surface Area	# of lifts	Total surface area	
Norhern Gate Bays	East Walls	91	23.00	2,093.00	11	23,023.00	
	West Walls	91	23.00	2,093.00	11	23,023.00	
Middle Gate Bays	East Walls	91	25.00	2,275.00	9	20,475.00	
Middle Gate Bays	West Walls	91	25.00	2,275.00	9	20,475.00	
Southern Gate Bay	East Wall	91.00	23.00	2,093.00	7	14,651.00	
Southern Gate Bay	West Wall	91.00	23.00	2,093.00	7.00	14,651.00	
						116,298.00	m^2

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COMPUTATION SHEET

Miter Gates
Double-Lift Concept

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Miter Gates

Quote Information

Quote from IHI (Japan) including delivery $6,990.00 / tonne
Includes delivery but not erection or taxes. (Fabrication Time - 30 months)

Quote from Doosan Heavy Industries (Korea) $4,550.00 / tonne
Includes delivery but not erection or taxes.

Quote from Bardella (Brazil) $4,850.00 /tonne
Includes delivery and erection at site. (Fabrication time - 3 years)

Quote from Alstom (Brazil) $3,890.00 /tonne
Includes delivery but not erection or taxes. (Fabrication Time - 34 to 40 months)

Installation cost approximately $1,000 / tonne.
Use an average of the quotes from Brazil, Japan and Korea. Add $1,000
for installation to the quotes which do not include it.

Avg		$5,820.00 /tonne
Prime Contractor's Markup	10%	$582.00 /tonne
Rounded Total		**$6,500.00 /tonne**

Miter Gates Fabrication and Delivery

	WT per two sets of gates	unit price	Total Cost
North Gate Bay	6920 mton	$6,500	$44,980,000
Center Gate Bay	6920 mton	$6,500	$44,980,000
South Gate Bay	4770 mton	$6,500	$31,005,000
		Total Cost	$120,965,000

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Miter Gates - Gate Operating Equipment
Double-Lift Concept

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Gate Operating Equipment

Unit cost, except for installation cost, based on quotation provided by Rexroth. Prices provided were in the 2005 price level. The cost data provided from Rexroth was left at the 2005 price level. The amount of inflation from 2002 to 2005 was viewed as additonal contingency for this item.

Bid Item	Qty	Unit	Unit Cost	Total Cost
HPU	1	ea	$253,000	$253,000
Local Control Cabinet	1	ea	$44,500	$44,500
Miter Gate Hydraulic Cylinder	1	ea	$246,000	$246,000
Installation	1	ea	$50,000	$50,000
			Subtotal	$593,500 /ea

Prime Contractor's Markup	20.00%	$118,700.00	/ea
	Total	$712,200.00	/ea
	Rounded Total	**$715,000.00**	/ea

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Valves
Double-Lift Concept

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Valves

Fabrication Cost Including Delivery

Quote from IHI (Japan) including delivery $11,800.00 / tonne
Includes delivery but not erection or taxes. (Fabrication Time - 30 months)

Quote from Doosan Heavy Industries (Korea) $4,750.00 / tonne
Includes delivery but not erection or taxes.

Quote from Bardella (Brazil) $3,990.00 /tonne
Includes delivery and erection at site. (Fabrication time - 3 years)

Use a cost of $5000/tonne including installation.

		$5,000.00 / tonne
Prime Contractor's Markup	10%	$500.00 / tonne
Total		$5,500.00 / tonne
Rounded Total Cost		$5,500.00 /tonne

Valves - Interlaced Bottom Lateral Option

	Wt per Valve	$/tonne	# of valves	Total Cost
Upper Lock Fill	84.64 mton	$5,500.00	2	$931,040
Between Locks	92.6 mton	$5,500.00	2	$1,018,600
Lower Lock Empty	84.64 mton	$5,500.00	2	$931,040
WSB	58.3 mton	$5,500.00	16	$5,130,400
		Total Cost		$8,011,080

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Valves
Double-Lift Concept

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Valves

Valve Bulkheads (No installation) - Interlaced Bottom Laterals Option

	Wt/bulkhead set	unit price	Qty	Total Cost
Upper and Lower Culvert Valves	68 mton	$5,000	1	$340,000
Center Culvert Valves	88 mton	$5,000	1	$440,000
Water Savings Basins	68 mton	$5,000	1	$340,000
			Total	$1,120,000

Valves - ILCS Option

	Wt per Valve	$/tonne	# of valves	Total Cost
Upper Lock Fill	66.4 mton	$5,500.00	4	$1,460,800
Between Locks	66.4 mton	$5,500.00	4	$1,460,800
Lower Lock Empty	66.4 mton	$5,500.00	4	$1,460,800

Valve Bulkheads (No installation) - ILCS Option

	Wt/bulkhead set	unit price	Qty	Total Cost
Lock Culvert Valves	60 mton	$5,000	2	$600,000
Water Savings Basins	64 mton	$5,000	1	$320,000
			Total	$920,000

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Miscellaneous Metals / Stainless Steels
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Miscellaneous Metals Miter Gate/Valve Anchorage

Production Rate	750 kg/hr		
Material		$1.50	/kg
Installation		$0.32	/kg
Load/unload		0.03	/kg
Field Paint		$0.20	/kg
Subtotal		2.05	/kg
Contractor Markup	20.00%	$0.41	/kg
Total		$2.46	/kg
Rounded Total		**$2.50**	**/kg**

Stainless Steel Gate sills and quoins

Production Rate	750 kg/hr		
Material		$5.00	/kg
Installation		$0.32	/kg
Load/unload		0.03	/kg
Subtotal		$5.35	/kg
Contractor Markup	20.00%	$1.07	/kg
Total		$6.42	/kg
Rounded Total		**$6.50**	**/kg**

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Miscellaneous Metals / Stainless Steels
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Miscellaneous Metals Miter Gate/Valve Anchorage

Installation Crew

	qty	$/hr	Total $/hr
Foreman	1	$50.00	$50.00
Crane Operator	2	$6.90	$13.80
Oiler	1	$5.00	$5.00
Steekworker	6	$9.40	$56.40
Helper	3	$7.20	$21.60
Signalman	1	$5.00	$5.00
Truck Crane	2	$40.00	$80.00
Power Tools	3	$2.00	$6.00
Small Tools	1	LS	$3.04
			$240.84

US Army Corps
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Pittsburgh District

Panama Canal Authority
Atlantic Locks
3rd Lane - Concept Design Study

COMPUTATION SHEET

Reinforcing Steel
Double-Lift Concept

Price Level: Oct 02

Sheet 1 of 1

Filename: ______
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Computed By: CRC Date 3/14/2003
Checked By: PGB Date 3/26/2003

Reinforcing Steel (International Pricing Source - MEPS Ltd. Steel Industry Market Analysis)

Bar cost w/delivery to Panama	$275.00 /tonne	(using international pricing)
Fabrication (cutting and bending)	$110.00 /tonne	(40% of steel cost)
Installation	$310.00 /tonne	
Miscellaneous (Sorting/unloading, Ties, Waste)	$55.00 /tonne	(20% of steel cost)
Total	$750.00 /tonne	
Prime's Markup	20.00%	
Total	$900.00 /tonne	
Rounded Total	**$900.00 /tonne**	

Installation Backup — Production Rate 3 tonnes / shift

	$/mh	Qty	Total $/mh
Supervisor	$45.00	0.33	$14.85
Rodman Foreman	$7.20	1	$7.20
Rodman	$6.90	4	$27.60
Rodman Helper	$5.00	2	$10.00
Crane Operator	$6.90	0.33	$2.28
Oiler	$5.00	0.33	$1.65
Crane	$85.00	0.33	$28.05
Small Tools (2% of labor)			$1.27
Total Cost/hr			$92.90
Installation cost per tonne			$309.66

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COMPUTATION SHEET

Miter Gate Bridges
Double-Lift Concept

Price Level: Oct 02

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Computed By: CRC Date 3/14/2003
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Miter Gate Bridges

Cost includes fabricating and placing 12 bridges over the gate recesses. Unit cost based on unit cost of valves.

Bid Item	Qty	Unit	Unit Cost	Total Cost
Weight Per Bridge	48.2	tonne	$5,500	$265,100
			Total	$265,100 /ea
			Rounded	**$300,000** /ea

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of Engineers
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COMPUTATION SHEET

Emergency Closure
Double-Lift Concept

Price Level: Oct 02

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Emergency Closure

Cost estimate based on lift up wicket system. Approximately 20 wickets (3 meters wide) required to span the lock width. Recent project (Olmstead Dam) used for cost basis of wickets, recess and lifting lowering mechanism.

Bid Item	Qty	Unit	Unit Cost	Total Cost
Wickets	20	ea	$500,000	$10,000,000
Recess in Sill	1	ls	$5,000,000	$5,000,000
Lifting	1	ls	$5,000,000	$5,000,000
				$20,000,000

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COMPUTATION SHEET

Power and Ligthing Systems - Electrical Systems/Lighting
Double-Lift Concept

Price Level: Oct 02 Sheet 1 of 5

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Power and Ligthing Systems - Electrical Systems/Lighting

Main Lock

Lumpsum cost for the power supply and lighting cost associated with the double-lift concept design. Note, some of the electrical costs are included in the operating machinery quotes. For the purpose of this estimate it was assumed that this work will be performed by a subcontractor.

Bid Item	Qty	Unit	Unit Cost	Total Cost
Materials	1	ls	$8,817,994	$8,817,994
Installation	1	ls	$772,140	$772,140
			Subtotal	$9,590,134
w/ Subcontractor's Markup		18.00%		$11,316,358
Contractor Markup		10.00%		$1,131,636
		Total		$12,447,993
		Rounded Total		**$12,500,000**

WSB's

Bid Item	Qty	Unit	Unit Cost	Total Cost
Materials	1	ls	$970,738	$970,738
Installation	1	ls	$171,587	$171,587
			Subtotal	$1,142,324
w/ Subcontractor's Markup		18.00%		$1,347,942
Contractor Markup		10.00%		$134,794
		Total		$1,482,737
		Rounded Total		**$1,500,000**

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COMPUTATION SHEET

Power and Ligthing Systems - Electrical Systems/Lighting
Double-Lift Concept

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Quantities Locks

Description	Unit	Quantity	Unit Cost	Total Material
Power Transfomers	ea	36	$16,000.00	$576,000.00
Sectionalizing switches	ea	36	$50,000.00	$1,800,000.00
Low voltage switchgear	ea	18	$84,000.00	$1,512,000.00
Medium voltage switchgear	ea	2	$500,000.00	$1,000,000.00
Aux power panel	ea	40	$1,000.00	$40,000.00
Contactor panel	ea	40	$1,000.00	$40,000.00
lv transformer	ea	40	$500.00	$20,000.00
				$0.00
				$0.00
Loop feeders				
				$0.00
#500 kcmil	m	23,000	$18.70	$430,100.00
				$0.00
				$0.00
				$0.00
Lighting				$0.00
HML poles	ea	29	$22,000.00	$638,000.00
HML Luminaires	ea	190	$500.00	$95,000.00
HML lowering device	ea	2	$6,300.00	$12,600.00
				$0.00
Gate floodlights	ea	24	$500.00	$12,000.00
gate poles	ea	12	$6,000.00	$72,000.00
Lock water level floods	ea	48	$500.00	$24,000.00
Tunnel ltng	ea	600	$125.00	$75,000.00
low voltage wiring (LS)	ls	1	$250,000.00	$250,000.00
PVC conduit	m	38500	$24.30	$935,550.00
Cable tray operating gallery	m	3660	$65.60	$240,096.00
cable tray electrical gallery	m	5200	$65.60	$341,120.00
crossover cable trays	m	730	$65.60	$47,888.00
GRS conduit	m	7625	$8.20	$62,525.00
Low voltage wiring to HPU's	m	6,100	$14.75	$89,975.00
				$8,313,854.00

Note: HPU starter panels and control enclosures included with HPU costs.

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COMPUTATION SHEET

Power and Ligthing Systems - Electrical Systems/Lighting
Double-Lift Concept

Price Level: Oct 02

Sheet 3 of 5

Filename:	Computed By: CRC	Date	3/14/2003
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Quantities WSB's

Description	Unit	Quantity	Unit Cost	Total Material
Power Transfomers	ea	8	$16,000.00	$128,000.00
Sectionalizing switches	ea	8	$50,000.00	$400,000.00
Low voltage switchgear	ea	4	$84,000.00	$336,000.00
Aux power panel	ea	4	$1,000.00	$4,000.00
Contactor panel	ea	4	$1,000.00	$4,000.00
lv transformer	ea	4	$500.00	$2,000.00
Loop feeders				
# 4/0	m	6,325	$11.50	$72,737.50
Lighting				
High Bay Lighting	ea	48	$500.00	$24,000.00
				$970,737.50

Note: HPU starter panels and control enclosures included with HPU costs.

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COMPUTATION SHEET

Power and Ligthing Systems - Electrical Systems/Lighting
Double-Lift Concept

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Quantities

Description	**Unit**	**Quantity**	**Unit Price**	**Total Price**
PLC Network				
Chassis - 4 Slot	ea	12	$260.00	$3,120.00
Chassis - 10 Slot	ea	5	$485.00	$2,425.00
Chassis - 17 Slot	ea	1	$690.00	$690.00
Power Supply	ea	18	$720.00	$12,960.00
ControlLogix Processor w/ 8MB Non-Volatile Memory	ea	12	$9,000.00	$108,000.00
Processor Battery Module	ea	12	$225.00	$2,700.00
EtherNet/IP Communication Module	ea	7	$1,800.00	$12,600.00
ControlNet Communication Module	ea	18	$1,635.00	$29,430.00
System Redundancy Module	ea	12	$4,350.00	$52,200.00
System Redundancy Module Cable	ea	6	$140.00	$840.00
Programming Software	ea	1	$25,000.00	$25,000.00
Fiber Optic Ethernet Modem	ea	6	$4,000.00	$24,000.00
PLC Chassis Enclosures and Associated Hardware	ea	6	$10,000.00	$60,000.00
PC Network				
Lock Control Server Terminal	ea	2	$2,000.00	$4,000.00
Lock Control Client Terminal	ea	4	$2,000.00	$8,000.00
Networking Equipment	ea	1	$5,000.00	$5,000.00
Lock Control Station	ea	1	$25,000.00	$25,000.00
Communication Cables & Equipment				
Fiber Optic Cable - Channel A, 36 Fibers	m	2750	$8.20	$22,550.00
Fiber Optic Cable - Channel B, 36 Fibers	m	2750	$8.20	$22,550.00
RGS 3/4" Conduit - Channel A	m	2750	$5.65	$15,537.50
RGS 3/4" Conduit - Channel B	m	2750	$5.65	$15,537.50
Fiber Optic Breakout Boxes - Channel A	ea	42	$500.00	$21,000.00
Fiber Optic Breakout Boxes - Channel B	ea	42	$500.00	$21,000.00
Fiber Optic Patch Cables and Terminations	ea	1	$10,000.00	$10,000.00
			TOTAL	**$504,140.00**

COMPUTATION SHEET

Power and Ligthing Systems - Electrical Systems/Lighting
Double-Lift Concept

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Power and Ligthing Systems - Electrical Systems/Lighting
Installation Crew

Crew	Qty	$/hr	Total $/hr
Foreman	1	$50.00	$50.00
Electrician	8	$7.10	$56.80
Electrician Appr.	4	$5.00	$20.00
Helper	4	$5.00	$20.00
Truck	3	$7.00	$21.00
Misc Power Tools	4	$2.00	$8.00
Small Tools	1	JB	$2.94
		Subtotal	$178.74

Assume contractor working 20 hours pre day 6 days a week.
Allow 9 months to complete this work

4320	hr	$178.74	**$772,140**

For WSB's allow 2.0 months to complete the electrical work

960	hr	$178.74	**$171,587**

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3rd Lane - Concept Design Study

COMPUTATION SHEET

Associated General Items - Stainless Steel Planking/Cover Plates/Rabbet Angles
Double-Lift Concept

Price Level: Oct 02

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Associated General Items

Stainless Steel Planking

Stainless Steel Planking, Cover Plates and Rabbet Angles are used to cover the recesses, culvert access points, and machinery trenches. The unit costs were developed using RS Means with a reduction for lower labor cost in Panama

Bid Item	Qty	Unit	Unit Cost	
Stainless Steel Planking	3095	m^2	$650.00	
	Contractor Markup	20.00%	$130.00	
		Total	$780.00	/m^2
		Rounded Total	**$780.00**	**/m^2**
Stainless Steel Cover Plates	112	m^2	$410.00	
	Contractor Markup	20.00%	$82.00	
		Total	$492.00	/m^2
		Rounded Total	**$500.00**	**/m^2**
Stainless Steel Rabbet Angles	4210	m	$55.00	
	Contractor Markup	20.00%	$11.00	
		Total	$66.00	/m
		Rounded Total	**$66.00**	**/m**

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COMPUTATION SHEET

Erosion / Sediment Control
Double-Lift Concept

Price Level: Oct 02

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Erosion and Sediment Control

Erosion and Sediment Control will be required during constuction. This includes but is not limited to the following; Sedimentation Traps, Silt Fence, Diversion Ditches, Channels, Temporary Seeding, Erosion Control Material, etc.. A percentage of the total excavation cost was developed using the Grays Landing Lock Project.

	Qty	Unit	Unit Cost	Total Cost
Cleaning Sedimentation Structures	4000	cy	$10.57	$42,280.00
Sedimentation Traps	8	ea	$9,128.57	$73,028.56
Silt Barrier Fence	5600	LF	$6.93	$38,808.00
Additional Silt Barrier Fence	1000	LF	$6.29	$6,290.00
Straw Bales	3600	LF	$4.50	$16,200.00
Rock Lined Drainage Channel, R-4 Rock	1800	LF	$55.00	$99,000.00
Rock Lined Drainage Channel, R-8 Rock	410	LF	$218.57	$89,613.70
Rock Lined Diversion Ditch, R-4 Rock	3350	LF	$35.43	$118,690.50
Grass Lined Diversion Ditch	280	LF	$10.14	$2,839.20
Blanket Lined Terrace Ditch	12600	LF	9.29	$117,054.00
Rock Barriers	250	LF	76.57	$19,142.50
Temporary Seeding	30	AC	896.43	$26,892.90
Erosion Control Material	1400	SY	5.61	$7,854.00
Rock Fill Drain	1	Job	13,242.86	$13,242.86
			Total	$670,936.22

Average of Excavation Items $3,371,550

Erosion and Sediment Control % 19.90% of excavation cost

Assumes this precentage reduces slightly due to project size and cost.
Use 15.00%

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Atlantic Locks
3rd Lane - Concept Design Study

COMPUTATION SHEET

Instrumentation (Temporary / Permanent)
Double-Lift Option

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Instrumentation

Instrumentation includes both the cost of installing and monitoring during construction, and also the installation of permanent instrumentation. Unit costs were developed using average unit prices from the Grays Landing Lock Project (Feb 90). Quantities updated for the double-lift lock concept design.

	Qty	Unit	Unit Cost	Total Cost
Observation Wells	10	ea	$3,900.00	$39,000.00
Open Standpipe Piezometers	15	ea	$4,971.43	$74,571.45
Inclinometers	10	ea	$7,300.00	$73,000.00
Misc Measurements*	1	Job	$45,000.00	$45,000.00
Data Management System*	1	Job	$112,500.00	$112,500.00
Data Readings, Basic*	1	Job	$112,500.00	$112,500.00
Instrumentation Reports*	1	Job	$485,000.00	$485,000.00
Instrumentation Coordinator	60	Months	$9,828.00	$589,680.00
Alignment Pins	200	EA	$65.71	$13,142.00
Control Monuments in Soil	6	EA	778.57	$4,671.42
Control Monuments in Concrete	4	EA	261.43	$1,045.72
Open Standpipe Piezometers, Lock	10	EA	3,871.00	$38,710.00

* Unit costs multiplied by a factor of 2.5.

Total	$1,588,820.59
ENR Factor	1.392435
Updated Total	$2,212,329.40
Rounded Total	**$2,210,000**

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COMPUTATION SHEET

Handrailing
Double-Lift Option

Price Level: Oct 02

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Fencing Handrailing

The contractor will place industrial railing (2 rail, welded, 1.2 meters high welded 4 cm pipe) around the Water Savings Basins. Unit price developed using RS Means

Handrailing

	Unit	Unit Cost	
Unit Cost	LM	$62.80	
Panama Factor		0.65	
		$40.82	
Contractor Markup		20.0%	
Total		**$48.98**	
Rounded		**$50.00**	/LM

Factors for this work were based on the following assumptions; local labor, no overtime, local equipment, and foreign supplied fencing material.

Panama Canal Concept Design
Atlantic Locks Structure
Third Lane
Double-Lift Lock
Construction Cost Estimate (Option 1 - Interlaced Bottom Lateral Filling System)

Price Level: October 2002

ITEM #	Description	Quantity	Unit	Unit Price	Amount	Contin-gencies	Total
	Mobilization & Demobilization (4%)	1	ls	$27,000,000.00	$27,000,000.00	10.0%	$29,700,000.00
01-01	**Preparatory Work**						
01-01001	Building Demolition	118	ea	$7,750.00	$914,500.00	20.0%	$1,097,400.00
01-01002	Clearing and Grubbing	10000	csm	$75.00	$750,000.00	20.0%	$900,000.00
01-01003	Construction Access Roads	0	km	$90,600.00	$0.00	20.0%	$0.00
01-01004	Construction Haul Roads	7	km	$227,700.00	$1,593,900.00	20.0%	$1,912,680.00
01-01005	Railroad Switches	8	ea	$15,000.00	$120,000.00	20.0%	$144,000.00
01-01006	Railroad Tracks	6	km	$270,000.00	$1,620,000.00	20.0%	$1,944,000.00
01-01007	Railroad Loading Dock	1	ls	$50,000.00	$50,000.00	20.0%	$60,000.00
01-01008	Offloading Dock	1	ls	$3,000,000.00	$3,000,000.00	20.0%	$3,600,000.00
01-01009	Developing Disposal Area	1	ls	$1,000,000.00	$1,000,000.00	20.0%	$1,200,000.00
				Subtotals	**$9,048,000.00**		**$10,858,000.00**
01-02	**Relocations**						
01-02001	Roadways (Temporary)	11000	m^2	$20.00	$220,000.00	25.0%	$275,000.00
01-02002	Roadway Removal	7200	m^2	$6.00	$43,200.00	25.0%	$54,000.00
01-02003	Gatun	1	ls	$660,000.00	$660,000.00	25.0%	$825,000.00
				Subtotals	**$923,000.00**		**$1,154,000.00**

Panama Canal Concept Design
Atlantic Locks Structure
Third Lane
Double-Lift Lock
Construction Cost Estimate (Option 1 - Interlaced Bottom Lateral Filling System)
Price Level: October 2002

ITEM #	Description	Quantity	Unit	Unit Price	Amount	Contin-gencies	Total
01-03	**Care & Diversion of Water**						
01-03001	Construction Berm Placement (Cost included in rock excavation cost)	990000	m^3	$0.00	$0.00	20.0%	$0.00
01-03002	Construction Berm Removal	772000	m^3	$5.25	$4,053,000.00	20.0%	$4,863,600.00
01-03003	Sheet Piling (Construction Berm)	5875	m^2	$105.00	$616,875.00	20.0%	$740,2[illegible]
01-0300[illegible]	[illegible] Piling Installation and Removal (Construction Berm)	16125	m^2	$100.00	$1,612,500.00	20.0%	$1,935,000.00
01-03005	Permanent Berm Placement (Cost included in rock excavation cost)	480000	m^3	$0.00	$0.00	20.0%	$0.00
01-03006	Sheet Piling (Permanent Berm)	6300	m^2	$105.00	$661,500.00	20.0%	$793,800.00
01-03007	Maintenance Pumping	1	ls	$2,000,000.00	$2,000,000.00	20.0%	$2,400,000.00
				Subtotals	**$8,944,000.00**		**$10,733,000.00**
01-04	**Earthwork for Structures**						
01-04001	Exploratory Drilling	1	ls	$1,320,000.00	$1,320,000.00	20.0%	$1,584,000.00
01-04002	Common Excavation (Dry)	4341117	m^3	$3.75	$16,279,188.75	20.0%	$19,535,027.00
01-04003	Rock Excavation (Dry)	4789875	m^3	$7.80	$37,361,025.00	20.0%	$44,833,230.00
01-04004	Common Excavation (In the Wet)	910000	m^3	$6.50	$5,915,000.00	20.0%	$7,098,000.00
01-04005	Rock Excavation (In the Wet)	790000	m^3	$23.00	$18,170,000.00	20.0%	$21,804,000.00
01-04006	Pervious (Structural) Backfill	321190	m^3	$18.00	$5,781,420.00	25.0%	$7,226,775.00
01-04007	Random Backfill	416847	m^3	$3.00	$1,250,541.00	20.0%	$1,500,649.00
01-04008	Foundation Prep	125000	m^2	$75.00	$9,375,000.00	20.0%	$11,250,000.00
				Subtotals	**$95,452,000.00**		**$114,832,000.00**

Panama Canal Concept Design
Atlantic Locks Structure
Third Lane
Double-Lift Lock
Construction Cost Estimate (Option 1 - Interlaced Bottom Lateral Filling System)

Price Level: October 2002

ITEM #	Description	Quantity	Unit	Unit Price	Amount	Contingencies	Total
01-05	**Sitework**						
01-05001	Permanent Seeding	600	MSM	$200.00	$120,000.00	20.0%	$144,000.00
01-05002	Fence (around parking lots)	220	M	$75.00	$16,500.00	20.0%	$19,800.00
01-05003	Security Gates (Electrically Operated)	2	ea	$15,000.00	$30,000.00	20.0%	$36,000.00
01-05004	Parking Lots (asphalt)	3000	m^2	$17.50	$52,500.00	20.0%	$63,000.00
01-05005	Roadway Paving (concrete road)	17500	m^2	$60.00	$1,050,000.00	20.0%	$1,260,000.00
01-05006	Storm Drainage	2700	m	$31.00	$83,700.00	20.0%	$100,440.00
01-05007	Project Signage	1	LS	$50,000.00	$50,000.00	25.0%	$62,500.00
				Subtotals	**$1,403,000.00**		**$1,686,000.00**
01-06	**Entrance Walls, Upper & Lower**						
01-06001	Soil Excavation (Caissons)	1930	m^3	$260.00	$501,800.00	30.0%	$652,340.00
01-06002	Rock Excavation (Caissons)	3550	m^3	$775.00	$2,751,250.00	30.0%	$3,576,625.00
01-06003	Caissons	2760	m	$3,000.00	$8,280,000.00	30.0%	$10,764,000.00
01-06004	Reinforcing Steel (Caissons)	2625316	kg	$0.90	$2,362,784.40	30.0%	$3,071,620.00
01-06005	Tremie Concrete	11520	m^3	$150.00	$1,728,000.00	30.0%	$2,246,400.00
01-06006	Testing/Monitoring Caissons	69	ea	$25,000.00	$1,725,000.00	30.0%	$2,242,500.00
01-06007	Concrete (Cap Wall)	43250	m^3	$335.00	$14,488,750.00	30.0%	$18,835,375.00
01-06008	Reinforcing Steel (Cap Wall)	349000	kg	$0.90	$314,100.00	30.0%	$408,330.00
01-06009	Sheet Piling (Cap Wall)	24680	m^2	$310.00	$7,650,800.00	30.0%	$9,946,040.00
01-06010	Conventional CIP (Gravity Walls)	24602	m^3	$93.00	$2,287,986.00	20.0%	$2,745,583.00
01-06011	RCC (Gravity Walls)	467438	m^3	$65.00	$30,383,470.00	20.0%	$36,460,164.00
01-06012	Reinforcing Steel (Dry Section)	2670000	kg	$0.90	$2,403,000.00	20.0%	$2,883,600.00
01-06013	Pervious (Structural) Backfill	179798	m^3	$18.00	$3,236,364.00	25.0%	$4,045,455.00
01-06014	Random Backfill	419528	m^3	$3.00	$1,258,584.00	20.0%	$1,510,301.00
01-06015	Fenders	1	Job	$11,500,000.00	$11,500,000.00	20.0%	$13,800,000.00
				Subtotals	**$90,872,000.00**		**$113,188,000.00**

Panama Canal Concept Design
Atlantic Locks Structure
Third Lane
Double-Lift Lock
Construction Cost Estimate (Option 1 - Interlaced Bottom Lateral Filling System)

Price Level: October 2002

ITEM #	Description	Quantity	Unit	Unit Price	Amount	Contin-gencies	Total
01-07	**Lock Structure**						
01-07001	Concrete for Lock Walls, (Conv)	541971	M3	$127.00	$68,830,317.00	20.0%	$82,596,380.00
01-07002	Concrete for Lock Walls, (RCC)	773889	M3	$59.00	$45,659,451.00	20.0%	$54,791,341.00
01-07003	Concrete in Place, Gate Monoliths, (Conv)	268148	M3	$110.00	$29,496,280.00	20.0%	$35,395,536.00
01-07004	Concrete for Lock Gate Monoliths, (RCC)	219044	M3	$51.00	$11,171,244.00	20.0%	$13,405,493.00
01-07005	Concrete for Lock Floors/Sills, (Conv)	41270	M3	$198.00	$8,171,460.00	20.0%	$9,805,752.00
01-07006	Concrete for Lock Floors, (RCC)	123144	M3	$46.00	$5,664,624.00	20.0%	$6,797,549.00
01-07007	Reinforcing Steel, Wall Monoliths	9661804	kg	$0.90	$8,695,623.60	20.0%	$10,434,748.00
01-07008	Reinforcing Steel, Floor/Sills	8638655	kg	$0.90	$7,774,789.50	20.0%	$9,329,747.00
01-07009	Reinforcing Steel, Gate Monoliths	5369501	kg	$0.90	$4,832,550.90	20.0%	$5,799,061.00
				Subtotals	**$190,296,000.00**		**$228,356,000.00**
01-08	**Lock Gates & Operating Machinery**						
01-08001	Furnish & Install Lower Miter Gates	2	sets	$22,490,000.00	$44,980,000.00	15.0%	$51,727,000.00
01-08002	Furnish & Install Center Miter Gates	2	sets	$22,490,000.00	$44,980,000.00	15.0%	$51,727,000.00
01-08003	Furnish & Install Upper Miter Gates	2	sets	$15,502,500.00	$31,005,000.00	15.0%	$35,655,750.00
01-08004	Furnish and Install Operating Machinery	12	ea	$715,000.00	$8,580,000.00	15.0%	$9,867,000.00
01-08005	Embedded Metals (Stainless Steel)	38000	kg	$6.50	$247,000.00	15.0%	$284,050.00
01-08006	Gate Anchorage (Structural steel)	908000	kg	$2.50	$2,270,000.00	15.0%	$2,610,500.00
01-08007	Bridges over recesses	12	ea	$300,000.00	$[illegible]00.00	20.0%	$4,320,000.00
01-08008	Emergency Closure	1	LS	$20,000,000.00	$20,000,000.00	15.0%	$23,000,000.00
				Subtotals	**$155,662,000.00**		**$179,191,000.00**
01-09	**Culvert Valves and Operating Machinery**						
01-09001	Upper Lock Filling Valves	2	ea	$465,520.00	$931,040.00	15.0%	$1,070,696.00
01-09002	Valves Between Locks	2	ea	$509,300.00	$1,018,600.00	15.0%	$1,171,390.00
01-09003	Lower Lock Emptying Valves	2	ea	$465,520.00	$931,040.00	15.0%	$1,070,696.00
01-09004	Embedded Metals (Stainless Steel)	1900	kg	$6.50	$12,350.00	15.0%	$14,203.00
01-09005	Valve Anchorage	19580	kg	$2.50	$48,950.00	15.0%	$56,293.00
01-09006	Bulkheads	1	LS	$1,120,000.00	$1,120,000.00	15.0%	$1,288,000.00
01-09007	Valves Operating Machinery	6	ea	$500,000.00	$3,000,000.00	15.0%	$3,450,000.00
				Subtotals	**$7,062,000.00**		**$8,121,000.00**

Panama Canal Concept Design
Atlantic Locks Structure
Third Lane
Double-Lift Lock
Construction Cost Estimate (Option 1 - Interlaced Bottom Lateral Filling System)
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ITEM #	Description	Quantity	Unit	Unit Price	Amount	Contin-gencies	Total
01-10	**Piping System**						
01-10001	Permanent Utilities	1	job	$1,500,000.00	$1,500,000.00	30.0%	$1,950,000.00
				Subtotals	**$1,500,000.00**		**$1,950,000.00**
01-11	**Power and Lighting Systems**						
01-11001	Electrical Systems/Lighting	1	job	$12,500,000.00	$12,500,000.00	20.0%	$15,000,000.00
01-11002	Standby Generator Unit (Permanent)	1	job	$5,000,000.00	$5,000,000.00	15.0%	$5,750,000.00
01-11003	Temp Power Supply during Construction	1	job	$5,000,000.00	$5,000,000.00	15.0%	$5,750,000.00
				Subtotals	**$22,500,000.00**		**$26,500,000.00**
01-12	**Associated General Items**						
01-12001	Stainless Steel Planking	3095	M2	$780.00	$2,414,100.00	15.0%	$2,776,215.00
01-12002	Stainless Steel Cover Plates	112	M2	$500.00	$56,000.00	15.0%	$64,400.00
01-12003	Stainless Steel Rabbet Angles	4210	M	$66.00	$277,860.00	15.0%	$319,539.00
				Subtotals	**$2,748,000.00**		**$3,160,000.00**
01-13	**Building, Project Operations**						
01-13001	Operations / Control Building	1	Job	$1,000,000.00	$1,000,000.00	25.0%	$1,250,000.00
				Subtotals	**$1,000,000.00**		**$1,250,000.00**
01-14	**Miscellaneous Items**						
01-14001	Erosion & Sediment Control	1	LS	$10,000,000.00	$10,000,000.00	15.0%	$11,500,000.00
01-14002	Permanent Instrumentation	1	LS	$2,210,000.00	$2,210,000.00	20.0%	$2,652,000.00
				Subtotals	**$12,210,000.00**		**$14,152,000.00**

Panama Canal Concept Design
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ITEM #	Description	Quantity	Unit	Unit Price	Amount	Contin-gencies	Total
01-15	**Maintenance Facility (Gates)**						
01-15001	Precast Concrete	326	m^3	$400.00	$130,400.00	25.0%	$163,000.00
01-15002	Tremie Concrete	227	m^3	$150.00	$34,050.00	25.0%	$42,563.00
01-15003	CIP Concrete	765	m^3	$300.00	$229,500.00	25.0%	$286,875.00
01-15004	Soil Excavation	2901	m^3	$10.00	$29,010.00	25.0%	$36,263.00
01-15005	8' Concrete Paving	600	m^3	$300.00	$180,000.00	25.0%	$225,000.00
01-15006	Reinforcing Steel	61223	kg	$1.25	$76,528.75	25.0%	$95,661.00
01-15007	Steel Piling (100,000 kg)	1000	m	$250.00	$250,000.00	25.0%	$312,500.00
01-15008	Hoist Systems	1	ea	$300,000.00	$300,000.00	25.0%	$375,000.00
01-15009	Cradle (Str. Steel)	193958	kg	$8.00	$1,551,664.00	25.0%	$1,939,580.00
				Subtotals	**$2,781,000.00**		**$3,476,000.00**
01-16	**Water Savings Basins**						
01-16001	Overburden Excavation	1250943	m^3	$3.75	$4,691,036.25	15.0%	$5,394,692.00
01-16002	Rock Excavation	1048947	m^3	$7.80	$8,181,786.60	15.0%	$9,409,055.00
01-16003	Concrete (Conventional)	88911	m^3	$150.00	$13,336,650.00	15.0%	$15,337,148.00
01-16004	Reinforcing Steel	4493075	kg	$0.90	$4,043,767.50	20.0%	$4,852,521.00
01-16005	Handrailing	1370	LM	$50.00	$68,500.00	20.0%	$82,200.00
				Subtotals	**$30,322,000.00**		**$35,076,000.00**
01-17	**Conduits**						
01-17001	Overburden Excavation	11700	M3	$3.75	$43,875.00	15.0%	$50,456.00
01-17002	Rock Excavation	23400	M3	$7.80	$182,520.00	15.0%	$209,898.00
01-17003	Concrete (Conventional CIP)	60000	M3	$210.00	$12,600,000.00	15.0%	$14,490,000.00
01-17004	Reinforcing Steel	6540000	kg	$0.90	$5,886,000.00	20.0%	$7,063,200.00
				Subtotals	**$18,712,000.00**		**$21,814,000.00**

Panama Canal Concept Design
Atlantic Locks Structure
Third Lane
Double-Lift Lock
Construction Cost Estimate (Option 1 - Interlaced Bottom Lateral Filling System)
Price Level: October 2002

ITEM #	Description	Quantity	Unit	Unit Price	Amount	Contin-gencies	Total
01-18	**Crossovers (Including with Lock Floor Costs)**						
01-18001	Earthwork (Incl w/ lock excavation)	0	M3	$3.75	$0.00	20.0%	$0.00
01-18002	Rock Excavation (Incl w./ lock)	0	M3	$7.80	$0.00	20.0%	$0.00
01-18003	Concrete	0	M3	$175.00	$0.00	15.0%	$0.00
01-18004	Reinforcing Steel	0	kg	$0.90	$0.00	15.0%	$0.00
01-19	**Conduit Valves and Operating Mach.**						
01-19001	Valves	16	ea	$320,650.00	$5,130,400.00	15.0%	$5,899,960.00
01-19002	Embedded Metals (Stainless Steel)	4000	kg	$6.50	$26,000.00	15.0%	$29,900.00
01-19003	Valve Anchorage (Structural Steel)	40000	kg	$2.50	$100,000.00	15.0%	$115,000.00
01-19004	Valve Operating Machinery	16	ea	$400,000.00	$6,400,000.00	15.0%	$7,360,000.00
01-19005	Electrical System/Controls	1	job	$1,500,000.00	$1,500,000.00	20.0%	$1,800,000.00
				Subtotals	**$13,156,000.00**		**$15,205,000.00**

Totals	**$691,591,000.00**	**$820,402,000.00**
Rounded	**$692,000,000.00**	**$820,000,000.00**

Panama Canal Concept Design
Atlantic Locks Structure
Third Lane
Double-Lift Lock

Construction Cost Estimate (Option 2 - ILCS Gravity Monoliths)

Price Level: October 2002

ITEM #	Description	Quantity	Unit	Unit Price	Amount	Contin-gencies	Total
	Mobilization & Demobilization (4%)	1	ls	$27,000,000.00	$27,000,000.00	10.0%	$29,700,000.00
01-01	**Preparatory Work**						
01-01001	Building Demolition	118	ea	$7,750.00	$914,500.00	20.0%	$1,097,400.00
01-01002	Clearing and Grubbing	10000	csm	$75.00	$750,000.00	20.0%	$900,000.00
01-01003	Construction Access Roads	0	km	$90,600.00	$0.00	20.0%	$0.00
01-01004	Construction Haul Roads	7	km	$227,700.00	$1,593,900.00	20.0%	$1,912,680.00
01-01005	Railroad Switches	8	ea	$15,000.00	$120,000.00	20.0%	$144,000.00
01-01006	Railroad Tracks	6	km	$270,000.00	$1,620,000.00	20.0%	$1,944,000.00
01-01007	Railroad Loading Dock	1	ls	$50,000.00	$50,000.00	20.0%	$60,000.00
01-01008	Offloading Dock	1	ls	$3,000,000.00	$3,000,000.00	20.0%	$3,600,000.00
01-01009	Developing Disposal Area	1	ls	$1,000,000.00	$1,000,000.00	20.0%	$1,200,000.00
				Subtotals	**$9,048,000.00**		**$10,858,000.00**
01-02	**Relocations**						
01-02001	Roadways (Temporary)	11000	m^2	$20.00	$220,000.00	25.0%	$275,000.00
01-02002	Roadway Removal	7200	m^2	$6.00	$43,200.00	25.0%	$54,000.00
01-02003	Gatun	1	ls	$660,000.00	$660,000.00	25.0%	$825,000.00
				Subtotals	**$923,000.00**		**$1,154,000.00**

Panama Canal Concept Design
Atlantic Locks Structure
Third Lane
Double-Lift Lock
Construction Cost Estimate (Option 2 - ILCS Gravity Monoliths)
Price Level: October 2002

ITEM #	Description	Quantity	Unit	Unit Price	Amount	Contin-gencies	Total
01-03	**Care & Diversion of Water**						
01-03001	Construction Berm Placement (Cost included in rock excavation cost)	990000	m^3	$0.00	$0.00	20.0%	$0.00
01-03002	Construction Berm Removal	772000	m^3	$5.25	$4,053,000.00	20.0%	$4,863,600.00
01-03003	Sheet Piling (Construction Berm)	5875	m^2	$105.00	$616,875.00	20.0%	$740,250.00
01-03004	Sheet Piling Installation and Removal (Construction Berm)	16125	m^2	$100.00	$1,612,500.00	20.0%	$1,935,000.00
01-03005	Permanent Berm Placement (Cost included in rock excavation cost)	480000	m^3	$0.00	$0.00	20.0%	$0.00
01-03006	Sheet Piling (Permanent Berm)	6300	m^2	$105.00	$661,500.00	20.0%	$793,800.00
01-03007	Maintenance Pumping	1	ls	$2,000,000.00	$2,000,000.00	20.0%	$2,400,000.00
				Subtotals	**$8,944,000.00**		**$10,733,000.00**
01-04	**Earthwork for Structures**						
01-04001	Exploratory Drilling	1	ls	$1,320,000.00	$1,320,000.00	20.0%	$1,584,000.00
01-04002	Common Excavation (Dry)	4188633	m^3	$3.75	$15,707,373.75	20.0%	$18,848,849.00
01-04003	Rock Excavation (Dry)	5112502	m^3	$7.80	$39,877,515.60	20.0%	$47,853,019.00
01-04004	Common Excavation (In the Wet)	910000	m^3	$6.50	$5,915,000.00	20.0%	$7,098,000.00
01-04005	Rock Excavation (In the Wet)	790000	m^3	$23.00	$18,170,000.00	20.0%	$21,804,000.00
01-04006	Pervious (Structural) Backfill	320208	m^3	$18.00	$5,763,744.00	25.0%	$7,204,680.00
01-04007	Random Backfill	418782	m^3	$3.00	$1,256,346.00	20.0%	$1,507,615.00
01-04008	Foundation Prep	125000	m^2	$75.00	$9,375,000.00	20.0%	$11,250,000.00
				Subtotals	**$97,385,000.00**		**$117,150,000.00**

Panama Canal Concept Design
Atlantic Locks Structure
Third Lane
Double-Lift Lock
Construction Cost Estimate (Option 2 - ILCS Gravity Monoliths)

Price Level: October 2002

ITEM #	Description	Quantity	Unit	Unit Price	Amount	Contin-gencies	Total
01-05	**Sitework**						
01-05001	Permanent Seeding	600	MSM	$200.00	$120,000.00	20.0%	$144,000.00
01-05002	Fence (around parking lots)	220	M	$75.00	$16,500.00	20.0%	$19,800.00
01-05003	Security Gates (Electrically Operated)	2	ea	$15,000.00	$30,000.00	20.0%	$36,000.00
01-05004	Parking Lots (asphalt)	3000	m^2	$17.50	$52,500.00	20.0%	$63,000.00
01-05005	Roadway Paving (concrete road)	17500	m^2	$60.00	$1,050,000.00	20.0%	$1,260,000.00
01-05006	Storm Drainage	2700	m	$31.00	$83,700.00	20.0%	$100,440.00
01-05007	Project Signage	1	LS	$50,000.00	$50,000.00	25.0%	$62,500.00
				Subtotals	**$1,403,000.00**		**$1,686,000.00**
01-06	**Entrance Walls, Upper & Lower**						
01-06001	Soil Excavation (Caissons)	1930	m^3	$260.00	$501,800.00	30.0%	$652,340.00
01-06002	Rock Excavation (Caissons)	3550	m^3	$775.00	$2,751,250.00	30.0%	$3,576,625.00
01-06003	Caissons	2760	m	$3,000.00	$8,280,000.00	30.0%	$10,764,000.00
01-06004	Reinforcing Steel (Caissons)	2625316	kg	$0.90	$2,362,784.40	30.0%	$3,071,620.00
01-06005	Tremie Concrete	11520	m^3	$150.00	$1,728,000.00	30.0%	$2,246,400.00
01-06006	Testing/Monitoring Caissons	69	ea	$25,000.00	$1,725,000.00	30.0%	$2,242,500.00
01-06007	Concrete (Cap Wall)	43250	m^3	$335.00	$14,488,750.00	30.0%	$18,835,375.00
01-06008	Reinforcing Steel (Cap Wall)	349000	kg	$0.90	$314,100.00	30.0%	$408,330.00
01-06009	Sheet Piling (Cap Wall)	24680	m^2	$310.00	$7,650,800.00	30.0%	$9,946,040.00
01-06009	Conventional CIP	24602	m^3	$91.00	$2,238,782.00	20.0%	$2,686,538.00
01-06010	RCC	467438	m^3	$63.00	$29,448,594.00	20.0%	$35,338,313.00
01-06011	Reinforcing Steel (Dry Section)	2670000	kg	$0.90	$2,403,000.00	20.0%	$2,883,600.00
01-06012	Pervious (Structural) Backfill	181227	m^3	$18.00	$3,262,086.00	25.0%	$4,077,608.00
01-06013	Random Backfill	422863	m^3	$3.00	$1,268,589.00	20.0%	$1,522,307.00
01-06014	Fenders	1	Job	$11,500,000.00	$11,500,000.00	20.0%	$13,800,000.00
				Subtotals	**$89,924,000.00**		**$112,052,000.00**

Panama Canal Concept Design
Atlantic Locks Structure
Third Lane
Double-Lift Lock
Construction Cost Estimate (Option 2 - ILCS Gravity Monoliths)

Price Level: October 2002

ITEM #	Description	Quantity	Unit	Unit Price	Amount	Contin- gencies	Total
01-07	**Lock Structure**						
01-07001	Concrete for Lock Walls, (Conv)	242627	M3	$90.00	$21,836,430.00	20.0%	$26,203,716.00
01-07002	Concrete for Lock Walls, (RCC)	1513644	M3	$56.00	$84,764,064.00	20.0%	$101,716,877.00
01-07003	Concrete in Place, Gate Monoliths	268148	M3	$111.00	$29,764,428.00	20.0%	$35,717,314.00
01-07004	Concrete for Lock Gate Monoliths, RCC	219044	M3	$49.00	$10,733,156.00	20.0%	$12,879,787.00
01-07005	Concrete for Lock Floors/Sills, (Conv)	50639	M3	$203.00	$10,279,717.00	20.0%	$12,335,660.00
01-07006	Concrete for Lock Floors, (RCC)	136438	M3	$45.00	$6,139,710.00	20.0%	$7,367,652.00
01-07007	Reinforcing Steel, Wall Monoliths	7939800	kg	$0.90	$7,145,820.00	20.0%	$8,574,984.00
01-07008	Reinforcing Steel, Floor/Sills	6401249	kg	$0.90	$5,761,124.10	20.0%	$6,913,349.00
01-07009	Reinforcing Steel, Gate Monoliths	5409222	kg	$0.90	$4,868,299.80	20.0%	$5,841,960.00
				Subtotals	**$181,293,000.00**		**$217,551,000.00**
01-08	**Lock Gates & Operating Machinery**						
01-08001	Furnish & Install Lower Miter Gates	2	sets	$22,490,000.00	$44,980,000.00	15.0%	$51,727,000.00
01-08002	Furnish & Install Center Miter Gates	2	sets	$22,490,000.00	$44,980,000.00	15.0%	$51,727,000.00
01-08003	Furnish & Install Upper Miter Gates	2	sets	$15,502,500.00	$31,005,000.00	15.0%	$35,655,750.00
01-08004	Furnish and Install Operating Machinery	12	ea	$715,000.00	$8,580,000.00	15.0%	$9,867,000.00
01-08005	Embedded Metals (Stainless Steel)	38000	kg	$6.50	$247,000.00	15.0%	$284,050.00
01-08006	Gate Anchorage (Structural steel)	908000	kg	$2.50	$2,270,000.00	15.0%	$2,610,500.00
01-08007	Bridges over recesses	12	ea	$300,000.00	$3,600,000.00	20.0%	$4,320,000.00
01-08008	Emergency Closure	1	LS	$20,000,000.00	$20,000,000.00	15.0%	$23,000,000.00
				Subtotals	**$155,662,000.00**		**$179,191,000.00**
01-09	**Culvert Valves and Operating Machinery**						
01-09001	Upper Lock Filling Valves	4	ea	$365,200.00	$1,460,800.00	15.0%	$1,679,920.00
01-09002	Valves Between Locks	4	ea	$365,200.00	$1,460,800.00	15.0%	$1,679,920.00
01-09003	Lower Lock Emptying Valves	4	ea	$365,200.00	$1,460,800.00	15.0%	$1,679,920.00
01-09004	Embedded Metals (Stainless Steel)	3800	kg	$6.50	$24,700.00	15.0%	$28,405.00
01-09005	Valve Anchorage	39160	kg	$2.50	$97,900.00	15.0%	$112,585.00
01-09006	Bulkheads	1	LS	$920,000.00	$920,000.00	15.0%	$1,058,000.00
01-09007	Valves Operating Machinery	12	ea	$500,000.00	$6,000,000.00	15.0%	$6,900,000.00
				Subtotals	**$11,425,000.00**		**$13,139,000.00**

Panama Canal Concept Design
Atlantic Locks Structure
Third Lane
Double-Lift Lock
Construction Cost Estimate (Option 2 - ILCS Gravity Monoliths)

Price Level: October 2002

ITEM #	Description	Quantity	Unit	Unit Price	Amount	Contingencies	Total
01-10	**Piping System**						
01-10001	Permanent Utilities	1	job	$1,500,000.00	$1,500,000.00	30.0%	$1,950,000.00
				Subtotals	**$1,500,000.00**		**$1,950,000.00**
01-11	**Power and Lighting Systems**						
01-11001	Electrical Systems/Lighting	1	job	$12,500,000.00	$12,500,000.00	20.0%	$15,000,000.00
01-11002	Standby Generator Unit	1	job	$5,000,000.00	$5,000,000.00	15.0%	$5,750,000.00
01-11003	Temp Power Supply during Construction	1	job	$5,000,000.00	$5,000,000.00	15.0%	$5,750,000.00
				Subtotals	**$22,500,000.00**		**$26,500,000.00**
01-12	**Associated General Items**						
01-12001	Stainless Steel Planking	3095	M2	$780.00	$2,414,100.00	15.0%	$2,776,215.00
01-12002	Stainless Steel Cover Plates	112	M2	$500.00	$56,000.00	15.0%	$64,400.00
01-12003	Stainless Steel Rabbet Angles	4210	M	$66.00	$277,860.00	15.0%	$319,539.00
				Subtotals	**$2,748,000.00**		**$3,160,000.00**
01-13	**Building, Project Operations**						
01-13001	Operations / Control Building	1	Job	$1,000,000.00	$1,000,000.00	25.0%	$1,250,000.00
				Subtotals	**$1,000,000.00**		**$1,250,000.00**
01-14	**Miscellaneous Items**						
01-14001	Erosion & Sediment Control	1	LS	$10,300,000.00	$10,300,000.00	15.0%	$11,845,000.00
01-14002	Permanent Instrumentation	1	LS	$2,210,000.00	$2,210,000.00	20.0%	$2,652,000.00
				Subtotals	**$12,510,000.00**		**$14,497,000.00**

Panama Canal Concept Design
Atlantic Locks Structure
Third Lane
Double-Lift Lock
Construction Cost Estimate (Option 2 - ILCS Gravity Monoliths)

Price Level: October 2002

ITEM #	Description	Quantity	Unit	Unit Price	Amount	Contin-gencies	Total
01-15	**Maintenance Facility (Gates)**						
01-15001	Precast Concrete	326	m^3	$400.00	$130,400.00	25.0%	$163,000.00
01-15002	Tremie Concrete	227	m^3	$150.00	$34,050.00	25.0%	$42,563.00
01-15003	CIP Concrete	765	m^3	$300.00	$229,500.00	25.0%	$286,875.00
01-15004	Soil Excavation	2901	m^3	$10.00	$29,010.00	25.0%	$36,263.00
01-15005	8' Concrete Paving	600	m^3	$300.00	$180,000.00	25.0%	$225,000.00
01-15006	Reinforcing Steel	61223	kg	$1.25	$76,528.75	25.0%	$95,661.00
01-15007	Steel Piling (100,000 kg)	1000	m	$250.00	$250,000.00	25.0%	$312,500.00
01-15008	Hoist Systems	1	ea	$300,000.00	$300,000.00	25.0%	$375,000.00
01-15009	Cradle (Str. Steel)	193958	kg	$8.00	$1,551,664.00	25.0%	$1,939,580.00
				Subtotals	**$2,781,000.00**		**$3,476,000.00**
01-16	**Water Savings Basins**						
01-16001	Overburden Excavation	1250943	m^3	$3.75	$4,691,036.25	15.0%	$5,394,692.00
01-16002	Rock Excavation	1048947	m^3	$7.80	$8,181,786.60	15.0%	$9,409,055.00
01-16003	Concrete (Conventional)	88911	m^3	$150.00	$13,336,650.00	15.0%	$15,337,148.00
01-16004	Reinforcing Steel	4493075	kg	$0.90	$4,043,767.50	20.0%	$4,852,521.00
01-16005	Handrailing	1370	LM	$50.00	$68,500.00	20.0%	$82,200.00
				Subtotals	**$30,322,000.00**		**$35,076,000.00**
01-17	**Conduits**						
01-17001	Overburden Excavation	11700	M3	$3.75	$43,875.00	15.0%	$50,456.00
01-17002	Rock Excavation	23400	M3	$7.80	$182,520.00	15.0%	$209,898.00
01-17003	Concrete (Conventional CIP)	60000	M3	$210.00	$12,600,000.00	15.0%	$14,490,000.00
01-17004	Reinforcing Steel	6540000	kg	$0.90	$5,886,000.00	20.0%	$7,063,200.00
				Subtotals	**$18,712,000.00**		**$21,814,000.00**

Panama Canal Concept Design
Atlantic Locks Structure
Third Lane
Double-Lift Lock
Construction Cost Estimate (Option 2 - ILCS Gravity Monoliths)

Price Level: October 2002

ITEM #	Description	Quantity	Unit	Unit Price	Amount	Contin-gencies	Total
01-18	**Crossovers (Including with Lock Floor Costs)**						
01-18001	Earthwork (Incl w/ lock excavation)	0	M3	$3.75	$0.00	20.0%	$0.00
01-18002	Rock Excavation (Incl w./ lock)	0	M3	$7.80	$0.00	20.0%	$0.00
01-18003	Concrete	0	M3	$175.00	$0.00	15.0%	$0.00
01-18004	Reinforcing Steel	0	kg	$0.90	$0.00	15.0%	$0.00
01-19	**Conduit Valves and Operating Mach.**						
01-19001	Valves	16	ea	$320,650.00	$5,130,400.00	15.0%	$5,899,960.00
01-19002	Embedded Metals (Stainless Steel)	4000	kg	$6.50	$26,000.00	15.0%	$29,900.00
01-19003	Valve Anchorage (Structural Steel)	40000	kg	$2.50	$100,000.00	15.0%	$115,000.00
01-19004	Valve Operating Machinery	16	ea	$400,000.00	$6,400,000.00	15.0%	$7,360,000.00
01-19005	Electrical System/Controls	1	job	$1,500,000.00	$1,500,000.00	20.0%	$1,800,000.00
				Subtotals	**$13,156,000.00**		**$15,205,000.00**
				Totals	**$688,236,000.00**		**$816,142,000.00**
				Rounded	**$688,000,000.00**		**$816,000,000.00**

US Army Corps
of Engineers
Pittsburgh District

Panama Canal Authority
Atlantic Locks
3rd Lane - Concept Design Study

COMPUTATION SHEET

Labor Rates
Double-Lift Concept

Price Level: Oct 02

Sheet 1 of 2

Filename: __________
Tab: __________

Computed By: CRC Date 6/30/2003
Checked By: PGB Date 6/30/2003

Labor Rates
Labor Rates for 2002 labor agreement for Panama City
Overtime based upon 2 - 10 hr shifts per day, 6 days per week.
Average Overtime factor = 30% Insurance, benefits, etc. = 1.6

Base labor rates adjusted upwards on the assumption that the contractor will set up a separate aggreement with the unions.

Adjustment Factors	Foreman	1.3
	Skilled	1.25
	Common	1.1

	Base	Adjusted	Incl Benefits	Incl OT	Rounded
Carpenter	$2.92	$3.21	$5.14	$6.10	$6.10
Carpenter (Helper)	$2.40	$2.64	$4.22	$5.02	$5.00
Carpenter (Water Based)					$8.00
Cement Fin (Foreman) (WB)					$8.00
Cement Finisher	$2.40	$2.64	$4.22	$5.02	$5.00
Cement Finisher (Foreman)	$2.92	$3.21	$5.14	$6.10	$6.10
Cement Finisher (WB)					$7.50
Concrete Equipment Oper	$2.57	$2.83	$4.52	$5.37	$5.40
Concrete Worker	$2.40	$2.64	$4.22	$5.02	$5.00
Crane Operator	$2.92	$3.65	$5.84	$6.94	$6.90
Deckhand					$6.00
Drill Operator (WB)					$12.50
Electrician	$2.97	$3.71	$5.94	$7.05	$7.10
Electrician Apprentice	$2.40	$2.64	$4.22	$5.02	$5.00
Floating Crane Operator					$25.00
Formworker (Helper)	$2.35	$2.59	$4.14	$4.91	$4.90
Formworker Helper (WB)					$7.00
Formworkers	$2.68	$2.95	$4.72	$5.60	$5.60
Formworkers (WB)					$8.00
Laborer	$2.40	$2.64	$4.22	$5.02	$5.00
Laborer (WB)					$7.50

US Army Corps
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Pittsburgh District

Panama Canal Authority
Atlantic Locks
3rd Lane - Concept Design Study

COMPUTATION SHEET

Labor Rates
Double-Lift Concept

Price Level: Oct 02 Sheet 2 of 2

Filename: ____
Tab: ____
Computed By: CRC Date 6/30/2003
Checked By: PGB Date 6/30/2003

Labor Rates (Continued)
Labor Rates for 2002 labor agreement for Panama City
Overtime based upon 2 - 10 hr shifts per day, 6 days per week.
Average Overtime factor = 30% Insurance, benefits, etc. = 1.6

	Base	Adjusted	Incl Benefits	Incl OT	Rounded
Laborer Foreman	$2.55	$2.81	$4.49	$5.33	$5.30
Loader Operator	$2.57	$3.21	$5.14	$6.10	$6.10
Mechanic	$3.52	$4.40	$7.04	$8.36	$8.40
Oiler	$2.40	$2.64	$4.22	$5.02	$5.00
Oiler (WB)					$7.00
Operator, Hvy Equip	$3.94	$4.93	$7.88	$9.36	$9.40
Operator, Light Equip	$3.07	$3.38	$5.40	$6.42	$6.40
Operator, Med Equip	$3.52	$4.40	$7.04	$8.36	$8.40
Pile Driverman (WB)					$12.50
Pileman (WB)					$10.00
Pump Operator (WB)					$7.50
Rodman	$2.92	$3.65	$5.84	$6.94	$6.90
Rodman Foreman	$2.92	$3.80	$6.07	$7.21	$7.20
Rodman Helper	$2.40	$2.64	$4.22	$5.02	$5.00
Steelworkers	$3.95	$4.94	$7.90	$9.38	$9.40
Steelworkers (apprent)	$3.44	$3.78	$6.05	$7.19	$7.20
Towboat Operator					$25.00
Truck Driver Heavy	$3.08	$3.85	$6.16	$7.32	$7.30
Truck Driver Light	$2.47	$2.72	$4.35	$5.16	$5.20
Truck Driver Medium	$2.74	$3.43	$5.48	$6.51	$6.50
Welders	$5.22	$6.53	$10.44	$12.40	$12.40
Welders (apprent)	$4.20	$4.62	$7.39	$8.78	$8.80
Contractor Supplied Labor					
Contractor Foreman					$50.00
Heavy Crane Operator					$45.00
Concrete Technician					$45.00

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Atlantic Locks
3rd Lane - Concept Design Study

COMPUTATION SHEET

Equipment Rates
Double-Lift Concept

Price Level: Oct 02

Sheet 1 of 1

Filename: ________
Tab: ________
Computed By: CRC Date 6/30/2003
Checked By: PGB Date 6/30/2003

Equipment Rates are based upon rates Mobile District has previously used when estimating construction costs in Panama. Assume the equipment is purchased new, delivered to Panama and used for an average of 2 to 3 years. Also assume that the contractor will apply for exemption from important tax to Panama.

Equipment	$/hr
Air Compressor 250 CFM	$9.00
Air Hose	$0.50
Barge	$20.00
Bucket Concrete	$3.00
CAT 5130B Excavator	$275.00
CAT 777D Truck	$125.00
Chain Saw, 16" - 36" Bar	$1.00
Chipper, 17" Disc Type, Trailer Mtd	$13.00
Concrete Vibrator	$2.00
D-3 Dozer	$20.00
D-5 Dozer	$25.00
D-6 Dozer	$40.00
Drill Auger, Hyd	$65.00
Floating Crane	$200.00
Hyd Excavator Cat 320-B	$32.00
Hyd Excavator Cat 325-BL	$45.00
Loader 4 m^3 articulated	$60.00
Loader w/ BH Cat 446-B	$24.00
Mechanical Crawler Crane (75 Ton, 170' Bm)	$85.00
Pile Hammer, Vib	$75.00
Pile Leads	$10.00
Pump Submersible	$2.50
Tampers	$2.00
Truck 25 Ton Rear Dump	$31.00
Truck F250 4x4	$7.00
Truck Hwy 43000 GVW 6x4, 3 axle	$20.00
Tug Boat	$100.00
Vibratory Roller 10Ton, 67" wide	$35.00
Vibratory Roller 2.7 Ton, 47.2" wide	$12.00
Water Jet	$1.50
Water Tank (3000 gallon)	$4.00
Work Float	$3.50

US Army Corps
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COMPUTATION SHEET

Overtime Rate Calculations
Double-Lift Concept

Price Level: Oct 02

Sheet 1 of 1

Filename: ________
Tab: ________

Computed By: CRC Date 6/30/2003
Checked By: PGB Date 6/30/2003

Overtime Calculations

2 - 10 hour shifts per day 6 days/week Total Hours per week 60

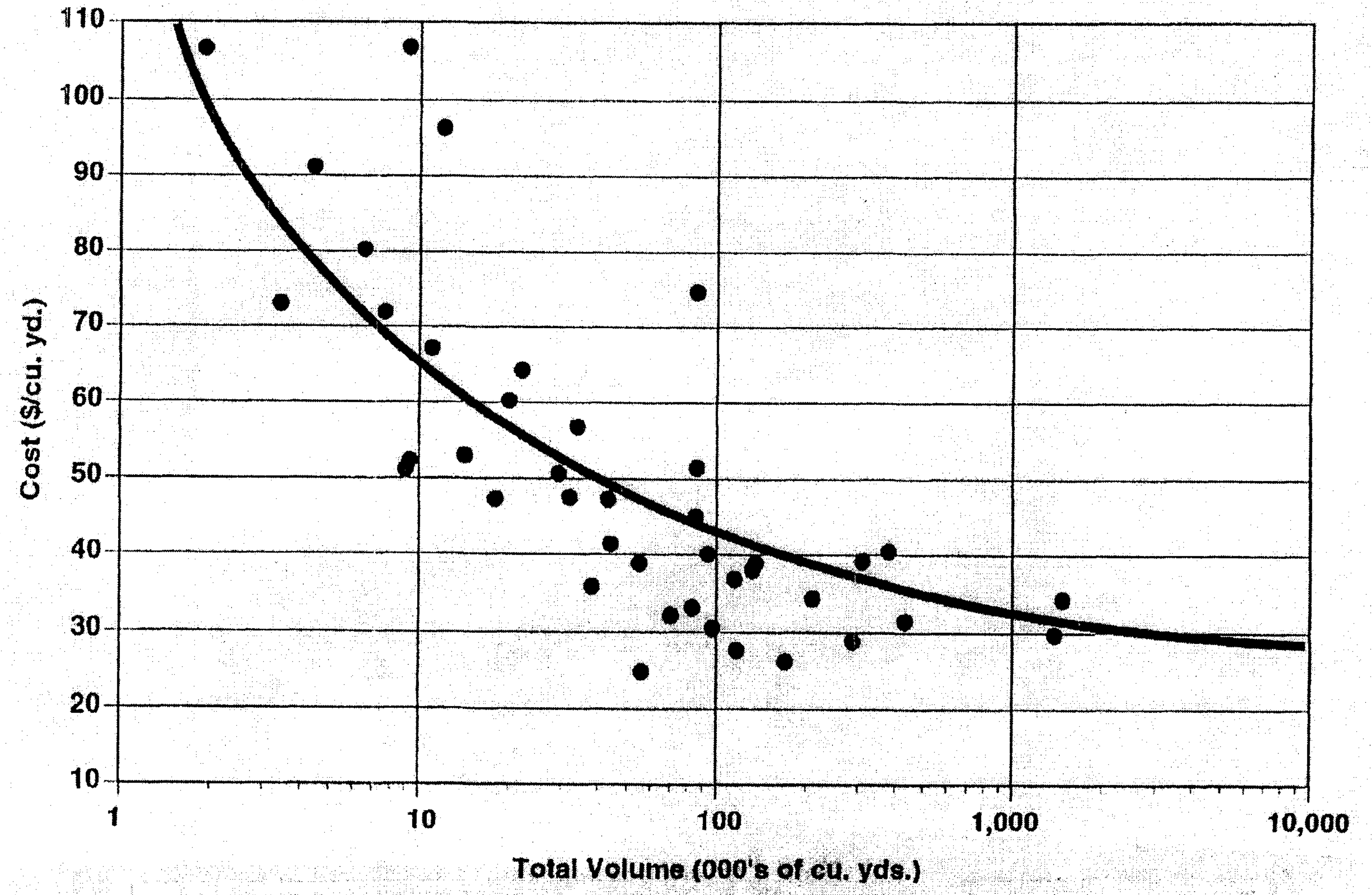
Day Shift	# of days	Reg Pay Hours		OT Hours	OT Adustment	OT Rate	Total/day	Total
Mon to Thur	4	8	$1.00	2	1.25	$1.25	$10.50	$42.00
Fri	1	8	$1.00	1	1.25	$1.25		
				1	1.75	$2.19	$11.44	11.4375
Sat	1	5	$1.00	0	1.50	$1.50		
				5	1.75	$2.63	$18.13	$18.13
							Total	$71.56
							Hour Avg	1.192708

Total Hours per week 54

Night	# of days	Reg Pay Hours		OT Hours	OT Adustment	OT Rate	Total/day	Total
Mon to Thur	4	8	$1.00	2	1.5	$1.50	$11.00	$44.00
Fri	1	8	$1.00	1	1.5	$1.50		
				1	1.75	$2.63	$12.13	12.125
Sat	1	5	$1.00	0	1.50	$1.50		
				5	1.75	$2.63	$18.13	$18.13
							Total	$74.25
							Hour Avg	1.375
							Total Avg	1.283854
							Use	1.30

FIGURE I—RCC CONCRETE DAMS IN USA
2001 Cost Curve

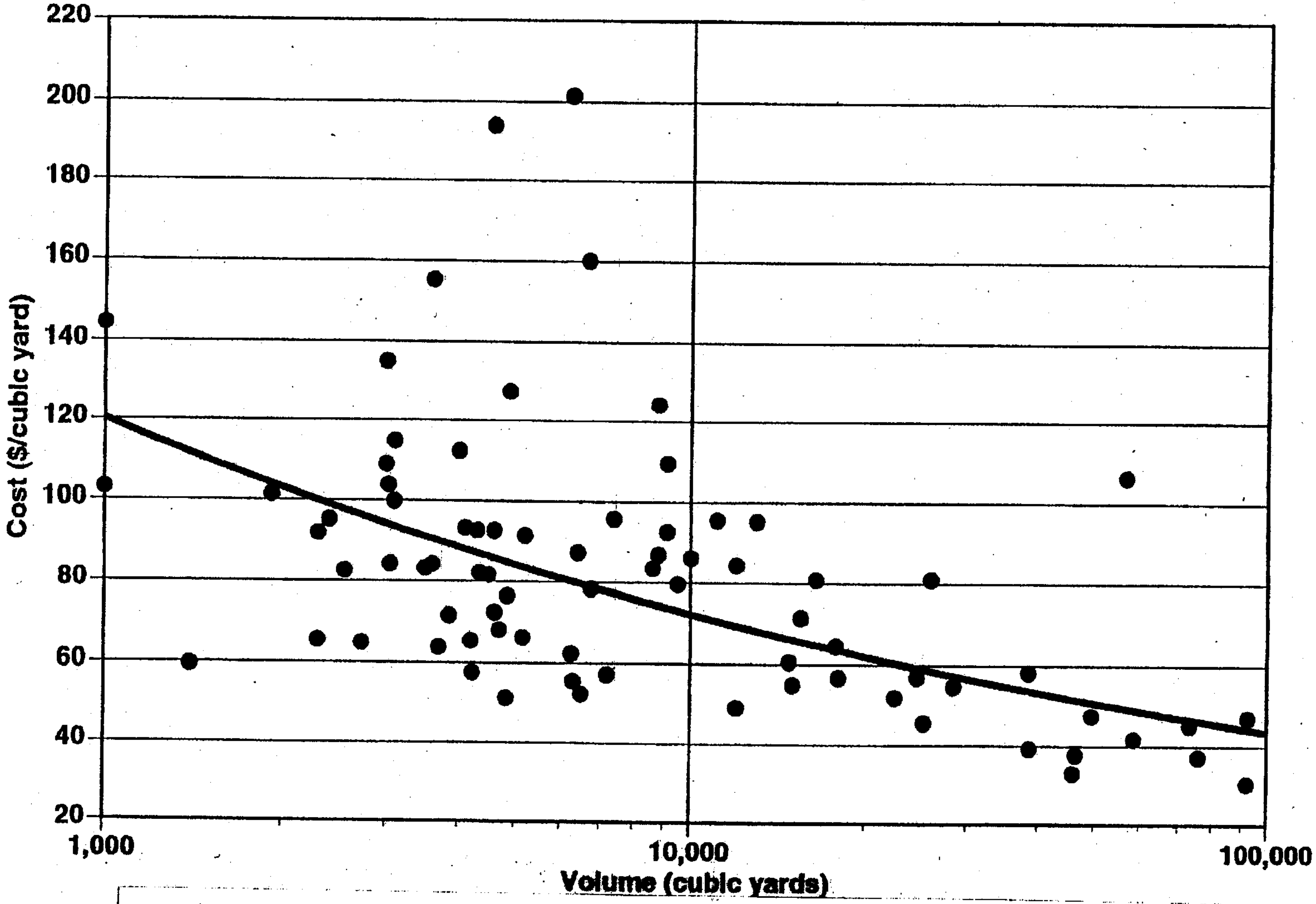
(Project bid unit prices are adjusted to a common cementitious content of 150 lbs cement + 90 lbs fly ash or 195 lbs cement for an all cement mix)



RCC Cost Curves from Roller Compacted Concrete Handbook – Portland Cement Association

FIGURE II—DAM REHABILITATION PROJECTS USING RCC
2001 Cost Curve

(No adjustments have been made to unit costs based on cementitious content)



RCC Cost Curves from Roller Compacted Concrete Handbook – Portland Cement Association

PANAMA CANAL CONCEPT DESIGN

Atlantic Locks Structure

Third Lane Lock

Appendix N

Modification 2, Triple-Lift Configuration

Prepared for

Canal Capacity Projects Office

By

US Army Corps
of Engineers

Final Report
23 July 2003

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Attachments

1. EXECUTIVE SUMMARY

Appendix N is a subset of the Main Report and follows the intent of Modification No. 2 to IAPWO No. SAA-80640, Changes to the Scope of Work, issued by the ACP on January 24, 2003. The primary deliverables specified in Modification 2 include a Lock Screening Study report of four alternate configurations for a double-lift lock, reconfiguration of the double-lift lock concept designs, selection of a filling and emptying system for the triple-lift lock, and a preparation of a construction cost estimate for a triple-lift lock. The Lock Screening Study was submitted in February 2003 and was included as Appendix J - Filling and Emptying System Screening Study in the Double-Lift Concept Design Report that was submitted in March 2003. The ACP provided guidance to the USACE design team to proceed on the triple-lift lock using an In-Chamber Longitudinal Culvert filling and emptying system and to explore the A-1 Alignment as a candidate site in March 2003. This appendix provides a cost estimate for a triple-lift lock based on a design performed to a level that assures safe and reliable operation.

This Appendix presents the concept level design for a single triple-lift structure lock configuration through abbreviated narratives, drawings, design calculations and cost computations. This design shows that the locks are constructible within the A-1 Gatun site using conventional construction techniques. In-the-wet construction techniques would be needed to construct the Gatun Lake entrance walls in the most efficient manner. This construction practice has been used successfully on several recently constructed locks and dams built by the US Army Corps of Engineers. The siting of the locks provides safe and efficient traffic management. The estimated first-cost for the construction of the lock is $1,033,000,000. The estimated construction time for the completion of all features is 5 1/2 years. This can be reduced as discussed below.

1.1. Project Features

This is a brief overview of the evaluation, conclusions reached, and the recommendations for the major project features. A summary of the main features is as follows:

1.1.1. Lock Gates

The mitering gate is the recommended gate type for use in the Atlantic Locks. Operation of the gates would be accomplished using direct-connect hydraulic cylinders similar to those being installed on the existing locks. Two methods for handling the gates for maintenance were developed and presented in the Main Report. A complete discussion on the evaluation of gate alternatives is presented in Appendix B – Gate Section Study.

Only two different gate designs are needed for the triple-lift lock. The Gatun Lake gates would be 22.34 m tall and the other gates would be 30.43 m tall. The total weight of all gates would be approximately 24 000 t including contact blocks and embedded metals. As with some gates owned and operated by the US Army Corps of Engineers, the gates could be sectionalized such that a lower section of the taller gates could be used as lake gates to minimize spare gate components.

An emergency closure system capable of closing open channel flow from Gatun Lake through the new Third Lane Locks is recommended as a project feature. This structure would be located upstream of the Gatun Lock Gates. The use of single gates as opposed to double lock gates may be justified as an additional cost saving measure in consideration of the protection offered by an emergency closure system and implementation of quick gate change out systems. Cost reduction could be realized in gate fabrication, masonry construction, operating equipment, and reduced length of in-the-wet entrance wall construction.

1.1.2. Lock Structure Alignment

The triple-lift lock structure alignment was optimized both longitudinally and transversely through a progressive process of studying various alignments and angled possibilities. Due to the length of the triple-lift lock and limited size of landmass in proximity, a waiver from the Scope of Work was requested and received to place the lock along the A-1 alignment. This alignment is at the best-fit location to use the geologic stratigraphy of the Gatun site and pre-excavation performed in 1939, which reduces the excavation costs. The recommended alignment is at an angle of 7.9-degrees from the Atlantic entrance channel. It has only a minor impact on the Gatun Lake mooring and boat facilities. The offset of the alignment with the addition of water saving basins provides sufficient distance to the side of the channel entry from the Atlantic Ocean and Gatun Lake to safely manage ships entering and exiting the existing and new locks. The additional separation between the existing locks and new locks provided by the A-1 alignment may also provide benefits from a security risk perspective.

1.1.3. Filling and Emptying System

In accordance with Modification 2 of the Scope of Work, the in-chamber longitudinal culvert system (ILCS) was adopted for the triple-lift design. Because the selected filling and emptying system was predetermined, a detailed screening analysis of alternatives was not performed. A brief summary of some considerations and recommendations related to the triple-lift configuration is presented in the following paragraphs. Additional information is presented in Section 2.5 of this report and details are provided in Section 11 of Attachment 2 - Hydraulic Analyses and Design.

The ILCS system has the culverts located longitudinally along the lock floor. The filling and emptying system with water conservation features (water saving basins) are designed as a combined system to operate together and provide the required fill/empty time of about 8-10 minutes. The filling and emptying system was also designed to minimize impacts for operations without water saving basins. Performance under maintenance conditions was also evaluated. The ILCS design provides equalization times ranging between 6.8 and 8.4 minutes for operations without water saving basins. Equalizations with use of water saving basins are expected to range between 9.5 and 10.3 minutes. Hawser forces will be within acceptable limits and slightly lower than the ILCS system for the double-lift design. The filling and emptying system is expected to perform adequately for the triple-lift configuration and is compatible with other recommended design features. The system is designed to operate safely and efficiently with water saving basins during normal operation. Hydraulic performance may be slightly degraded for the ILCS when operating under maintenance conditions due to potential loss of symmetry.

The USACE recommends that the interlaced bottom lateral filling system should be given serious consideration in any future studies of the triple lift. It would provide improved performance over the ILCS system, especially under maintenance. Based on comparison studies of the double lift, the difference in cost between the two systems is expected to be low. Limited information pertaining to the bottom lateral system for the triple-lift arrangement is included in Attachment 2 - Hydraulic Analyses and Design.

1.1.4. Lock Walls

The lock walls have been designed considering the related features, with space provided for locomotives as the ship-positioning system, and provide the most economical solution for the integration of the project features. The water saving basins are located on the west side of the lock and are integrated spatially (non-structural) into the back of the walls. The valve operation monoliths are incorporated into the walls and basins. The culverts have been removed from the walls except as required to accommodate culvert valves. The lock walls are gravity monoliths founded on rock. Roller compacted concrete is used extensively for economy of construction of the lock walls; conventional concrete is used in the areas of culverts, galleries, the lock chamber face and the top surface and land side of the monoliths. The lock walls and water saving basins contain approximately 3 870 000 m^3 of concrete of which 990 000 m^3 is cast-in-place concrete and 2 880 000 m^3 of roller compacted concrete. Aggregates for concrete would come from the Pacific excavation and likely be delivered by rail to the Atlantic lock site. Earthquake event loading is the controlling load case. Space is provided at the top of walls to include a ship positioning system similar to the existing locks. The lock gate monoliths would be constructed as conventional gravity structures founded on a rock foundation.

1.1.5. Entrance Walls

These walls present a special condition because of the size of the impact loads that would be transmitted by the large Post-Panamax ships. Loads developed based on discussion with the Canal pilots were considered and found to be excessively high. Criteria for ship impact was developed and is based on consultation with fender manufactures and PIANC design recommendations. However, a detailed investigation should be performed before final design to define the necessity and magnitude of these loads. The wall length represents one and one-half ship length as requested by the Canal Capacity Projects Office. The Atlantic entrance walls would be constructed on roller compacted concrete and the Gatun entrance walls would be cast-in-place concrete cap walls founded on a drilled shaft foundations and would be constructed for the most part in-the-wet using specialized construction techniques. If tugs are used to manage the ships in the lock entry, these walls could be reduced in length and size and have a significant savings in project cost.

1.2. Recommendations

In proceeding with this design process, it is recommended that Feature Design Memorandum Reports be prepared concurrently with physical modeling for the major features of work before proceeding into the design-for-construction and preparation of the construction plans and specifications. This report would provide a final evaluation of the options available for the specific site conditions, select the most appropriate features, optimize the design, and establish the design parameters. Using this document, final construction plans and specifications would be prepared. While the concept level design report presents the design for various features for the specific site, it does not optimize the design nor consider possible ongoing changes. Changes could include the method of handling the ships that would change the dimensions of the locks and reduce wall loads by eliminating the loads transmitted to the walls with the use of locomotives. Selection of emergency closure systems should be considered with development of any project specific security considerations. Also, decisions need to be made on the methods of maintaining the locks and gates, and these decisions could change certain presented details and/or designs of the features. A life cycle economic cost analysis should be performed to assess viability of purchasing a high capacity gate lifter crane to serve in emergency response scenarios and support other canal system maintenance activities. The use of a single lock gate at the Gatun Entrance should be re-evaluated in conjunction with an emergency closure system as a potential cost savings measure.

A Bottom Interlaced Lateral filling and emptying system should be considered in future studies. Based on the double-lift studies, the cost difference between the interlaced bottom lateral and in chamber longitudinal systems would be low. In addition, the interlaced bottom lateral would provide improved hydraulic performance. A cursory investigation indicates that the excavation and founding elevation of lock walls could be raised 4 m compared with the In-Chamber Longitudinal Culvert filling and emptying system design. This design could reduce concrete and excavation requirements.

2. PROJECT FEATURES

2.1. Geotechnical Considerations

2.1.1. General

As noted in Appendix C - Geotechnical Investigations, Analyses and Designs, the geology across the entire site is similar. Bedrock at the proposed foundation depths is part of the Gatun Formation as described in the Double-Lift report. Geotechnical design parameters described in the Double-Lift Report are appropriate for use in the limited design analysis performed for the triple-lift alternative.

The intent of this section is to briefly point out some of the similarities and differences in the geotechnical conditions between the two alignments.

2.1.2. Stratigraphy

The same basic strata units occur along the Triple-Lift alignment as described in the Double-Lift Report with some variations. Figure GG-13, at the end of this Appendix, shows the stratigraphy along the Triple-lift centerline. The figure is a composite of Figures 5-13, 15 and 17 as taken from Part II Design, Chapter 5, Foundations and Slopes of the Final Report on Modified Third Locks Project dated December 1943. The north-south directions were reversed on the old plans so Gatun Lake is to the left.

As noted in the double-lift report, the strata in the older 1930's report are classified by a different rock unit numbering system. The unit numbers used in the double-lift report have been superimposed on this figure. Since there is a general dip to the north, strata shown on the double-lift geologic profile occur at a higher elevation on the triple-lift profile. The maximum elevation of the conglomerate marker bed is about elevation 28 m on the 2-lift profile but rises to a maximum of almost 40 m at the south end of the double-lift profile. The rise in elevation also means that some of the strata encountered along the triple-lift alignment are too deep on the double-lift alignment to be intercepted by the drilling program.

The original top of sound rock is generally higher along the triple-lift alignment. The highest top of rock elevations are in the 60 m range and occur at the Gatun Lake (southern) end of the alignment. The highest top-of-rock elevations on the Double-Lift alignment are in the range of 20 m and also occur at the Gatun end.

Due to the rise in strata elevation some of the material that is exposed in the existing cuts at the Gatun end of the alignment were not encountered in the most of the 2001 drilling. It appears that TAIC-10 and TA1C-11 did penetrate the sandstones and tuffs of Units 1, 2 and 3 of the old numbering system. These units occur stratigraphically below Unit 7 of the numbering system used in the double-lift report.

Since the top of rock elevation is higher for the A-1 alignment, the Atlantic Muck at the northern end of the alignment is not as thick in comparison to the double-lift alignment. As shown on Figure GG-13, the top of rock surface below the muck is more irregular. The top of rock surface on the double-lift alignment profiles appears smoother because there are fewer borings to define the surface. The large number of borings on the triple-lift alignment enabled the geologists at that time to better define the top of rock surface.

2.1.3. Strength Parameters

The strength parameters recommended in the double-lift report were based on old testing along the original 1930's cut and are assumed to be applicable to the triple-lift alignment.

2.1.4. Slopes

2.1.4.1. Soil

There will be extensive soil cuts for the entrance walls at the northern end of the alignment. The cuts will be primarily through the Atlantic Muck strata. For the purposes of this study, the cut slopes were designed to be at the same slope as the existing natural slopes for this level of study. The slopes are on a 1V:6H slope.

2.1.4.2. Rock

The rock cut slope design used for this report will generally follow the existing cuts that have been stable for 50 years. Some of the cuts within the old lock excavation were intended only as temporary cuts during lock construction but they have remained stable.

There will also be a short approach rock cut at the Gatun end of the alignment that is being designed at a 1V:1H slope.

2.1.5. Future Subsurface Investigations

2.1.5.1. Historical Data

The approach to subsurface investigation along the proposed triple-lift alignment will differ from traditional programs. Since a complete design study was done along this line in the 1930's there is a large body of information that can be used in future design.

Over 400 borings were drilled in the 1930's in addition to the 16 borings drilled in 2001. There also appears to have been a large amount of soils and rock testing done in the 1930's. There also should be some records of conditions and problems encountered during the initial excavation.

The first phase of any future investigation will be an intensive search for and review of the existing information. The old borings will have to be correlated to the terminology used in the new borings. The existing laboratory data will be evaluated and associated with the rock unit designations used in the new study. Old constructions diaries and correspondence should be reviewed for problems encountered during the excavation.

2.1.5.2. Geophysical Investigations

After considering all the existing data, the need for a geophysical exploration program for the next phase of study should be evaluated. If enough information for design is obtained from all the existing subsurface information a geophysical study may not have to be considered until final design.

2.1.5.3. Additional Drilling

Finally the need for additional drilling must be considered. It is likely there will be anomalous features, such as the 'erosional surfaces' described in some of the 2001 logs that will need further investigation.

The need for additional drilling will most likely be evaluated in the final stages of the design process.

2.2. Lock Siting and Layout

The Scope of Work required that the alignment be optimized within the A-2 alignment, which is positioned immediately to the east of Gatun Locks. Several alignments were developed with optimization objectives to minimize construction costs while satisfying functional and operational considerations. The preferred alignment placed the Triple-Lift Lock in proximity to alignment A-1 (1939 lock excavation) with excavation lines that breached the 1939 excavation. Upon further considerations of potential cost saving stemming from siting the lock in the A-1 corridor, the design team requested and received a waiver from the ACP to consider the use of the A-1 alignment corridor. The A-1 alignment was selected for the following reasons:

- Utilization of a site that was previously excavated for a smaller lock reduces soil and rock excavation and duration of site work for a new lock. Approximately 8 800 000 m^3 of rock and overburden were excavated at this site in 1939.
- Eliminates the need for a pile foundation for construction of the north water saving basin because rock is generally encounter at a higher elevation and permits use of spread foundations.
- The easterly alignment of the A-1 corridor minimizes impacts to existing boat facilities along the shores of Gatun Lake.
- Rock elevations are generally higher along the A-1 alignment, which reduces backfill loads on the lock walls and allows for more economical wall sections to be used.
- The berms at the northern and southern ends of the existing excavation can serve as barriers to dewater the work site.
- Provides more flexibility for future development of two-way traffic in the Atlantic approach.

The selected alignment A-1 alignment (azimuth 172° 09' 54") turns to the east 7.9-degrees from the Atlantic approach (azimuth 180° 04' 23"). Ships would travel 2 400 m from the point of intersection (1030333.82N, 618676.75E) to the north entrance wall. Future expansion for two-way traffic can be developed by additional channel excavation in the Atlantic Approach Channel.

The existing slope of the ground adjacent to the existing cut was used for new excavation lines in the overburden (see Section 2 for additional geotechnical information). Cut slopes for overburden Excavation quantities (bank) are shown in Table N-2.2-1; these quantities do not include the approach channel work.

Table N-2.2-1 Summary of Earthwork Quantities

Classification	Quantity (m^3)
Rock	8 408 000
Overburden	5 935 000
Random Backfill	1 156 000
Structural Backfill	725 000

2.3. Lock Walls

The lock walls are similar to those selected for Alternative 2 of the Double-Lift Concept Design. To establish quantities and safe operation for the Triple-Lift Lock, 20 representative lock wall sections and all gate bay monoliths were analyzed. As with previous studies, load case 2G – Maximum Design Earthquake was the governing load case. The backfill elevations generally follow the gallery floor elevation to allow easy access to areas of the lock. The foundation elevation of all lock walls was set to 1 m below the culvert to reduce potential damage to the filling culvert during seismic events. The top of wall elevation was raised from the theoretical hydraulic minimum to accommodate mechanical operating equipment for lock gates. A full description of design criteria is provided in Appendix A – Design Criteria Report.

2.4. Entrance Walls

The Atlantic Locks Third Lane Project is designed to permit transit of vessels significantly larger than those vessels utilizing the Panama Canal at this time. The Entrance Walls are the locations where the vessels first encounter the new Locks, either by connecting with the Ship Positioning System, or by physically impacting or rubbing against the walls. The geometry, displacement and handling characteristics of these Post-Panamax ships will be the primary considerations for the design of the Entrance Walls. In Appendix F - Lock Masonry Analyses and Designs, there is an extensive discussion of these vessels and the resulting impact forces that must be mitigated. At this Concept design level, two main long and two short stub Entrance Walls are planned. The Corps Design Team optimized wall lengths after consultation with ACP Canal Pilots. The lengths of the walls are provided in Appendix F.

The two east Entrance Walls would be oriented parallel to the lock chamber walls, and flush with the lock chamber face. A significant reach of the Gatun Lake entrance wall would be built in-the-wet and would be set back from the chamber wall faces, to permit space for installation of the selected fender system. A tapered sacrificial fixed end pier would be located at the ends of each wall most remote from the Locks, to protect the Entrance Walls from direct "head-on" impacts. These end sections are referred to herein as Nose Piers. The Nose Piers would be protected with fenders.

The top-of-wall elevations have been selected to permit installation of a continuous high-capacity fender system, such that maintenance of the fenders and access to anchor bolts can be accomplished entirely above the "normal" water line. The fenders are a critical component of the Gatun Lake entrance wall design and dynamic response of the walls. The energy absorbing capacity of the fenders, combined with the stiffness of the wall structures and the assumed vessel hull stiffness, would all contribute to the Gatun Lake Entrance Wall's system response in the event of a vessel impact.

Gravity Monoliths similar to those recommended for the lock chambers were evaluated in areas of in-the-dry construction. Preliminary stability analyses were performed for typical sections along the wall alignments. These wall sections would be backfilled to buttress the wall for the extreme vessel impact case. Preliminary screening found gravity entrance walls to be feasible and cost effective. RCC entrance walls would be provided in all areas that can be constructed economically in a dewatered work site.

It is recommended to construct the Entrance Walls in-the-wet with a foundation consisting of 2.44-m diameter drilled shafts spaced at 30 m center-to-center, each having permanent steel casing through the overburden. Drilled shafts are recommended because they are extensively used by USACE for hydraulic concrete structures, relatively simple to construct, and the technology offers a high level of confidence in their structural integrity and performance upon completion. They can carry extremely high axial and lateral loads. One large-diameter drilled shaft can replace a large numbers of piles. Perhaps most critical to Panama, drilled shafts are desirable and economical for seismic (low mass) and vessel impact loadings due to their high lateral load capacity.

For the Gatun Lake Entrance Wall, the installation of these foundation elements can be accomplished "in the wet" out in Gatun Lake, utilizing barge-mounted equipment. The foundation elements would support conventional cast-in-place or precast concrete Cap Beams that would span between the shafts. These rectangular cross-section beams would support the Ship Positioning Locomotives, and would accept and distribute the vessel impact reaction loads that are transmitted from the continuous fender system. A continuous fender system would be mounted on the face of all of the flexible Entrance Walls to absorb impact energy. The fenders are flexible and have been designed to absorb nearly all of the impact energy from collisions. Individual panels of the fender system may be replaced if they are damaged.

2.5. Hydraulic Features

The following paragraphs provide a brief overview and summary of hydraulic features for the third lane, triple-lift lock design. Additional details are provided in Attachment 2 - Hydraulic Analyses and Design.

2.5.1. Design Considerations

2.5.1.1. Lock Profile

The triple-lift lock profile was established in the same manner as the double-lift. Considerations included the range of water surface elevations in Gatun Lake (26.670 to 23.927 m PLD) and Limon Bay (0.564 to –0.381 m PLD). Additional factors include the required minimum sill clearance (18.288 m) and hydraulic freeboard requirements (1.311 m). Maximum equalization levels were set based on the maximum lake and tide elevations to avoid spillage and minimize water consumption. Hydraulic freeboard was then added to obtain minimum top of wall and gate elevations. The sill levels were set based on the minimum clearance from the minimum lake and tide elevations to avoid draft restrictions, avoid make up water, and minimize water consumption.

Table 2.5-1 summarizes the minimum top of wall and gate elevations, maximum and minimum operating elevations, range of freeboard, and lock sill elevations.

Table N-2.5-1 Recommended Lock Profile

Upper lock	Minimum top of wall (m PLD)	27.981		
	Freeboard (m)	1.311	→	4.054
	Maximum upper pool elevation (m PLD)	26.670	Minimum upper pool elevation (M PLD)	23.927
	Sill (m PLD)	-2.464		
Middle lock	Minimum top of wall (m PLD)	19.279		
	Freeboard (m)	1.311	→	3.314
	Maximum upper pool elevation (m PLD)	17.968	Minimum upper pool elevation (M PLD)	15.824
	Sill (m PLD)	-10.566 (used –11.180 for common gate heights)		
Lower lock	Minimum top of wall (m PLD)	10.577		
	Freeboard (m)	1.311	→	2.855
	Maximum upper pool elevation (m PLD)	9.266	Minimum upper pool elevation (M PLD)	7.722
	Sill (m PLD)	-18.669 (used –19.570 for common gate hieght)		

A duration analysis, which considered the entire range of possible lake and ocean elevation combinations, was conducted to determine the average amount of water required for a single down bound lockage without water saving basins. The average amount of water required in terms of a water column was computed as 8.693 m. The total volume of water required can be computed by multiplying the water column by the surface area of the lock.

2.5.1.2. Water Saving Basins

The water saving basin designs are based on a configuration of two water saving basins per lock located to one side with a target water savings of 50%. A detailed screening analysis was not performed for the triple-lift configuration since the double-lift screening study serves as the basis for the triple-lift configuration selection. Consistent with the double-lift design, the low floor alternative is recommended. A summary of the low and high floor alternatives is presented in Attachment 2 - Hydraulic Analyses and Design.

The basin wall elevations were selected based on high lake and ocean levels and the resultant equalizing elevations in the water saving basins. This eliminates the need to spill water during high water periods when the locks and basins will equalize at a high level.

The 1 m of freeboard would be used to set the minimum top of wall elevations for hydraulic design concerns. This freeboard should be applied above the maximum operating elevation so that there will always be 1 m or more of freeboard.

The lake level used was 26.670 m PLD and the ocean level was 0.564 m PLD. Table N-2.5-2 summarized the minimum top of wall elevations, maximum operating elevations, freeboard, and basin floor elevations.

Table N-2.5-2 Recommended Basin Configuration

Basin 1A	Top of Wall (m PLD)	25.494
	Freeboard (m)	1
	Maximum Water Surface (m PLD)	24.494
	Floor Elevation (m PLD)	20.934
Basin 1B	Top of Wall (m PLD)	23.319
	Freeboard (m)	1
	Maximum Water Surface (m PLD)	22.319
	Floor Elevation (m PLD)	18.818
Basin 2A	Top of Wall (m PLD)	16.792
	Freeboard (m)	1
	Maximum Water Surface (m PLD)	15.792
	Floor Elevation (m PLD)	12.469
Basin 2B	Top of Wall (m PLD)	14.617
	Freeboard (m)	1
	Maximum Water Surface (m PLD)	13.617
	Floor Elevation (m PLD)	10.354
Basin 3A	Top of Wall (m PLD)	8.090
	Freeboard (m)	1
	Maximum Water Surface (m PLD)	7.090
	Floor Elevation (m PLD)	4.005
Basin 3B	Top of Wall (m PLD)	4.953
	Freeboard (m)	1
	Maximum Water Surface (m PLD)	3.953
	Floor Elevation (m PLD)	1.887

2.5.1.3. Design Ships

The two design ship types specified by ACP are the bulk carrier and container ship. They apply to both the double- and triple-lift designs. The bulk carrier has a length of 290.0 m, a beam of 45.0 m, and a draft of 15.2 m. The container vessels have a length of 350-400 m, a beam of 50-54 m, and a draft of 14-15 m. A summary of the design ships is presented in Table N-2.5-3.

Table N-2.5-3 Recommended Design Ships

Vessel Type	Length (m)	Beam (m)	Draft (m)	Block Coefficient	Deadweight (t)	Displacement (t)
Container	385.7	54.9	15.2	0.65	125 000	209 000
Bulk Carrier	290.0	45.0	15.2	0.85	135 000	169 000

2.5.1.4. Lock Filling and Emptying Systems

The primary goal in the design of the filling and emptying systems is to safely equalize differential pool elevations within the specified target times with the use of water saving basins. For operation without water saving basins, hydraulic features are designed to maintain a safe operation. The filling and emptying system was designed to meet the 8-10 minute target times for operations with water saving basins. Connections to water saving basins were also designed to approximately meet target equalization times for operations with water saving basins. End to end (longitudinal) water surface slopes in the locks are used as an indicator of hawser forces and safe performance. Computed water surface slopes for the proposed filling and emptying system are compared with existing systems and international criteria to evaluate lock performance. Maintenance conditions are also considered in the design.

All of the filling and emptying systems that are acceptable for the double-lift are also acceptable for the triple-lift.

2.5.1.4.1. ILCS

ACP selected the ILCS (In-Chamber Longitudinal Culvert System) as specified by Modification 2. For equalizations with and without water saving basins, the in-chamber system would provide acceptable performance. Under certain maintenance conditions, hydraulic performance could be degraded due to the loss of symmetry. Connection to the water saving basins will require conduits from the basin to enter the lock chamber and connect to the longitudinal lock culverts.

The ILCS system would have conventional intake and outlet manifolds in the lock walls. The main lock culverts would be 8 m wide and 8 m high with bifurcated valves that are 4 m wide and 8 m high. The emptying valves of the lower lock are an exception, at 5 m wide by 8 m high. The increased size is needed to meet time targets for emptying the lower lock with water saving basins. Water is transferred from the longitudinal culverts to the lock though a series of ports. There are 64 ports along each culvert with each port being 0.7 m wide and 1.95 m high. Connection to the water saving basins is achieved though a set of four conduits and valves per basin that would be 6 m wide and 8 m high. Detailed hydraulic data is presented in Attachment 2 Hydraulic Analysis and Designs.

A summary of equalization times for the ILCS for normal operation at the average lift is presented in Table N-2.5-4. A summary of maximum end-to-end water surface slopes and estimated hawser forces are presented in Table 2.5-5.

Table N-2.5-4 Summary of Equalization Times - ILCS

Equalization	Without WSBs	With WSBs
Gatun Lake to Upper Lock	8.4	10.3
Upper Lock to Middle Lock	6.8	9.5
Middle Lock to Lower Lock	7.0	9.5
Lower Lock to Atlantic Ocean	7.4	10.1

Table N-2.5-5 Estimated Maximum Longitudinal Hawser Forces for ILCS (Design Container Ship)

Equalization	Operation Without WSBs		Operation With WSBs	
	Maximum Slope (1/1000)	Estimated Hawser (t)	Maximum Slope (1/1000)	Estimated Hawser (t)
Lake Gatun to Upper Lock	0.61	127	0.74	155
Upper Lock to Middle Lock	0.45	94	0.63	132
Middle Lock to Lower Lock	0.46	96	0.60	125
Lower Lock to Atlantic Ocean	0.40	84	0.86	180

2.5.1.4.2. Interlaced Bottom Lateral

The bottom lateral system would be a good alternative for the triple-lift configuration of the third lane. Using an interlaced arrangement, hydraulic performance would be improved in comparison to the ILCS for equalizations with or without water saving basins under both normal and maintenance conditions. Connection to the water saving basins could be achieved by direct connection to the lock culverts. Attachment 2 - Hydraulic Analyses and Design includes limited hydraulic data pertaining to the interlaced bottom lateral system for the triple-lift. This information is presented in the report because it was developed prior to Modification 2.

2.5.2. Recommended Modeling

Filling and emptying systems for the triple-lift lock configuration are designed using existing Corps criteria to safely meet target equalization times between 8 and 10 minutes for operations with use of water saving basins. At the average lift of approximately 8.6 m, more than 275 000 000 l of water is transferred in 10 minutes or less for each equalization operation. Considering the size of the locks and the complexity of the filling and emptying system design, physical hydraulic modeling is recommended in future studies. Physical modeling prior to final design would be part of the normal design process used by the Corps for a project of this scope. Physical modeling provides the opportunity to validate and make refinements to the design that would enhance the overall performance of the system.

A physical model of the complete filling and emptying system at an approximate scale of 1:25 is recommended to evaluate overall system performance. Typical parameters to measured in the lock chamber with this model include equalization times, hawser forces (longitudinal and transverse), surface turbulence, loads on lock gates, emergency gates, and adjacent structures, and ship effects. Pressures and discharges at various key locations (e.g. transitions, junctions, valves) within the culverts and conduits would also be measured and evaluated. The valves would be evaluated for design loads and cavitation potential for varying operating schedules. Performance of the intakes for both the lock culverts and WSB conduits needs to be evaluated for vortex formation. Additional parameters may be determined as needed to make improvements to the design.

Operation of the miter gates would be modeled to validate the assumptions and computations used to predict the interaction of the gate with the surrounding water during operation. This testing could be incorporated into the filling and emptying system model described in the preceding paragraph.

Culvert and conduit valve testing requires a separate model at an approximate scale of 1:10 to optimize their performance. The goals are to minimize vibration potential and to evaluate performance of the conduit configuration. Model testing would facilitate optimization of the edge and recess slot geometries to minimize vibration potential. Results would validate performance of the system to ensure reliability and long-term durability of the valves.

2.6. Lock Gates

The proposed 61 m wide, triple-lift lock concept design would have four gate bays numbered consecutively 1 through 4 with gate bay 1 at the northern Atlantic entrance and gate bay 4 at the southern entrance to Gatun Lake. Double sets of gates (four individual gate leafs) would be provided at each gate bay. A vehicular bridge would be provided in proximity to the northern most gates to provide access across the lock chamber. The double gate arrangement would allow a measure of protection against loss of lake storage resulting from potential ship impacts and allows for continuing service during periodic maintenance cycles. The proposed lock gates are shown in Attachment 1 - Report Drawings.

A Gate Selection Study was performed to determine the most advantageous lock gate system for the double-lift locks. This study is attached to the Main Report as Appendix B - Lock Gates Analyses and Designs. The Gate Selection Study shows that mitering lock gates offer a unique mesh of attributes with benefits in comparison to other alternatives in initial investment cost, reliability of continued operation, installation and removal, and ease of maintenance. The Gate Selection Study's conclusion for a double-lift lock is also valid for the triple-lift lock with the cost differential between mitering gates and other gate types increasing with the number of gates used in the project. The design considers hydrodynamic loads during earthquake events, expected range of Gatun Lake pool elevations, Atlantic Ocean tidal variations, torsional deflection and stresses during operational movements in water, machinery stall loads applied to a gate while motion is inhibited by an object on the sill, and installation and removal methods.

2.6.1. Geometry and Fabrication

The gate height selection considered variations of Gatun Lake operating pool elevations, tidal variation of the Atlantic Ocean, and operations with water saving basins. Table N-2.6-1 lists the gate and sill elevations and height of gates considered. The gate sills of gate bays 1 and 2 were lowered approximately 0.25 m to allow the same gates to be used in gate bays 1, 2, and 3. The use of common gates is beneficial from an operational and maintenance perspective.

Table N-2.6-1 Gate Heights

Gate Bay	Top of Gate Elevation	Sill Elevation	Gate Height
1	10.86	-19.57	30.43
2	19.27	-11.17	30.43
3	27.97	-2.46	30.43
4	27.97	5.64	22.33

The minimum clearance provided over the gate sill would be 18.3 m. All gates extend 1.3 m above maximum operating pool elevations to provide freeboard and prevent overtopping from wind and ship induced waves. The top of lock wall would be approximately 3.6 m above the damming height of the lock gates (top of skin plate). The physical top of gate-mounted accessories extends above the top of skin plate for attachment of a walkway and connection of the hydraulic cylinder. The spacing between gate bays provides a clear usable lock dimension of 426.7 m with redundancy for upbound and downbound lockages. The usable chamber length could be increased to a maximum of 472.2 m with redundancy for upbound lockages. A length of 472.2 m is available for downbound lockages without redundancy. The adjacent pintle-to-pintle spacing within each gate bay is 45.5 m.

The gate leafs would be approximately 35.5 m long from the miter contact to the quoin contact. The angle that the gate leaf makes with the lock centerline when the gate is in the fully mitered position is 1 on 3. The gates would be straight horizontally framed, welded steel construction with the skin plate located on the upstream and downstream side to form buoyancy chambers to augment installation, transportation, and reduce operating loads. Bolted connections would be provided for removable features such as the pintle base.

The girder web and flanges, diaphragms, skin plate and intercostals, and miscellaneous plates would be ASTM A572M GR 345 steel. The gates would be supported by and swing on hemispherical pintles. The pintles would be designed to limit movement in the pintle base. The gates would be operated with direct connect hydraulic cylinders. The top of the gates would be hinged to the top of wall by means of an anchorage arrangement incorporating a turnbuckle type adjustment for leveling the gate. A gate latch system would be included within the gate recess to limit drift while the gates are in a recessed position.

Adjustable stainless steel miter and quoin contact blocks would be provided at the miter and quoin ends of the gates to seal water and transmit the thrust loads imposed on the gates through the gate framing into the concrete lock wall. A vertical rubber to metal seal would be provided at the pintle and across the bottom of the gate between the bottom girder and the sill. The bottom seal would be located on the gate to minimize hydrostatic uplift with differential head on the gate. The gates would be equipped with mitering devices to aid in accomplishing correct mitering.

Several alternatives have been developed to install and remove the gates. The gates could be installed in a similar manner to the existing Canal gates. The existing ACP Titan crane, with a rated capacity of 350 t would be used to augment a simple ballast procedure. As a provision for future maintenance flexibility, the gates would also be designed to be lifted for maintenance or emergency conditions by a gate-lifting crane. Jacking supports would be provided on the bottom girder to allow the gates to be jacked from below in the dry. A 4 m wide bridge would cross the top of the miter gates and be designed to support the needs of lock personal and maintenance activities.

2.7. Culvert and Conduit Valves

The filling and emptying valves controlling the flow in the culverts and conduits are of the wheel gate type of welded steel construction. Reverse tainter valves were considered and dismissed due to limitations on space needed for the redundant valve and required separation transition zone. The valves would be horizontally framed with skin plating provided on both the upstream and downstream sides. The top and side seals of the valves would be molded rubber J-seals and would seal against a metal frame embedded at the culvert perimeter. The bottom lip would be a metal-to-metal seal. The culvert valve design would be based on the loading criteria and the allowable stresses as provided in EM 1110-1-2105, Design of Hydraulic Steel Structures. The culverts in each wall bifurcate and transition to twin filling and emptying valves. The bifurcation allows for the use of smaller valves and permits safe operations during maintenance periods. For the purpose of preparing a cost estimate for the triple-lift lock concept design, estimated valve weights were determined by portioning weights from the double-lift concept design based on operating heads and valve size. The valve design for the Upper Lock would use the same design as the valves between the locks to maximize like components.

Table N-2.7-1 Design Head for Valve Design

Application	Size		Hydrodynamic (m)	Hydrostatic (m)
	Width	Height		
Upper Lock	4	8	15.53	9.02
Valves Between Locks	4	8	27.05	18.03
Lower Lock Valves	5	8	13.53	9.02
Water Saving Basins	6	8	6.76	6.76

2.8. Electrical and Mechanical Operating Systems

The electrical and mechanical operating systems are similar to the ones used on the double-lift design (hydraulic cylinders with PLC based controls) except that they are scaled down for estimating purposes. Electrical and mechanical quantities were adjusted for the triple-lift configuration. The electrical and mechanical operating systems are described in Appendix H - Electrical and Mechanical Lock Operating Systems

2.9. Maintenance and Emergency Closures

Design of maintenance closures are beyond the scope of the Concept Design Contract. However, the lock was designed to accommodate placement of a caisson or bulkheads at the Atlantic and Gatun Lake entrances.

2.9.1. Culvert And Conduit Bulkheads

Culvert bulkheads would be provided to dewater the culvert and conduit valves. The bulkheads would be approximately the same dimensions as the valves for which they are intended to service. Two sets of culvert bulkheads would be provided to service the eight culvert valve locations; one set of conduit bulkheads would be provided to service the three water saving basin hydraulic systems. The bulkheads would be of welded steel construction, horizontally framed with the skin plate on the sealing side. The bulkheads would be stored in the culvert and conduit bulkhead slots. A portable "A-frame" and power winch would be provided to aid in the placement and removal of the bulkheads. For the purpose of preparing a cost estimate for the triple-lift lock concept design, estimated bulkhead weights were determined by portioning weights from the double-lift concept design based on design heads and bulkhead size.

2.9.2. Emergency Closure

Several alternatives for emergency closure systems have been reviewed. These include:

- Dumping rock.
- Sinking barges.
- Rising bulkhead or caisson structure
- Wicket systems
- Emergency bulkheads

In evaluating these alternatives, only the structural feature solutions are viable. Placement of rock requires a floating plant and may wash away unless adequately sized or restrained by netting anchorage to a pile head. The required rock size would make placement difficult. Placement of bulkheads or dumped stone with a floating plant is not a safe operation since this would place the crane in proximity to very turbulent waters. Access to these operations by land-based equipment may be a feasible alternative. A transfer structure on the east wall may be used to set stacking bulkheads. Viable options lead to using a rising caisson, a transfer bulkhead arrangement, or a wicket system.

A rising caisson structure would be constructed and stored in a pit located below the approach floor elevation. This option would be expensive to build in consideration of the extensive rock excavation. Transfer systems for launch across the top of lock walls can be used to move bulkheads from a storage pit to a powered slot system in the lock wall. The bulkheads would stack and have end rollers to allow installation in flowing water. This arrangement, although smaller, is in service at the Bonnevile Lock.

A wicket system would minimize excavation and appears to be the most economical solution. A wicket system of the size required for the Third Lane project does not exist. Emergency bulkhead systems and the wicket system are recommended for additional evaluation in future studies. A cost for emergency closure systems is included in the cost estimate. Scaling a system developed for the Markland Lock and Dam project on the Ohio River derived this cost.

2.10. Operating Structures

Locking operations include activities such as opening and closing of the lock gates and controlling water level within the new Third Lane Lock chambers. These operations would be closely controlled using state of the art electronic equipment such as cameras, monitor displays, and “touch screen” technology to activate lock operating systems. The new facility can also serve as the “hub” and communications control center for all daily activities occurring at the Canal’s Atlantic side locking operations. This includes such activities as directing all shipboard movement in proximity to the locks and directing all personnel activities and security within the cantonment area. This facility would function similar to an airport control tower.

Conceptual plans for a new lock operations communications center have been prepared and are included with the Main Report. The functional layout and vertical configuration is based on an ACP communications and model command structure shown as Figure 5.11-1. Using this model command structure, the new lock operations center span of control can be comprehensive and include all personnel movement, ground based activities, and water borne activity within the three locks' sphere of influence. Operations of the existing lock would be provided at the new control station with supplemental camera providing a visual observation of the existing lock.

3. COST ESTIMATE

3.1. Scope

This section details the total project cost for the concept level design of the new third lane, Atlantic Ocean side. It includes a breakdown of the construction costs for a triple-lift lock configuration. It also includes cost estimates for final design, construction management and engineering support during construction. These estimates are at the concept level of detail and therefore include contingencies assigned to individual line items.

3.2. Criteria

The concept design level total project cost estimate includes construction cost (broken down into various features of work), anticipated design cost, construction management cost, and engineering support during construction. The construction cost is based upon costs (unit and lump sum) developed for the double-lift lock estimate. These costs are applied to newly developed quantities or manipulated to reflect three chambers versus two chambers. The design, engineering support during construction, and construction management costs are derived by applying percentages developed for the double-lift lock estimate to the construction cost. Notes are included in this section describing the cost items as well as any manipulations to the double-lift costs.

3.3. Construction Cost Estimate

The construction cost estimate is based upon costs developed for the double-lift lock estimate. In preparing the double-lift estimate, most of the cost estimating effort was geared to the most significant cost items. These items include the concrete, reinforcing steel, excavation, and lock gates. The lower cost items were priced out in less detail, but their inclusion in the estimate serves to comprehensively identify the cost items associated with building a lock. The costs for the triple-lift lock estimate are broken down into features of work, with a more detailed breakdown for the larger cost features. New quantities have been prepared for these larger cost items.

The construction cost estimate was based upon the same assumptions as the double-lift lock estimate. These assumptions include the project being awarded in one construction contract to a joint venture and local labor being used for a majority of the work. Refer to the double-lift report for other assumptions and details pertaining to the basis of the construction cost estimates.

The construction cost estimate is based upon an October 2002 cost level. The cost has not been escalated over the life of the project.

Description	Total Construction Cost w/ Contingency (October 2002 Price Level)
Triple-Lift Lock w/ In-Chamber Longitudinal Filling and Emptying System	$1,033,000,000

3.3.1. Mobilization and Demobilization

This item includes the mobilization and demobilization costs associated with the construction contract. A rate of 4.00 percent of construction cost was used due to the fact that a lot of heavy equipment will be required and will probably come from outside of Panama.

3.3.2. Preparatory Work

This feature of work is comprised of upfront work requiring completion prior to the actual start of construction on the locks structure. It includes site clearing, building demolition, access roads, haul roads, railroad development, offloading dock construction, and developing the disposal area. The costs associated with this feature of work for the triple-lift lock design was assumed to be similar to those prepared for the double-lift estimate. The overall cost was raised by approximately 10% to account for an increase in length of the access roads, haul roads and rail lines. The rest of the items should have basically the same cost for either design.

3.3.3. Relocations

This feature of work involves relocations of roadways, railroad tracks, utilities, and buildings necessary for construction of the new locks structure. Building relocations have been handled under preparatory work, as the assumption was made that instead of relocating the buildings, they will simply be demolished. Roadway relocation includes the relocation of several roadways, including the roadway that goes from the east side of the lake to the west side. This roadway will be relocated northward across an extension to the existing plug that the current road crosses. It will also have to be moved eastward along with the existing railroad tracks on the eastern side of the 1939 excavation. The cost associated with this estimate is for a temporary relocation of the roadway, but a permanent relocation of the railroad tracks. The utilities relocations include the electric, water, and telephone services to the existing Gatun Locks. These utility relocations are also just temporary relocations during construction of the new locks. The cost for relocations associated with the triple-lift lock was increased by a factor of 1.5 from that of the double-lift locks in consideration of the railroad relocation. The 1.5 factor accounts for the increase from two chambers to three chambers.

3.3.4. Care and Diversion of Water

The cost associated with the care and diversion of water includes the cost for dewatering the existing cut prior to commencing with excavation for the locks structure, and also the maintenance dewatering associated with keeping the site dry during construction. Unlike the double-lift design, the construction of a berm is not necessary as there are already plugs in place on either side of the 1939 excavation. The downstream plug will be expanded as some of the existing plug will have to be eliminated to construct the entrance wall, but the expansion is more for the purpose of roadway relocation and temporary access roads than to support the dewatering effort. The cost for this item has been reduced from that of the double-lift concept estimate to reflect the lack of construction berms.

3.3.5. Earthwork for Structures

This feature of work includes the excavation required for construction of the locks structure. It also includes the costs associated with exploratory drilling, backfill, and foundation preparation. The unit costs prepared for the double-lift cost estimate were used for most of the items included in this feature. New quantities were developed for these items and applied to the existing unit costs. The lump sum cost used for exploratory drilling was simply multiplied by 1.5 to account for the increase from two lock chambers to three lock chambers. The unit costs for this item were derived based upon the unit costs of dry excavation and rock excavation. A breakdown of this feature of work is shown in the cost estimate backup.

3.3.6. Sitework

This feature of work includes the work involved with the site surrounding the locks structure. It includes permanent seeding, fencing, parking lots, access roadways, storm drainage, and project signage. The costs associated with these items are based upon the lump sum costs for the same items prepared for the double-lift estimate. These double-lift costs were multiplied by 1.5 to account for the increase in length associated with the triple-lift lock design versus the double-lift design.

3.3.7. Entrance Walls, Upper and Lower

This work includes construction of both the upper and lower entrance walls for the lock structure. Most of the walls will be constructed in the dry using roller compacted concrete. A portion of the walls will have to be built within Gatun Lake and will be comprised of a concrete cap wall mounted on drilled shaft caissons. Quantities were calculated for the triple-lift concept design and applied to the unit costs developed for the double-lift cost estimates. A breakdown of this feature of work is shown in the cost estimate backup.

3.3.8. Lock Structure

This feature of work consists of the concrete and reinforcing steel for the lock chambers. Two separate concrete placement methods have been included in the design of the lock chambers, roller compacted concrete (RCC) and conventional mass concrete. Separate unit costs have been developed for the different placement methods as well as the different placement features for the double-lift cost estimates. These unit costs are applied to newly developed quantities for the triple-lift concept design in order to develop the cost for this feature of work. A detailed breakdown of the individual cost items comprising this feature of work is included with the cost estimate backup.

3.3.9. Lock Gates and Operating Machinery

This feature of work covers all of the work associated with furnishing and installing the miter gates and their operating machinery. It also includes the gate anchorages, embedded metals, bridges over recesses, and an emergency closure system. New gate weights were developed for the triple-lift lock design. The costs for the miter gates and operating machinery for the double-lift lock estimate were based upon quotes received from several fabricators. Additional quotes were not obtained for the triple-lift estimate since the costs for the double-lift estimate were adjusted to account for the new gate weights and the increase in number of gates.

3.3.10. Culvert Valves and Operating Machinery

This feature includes the culvert valves and operating machinery associated with the filling and emptying system. It also includes embedded metals, anchorages, and bulkheads for the valves. Again, new quantities (valve weights and number of valves) were developed for the triple-lift lock design. These new quantities were applied to the costs developed for the double-lift concept design, which were based upon quotes from fabricators.

3.3.11. Piping System

This feature of work accounts for the cost of tying in the Operations/Control Building with existing water, gas, and sanitary sewage systems. The cost associated with this feature of work has been increased by a factor of 1.5 for the triple-lift design. This factor accounts for the increase from two lock chambers to three lock chambers.

3.3.12. Power and Lighting System

This feature of work consists of the cost associated with supplying the necessary power to run the locks operating machinery. It also includes the cost for lighting the chambers. The cost associated with the permanent electrical systems and lighting has been increased by 1.5 to account for the increase in structure from 2 chambers to 3 chambers. This cost is only a portion of the total, which also includes a standby generator unit and the cost of temporary power supply during construction, which were not increased from the double-lift cost estimate.

3.3.13. Associated General Items

This feature covers general items not accounted for under other features of work. For this estimate it consists of stainless steel planking, cover plates, and rabbet angles. These items are associated with covering the recesses, culvert access points, and machinery trenches on top of the lock walls. The total cost for this feature from the double-lift design was increased by 1.5 to account for the additional lock chamber.

3.3.14. Building, Project Operations

This cost is associated with building the Operations building for the new locks structure. It was assumed that the building design would be the same regardless of the number of lifts associated with the lock. Therefore the cost prepared for the double-lift lock estimate will be applied to the triple-lift estimate.

3.3.15. Miscellaneous Items

This feature of work covers erosion and sediment control as well as permanent instrumentation. The cost previously prepared for this feature for the double-lift estimate has been raised by a factor of 1.5 to account for the increase from 2 to 3 lock chambers.

3.3.16. Maintenance Facility

This work comprises building a maintenance facility for repair and maintenance of the miter gates. The cost of this facility will be the same regardless of whether the lock consists of two or three chambers. Therefore, the cost previously prepared for the double-lift lock design was used for this feature.

3.3.17. Water Saving Basins

This feature of work consists of the excavation, concrete, reinforcing steel, and miscellaneous items associated with the water saving basins. The unit costs developed for the double-lift cost estimate were used for this cost estimate. New quantities have been developed for the triple-lift design and applied to the existing unit costs. A breakdown of the costs associated with this feature of work is included with the cost estimate backup.

3.3.18. Conduits, WSB's

This work accounts for the conduits connecting the water saving basins with the lock chambers. It consists of excavation, concrete, and reinforcing steel. Again the unit costs developed for the double-lift cost estimate were used for the preparation of this cost. New quantities have been developed and applied to these unit costs. A breakdown of these costs can be seen in the cost estimate backup.

3.3.19. Conduit Valves & Operating Machinery, WSB's

This feature includes the culvert valves and operating machinery associated with the water saving basins. It also includes embedded metals, anchorages, and the electrical system/control for the valves. Again, new quantities (valve weights and number of valves) were developed for the triple-lift lock design. These new quantities were applied to the unit costs developed for the double-lift concept design, which were based upon quotes from fabricators.

3.4. Total Project Cost Estimate

3.4.1. Engineering and Design

This includes all estimated costs of engineering and design to take this project from concept through construction. The same recommendations previously stated for the double-lift lock concept apply to the triple-lift concept. Again, USACE recommends that Feature Design Memorandum Reports be prepared for the major features of work prior to proceeding into the design-for-construction and preparation of construction plans and specifications. Hydraulic modeling of the new locks, as well as physical modeling of the gates and valves is recommended. The costs associated with the above items are the same for the triple-lift concept as they were for the double-lift. Additional items with an increased cost included subsurface investigation of the site and the preparation of the plans and specifications. The costs for these items are $2,500,000 and $22,000,000 respectfully. The subsurface investigation cost represents an increase of 1.5 times that of the double-lift lock to account for the increase in project area. The increase in the plans and specifications cost was based on an increase in the amount of drawings from 2,000 to 2,200. It was previously estimated that each drawing would cost approximately $10,000. This drawing cost includes all engineering design and computations required to produce each drawing.

Description	Cost
Subsurface Investigations	$2,500,000
Physical Models	$5,250,000
Feature Design Memorandum Reports	$10,000,000
Plans and Specifications	$22,000,000
Total	$39,750,000

3.4.2. Construction Management

The costs for construction management were developed based upon USACE experience with similar work with consideration for the immense size of the construction project. Costs are estimated to be approximately 1 ¾ percent of the total construction cost. This is based upon the assumption that a process similar to the USACE Quality Management system will be used where the construction contractor is responsible for quality control including planning, procedures, testing and inspections. The construction contractor's costs for quality control were included in the overhead applied to the construction cost estimate. The 1 ¾ percent accounts for a construction management firm hired by the ACP to oversee the project. An additional cost (3/4 percent of the total construction cost) for the design firm to provide engineering services during construction has also been added under construction management.

Item	Percentage of Construction Cost	Total Cost (Rounded)
Construction Management	1.75%	$18,075,000
Engineering During Construction	0.75%	$7,750,000
Total	2.5%	$25,825,000

3.4.3. Summary of Total Project Costs

Cost Level October 2002	Cost	Cont%	Contingency	Total Cost
Construction Cost	$872,000,000	N/A	$161,000,000	$1,033,000,000
Design Cost	$39,750,000	15%	$5,960,000	$45,710,000
Construction Mgmt	$18,075,000	15%	$2,710,000	$20,785,000
Engineering During Construction	$7,750,000	15%	$1,160,000	$8,910,000
Total Project Cost	$937,575,000	N/A	$170,830,000	$1,108,405,000

3.5. Summary

The total first construction cost including contingencies for the triple-lift locks design is estimated at $1,033,000,000 (October 2002 price level) and the total project cost for this design, including construction, engineering, design, and construction management is estimated to be $1,108,405,000.

Attachment 4 - Cost Estimates includes a breakdown of the cost associated with the construction of the triple-lift locks structure.

4. CONSTRUCTION PLAN AND SCHEDULES

4.1. Scope

This section details a construction plan and schedule for the concept level design of the new third lane locks, Atlantic Ocean side of the canal. It includes a construction schedule for the concept level design of a triple-lift lock scenario. The construction schedule identifies the major features of work, appropriate sequencing and expected duration of the various activities. This section also includes a work plan discussing the various aspects of construction of the triple-lift lock including, land requirements, staging areas, work areas, and materials storage and processing areas.

4.2. Criteria

The construction work plan and schedule were prepared with guidance from the design team as well as construction personnel from within the USACE. The schedule focuses on the main tasks associated with the construction of the locks structure and water saving basins. Durations of activities are based upon production rates prepared previously for the double-lift cost submittal applied to updated quantities for the triple-lift design. It has been prepared using Primavera Project Planner.

4.3. Construction Work Plan

4.3.1. Construction Contracts

The construction schedule included in this section is based upon the assumption that the work will all be included in one construction contract. This assumption was used so that the construction schedule is based upon the same criteria as the cost estimate. Awarding the work under one construction contract minimizes the management responsibilities of the ACP. However, other contracting strategies may result in both time and cost savings if the ACP is willing to accept increased management responsibilities during the construction process. Additional discussions on the advantages and disadvantages of various construction contracting strategies are included in Appendix L - Project Construction Schedules.

4.3.2. Land Requirements

The size and nature of this project require a large project work area and significant land use. Drawing ACP-RM-93/1 identifies the various land needs and uses as described in this section. The designated alignment of the triple-lift lock design utilizes the existing 1939 excavation. This alignment represents an eastern shift from the double-lift alignment. As a result of this alignment shift, land is now required on both sides of the 1939 excavation. The project work area would consist of most of the area between the 1939 excavation and the existing Gatun Locks, eastward of the existing cut to the real estate limits of the ACP and a disposal area approximately 6 km north of the new locks site. These areas plus areas set aside for haul roads and railroad sidings would makeup the land required by the contractor for this work.

Staging areas and material storage/processing areas will be located on both sides of the 1939 excavation. Temporary rail lines and haul roads will be established to serve these staging and storage areas.

The contractor will utilize several batch plants in order to maintain a consistent source of concrete. At a minimum, there will be one batch plant on each side of the cut. Each batch plant will have a material stockpile in the close vicinity.

Railroad sidings will be required in order to allow delivery of materials by rail to the project site. There will most likely be a siding on each side of the cut. The plug on the northern end will be expanded northward, and the railroad siding will crossover the cut at this point and follow the existing right of way on the western side of the cut. The railroad siding on the eastern side of the cut will be an extension of the relocated main line. The two siding will tie in together just north of the extended plug. Access to rail delivery is important since it will open the possibilities of bringing in material over land from both the Atlantic and Pacific ports. Also, the aggregate will most likely come from the excavation for the Pacific Locks and rail appears to be the optimum transportation alternative of the sand and aggregate.

The main road across the existing Gatun Locks will have to be relocated east of the existing cut and also over the northern plug. The roadway will have to be relocated eastward to allow room for the excavation required for the new locks and also to allow room for a construction work area on the eastern side of the cut. The existing northern plug will be expanded to the north to allow for eventual excavation of the southern part of the plug to build the lock chamber. The roadway that crosses over this plug will have to be relocated northward on the expanded plug.

A construction haul road will also be required in order to transport the excavated material from the locks site to the disposal area. This haul road will travel on the western side of the cut, go across the expanded northern plug, and then head north to the disposal area. An additional haul road will run on the eastern side of the existing cut and join in with the main haul road at the existing northern plug location. This will allow the locks excavation to begin prior to the plug expansion required for the main haul road. These haul roads can also be used for delivery of materials to both storage and placement areas.

The construction offices will be placed on the western side of the existing cut. There are several existing buildings at this location that can potentially be converted into office space. There is also a lot of room available for office trailers and parking. Other smaller offices will be located next to the concrete batch plants, and material storage areas.

4.3.3. Batch Plants/Concrete Placement

There will be several different types of concrete applications required for the construction of the triple-lift locks structure. It will include mass concrete, roller compacted concrete, and tremie concrete. Due to the large quantity of concrete, as well as the varying types of concrete, several batch plants would be required. The batch plants used for concrete other than RCC should be equipped with rotating drums. For tremie, and other flowable concrete mixtures, a tilting rotating drum mixer is best suited. Various types of mixers are suitable for the production of RCC and conventional mass concrete. Horizontal shaft mixtures, known as pugmills are suitable for both and have become the preferred type of mixing plant for high production RCC.

For this job, the contractor would use a combination of horizontal shaft mixers and rotating tilt drum mixers. Each batch plant should be able to handle approximately 600 m^3 hour. This might require multiple mixers per batch plant. In order to support the RCC effort, the horizontal shaft mixer should be a continuous batch type system.

The cost estimate and construction schedule for this concept study were based on 3 batch plants. Two batch plants would be equipped with horizontal shift mixer(s). The third batch plant would be equipped with a tilting rotating drum mixer. One of the batch plants with a horizontal shaft mixer would also be equipped with a tilting rotating drum mixer.

The concrete for this job will be transferred to its placement location using large concrete hopper trucks. Placement will be from a conveyor crane apparatus, concrete pumps, and concrete buckets. A conveyor to transport the concrete from the batch plants to the placement sites is an option, but with the length of this project, trucks appear to be a more suitable option.

4.3.4. Sequencing

As previously stated, the construction schedule for the triple-lift locks is based upon work being completed under one construction contract. The sequencing of work is basically the same as that of the double-lift construction schedule. The first items of work consist of the preparatory work readying the site for the construction of the locks structure. Most of the site preparation work can take place simultaneously, except the clearing and grubbing and building demolition work which must be completed in the areas where the new roads and rail lines are to be constructed.

The sequence involved with the actual construction of the locks structure is a little more complicated. The locks construction work will follow two separate paths until completion. The first path is the construction of the lock chambers and the gravity entrance walls. The second path consists of the construction of the in-the-wet portion of the upstream entrance wall. This portion of the upstream entrance wall involves a more complicated construction method, walls founded on drilled shaft caissons, than the more conventional methods used in the lock chambers construction. Due to the complexity and potentially long duration involved in constructing the in-the-wet portion of the upstream entrance wall, it is perceived that it will be built simultaneously with the lock chambers construction.

The work sequence for the lock construction begins with the overburden and rock excavation. The excavation will start at the Gatun Lake (upstream) side and commence downstream to the Atlantic Ocean approach. The concrete placement will begin with the upper gate monoliths, sills, and floors then progress downstream following the completion of the rock excavation. The roller compacted concrete lock walls will be placed after completion of the gate monoliths. The gravity entrance walls will be constructed along with the lock chamber concrete and are not on the critical path.

The miter gates will be installed as they arrive on site and upon completion of each of the miter gate monoliths, and installation of the operating equipment.

The critical path for the construction of the triple-lift locks is controlled by the rock excavation and concrete placement. The fabrication and delivery of Miter Gates is not on the critical path, but could become a critical item if the fabrication process takes longer than anticipated. The water saving basins are not on the critical path and whether or not they are included in the locks structure should not have an effect on the total construction contract duration. The overall construction duration for the triple-lift locks structure is estimated at approximately 5 ½ years.

4.3.5. Construction Schedule

The construction schedule is included with this Appendix as Attachment 5 - Project Construction Schedules. The schedule identifies the major features of work, appropriate sequencing, and expected duration for the various activities. The major features of work include; Site Preparation, General Items, Berms, Earthwork, Concrete, Electrical, Mechanical, Water Saving Basins, Entrance Walls, and Control Building.

Three separate work calendars were used in the preparation of the construction schedule. These calendars represent workweeks from seven days a week, six days a week or five days a week. Each individual activity uses a separate calendar, however most of the contract utilized a six-day workweek. The five-day workweek was used sparingly, mostly for subcontracted work.

Weather delays are not shown separately in the Primavera Schedule at this concept level, but were considered when preparing production rates and durations, especially the concrete production rates.

The assigned durations were calculated by using production rates, information provided by suppliers, and estimator/designer judgment based upon production rates on similar Corps projects. When determining the durations for the items perceived to be on the critical path, it was assumed that the contractor will work 6 days a week, 20 hours a day.

4.3.6. Summary

Construction of the concept level design for the triple-lift locks structure would have a length of approximately 5 ½ years. The critical path is dependent on the rock excavation and concrete placement. Fabrication and delivery of the Miter Gates is not on the critical path, but due to its long lead-time a higher risk is associated with these items. The water saving basins are also not on the critical path, and eliminating them from the project would not result in a time savings.

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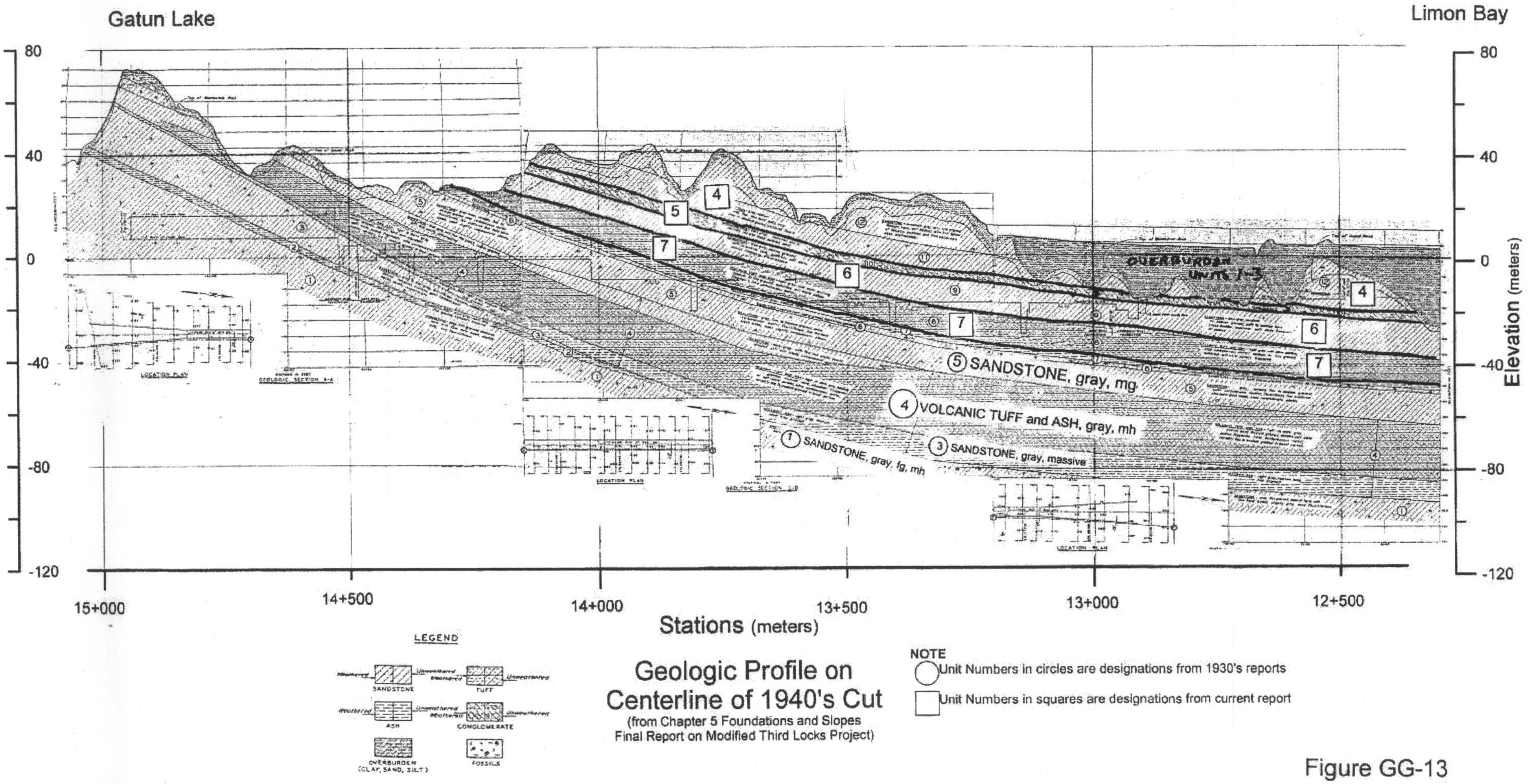


Geologic Profile on Centerline of 1940's Cut
(from Chapter 5 Foundations and Slopes Final Report on Modified Third Locks Project)

NOTE
○ Unit Numbers in circles are designations from 1930's reports
☐ Unit Numbers in squares are designations from current report

Figure GG-13

PANAMA CANAL CONCEPT DESIGN

Atlantic Locks Structure

Third Lift Lock

Appendix N, Attachment 1

Report Drawings

Prepared for

Canal Capacity Projects Office

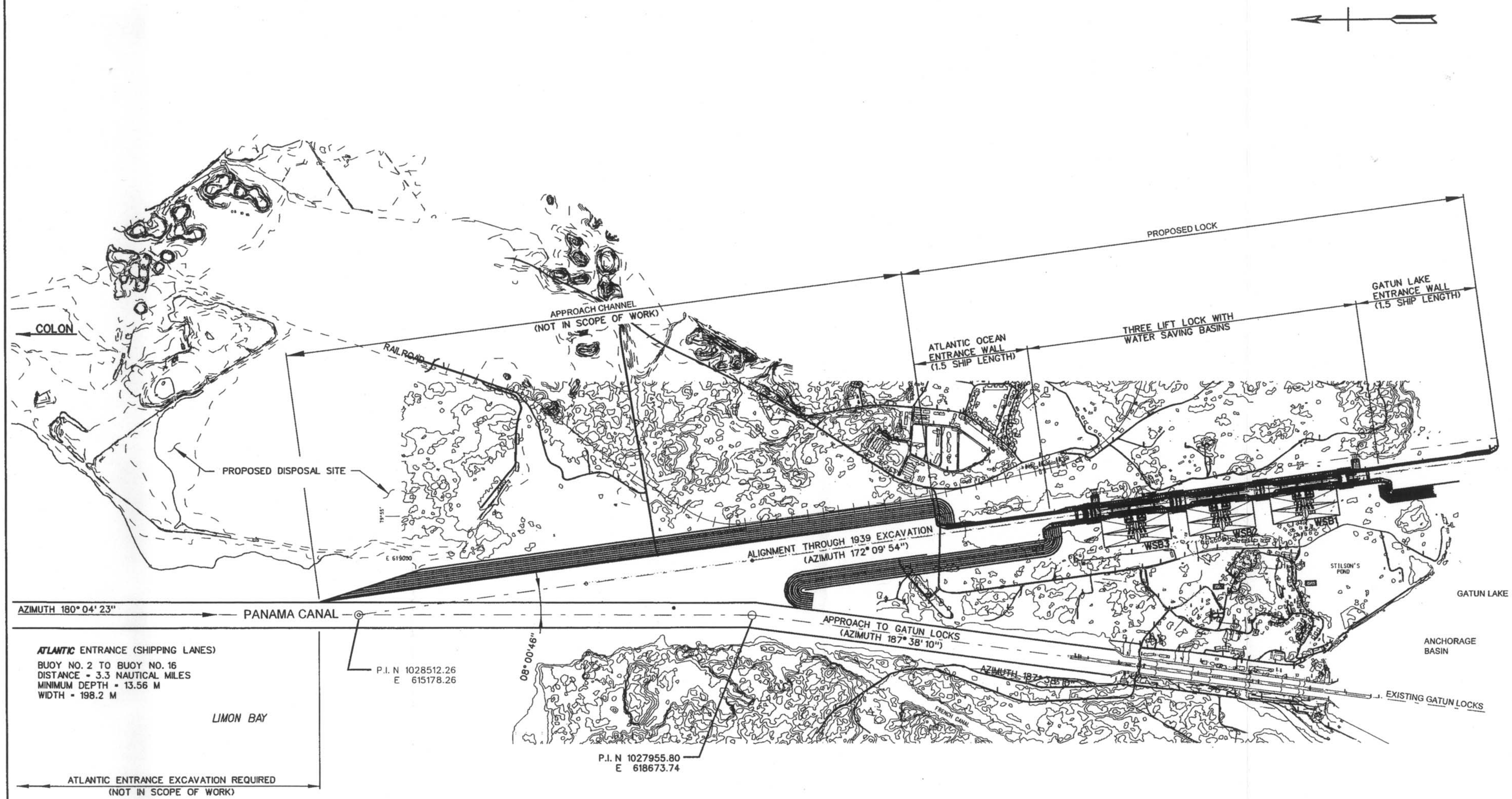
By

US Army Corps
of Engineers®

Final Report

Triple-Lift Configuration

23 July 2003



ALL DIMENSIONS AND/OR DIMENSIONS SHOWN IN CALLOUTS/NOTES ARE IN METERS UNLESS OTHERWISE NOTED.

SCALE: 1:12000

US Army Corps
of Engineers
Pittsburgh District

ACP
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Pen Table:
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Design by: T. SHILLEY, P.E.
Dwn by: DJM
Ckd by: TDS/ATR
Submission Date: MAR 2003
Revision Date: X
Submitted by: W.A. HARKNESS, P.E.
TECHNICAL LEAD
FB NO.:
Sheet 1 of 1

Symbol	Description	Date	Appr.
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X			

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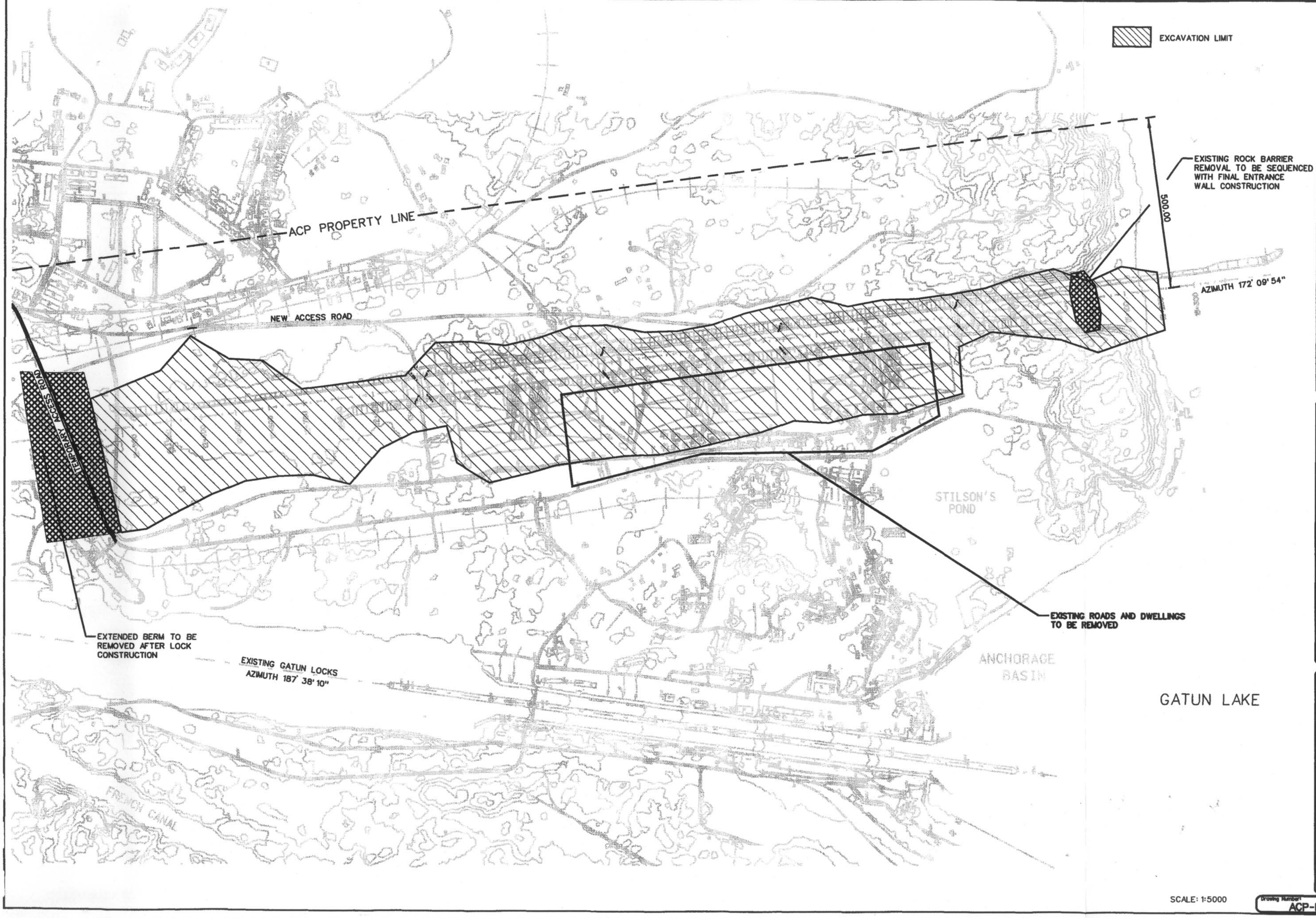
PANAMA CANAL
ATLANTIC LOCKS CONCEPT DESIGN
TRIPLE LIFT LOCK
GENERAL SITE MAP

Drawing Number: ACP-RM-3/1



US Army Corps
of Engineers
Pittsburgh District

Submitted by:
W.A. HARKNESS, P.E.
TECHNICAL LEAD

Sheet X of X

Design by: X
Dwn by: JET
Ckd by: X
Submission Date: MAY 2003
Revision Date: X
FB NO.:

ACP
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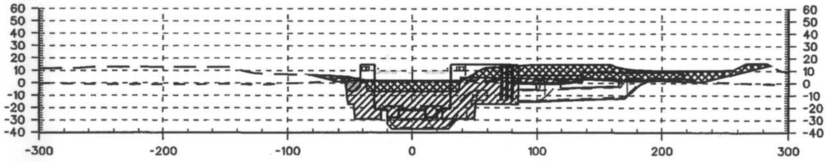
PANAMA CANAL
ATLANTIC LOCKS CONCEPT DESIGN
TRIPLE LIFT LOCK
SITE PLAN

Drawing Number:
ACP-RM-3/2

LEGEND

LOCK OVERBURDEN EXCAVATION	▩
LOCK ROCK EXCAVATION	▨
STRUCTURAL BACKFILL	■
RANDOM BACKFILL	░



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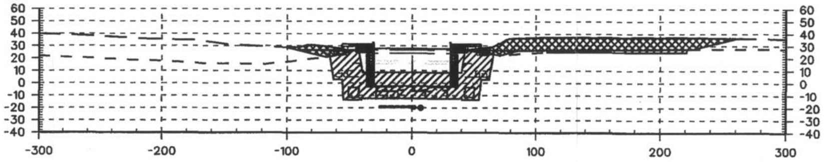

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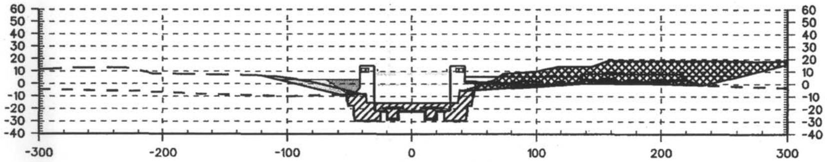

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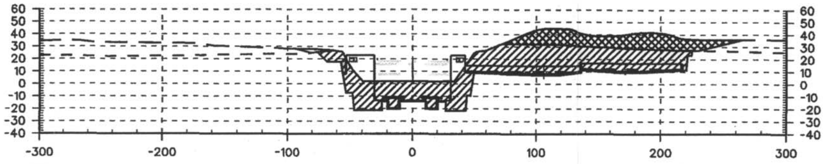

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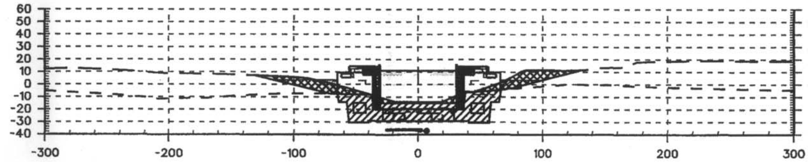

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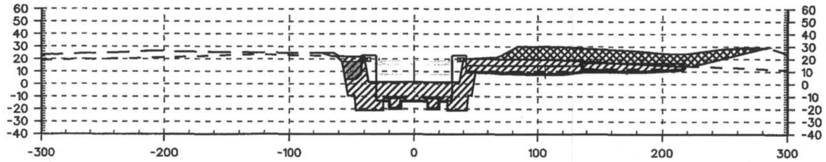

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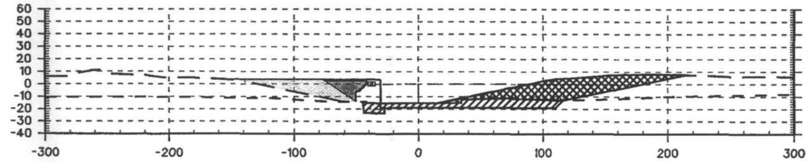

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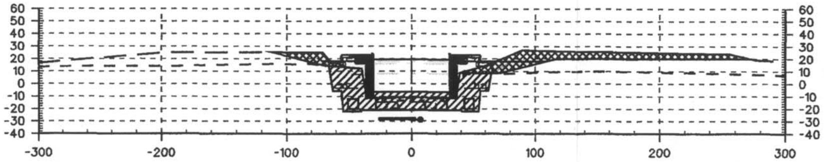

13+600.00

ALL DIMENSIONS AND/OR DIMENSIONS
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SCALE: 1:2000

US Army Corps
of Engineers
Pittsburgh District

Design by: SILVIO IERA, P.E.
Dwn by: DJM
Ckd by: TDS/ATR
Submission Date: MAR 2003
Revision Date: X
Submitted by: W.A. HARKNESS, P.E.
TECHNICAL LEAD
FB NO.:
Sheet 1 of 1

ACP
AUTORIDAD DEL CANAL DE PANAMA

User: jtankosh
Date: 12-MAY-2003 14:28
Plot Scale: 2.888901:1.000000
Pen Table:
Color Table

Symbol	Description	Date	Appr.
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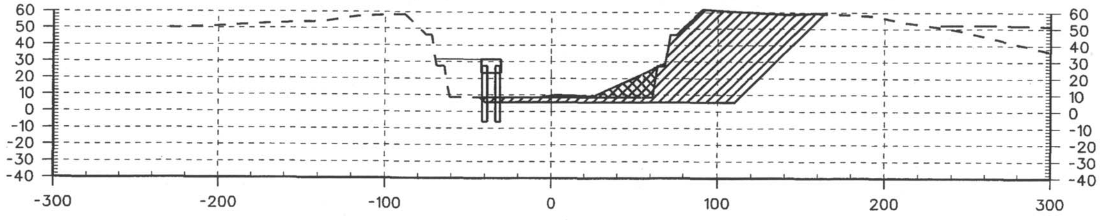
PANAMA CANAL
ATLANTIC LOCKS CONCEPT DESIGN
DOUBLE LIFT LOCK
LOCK AND WATER SAVING BASIN EXCAVATION
SECTIONS

Drawing Number:
ACP-RM-3/3



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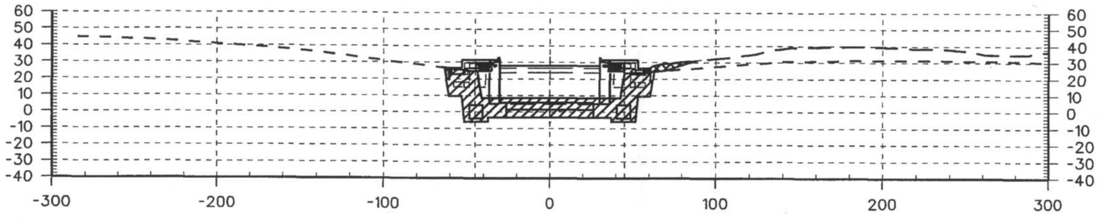

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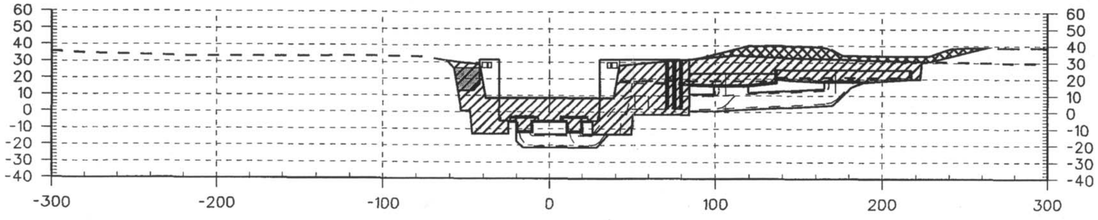

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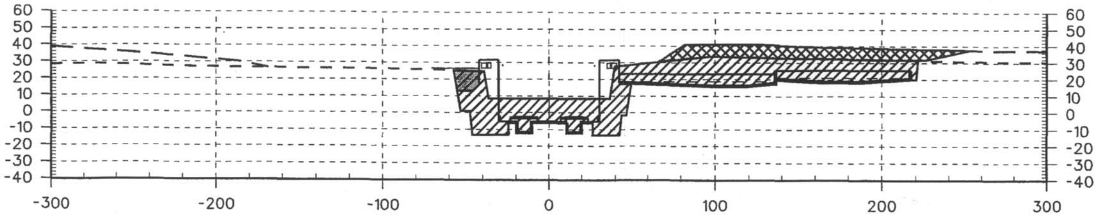

14+300.00

LEGEND

LOCK OVERBURDEN EXCAVATION	▩
LOCK ROCK EXCAVATION	▨
STRUCTURAL BACKFILL	■
RANDOM BACKFILL	░

ALL DIMENSIONS AND/OR DIMENSIONS SHOWN IN CALLOUTS/NOTES ARE IN METERS UNLESS OTHERWISE NOTED.

US Army Corps of Engineers
Pittsburgh District

Submitted by: W.A. HARKNESS, P.E.
TECHNICAL LEAD

Sheet X of X

Design by: X
Dwn by: WAH/JET
Ckd by: X
Submission Date: MAY 2003
Revision Date: X
P/B NO.:

ACP
AUTORIDAD DEL CANAL DE PANAMA

User: jtankosh
Date: 12-MAY-2003 14:29
Plot Scale: 2.888901:1.000000
Pen Table:
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Symbol	Description	Date	Appr.
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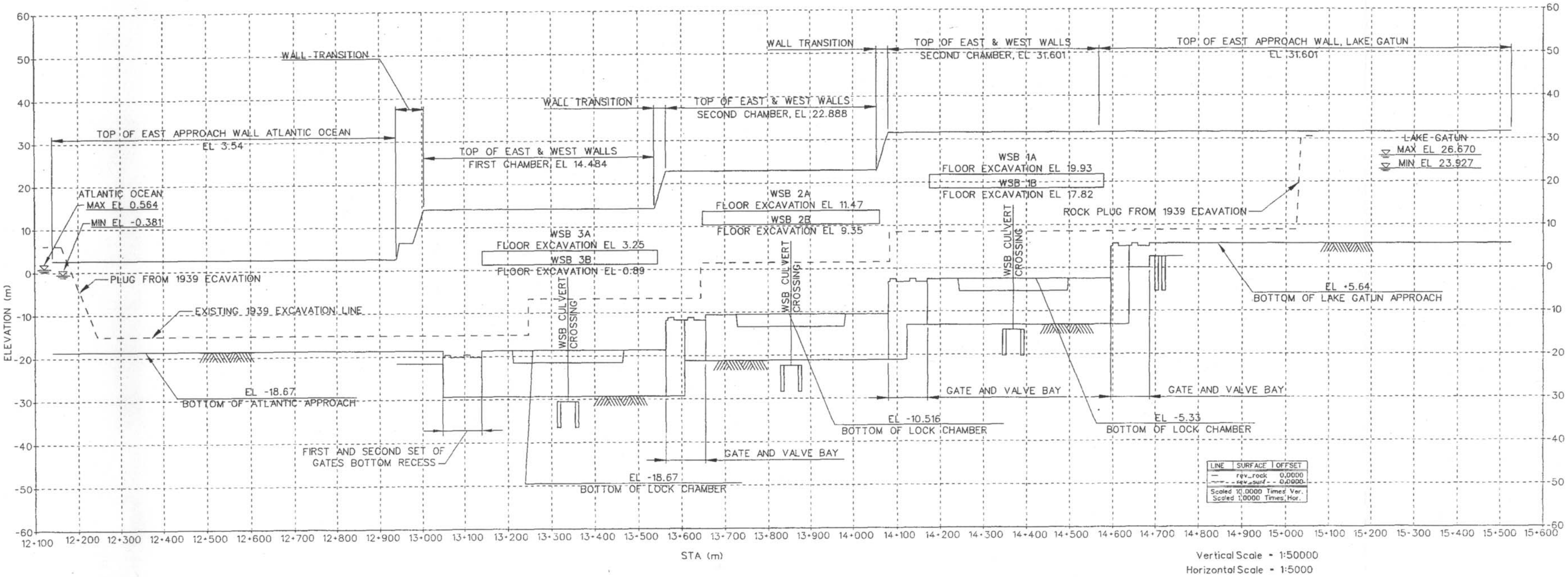
PANAMA CANAL
ATLANTIC LOCKS CONCEPT DESIGN
TRIPLE LIFT LOCK
LOCK AND WATER SAVING BASIN EXCAVATION
SECTIONS

Drawing Number:
ACP-RM-3/4



Vertical Scale - 1:50000
Horizontal Scale - 1:5000

PROFILE OF THREE LIFT LOCK IN 1939 EXCAVATION

LEGEND
— — — EXISTING SURFACE
- - - - - TOP OF ROCK SURFACE
———— TOP OF APPROACH WALL AND LOCKWALL
▨ EXCAVATION ELEVATION

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SCALE: 1:5000

Drawing Number: ACP-R-3/5

US Army Corps
of Engineers
Pittsburgh District

Submitted by:
W.A. HARKNESS, P.E.
TECHNICAL LEAD

Sheet 1 of 1

IFB NO.:

Design by:
SILVIO IERA, P.E.

Dwn by:
DJM

Ckd by:
TDS/ATR

Submission Date:
MAR 2003

Revision Date:
X

ACP
AUTORIDAD DEL CANAL DE PANAMA

User: jlankosh
Date: 10-JUL-2003 15:43
Plot Scale: 2.0000000:1.0000000
Pen Table:
Color Table

Symbol	Description	Date	Appr.
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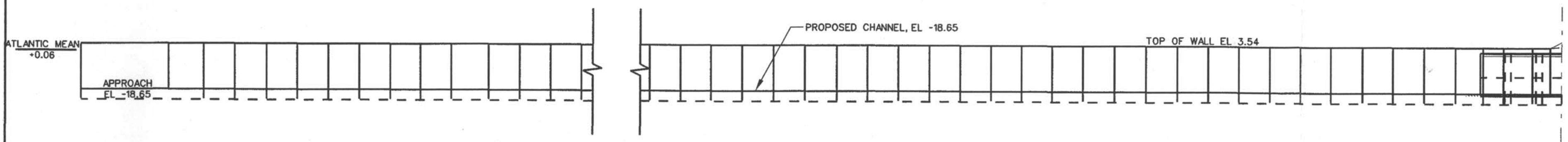
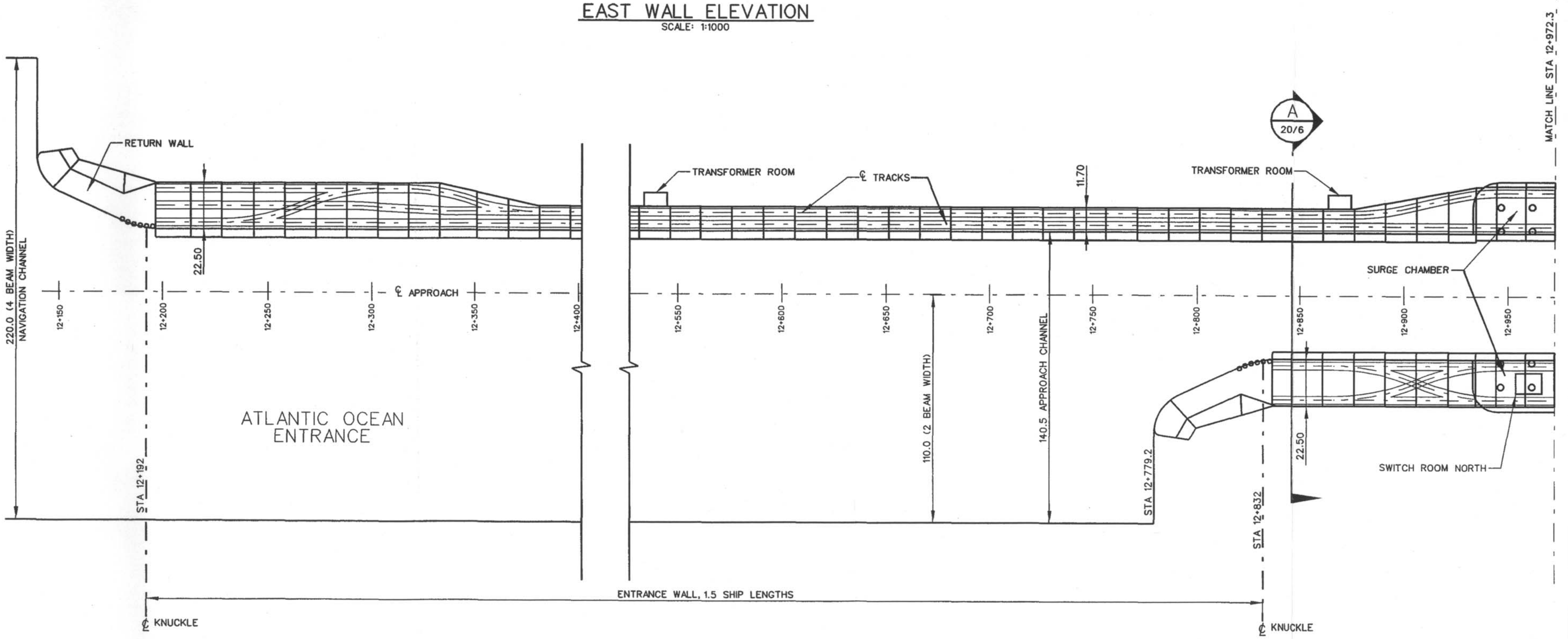
PANAMA CANAL
ATLANTIC LOCKS CONCEPT DESIGN
TRIPLE LIFT LOCK
PROFILE



EAST WALL ELEVATION

SCALE: 1:1000



PLAN - NORTH ENTRANCE WALL

SCALE: 1:1000

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US Army Corps
of Engineers
Pittsburgh District

Submitted by:
W.A. HARKNESS, P.E.
TECHNICAL LEAD

Sheet X of X

Design by: X
Dwn by: JET
Ckd by: X
Submission Date: MAY 2003
Revision Date: X
IFB NO.:

ACP
AUTORIDAD DEL CANAL DE PANAMA

User: jtonkosh
Date: 12-MAY-2003 14:29
Plot Scale: 2.888901:1.000000
Pen Table:
Color Table

Symbol	Description	Date	Appr.
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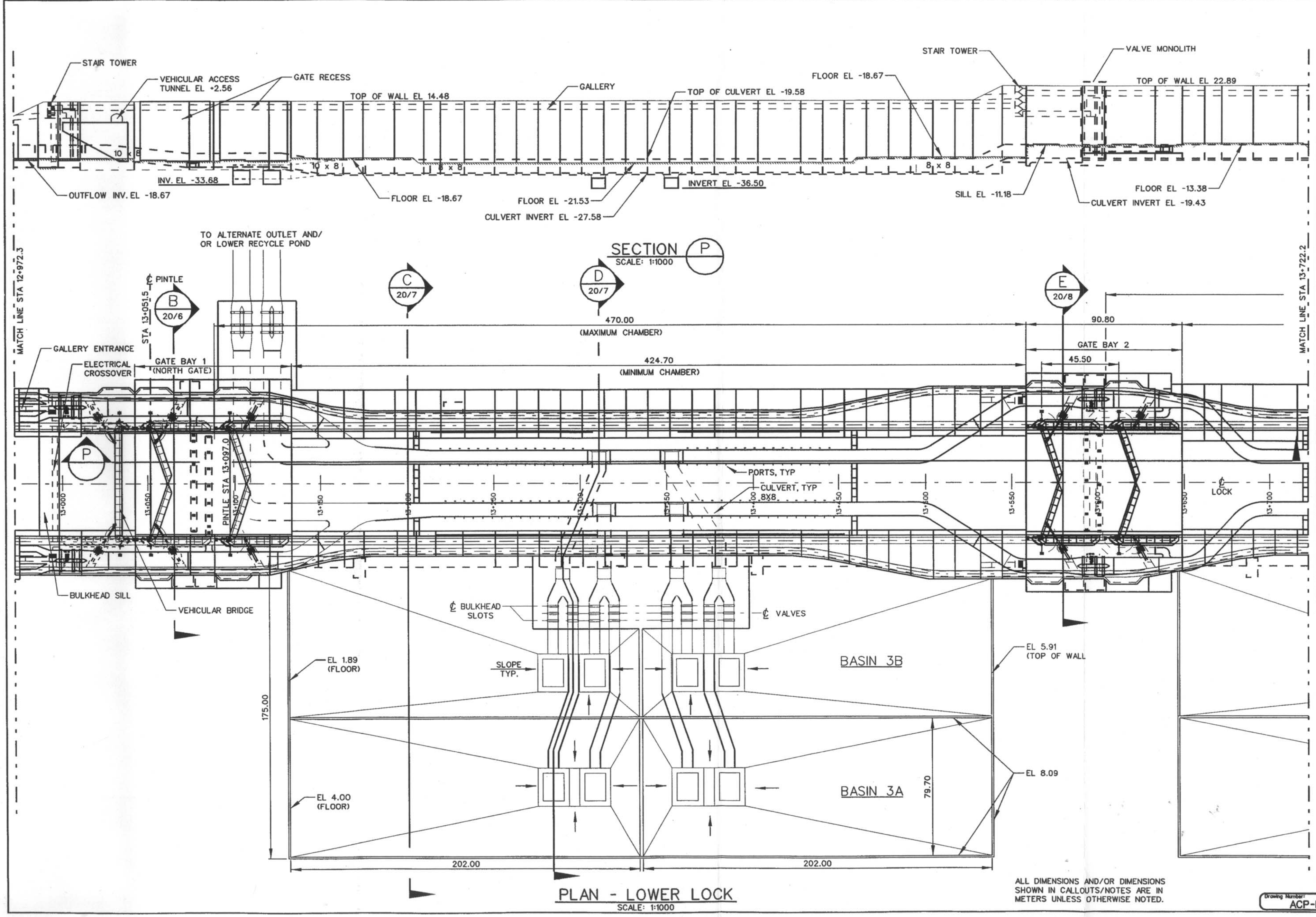
PANAMA CANAL
ATLANTIC LOCKS CONCEPT DESIGN
TRIPLE LIFT LOCK
NORTH ENTRANCE WALL
PLAN AND ELEVATION

Drawing Number:
ACP-RM-20/1



SECTION (P)
SCALE: 1:1000

PLAN - LOWER LOCK
SCALE: 1:1000

ALL DIMENSIONS AND/OR DIMENSIONS SHOWN IN CALLOUTS/NOTES ARE IN METERS UNLESS OTHERWISE NOTED.

US Army Corps
of Engineers
Pittsburgh District

Submitted by:
W.A. HARKNESS, P.E.
TECHNICAL LEAD

Sheet X of X

Design by:	Dwn by:	Ckd by:	Submission Date:	Revision Date:	FB NO.:
X	JET	X	MAY 2003	X	

ACP
AUTORIDAD DEL CANAL DE PANAMA

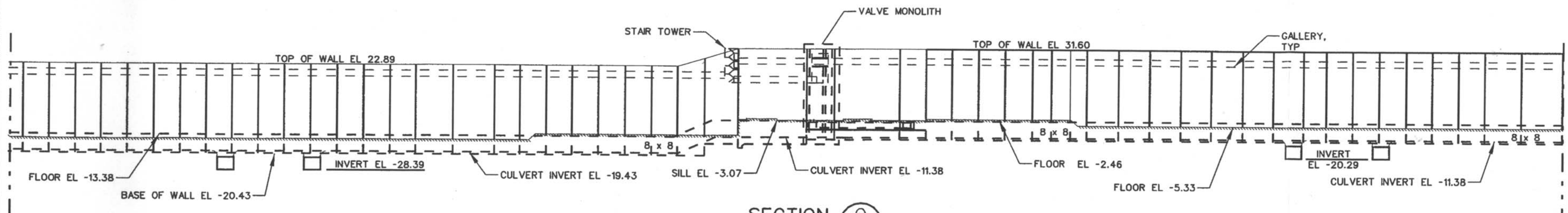
User: jtunkosh
Date: 12-MAY-2003 14:29
Plot Scale: 2.88890:1.000000
Pen Table:
Color Table

Symbol	Description	Date	Appr.
X	X	X	X

F:\ACP\sheet\Three-Lift Lock\ACP-RM-2002.s01

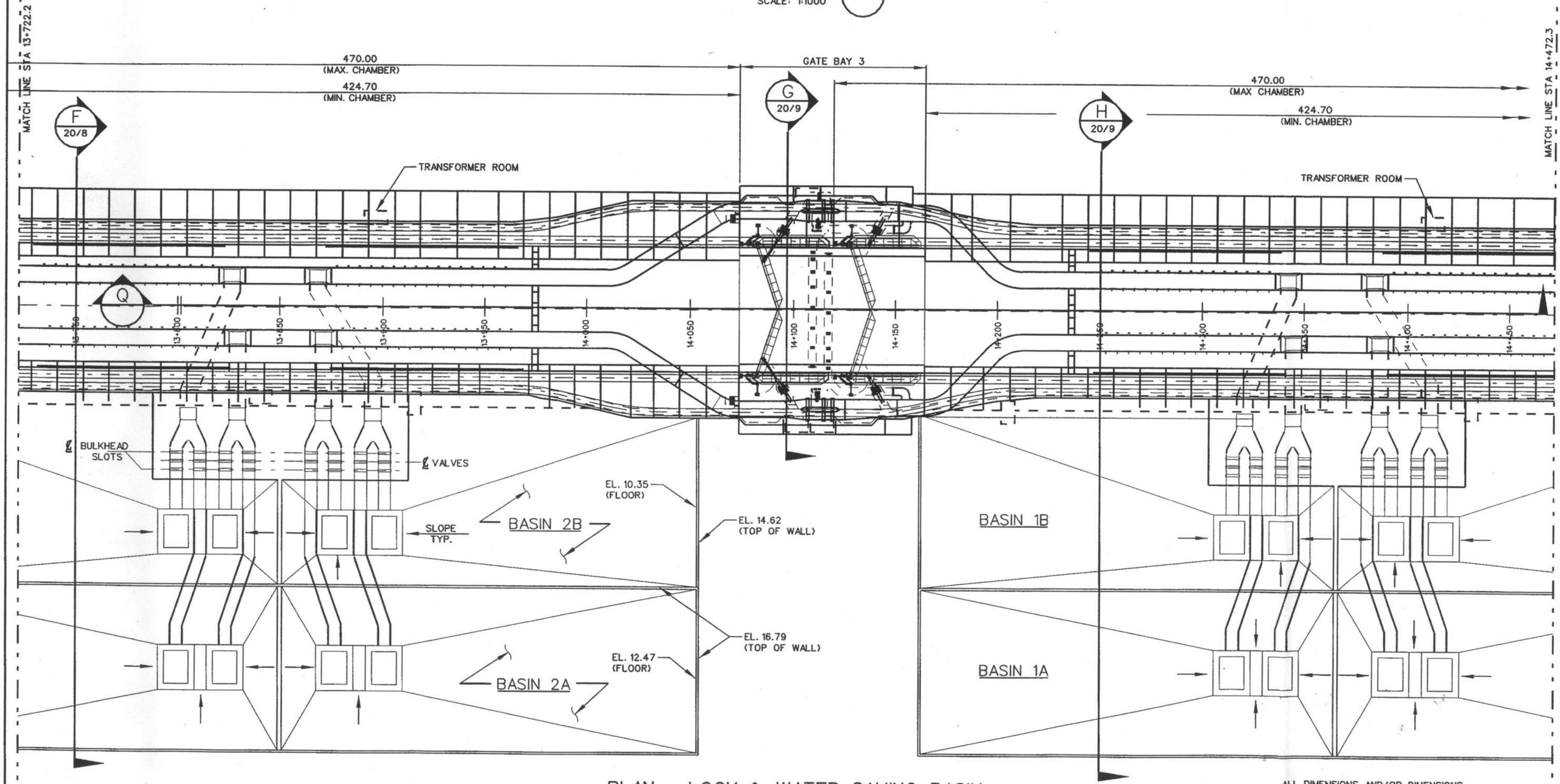
PANAMA CANAL
ATLANTIC LOCKS CONCEPT DESIGN
TRIPLE LIFT LOCK
LOWER LOCK & WATER SAVINGS BASINS
PLAN AND SECTION

Drawing Number:
ACP-RM-20/2



SECTION Q

SCALE: 1:1000



PLAN - LOCK & WATER SAVING BASIN

SCALE: 1:1000

ALL DIMENSIONS AND/OR DIMENSIONS SHOWN IN CALLOUTS/NOTES ARE IN METERS UNLESS OTHERWISE NOTED.

US Army Corps of Engineers
Pittsburgh District

Submitted by: W.A. HARKNESS, P.E.
TECHNICAL LEAD

Design by: X
Dwn by: JET
Ckd by: X
Submission Date: MAY 2003
Revision Date: X
FB NO.:

Sheet X of X

ACP
AUTORIDAD DEL CANAL DE PANAMA

User: jtankosh
Date: 12-MAY-2003 14:30
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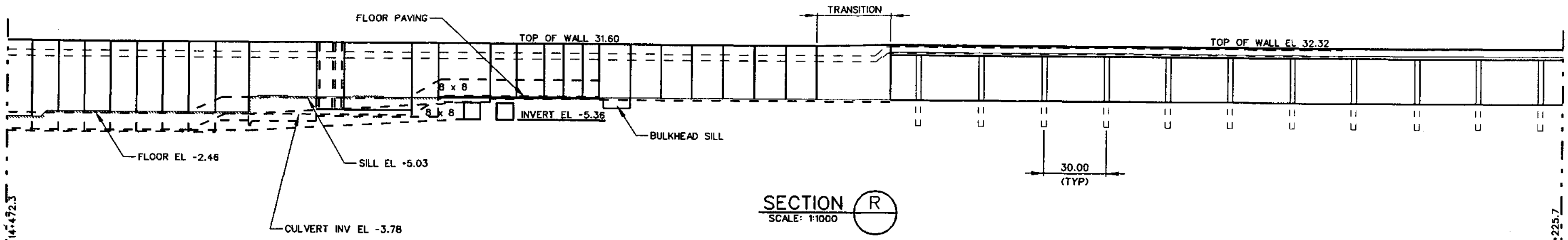
Color Table

Symbol	Description	Date	Appr.
X	X	X	X

F:\ACP\sheet\Three-Lift Lock\ACP-RM-2003.s01

PANAMA CANAL
ATLANTIC LOCKS CONCEPT DESIGN
TRIPLE LIFT LOCK
LOCK CHAMBER AND WATER SAVINGS BASIN
PLAN AND SECTION

Drawing Number: ACP-RM-20/3



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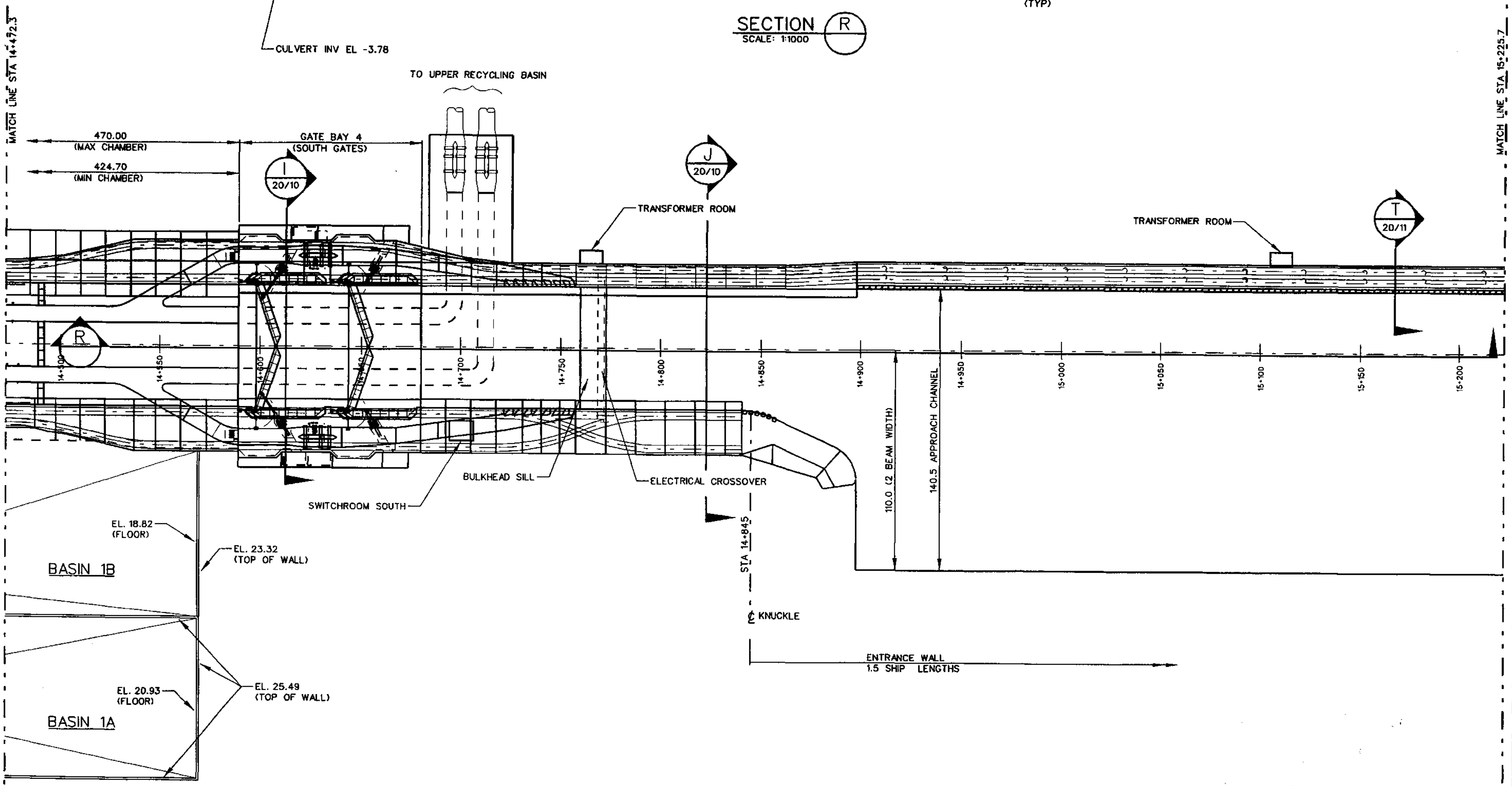

PLAN - SOUTH GATES & APPROACH
SCALE: 1:1000

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US Army Corps
of Engineers
Pittsburgh District

Submitted by:
W.A. HARKNESS, P.E.
TECHNICAL LEAD

Sheet X of X

Design by: X
Dwn by: JET
Ckd by: X
Submission Date: MAY 2003
Revision Date: X
PB NO.:

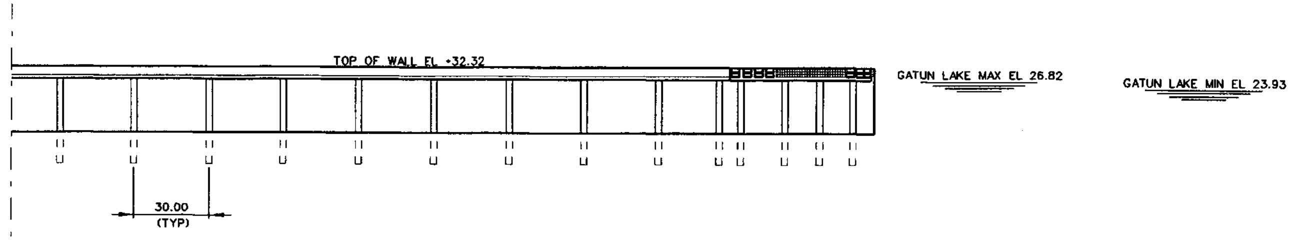
ACP
AUTORIDAD DEL CANAL DE PANAMA
User: Raskash
Date: 12-MAY-2003 14:30
Plot Scale: 2.888801:1.000000
Pen Table:
Color Table

Symbol	Description	Date	Appr.
X	X	X	X

F:\ACP\sheet\Three-Lift Lock\ACP-RM-2004.s01

PANAMA CANAL
ATLANTIC LOCKS CONCEPT DESIGN
TRIPLE LIFT LOCK
SOUTH ENTRANCE
PLAN AND ELEVATION

Drawing Number:
ACP-RM-20/4



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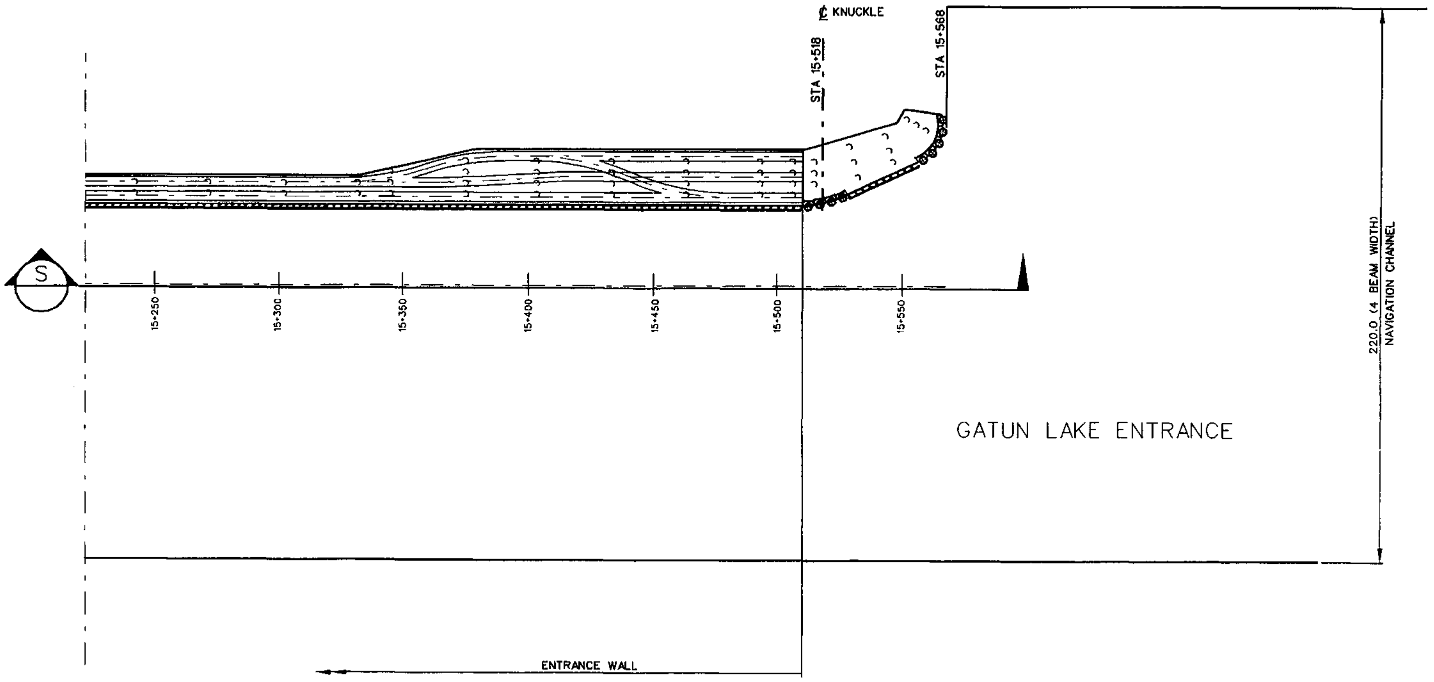

PLAN - SOUTH ENTRANCE WALL

SCALE: 1:1000

ALL DIMENSIONS AND/OR DIMENSIONS SHOWN IN CALLOUTS/NOTES ARE IN METERS UNLESS OTHERWISE NOTED.

US Army Corps
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Pittsburgh District

Submitted by:
W.A. HARKNESS, P.E.
TECHNICAL LEAD

FB NO.:

Sheet X of X

Design by: X
Ckd by: X
Dwn by: JET
Submission Date: MAY 2003
Revision Date: X

ACP
AUTORIDAD DEL CANAL DE PANAMA

User: jkenkom
Date: 12-MAY-2003 14:30
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Pen Table:
Color Table:

Symbol	Description	Date	Appr.
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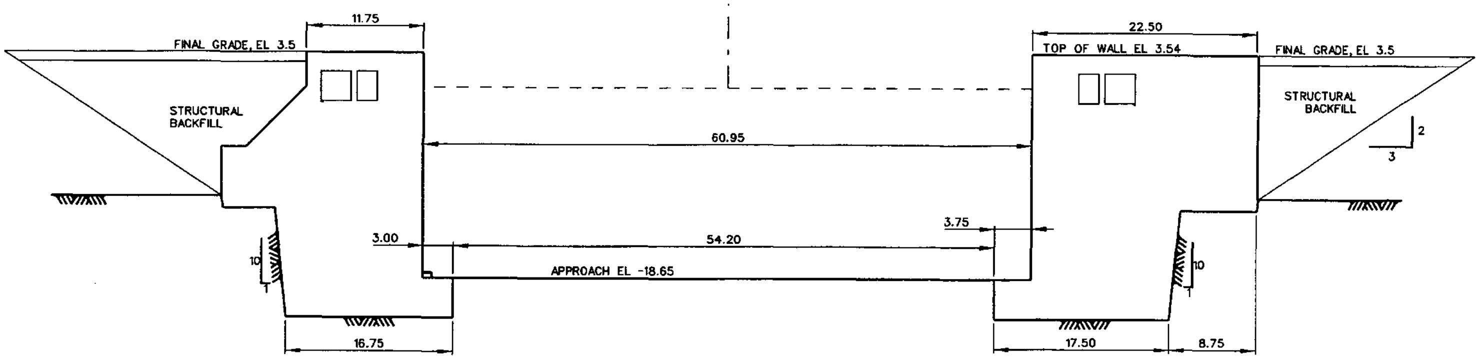
PANAMA CANAL
ATLANTIC LOCKS CONCEPT DESIGN
TRIPLE LIFT LOCK
SOUTH ENTRANCE
PLAN AND ELEVATION

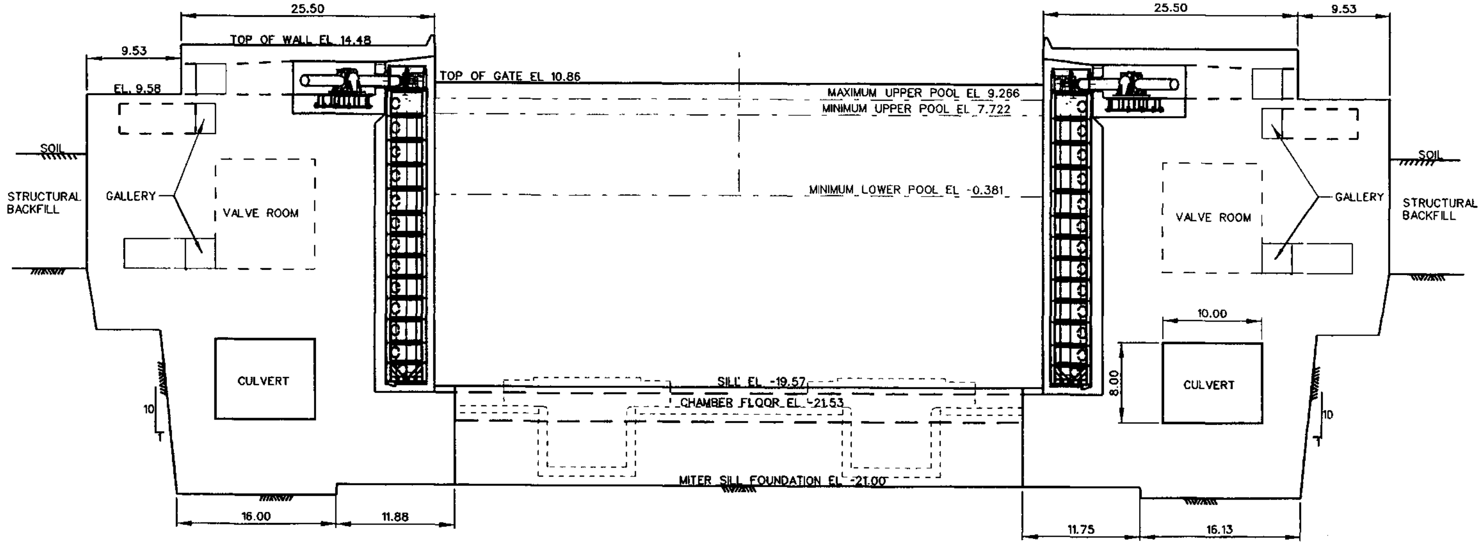
Drawing Number:
ACP-RM-20/5



SECTION A

SCALE: 1:250

20/1



SECTION B

SCALE: 1:250

20/2

US Army Corps
of Engineers
Pittsburgh District

Submitted by:
W.A. HARKNESS, P.E.
TECHNICAL LEAD

Sheet X of X

Design by: X
Dwn by: JET
Ckd by: X
Submission Date: MAY 2003
Revision Date: X
PB NO.:

ACP
AUTORIDAD DEL CANAL DE PANAMA

User: Harkness
Date: 12-MAY-2003 14:30
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Pen Table:
Color Table:

Symbol	Description	Date	Appr.
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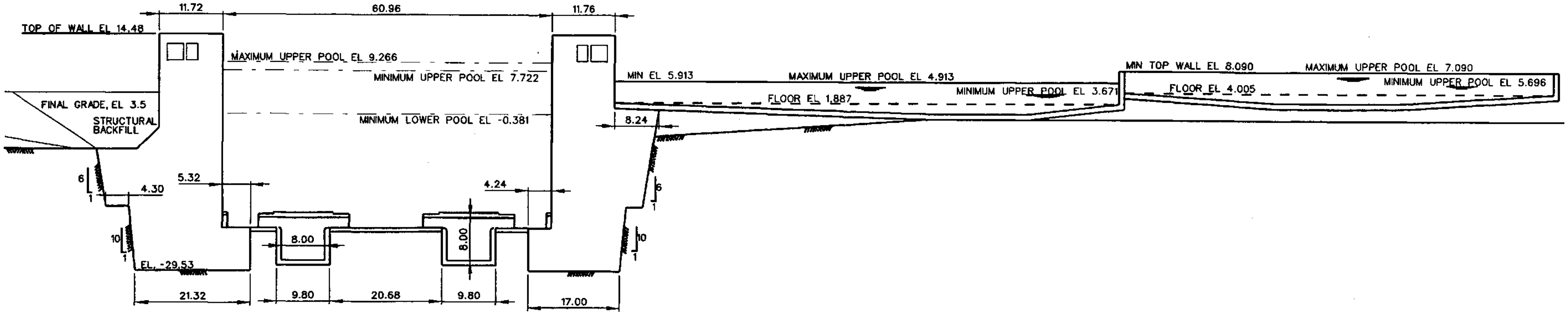
F:\ACP\sheet\Three-Lift Lock\ACP-RM-2006.s01

PANAMA CANAL
ATLANTIC LOCKS CONCEPT DESIGN
TRIPLE LIFT LOCK
WALL SECTIONS

Drawing Number:
ACP-RM-20/6



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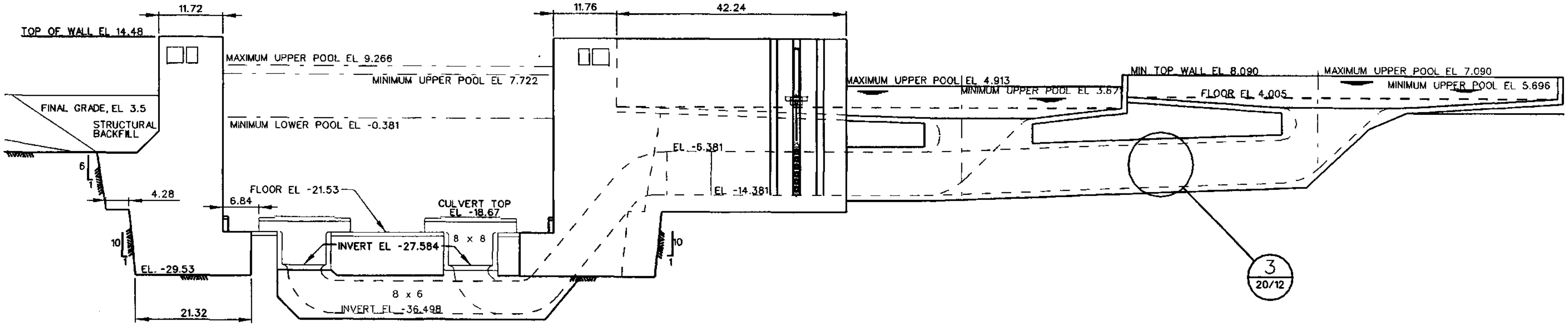
SCALE: 1:400
20/2



SECTION D
SCALE: 1:400
20/2

US Army Corps of Engineers
Pittsburgh District

Submitted by:
W.A. HARKNESS, P.E.
TECHNICAL LEAD

FB NO.:

Sheet X of X

Design by: X
Dwn by: JET
Ckd by: X
Submission Date: MAY 2003
Revision Date: X

ACP
AUTORIDAD DEL CANAL DE PANAMA

User: [illegible]
Date: 12-MAY-2003 14:30
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Pen Table:
Color Table:

Symbol	Description	Date	Appr.
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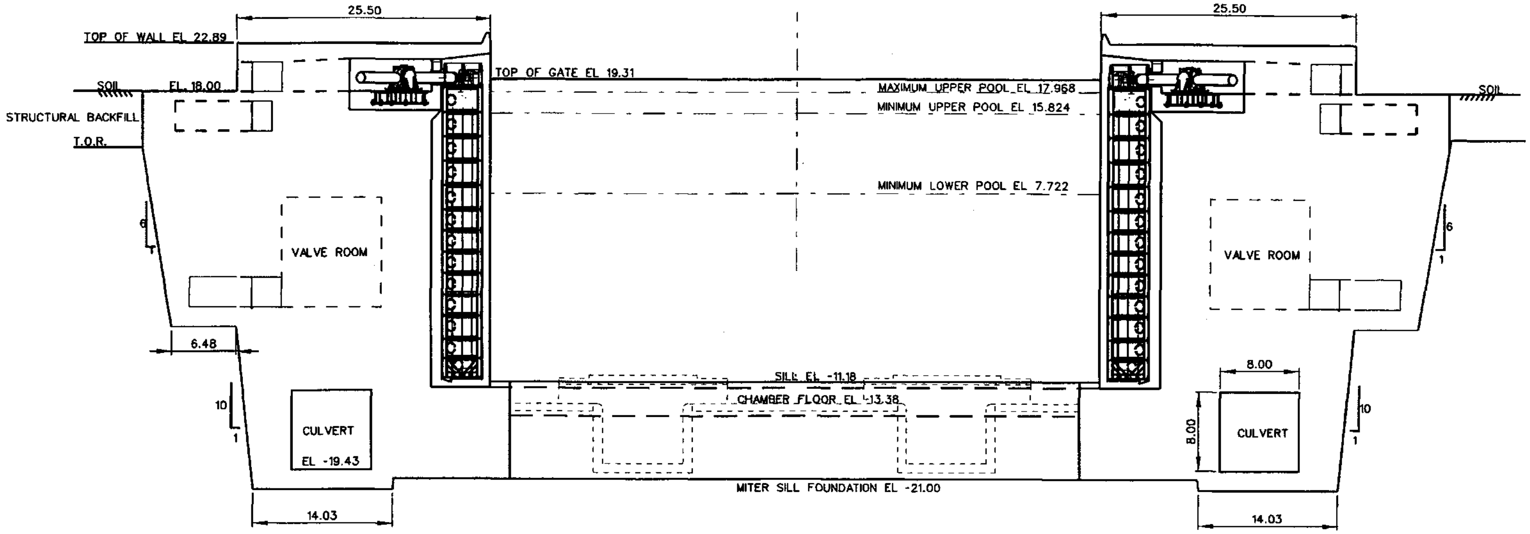
PANAMA CANAL
ATLANTIC LOCKS CONCEPT DESIGN
TRIPLE LIFT LOCK
WALL SECTIONS

Drawing Number:
ACP-RM-20/7



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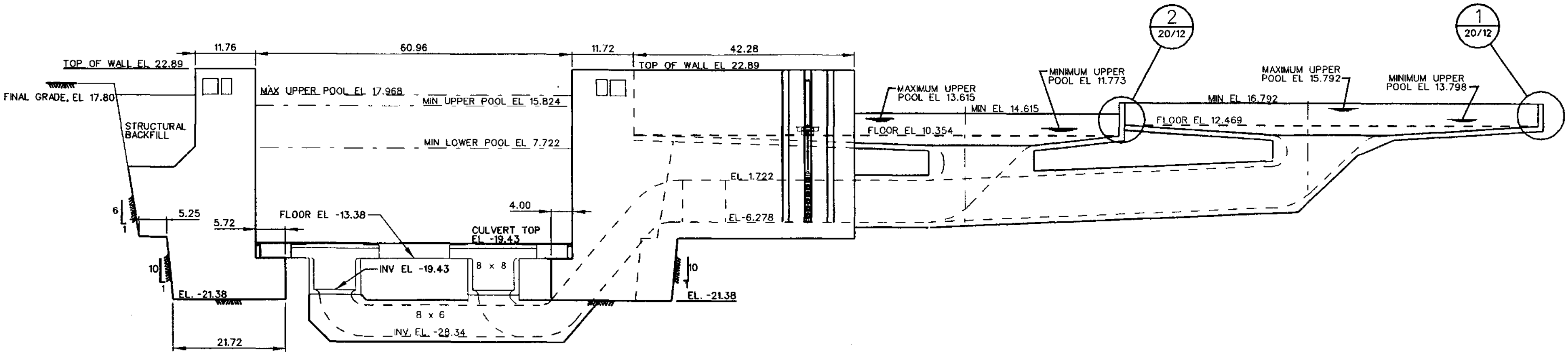

SECTION (F 20/3)
SCALE: 1:400

US Army Corps of Engineers
Pittsburgh District

Submitted by: W.A. HARKNESS, P.E.
TECHNICAL LEAD

Sheet X of X

Design by: X
Dwn by: JET
Ckd by: X
Submission Date: MAY 2003
Revision Date: X
FB NO.:

ACP
AUTORIDAD DEL CANAL DE PANAMA

User: Rankosh
Date: 12-MAY-2003 14:31
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Color Table

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PANAMA CANAL
ATLANTIC LOCKS CONCEPT DESIGN
TRIPLE LIFT LOCK
WALL SECTIONS

Drawing Number:
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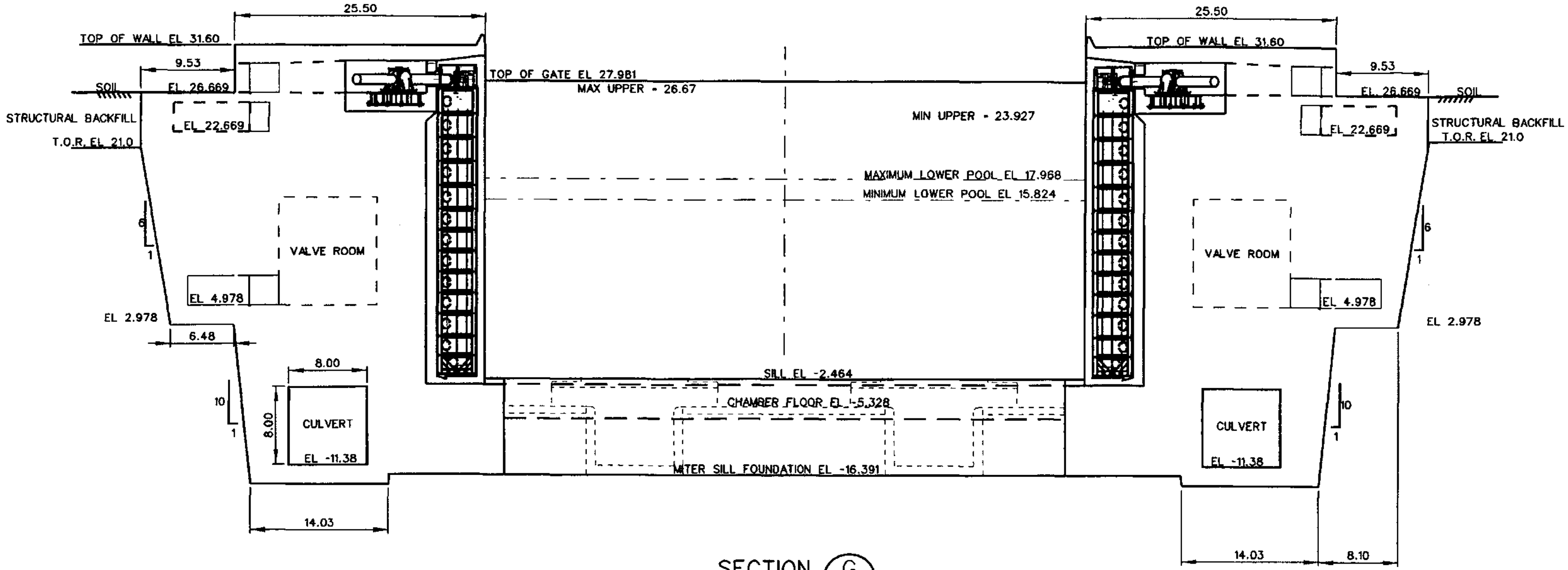
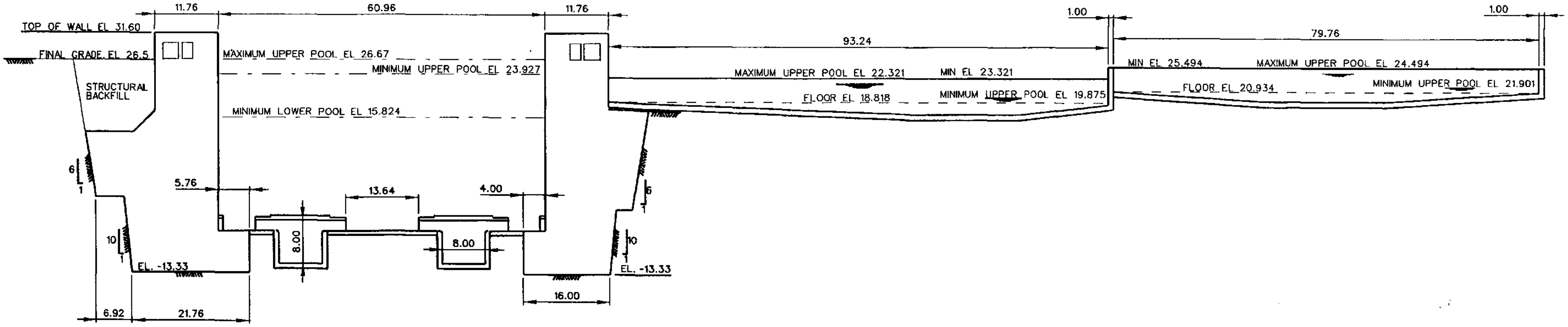


SECTION G
SCALE: 1:250
20/3



SECTION H
SCALE: 1:400
20/3

US Army Corps
of Engineers
Pittsburgh District

Submitted by:
W.A. HARKNESS, P.E.
TECHNICAL LEAD

Sheet X of X

Design by: X

Dwn by: JET

Ckd by: X

Submission Date: MAY 2003

Revision Date: X

FB NO.:

ACP
AUTORIDAD DEL CANAL DE PANAMA

User: Ronkosh
Date: 12-MAY-2003 14:31
Plot Scale: 2.88890:1.000000
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Color Table:

Symbol	Description	Date	Appr.
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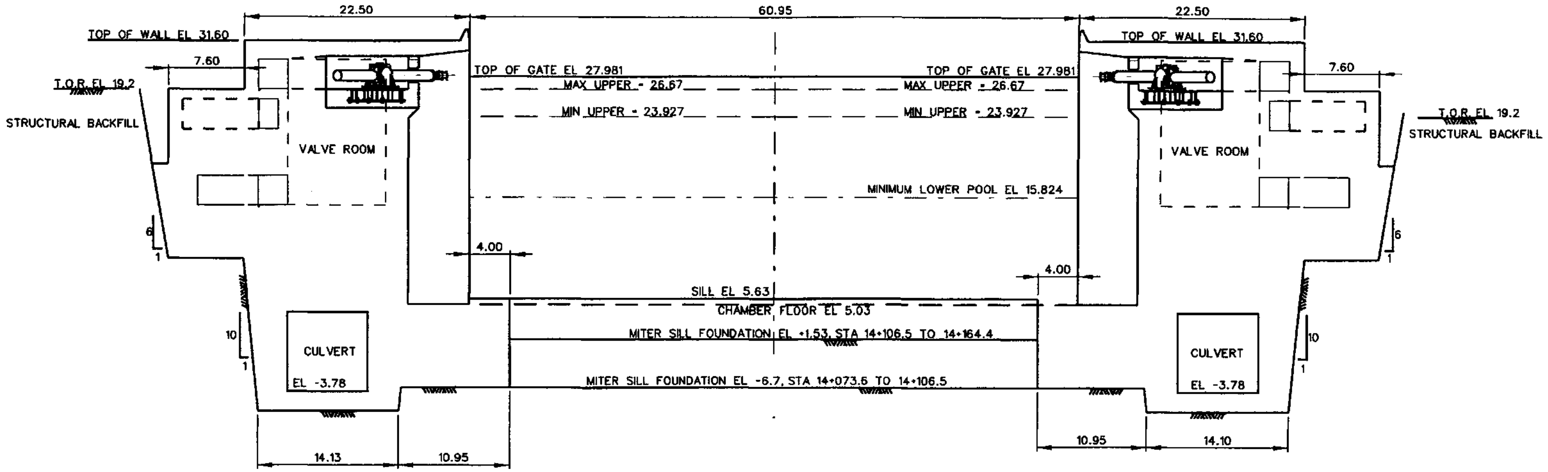
PANAMA CANAL
ATLANTIC LOCKS CONCEPT DESIGN
TRIPLE LIFT LOCK
WALL SECTIONS

Drawing Number:
ACP-RM-20/9



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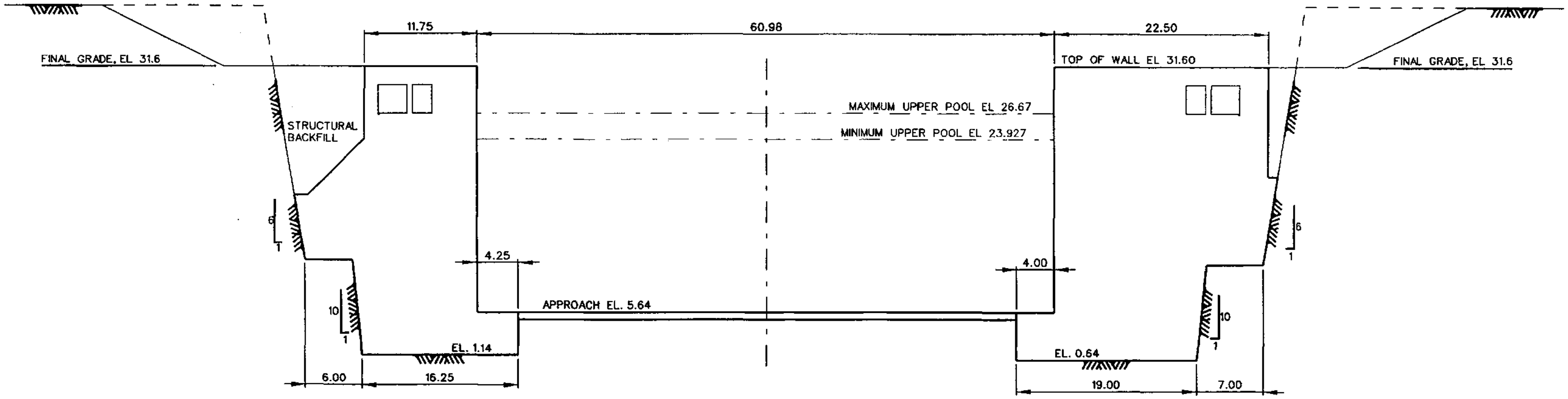
20/4



SECTION J
SCALE: 1:250
20/4

US Army Corps of Engineers
Pittsburgh District

Submitted by:
W.A. HARKNESS, P.E.
TECHNICAL LEAD

Sheet X of X

Design by: X
Dwn by: JET
Ckd by: X
Submission Date: MAY 2003
Revision Date: X
PB NO.:

ACP
AUTORIDAD DEL CANAL DE PANAMA

Symbol	Description	Date	Appr.
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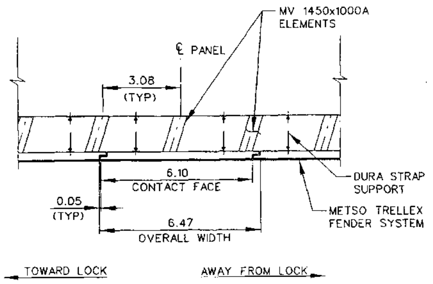
F:\ACP\sheet\Three-Lift Lock\ACP-RM-2010.s01

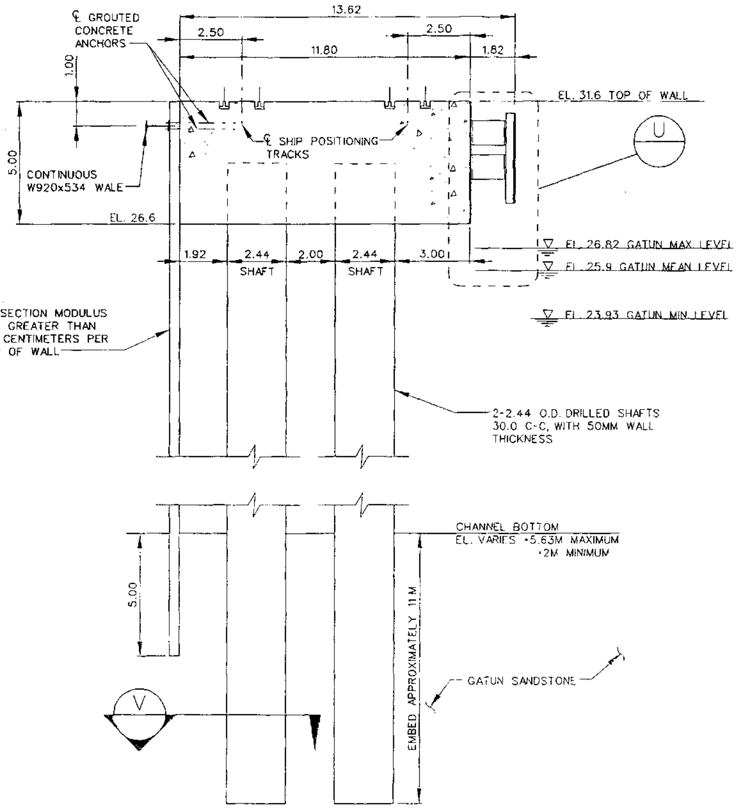
PANAMA CANAL
ATLANTIC LOCKS CONCEPT DESIGN
TRIPLE LIFT LOCK
WALL SECTIONS

Drawing Number:
ACP-RM-20/10



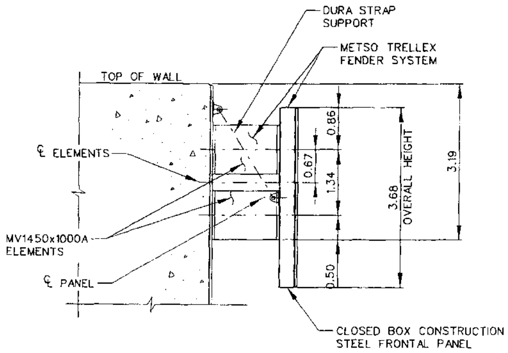
PARTIAL PLAN

SCALE: 1:100



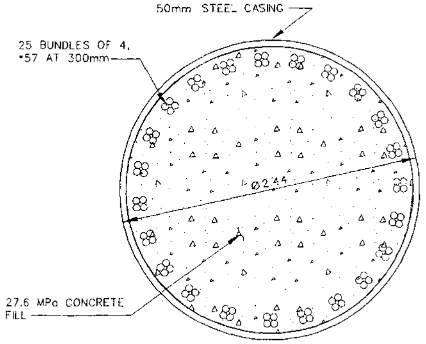
GATUN ENTRANCE WALL SECTION (T) 20/4

SCALE: 1:100



FENDER SYSTEM SECTION (U)

SCALE 1:50



DRILLED SHAFT DETAIL (V)

SCALE: 1:5

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US Army Corps
of Engineers
Pittsburgh District

Submitted by: W.A. HARKNESS, P.E.
TECHNICAL LEAD

IFB NO.:

Sheet X of X

Design by: T. SULLIVAN

Dwn by: B. HUSTON

Ckd by: B.PATEV

Submission Date: MAY 2003

Revision Date: X

ACP
AUTORIDAD DEL CANAL DE PANAMA

User: jlonkosh
Date: 10-JUL-2003 15:43
Plot Scale: 2.000000:1.000000
Pen Table:
Color Table

Symbol	Description	Date	Appr.
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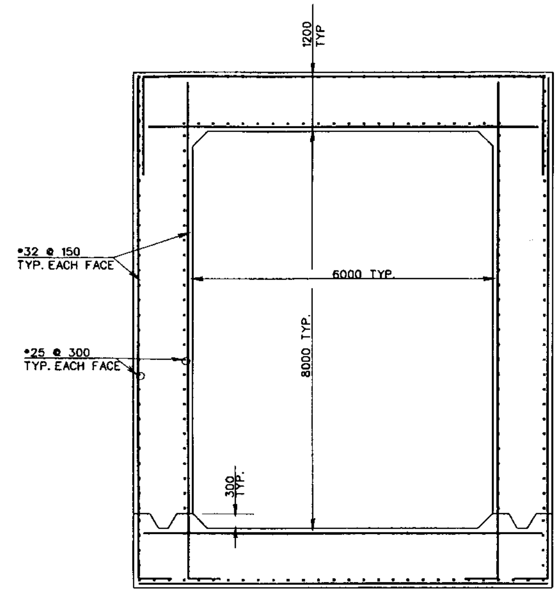
F:\ACP\sheet\Three-Lift Lock\ACP-RM-2011.s01

PANAMA CANAL
ATLANTIC LOCKS CONCEPT DESIGN
TRIPLE LIFT LOCK
GATUN ENTRANCE WALL
SECTIONS AND DETAILS

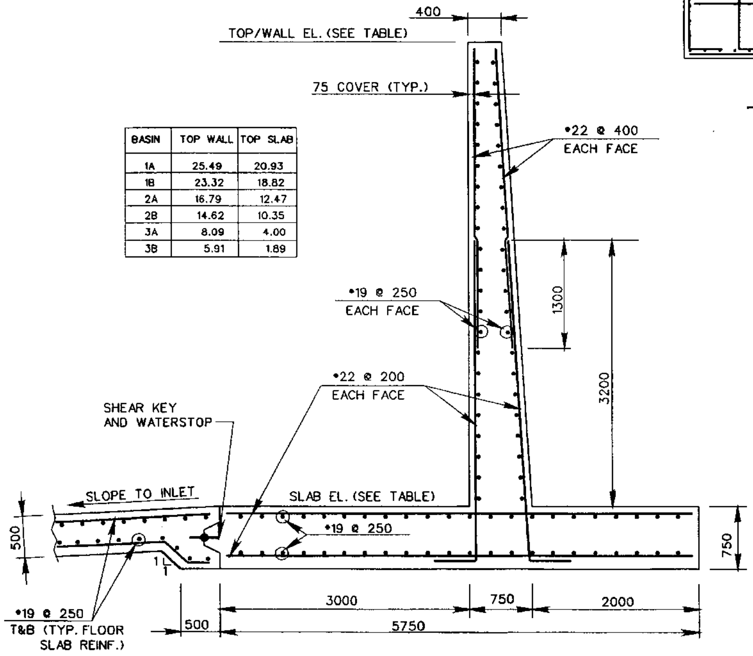
Drawing Number:
ACP-RM-20/11

USE 25 MPa CONCRETE
USE A20 MPa REINFORCING BARS

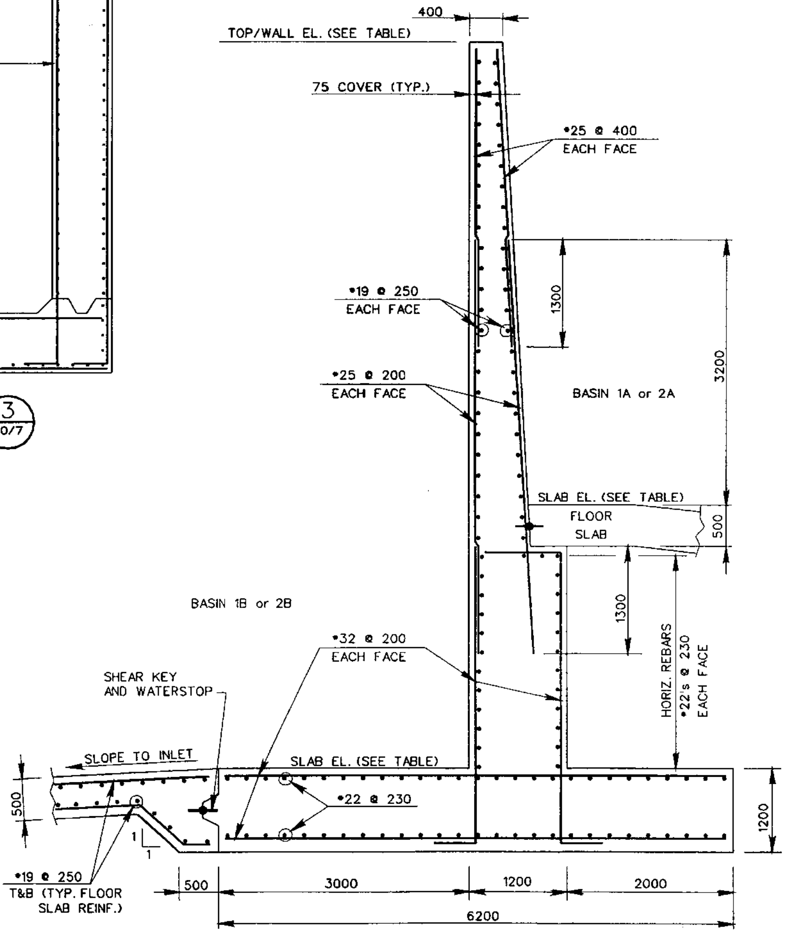


CONDUIT SECTION ③
SCALE: 1:50
20/7

BASIN	TOP WALL	TOP SLAB
1A	25.49	20.93
1B	23.32	18.82
2A	16.79	12.47
2B	14.62	10.35
3A	8.09	4.00
3B	5.91	1.89



EXTERIOR WALL SECTION ①
SCALE: 1:30
20/8



MIDDLE WALL SECTION ②
SCALE: 1:30
20/8

ALL DIMENSIONS AND/OR DIMENSIONS
SHOWN IN CALLOUTS/NOTES ARE IN
MILLIMETERS UNLESS OTHERWISE NOTED.

US Army Corps
of Engineers
Pittsburgh District

Submitted by: W.A. HARKNESS, P.E.
TECHNICAL LEAD
Design by: K. HULL, P.E.
Dwn by: KH/JET
Ckd by: X
Submission Date: MAY 2003
Revision Date: X
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Sheet X of X

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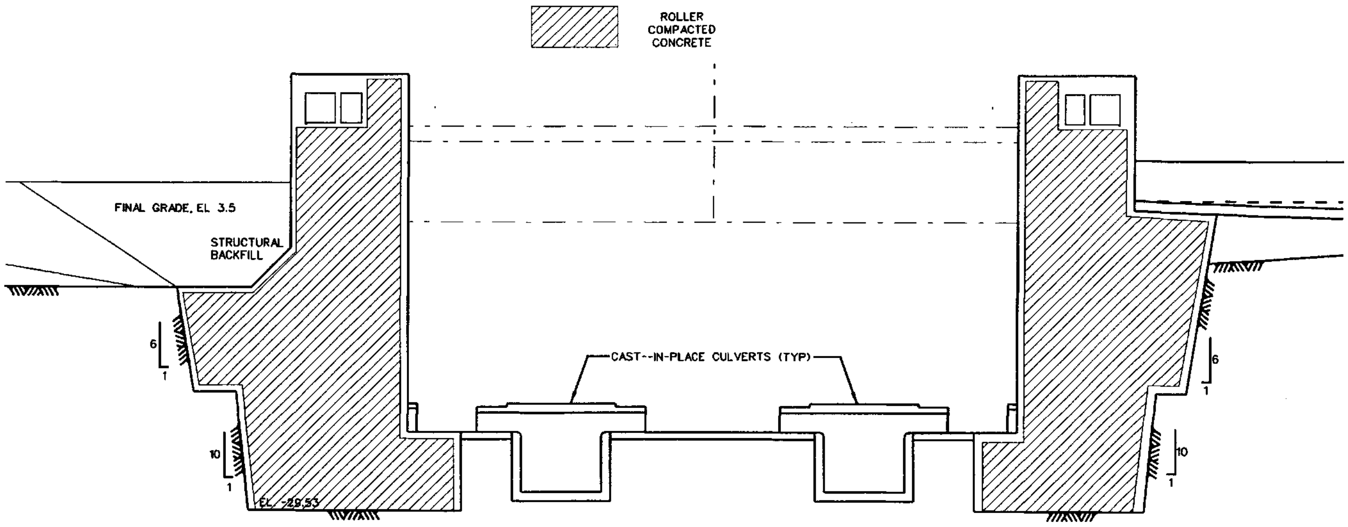
PANAMA CANAL
ATLANTIC LOCKS CONCEPT DESIGN
TRIPLE LIFT LOCK
WATER SAVING BASINS WALL & CONDUIT
SECTIONS & DETAILS

Drawing Number:
ACP-RM-20/12



TYPICAL CONCRETE PLACEMENT SECTION C 20/2

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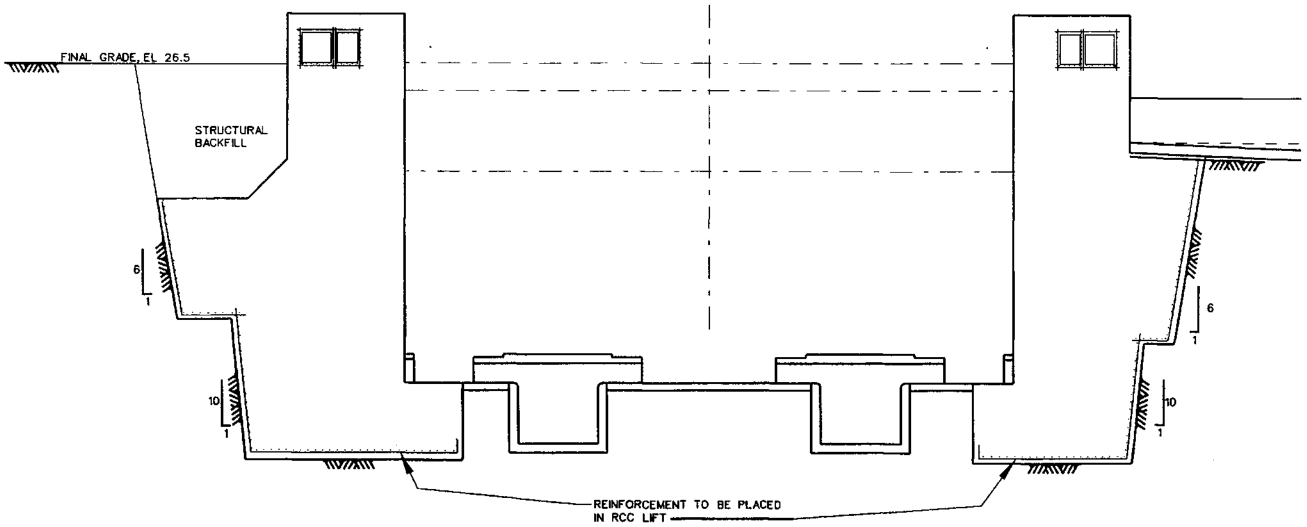

TYPICAL REINFORCEMENT PLACEMENT SECTION H 20/3

SCALE: 1:250

US Army Corps
of Engineers
Pittsburgh District

Submitted by:
W.A. HARKNESS, P.E.
TECHNICAL LEAD

Sheet X of X

Design by: X
Dwn by: JET
Ckd by: X
Submission Date: MAY 2003
Revision Date: X
PB NO.:

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PANAMA CANAL
ATLANTIC LOCKS CONCEPT DESIGN
TRIPLE LIFT LOCK
REINFORCEMENT & CONCRETE PLACEMENT
TYPICAL SECTIONS

Drawing Number:
ACP-RM-20/13

NOTES

1.) TEMPORAL LOAD = 0.23 M APPLIED IN ADDITION TO MAXIMUM NORMAL HEAD

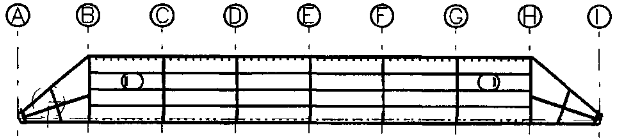
2.) SEISMIC LOADING: ∝= 0.14g, (OBE) ∝ = 0.31g (MCE), GATES DESIGNED FOR 2/3 MCE. APPLIED TO GATE MASS AND USED FOR HYDRODYNAMIC WATER LOADING.

3.) 2.5M WIDE BRIDGE ON GATE TOP IS DESIGNED FOR 400KN LOADING. APPLIED AT MITER END.

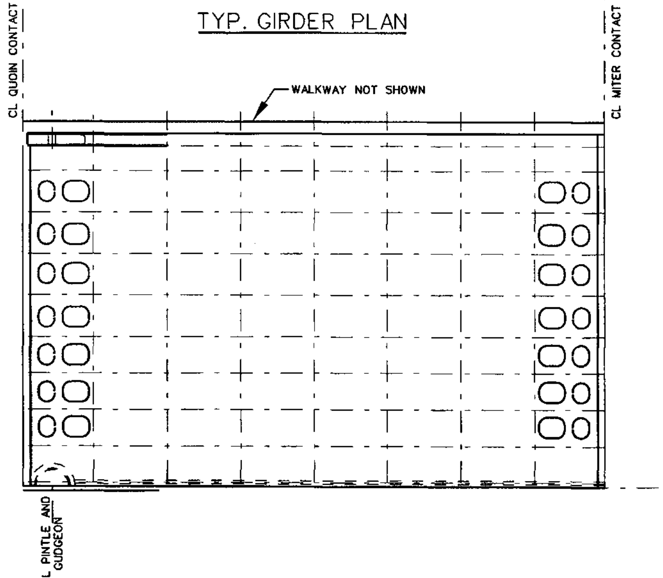
4.) GATES DESIGNED TO BE USED TO DEWATER LOCK CHAMBER, INTERMEDIATE POOL SET TO EL. 5.65

LEGEND

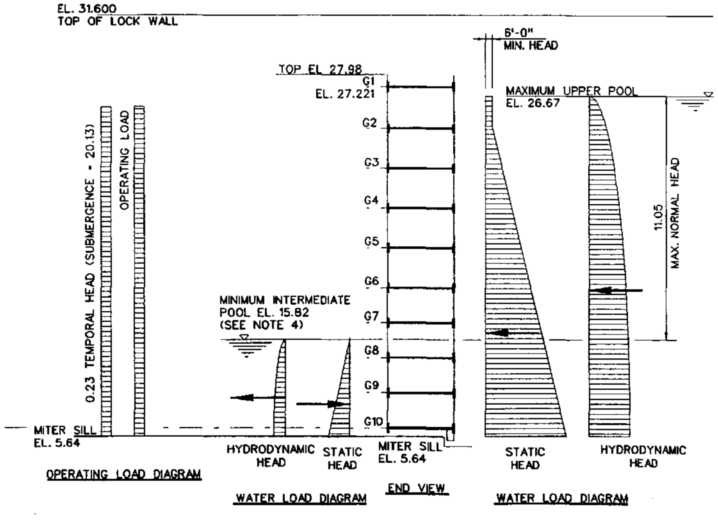
Ⓗ- DIAPHRAGM LETTERS, SET AT CL OF DIAPHRAGMS AND CONTACT POINTS
GXX - GIRDER NUMBERS, SET AT CL OF GIRDERS
←—— - INDICATES DIRECTION OF LOADING



TYP. GIRDER PLAN



SOUTH MITER GATE LEAF D.S. ELEVATION



LOAD CASE 1

(GATUN LAKE TO INTERMEDIATE POOL)

ALL DIMENSIONS AND/OR DIMENSIONS SHOWN IN CALLOUTS/NOTES ARE IN MILLIMETERS UNLESS OTHERWISE NOTED.

US Army Corps
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Pittsburgh District

Submitted by: W.A. HARKNESS, P.E.
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Sheet X of X

Design by: A. HARKNESS, PE
Dwn by: AH
Ckd by: RAA
Submission Date: MAR 2003
Revision Date: X

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PANAMA CANAL
ATLANTIC LOCKS CONCEPT DESIGN
TRIPLE LIFT LOCK
LOCK GATES - GATE BAY 1 (SOUTH GATES)
LOADING DIAGRAMS

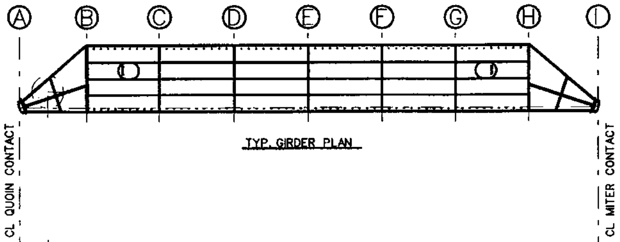
Drawing Number
ACP-RM-21/1

NOTES

1.) TEMPORAL LOAD - 0.23 M APPLIED IN ADDITION TO MAXIMUM NORMAL HEAD

2.) SEISMIC LOADING: α = 0.14g (OBE), α = 0.31g (MCE). GATE DESIGNED FOR 2/3 MCE (0.21g) CRITICAL STRUCTURE. APPLIED TO GATE MASS AND USED FOR HYDRODYNAMIC WATER LOADING.

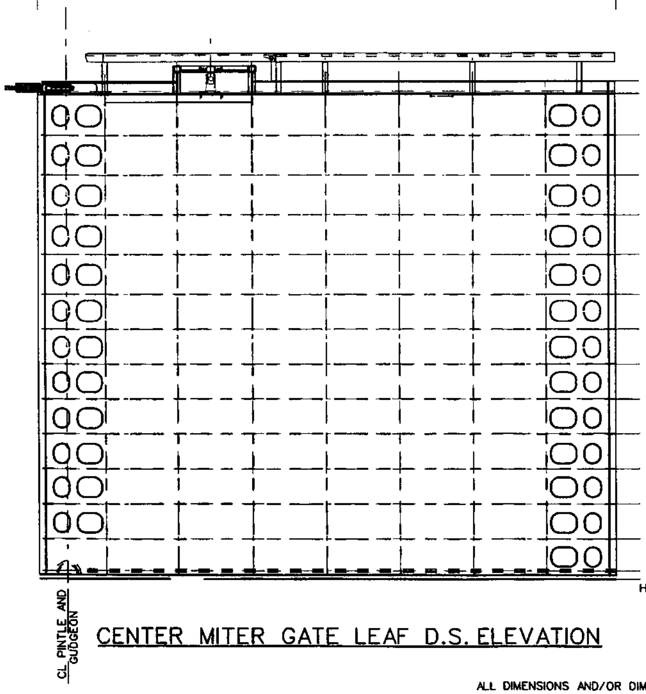
3.) 2.5M WIDE BRIDGE ON GATE TOP IS DESIGNED FOR 400KN LOADING APPLIED AT MITER END.



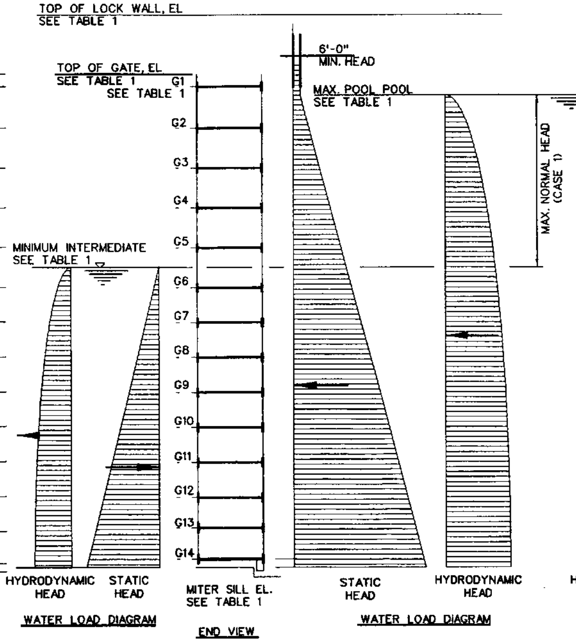
TYP. GIRDER PLAN

TABLE 1 - ELEVATIONS

GATE BAY	TOP OF LOCK WALL ELEVATION	TOP OF GATE ELEVATION	CL OF TOP GIRDER ELEVATION	SILL ELEVATION	CASE 1 LOADING CONDITION		CASE 2 LOADING CONDITION	
					UPPER POOL ELEVATION	LOWER POOL ELEVATION	UPPER POOL ELEVATION	LOWER POOL ELEVATION
1	14.48	10.86	10.10	-19.57	9.27	-0.381	N/A	N/A
2	22.89	19.27	18.51	-11.17	17.97	7.72	9.27	-0.81
3	31.60	27.97	27.21	-2.46	26.67	15.82	17.97	7.72

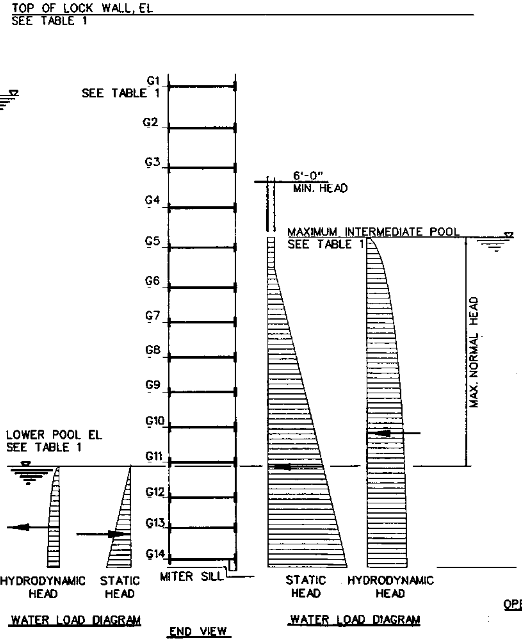


CENTER MITER GATE LEAF D.S. ELEVATION



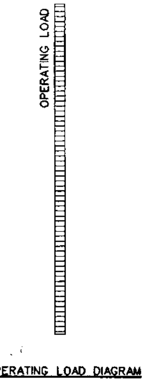
LOAD CASE 1

(GATUN LAKE TO INTERMEDIATE POOL)



LOAD CASE 2

(INTERMEDIATE POOL TO ATLANTIC OCEAN)



OPERATING LOAD DIAGRAM

ALL DIMENSIONS AND/OR DIMENSIONS SHOWN IN CALLOUTS/NOTES ARE IN MILLIMETERS UNLESS OTHERWISE NOTED.

US Army Corps
of Engineers
Pittsburgh District

Submitted by: W.A. HARKNESS, P.E.
TECHNICAL LEAD

FB NO.:

Sheet X of X

Design by: A. HARKNESS, PE
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Submission Date: MAR 2003
Revision Date: X

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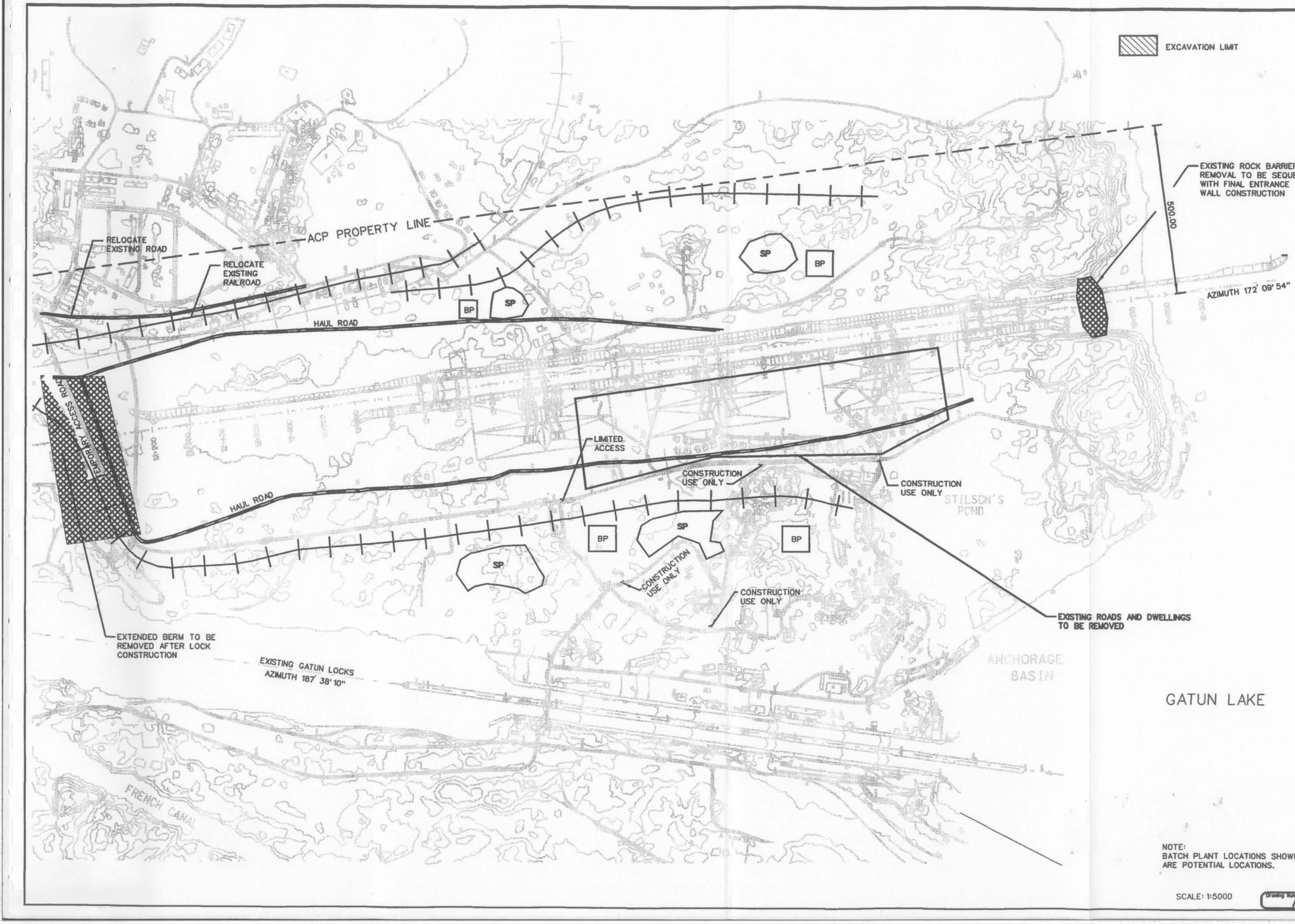
PANAMA CANAL
ATLANTIC LOCKS CONCEPT DESIGN
TRIPLE LIFT LOCK
LOCK GATES, GATE BAYS 1, 2, AND 3
LOADING DIAGRAMS

Drawing Number: ACP-RM-21/2



NOTE:
BATCH PLANT LOCATIONS SHOWN ARE POTENTIAL LOCATIONS.

SCALE: 1:5000

US Army Corps
of Engineers
Pittsburgh District

Submitted by: W.A. HARKNESS, P.E.
TECHNICAL LEAD

Sheet X of X

Design by: CRAIG CARNEY
Dwn by:
Ckd by: X
Submission Date: MAY 2003
Revision Date: X
PB NO.:

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AUTORIDAD DEL CANAL DE PANAMA

User: jtankosh
Date: 12-MAY-2003 14:32
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PANAMA CANAL
ATLANTIC LOCKS CONCEPT DESIGN
TEMPORARY CONSTRUCTION
DETAILED SITE PLAN

Drawing Number:
ACP-RM-93/1

PANAMA CANAL CONCEPT DESIGN

Atlantic Locks Structure
Third Lift Lock
Appendix N, Attachment 2
Hydraulic Analyses and Designs

Prepared for

ACP

Canal Capacity Projects Office

By

US Army Corps
of Engineers®

Final Report

Triple-Lift Configuration

23 July 2003

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HYDRAULIC FEATURES FOR TRIPLE-LIFT CONFIGURATION

The following paragraphs provide a brief overview and summary of the analysis and design of hydraulic features for the triple-lift configuration of the Third Lane. Many design procedures and assumptions have been carried forward from the double-lift design and are not repeated in this section. Refer to Appendix E for more detailed information on the development of design procedures and assumptions.

1. REFERENCES

A complete list of technical references is provided in Section 2.1 of Appendix A.

2. STAGE DURATION DATA

Stage duration relationships for Gatun Lake and the Atlantic Ocean previously developed by Moffatt and Nichol Engineers were used for both the double- and triple lift configurations. Details of the analyses are provided in Sections 2.1 and 2.2 of Appendix E.

Stage duration relationships for the middle and lower locks were derived from the duration data for Gatun Lake and the Atlantic Ocean. A detailed explanation of the computation procedures is presented in Section 2.3 of Appendix E. Sample computation matrices for the middle and lower locks using four intervals are summarized in Tables N2-2-1 and N2-2-2. Percent exceedence tables for the middle and lower locks using these four intervals are presented in Tables N2-2-3 and N2-2-4. The final adopted duration curves for the locks, which were developed using fourteen intervals to improve accuracy, are presented in Figure N2-2-1.

Table N2-2-1 Four Interval Computation Matrix (Middle Lock)

		Representative Gatun Lake Elevations (m PLD) and Probabilities			
		26.588	**26.109**	**25.634**	**25.167**
		0.25	**0.55**	**0.10**	**0.10**
Representative Atlantic Ocean Elevations (m PLD) and Probabilities	**0.274**	17.817	17.497	17.181	16.869
	0.20	*0.05*	*0.11*	*0.02*	*0.02*
	0.094	17.757	17.437	17.121	16.809
	0.15	*0.04*	*0.08*	*0.02*	*0.02*
	-0.073	17.701	17.382	17.065	16.754
	0.55	*0.14*	*0.30*	*0.06*	*0.06*
	-0.229	17.649	17.330	17.013	16.702
	0.10	*0.03*	*0.06*	*0.01*	*0.01*

Table N2-2-2 Four Interval Computation Matrix (Lower Lock)

		Representative Gatun Lake Elevations (m PLD) and Probabilities			
		26.588	**26.109**	**25.634**	**25.167**
		0.25	**0.55**	**0.10**	**0.10**
Representative Atlantic Ocean Elevations (m PLD) and Probabilities	**0.274**	9.045	8.886	8.727	8.570
	0.20	*0.05*	*0.11*	*0.02*	*0.02*
	0.094	8.925	8.766	8.607	8.452
	0.15	*0.04*	*0.08*	*0.02*	*0.02*
	-0.073	8.814	8.654	8.496	8.340
	0.55	*0.14*	*0.30*	*0.06*	*0.06*
	-0.229	8.710	8.550	8.392	8.236
	0.10	*0.03*	*0.06*	*0.01*	*0.01*

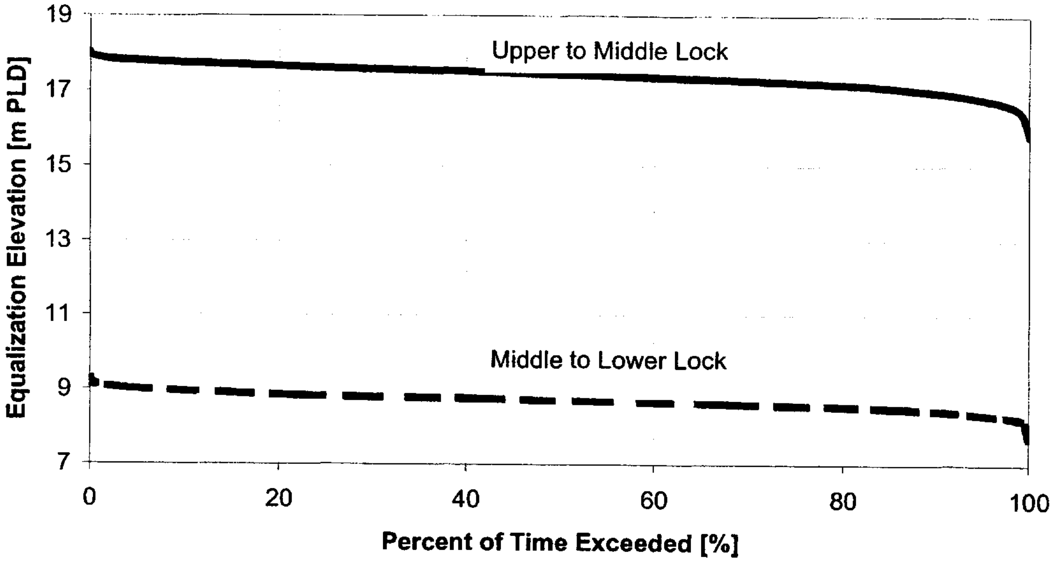
Table N2-2-3 Four Interval Percent Exceedence (Middle Lock)

Equalization Elevation (m PLD)	**Percent Exceedence (%)**
15.834	100
16.702	99
17.065	91
17.437	45
17.817	5
18.063	0

Table N2-2-4 Four Interval Percent Exceedence (Lower Lock)

Equalization Elevation (m PLD)	Percent Exceedence (%)
7.727	100
8.236	99
8.496	91
8.766	45
9.045	5
9.314	0

Figure N2-2-1 Equalization Elevation Duration



3. LOCK PROFILE

In accordance with the terms of reference, the triple-lift locks configuration has been designed to operate between Gatun Lake levels of 26.670 and 23.927 m PLD and Atlantic Ocean levels of 0.564 and –0.381 m PLD.

3.1. Sill Elevations

Sill elevations were selected based on low lake and ocean levels and the required minimum sill clearance of 18.288 m. The sill between the middle and lower locks was lowered slightly from –10.566 to –11.166 m PLD for structural reasons. The sill between the lower lock and the Atlantic Ocean was also lowered from –18.669 to –19.570 m PLD. Table N2-3-1 provides a summary of sill elevations for the triple-lift configuration.

Table N2-3-1 Sill Elevations

Sill Location	Elevation (m PLD)
Gatun Lake to Upper Lock	5.639
Upper Lock to Middle Lock	-2.464
Middle Lock to Lower Lock	-11.180
Lower Lock to Atlantic Ocean	-19.570

3.2. Hydraulic Freeboard

Consistent with the double-lift design, a minimum hydraulic freeboard of 1.311 m is recommended for the triple-lift configuration. The recommended freeboard would be similar to the existing Gatun Locks and other large locks. It would accommodate the expected ship induced surcharges and overtravel during equalizations. A freeboard duration curve for the locks is presented in Figure N2-3-1.

3.3. Recommended Lock Profile

A schematic of the recommended lock profile for operations without water saving basins is presented in Figure N2-3-2. For this profile, an average water column of 8.693 m would be required per lockage. The total volume of water required would be the water column times the surface area of the lock.

Figure N2-3-1 Freeboard Duration

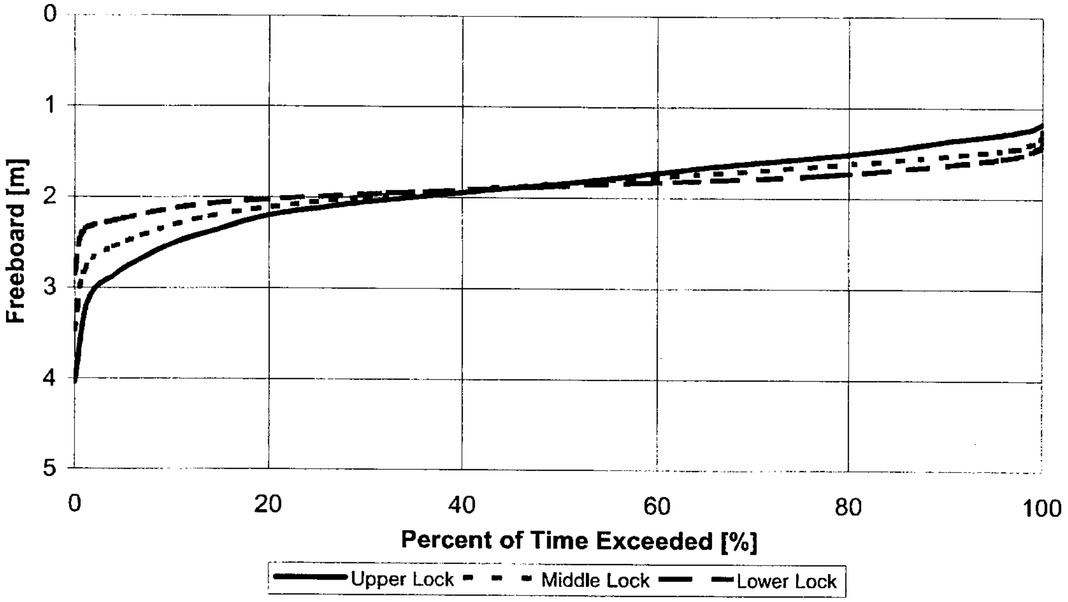
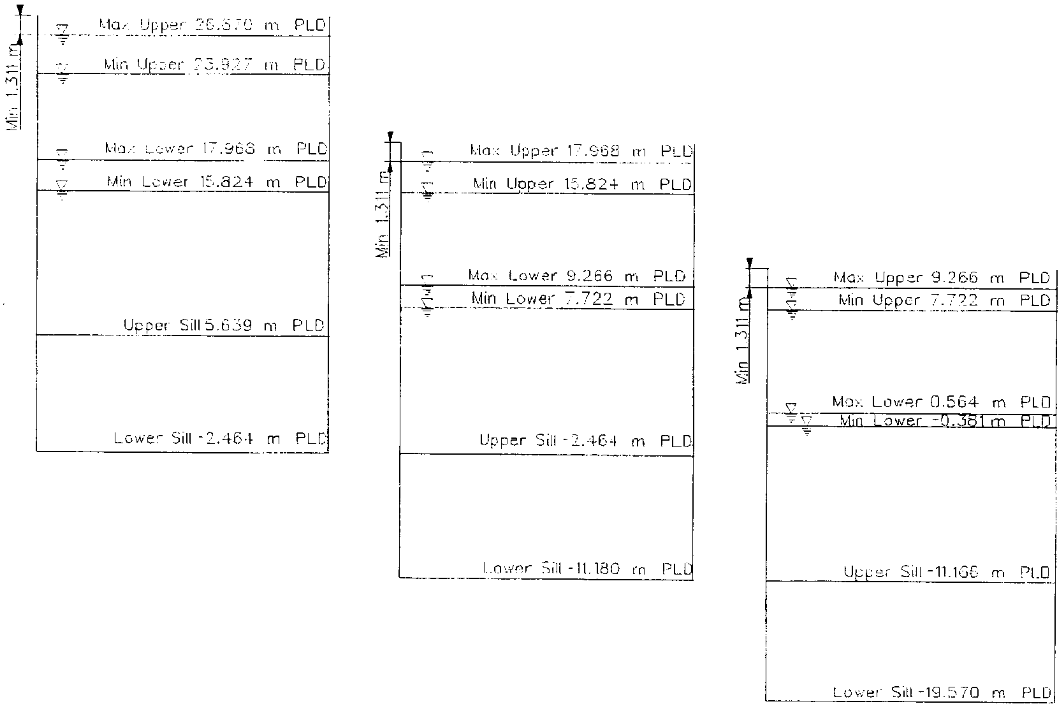


Figure N2-3-2 Lock Profile Without Water Saving Basins



4. USEABLE LOCK LENGTH

The lock configuration used for the double-lift design has been adopted for the triple-lift configuration. The arrangement is presented as configuration B in Section 4 of Appendix E. A useable length of 426.720 m is provided with redundancy for all situations. Additional capacity is available for a 472.230 m lock length with redundancy in the upbound direction only. Redundancy would not be provided in the downbound direction at the 472.230 m length.

5. WATER SAVING BASINS

Recommended water saving basin design parameters in Equation N2-5-1 for the triple-lift configuration are presented in Table N2-5-1. Analysis of the various design parameters and basin configurations was accomplished using a numerical model. The modified version of the Moffatt and Nichol spreadsheet described in Section 5.1.6 of Appendix E was used.

$$E = \frac{n \cdot m \cdot (H - 2e)}{H[(1 + m(1 + n))]} \qquad \text{(N2-5-1)}$$

Table N2-5-1 Water Saving Basin Parameters

Parameter	Value	Source
Target Water Savings (E)	50%	Terms of Reference
Average Lift Height (H)	8.616 m	Derived from average lake and ocean levels specified in Terms of Reference
Number of Basins (n)	2	Terms of Reference
Basin to Lock Area Ratio (m)	1.0	Section 5.1.3, Appendix E
Basin Residual (e)	0.0	Section 5.1.4, Appendix E

5.1. Floor Elevations

A detailed screening analysis was not performed for the triple-lift configuration. Consistent with the double-lift design, the low floor alternative is recommended. A summary of the low and high floor alternatives is presented in Table N2-5-2.

5.2. Operating Water Surface Elevations

The range of possible basin equalization elevations was determined the same way that the operating elevations for the locks were evaluated. The locks and water saving basins would equalize at the elevations shown in Figure N2-5-1.

5.3. Hydraulic Freeboard

A minimum freeboard of 1 m has been used for the triple-lift configuration to be consistent with the double-lift design.

5.4. Water Saving Basin Profile

The recommended profile for operations with water saving basins is presented in Figure N2-5-2. For this profile, an average water column of 4.346 m would be required per lockage. The total volume of water required would be the water column times the surface area of the lock.

Table N2-5-2 Water Saving Basin Floor Alternatives

		Low Floor	High Floor
Average Water Savings (%)		50.00	47.78
Minimum Water Savings at Extreme Low Water* (%)		45.81	39.67
Average Water Column Required Per Lockage**(m)		6.520	6.767
Floor Elevation (m PLD)	Basin 1A	20.934	22.202
	Basin 1B	18.818	20.010
	Basin 2A	12.469	13.431
	Basin 2B	10.354	11.238
	Basin 3A	4.005	4.660
	Basin 3B	1.887	2.466

*Gatun Lake at 23.927 m PLD and Atlantic Ocean at –0.381 m PLD

**Total volume is water column times surface area of lock

Figure N2-5-1 Equalization Elevations With WSBs

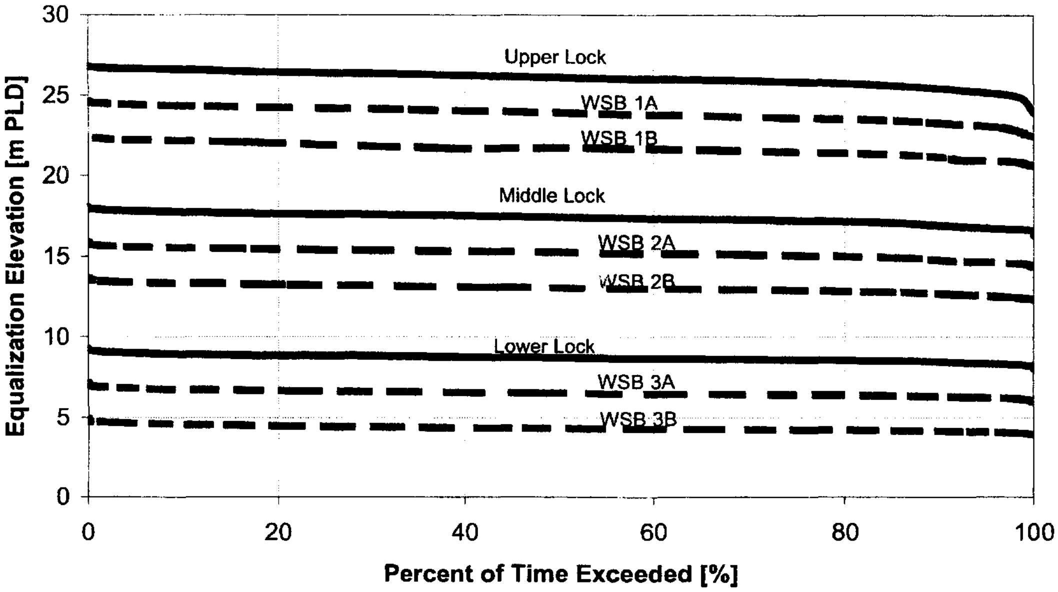
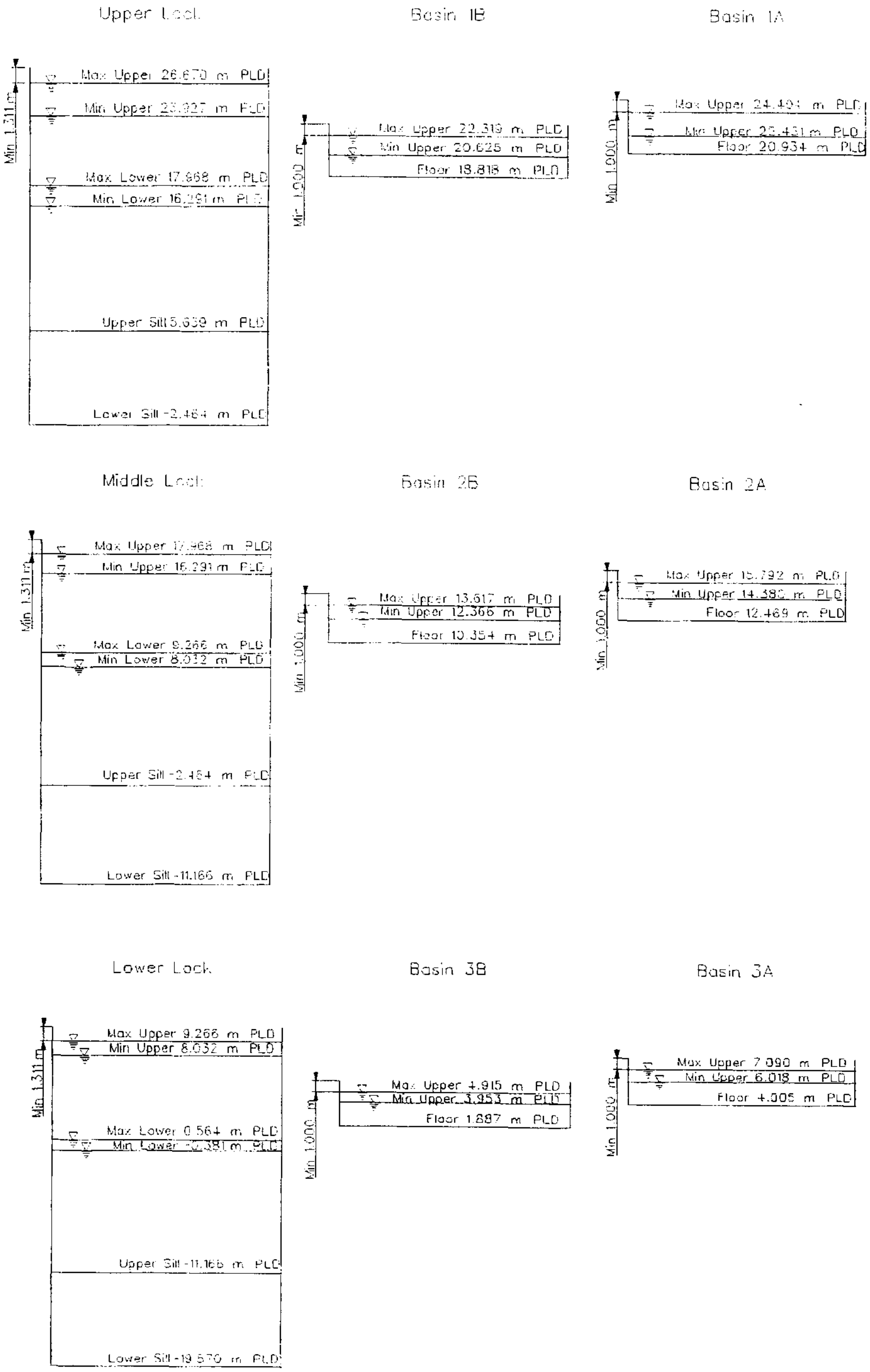


Figure N2-5-2 Lock Profile With Water Saving Basins



6. DESIGN SHIPS

The ships used for the triple-lift design are the same as those used for the double-lift design. A summary is provided in Table N2-6-1.

Table N2-6-1 Design Ships

Vessel Type	Length (m)	Beam (m)	Draft (m)	Block Coefficient	Deadweight (t)	Displacement (t)
Container	385.7	54.9	15.2	0.65	125 000	209 000
Bulk Carrier	290.0	45.0	15.2	0.85	135 000	169 000

7. LOCKSIM

The LOCKSIM numerical model was used to evaluate filling and emptying systems for the triple-lift configuration. Details on the model are provided in Section 7 of Appendix E.

8. HAWSER FORCES

Hawser forces for the triple-lift configuration were evaluated using procedures and criteria consistent with the double-lift design. Details on the development of hawser criteria are presented in Section 8 of Appendix E.

8.1. Longitudinal Hawser Forces

The recommended maximum allowable water surface slope is 0.5/1000 as predicted by LOCKSIM for an unoccupied chamber. This should equate to approximately 1/1000 for a ship with a high blockage factor in the chamber. This criterion is consistent with international criteria and the existing Miraflores Locks. Future studies should include a physical hydraulic model testing program to measure and verify longitudinal hawsers.

8.2. Transverse Hawser Forces

The forces associated with transverse hawsers cannot be estimated from a one-dimensional model such as LOCKSIM. To address the potential for transverse hawsers, design of the locks is based on designs of similar systems that have been evaluated with a physical hydraulic model and shown to have acceptable transverse hawsers. Future design studies should include a physical hydraulic model testing program to measure and evaluate transverse hawser forces.

9. OVEVIEW OF LOCK FILLING AND EMPTYING SYSTEMS

Filling and emptying systems can be grouped into three general classes. The first class is designated as end filling. In this type of system, water enters the lock only at the upstream end of the chamber. The second class includes systems that use longitudinal culverts in the lock walls or along the chamber floor to distribute flow more evenly into the lock chamber. The third class is a hybrid that incorporates elements of both the end filling and culvert systems.

A general overview of filling and emptying systems considered for the design is presented in Section 9 of Appendix E.

10. SCREENING OF LOCK FILLING AND EMPTYING SYSTEMS

In accordance with Modification 2 of the terms of reference, the interlaced bottom lateral system was adopted for the triple-lift design. Because the selected filling and emptying system was predetermined, a detailed screening analysis of alternatives was not performed. A brief summary of some considerations and recommendations related to the triple-lift configuration is presented in the following paragraphs. Additional details are presented in Section 10 of Appendix E.

10.1. End-Filling

Without water saving basins, the maximum head differential for lock-to-lock equalization (18 m) greatly exceeds the maximum design lift recommended by Corps guidance (3 m). With water saving basins, the maximum initial head differential is reduced to 4.5 m, which still exceeds accepted limits. This type of system is not recommended for further study because the design lift is greater than the recommended maximum. The system would not be able to safely meet equalization time criteria for a triple-lift configuration of the Third Lane.

10.2. Side Port

Without water saving basins, the maximum head differential for lock-to-lock equalization (18 m) exceeds the maximum design lift recommended by Corps guidance (9 m). Assuming equalizations with water saving basins represent the primary mode of operation, the maximum initial lift is reduced to 4.5 m, which is within acceptable limits. The maximum head differential for lock-to-lock operations would be reduced to 9 m, which is also within acceptable limits.

Hydraulic performance would be acceptable under normal operating conditions in the range of the recommended lift. Safe and efficient equalizations would be achieved, but hawser forces would be somewhat higher than the other systems under consideration. Surface turbulence during equalizations would also be more significant with this system. The side port system would require a lower lock floor to provide additional submergence and minimize the effects of turbulence. With water saving basins on one side of the lock, there are some concerns regarding distribution of flow from the basins to each lock culvert. It is likely that a reasonably balanced distribution could be achieved through physical modeling.

A side port system would be acceptable for the triple-lift configuration of the Third Lane if water saving basins would be used most of the time. Significant increases in equalization time can be expected under certain maintenance conditions due to a reduction in flow capacity and poor hydraulic performance resulting from a loss of symmetry.

10.3. Multi Port

The multi port system is a variation of the side port design. Generally speaking, the number of ports is increased while the size of each port is decreased. There appears to be no clear advantage in performance or cost compared to a side port system. The multi port system would be acceptable for the triple-lift configuration of the Third Lane with constraints similar to those presented for the side port system.

10.4. In Chamber Longitudinal Culvert (ILCS)

Without water saving basins, the maximum head differential for lock-to-lock equalization (18 m) exceeds the maximum design lift suggested by Corps research (12 m). Assuming equalizations with water saving basins represent the primary mode of operation, the maximum initial lift is reduced to 4.5 m, which is within acceptable limits. The maximum head differential for lock-to-lock operations would be reduced to 9 m, which is also within acceptable limits.

Performance would be hydraulically acceptable under normal operating conditions in the range of the suggested lift. Safe and efficient equalizations would be achieved, but hawser forces would be somewhat higher than the bottom lateral and bottom longitudinal type systems. Hawser forces would probably be slightly lower than the side port system. The system would not perform well under certain maintenance conditions and would require increases in equalization time for safe operation. Water saving basins on both sides of the lock is hydraulically preferable because the symmetry would balance the flow between culverts; however, there is nothing to preclude the basins from being on one side.

An ILCS system would be acceptable for the triple-lift configuration of the Third Lane if water saving basins would be used most of the time. Increases in equalization time would be expected under certain maintenance conditions due to a reduction in flow capacity and slightly degraded hydraulic performance resulting from a loss of symmetry.

10.5. Interlaced Bottom Lateral

Without water saving basins, the maximum head differential for lock-to-lock equalization (18 m) exceeds the typical design lift for this type of system but is within the feasible range. For equalizations with water saving basins, the maximum initial lift is reduced to 4.5 m, which is well below acceptable limits. The maximum head differential for lock-to-lock operations would be reduced to 9 m, which is also well below acceptable limits.

Performance would by hydraulically acceptable under all normal operating conditions. Safe and efficient equalizations would be achieved, but hawser forces would be higher than the bottom longitudinal system. Hawser forces would be lower than the side port and ILCS type systems. The system would perform well under most maintenance conditions and would require only moderate increases in equalization time for safe operation. The system would provide acceptable performance with or without use of water saving basins. Water saving basins could be located either to one side or both sides of the lock.

The interlaced bottom lateral system would be acceptable for the triple-lift configuration of the Third Lane. Performance would be good under both normal and maintenance conditions. Maintenance conditions would have only minor impacts on the hydraulic performance of the system.

10.6. Split Bottom Lateral

The range of recommended design lifts for a split lateral system is similar to those presented for the interlaced lateral arrangement. There are no significant differences in cost between the split and bottom lateral type systems. Performance under normal operating conditions is slightly better with the split arrangement; however, performance under maintenance conditions is significantly improved with an interlaced arrangement. Because the cost would be similar and the maintenance performance of a split lateral system is relatively poor, the interlaced lateral arrangement is preferred.

10.7. Bottom Longitudinal

Without water saving basins, the maximum head differential for lock-to-lock equalization (18 m) is within acceptable limits for this type of system. For equalizations with water saving basins, the maximum initial lift is reduced to 4.5 m, which is well below acceptable limits.

The maximum head differential for lock-to-lock operations would be reduced to 9 m, which is well below acceptable limits.

Performance would be very good hydraulically under all operating conditions. Safe and efficient equalizations would be achieved and hawser forces would be lower than the other systems. The system would perform well under maintenance conditions. The system would provide very good performance with or without use of water saving basins. Water saving basins could be located either on one side or both sides of the lock.

The bottom longitudinal system would provide superior performance for the triple-lift configuration of the Third Lane under both normal and maintenance conditions. Maintenance conditions would have no impact on the hydraulic performance of the system.

11. IN CHAMBER LONGITUDINAL CULVERT SYSTEM (ILCS)

Plate N2-1 shows a plan and profile of the in chamber longitudinal culvert filling and emptying system for the upper lock. The middle lock layout is presented in Plate N2-2. The lower lock layout is presented in Plate N2-3. Typical sections are shown on Plate N2-4.

11.1. Lock Components

The design of the triple-lift ILCS system is similar to the double-lift ILCS configuration with minor changes to the size of some features. Changes from the double-lift ILCS design are documented in the following paragraphs. Specific details related to the design of features are presented in Section 13.1 of Appendix E.

11.1.1. Culverts

A preliminary culvert size was determined using Equation N2-11-1.

$$A_c = \frac{A_s\left(\sqrt{H+d} - \sqrt{d}\right)}{C_L\sqrt{2g}\left(T - Ut_v\right)} \qquad \text{(N2-11-1)}$$

Parameters used in Equation N2-11-1 are summarized in Table N2-11-1. The estimated culvert size required for an equalization time of 9 minutes is 59 m^2. The culvert size selected for design is 8 m wide and 8 m high with an area of 64 m^2. The additional culvert area would allow target equalization times to be met when using the water saving basins.

Table N2-11-1 Parameters to Estimate Culvert Size (ILCS)

Parameter	Description	Estimated Value
A_s	Surface area of lock (m^2)	32,140
H	Lift height (m)	8.61
d	Overtravel (m)	0.3
C_L	Lock coefficient	0.62
g	Gravity (m/s^2)	9.81
T	Target equalization time (s)	540
U	Valve coefficient	0.50
t_v	Valve time (s)	120

The culverts are located in the same configuration as the double-lift design. The tops of the culverts were set at the minimum sill clearance elevations (-2.464 for the upper lock, -10.516 for the middle lock, and -18.670 for the lower lock). Because the middle and lower lock sills were lowered slightly to accommodate the structural design, the culvert roofs will be slightly higher than these sills.

11.1.2. Intakes

A conventional manifold type intake is proposed for the upper lock. The intake has the same configuration as the double-lift design.

11.1.3. Valves

Vertical lift valves are proposed similar to the double-lift design. The culvert would bifurcate to accommodate side-by-side valves, each 4 m wide by 8 m high. The lower lock emptying valves were increased to 5 m wide by 8 m high to meet time criteria for emptying the lower lock.

Reverse tainter valves are not recommended due to the relatively large recess required for this type of valve.

11.1.4. Ports and Port Extensions

Each port is 1.95 m high by 0.70 m wide with the same number and configuration of ports as the double-lift design. This port size provides a culvert port to water saving basin conduit area ratio of 1.0. Port extensions have been provided in the same arrangement as that used for the double-lift design.

11.1.5. Wall Baffles

Wall baffles typical of the ILCS design are proposed as shown in Plate N2-3.

11.1.6. Laterals

Each lateral between gates is proposed to be 3.75 m wide by 2.48 m high with eight ports in the ceiling. Each port has an area of 1.02 m^2 for a total of 8.16 m^2.

11.1.7. Outlet

The size of the culverts from the empty valves of the lower lock to the outlet diffusion chamber was increased to meet equalization time criteria for emptying the lower lock. A diffusion chamber similar to that proposed for the double-lift design was assumed.

Consistent with the double-lift design, recycling provisions could also be used to convey water to an alternate discharge channel.

11.2. Water Saving Basin Components

11.2.1. Conduits and Crossovers

The conduits from the basin intakes through the valves will be 8 m high by 6 m wide. The layout of conduits and crossovers is similar to the double-lift design. The conduit size will change from 8 m high by 6 m wide to 6 m high by 8 m wide near the vertical transition into the crossover.

11.2.2. Intakes

Intakes would have features similar to the double-lift design. The intake would be flared and lowered to improve hydraulic efficiency. Conduit roofs at the bottom of the intake shaft will be set to avoid strong vortices at the intakes.

11.2.3. Valves

The valves for the water saving basins are 8 m high by 6 m wide and would have features similar to the double-lift design.

11.3. Recycling

Culvert connections for possible recycling ponds were included on the east side near the upstream end of the upper lock and downstream end of the lower lock in a configuration similar to the double-lift design. Recycling ponds could just as easily be located to the west.

11.4. LOCKSIM Model

The LOCKSIM model represents the entire system including both locks and all water saving basins. The valve operations and starting water surface elevations determine the mode of operation. The head losses for various system components are consistent with the values used for the double-lift design.

11.5. LOCKSIM Analysis

Lock water surface elevations at the upper sill, middle of chamber, and lower sill were computed to evaluate slopes and equalization times. Basin water surfaces were also monitored in trial and error model runs to arrive at the correct valve timing for water saving basin operations. Computations were performed at the average lift. Unless otherwise noted, the downstream inner gates were assumed to be open to provide the specified nominal lock length of 457.200 m. Cursory checks were made with the downstream inner gates closed.

11.6. Baseline Equalizations

Baseline equalizations were performed for operations with and without water saving basins. Results are summarized in Table N2-11-2. The valve times presented in Table E-11-2 of Appendix E were used with the inner gates opened. Equalization times generally satisfy the 8-10 minute criteria with the exception of filling the upper lock and emptying the lower lock with water saving basins, which are slightly over 10 minutes.

Table N2-11-2 Baseline Equalizations (ILCS)

Equalization	Time (Minutes)	
	Without WSBs	With WSBs
Lake Gatun to Upper Lock	8.4	10.6
Upper Lock to Middle Lock	6.8	9.9
Middle Lock to Lower Lock	7.0	9.9
Lower Lock to Atlantic Ocean	7.4	10.5

11.7. Valve Overlap

Equalization times with valve overlap are presented in Table N2-11-3. An overlapping valve sequence is recommended because it reduced equalization times by about 0.4 minutes.

Table N2-11-3 Equalization Times with WSBs and Valve Overlap (ILCS)

Equalization	Time (Minutes)
Lake Gatun to Upper Lock	10.3
Upper Lock to Middle Lock	9.5
Middle Lock to Lower Lock	9.5
Lower Lock to Atlantic Ocean	10.1

11.8. Valve Loads

The valve loads for the triple-lift configuration are presented in Table N2-11-4.

Table N2-11-4 Design Head Differentials Across Valves

Valve Location	Maximum Head Differentials Normal Operating Conditions (m)	
	Hydrodynamic	Hydrostatic
Upper lock fill valves	13.525	9.017
Valves between locks	27.051	18.034
Lower lock empty valves	13.525	9.017
Water saving basin valves	6.763	6.763

11.9. Lock Gate Head Differentials

11.9.1. Overtravel

LOCKSIM analyses indicated a reverse heads of approximately 0.40-0.44 m for the upper and lower locks and 0.96-1.02 m for lock-to-lock operations. There was no significant difference between operations with or without water saving basins.

11.9.2. Between Gates

For operations without water saving basins, LOCKSIM analyses indicated reverse heads of approximately 0.30 for the lower lock and 0.48-0.50 m for lock-to-lock operations. For operations with water saving basins, reverse heads were approximately 0.61 m for the lower lock and 0.75-0.75 m for lock to lock operations.

11.10. Cavitation Index

A value of K_i greater than 0.61 is generally considered to be acceptable. For the ILCS, a minimum value of approximately 1.90 was computed for a normal operation at the average lift.

11.11. Culvert Velocity

Culvert velocities were computed using LOCKSIM. Maximum culvert velocities were estimated between 6.1 m/s for equalization with water saving basins and 8.1 m/s for operation without water saving basins. Maximum water saving basin conduit velocities were estimated to be 3.8 m/s.

11.12. Water Saving Basin Intakes

Cursory checks were made concerning the potential for serious vortices forming at the water saving basin intakes with the ILCS system. Refer to Appendix E for a more detailed description of the computations. The minimum value of S/D calculated for draining the upper basin of the upper lock equals 2.9 times the Froude Number. The minimum desirable value is 2.3, suggesting vortices should not be a problem.

The plan shows both intakes for the lower basin located in a narrow corner opposite the valve platform. Based on computations for the double-lift ILCS, water surface drawdown is expected to be less than 0.09 m, and should not have a significant effect on intake efficiency. Although the basin velocity does not seem excessive, contraction at the valve platform corner could contribute to a vortex. This should be checked with the physical model. If necessary, one or both intakes could move to another location within the basin.

11.13. Maintenance Conditions

Several maintenance conditions were evaluated to determine the potential impact of maintenance on system performance. The first maintenance condition assumes equalizations without use of the water saving basins while one valve in each lock culvert is out of service. Even if only one of the valves requires maintenance, one from each culvert should be taken out of service to maintain symmetry of the system. Two additional maintenance conditions were evaluated for equalizations with use of the water saving basins. One of these conditions assumes that all lock culvert valves are in service and one conduit per basin is out of service. The other condition assumes that one valve in each lock culvert is out of service and all basin conduits are in service. Results of these analyses are presented in Table N2-11-5.

It is possible that the valves may need to be slowed down to prevent high transverse hawser forces due to unbalanced flows under some of the maintenance conditions. This would increase the equalization times further. These effects cannot be evaluated using LOCKSIM and will require physical modeling.

Table N2-11-5 Effect of Maintenance Conditions on Equalization Time (ILCS)

Equalization	Equalization Time (Minutes)				
	Operation Without WSBs		Operation With WSBs		
	Normal Operation	One Valve Per Culvert Out of Service	Normal Operation	One Valve Per Culvert Out of Service	One Conduit Per WSB Out of Service
Lake Gatun to Upper Lock	8.4	13.9	10.6	14.4	11.8
Upper Lock to Middle Lock	6.8	10.8	9.9	12.5	11.2
Middle Lock to Lower Lock	7.0	10.9	9.9	12.6	11.3
Lower Lock to Atlantic Ocean	7.4	11.5	10.5	13.2	11.8

11.14. Hawser Forces

11.14.1. Longitudinal Hawsers

Computed end-to-end water surface slopes for an unoccupied chamber were less than the recommended design criteria of 0.5/1000. The estimated slopes and hawsers presented in the following paragraphs are a relative indicator of lock performance and not necessarily a prediction of actual forces. Future studies should include a physical hydraulic model that would include measurement of longitudinal hawser forces.

11.14.1.1. Downstream Inner Gates Open

A summary of longitudinal water surface slopes for equalizations with the downstream inner gates open is presented in Table N2-11-6.

Table N2-11-6 Estimated Typical Longitudinal Water Surface Slopes (ILCS with Downstream Inner Gates Open)

Equalization	Operation Without WSBs	Operation With WSBs
	Maximum Slope (1/1000)	Maximum Slope (1/1000)
Lake Gatun to Upper Lock	0.27	0.25
Upper Lock to Middle Lock	0.22	0.28
Middle Lock to Lower Lock	0.20	0.20
Lower Lock to Atlantic Ocean	0.25	0.34

11.14.1.2. Downstream Inner Gates Closed

A summary of longitudinal water surface slopes for equalizations with the downstream inner gates closed is presented in Table N2-11-7. Overall, the values are slightly lower than Table N2-11-6.

Table N2-11-7 Estimated Typical Longitudinal Water Surface Slopes (ILCS with Downstream Inner Gates Closed)

Equalization	Operation Without WSBs	Operation With WSBs
	Maximum Slope (1/1000)	Maximum Slope (1/1000)
Lake Gatun to Upper Lock	0.24	0.20
Upper Lock to Middle Lock	0.19	0.21
Middle Lock to Lower Lock	0.17	0.20
Lower Lock to Atlantic Ocean	0.18	0.24

11.14.1.3. Maximized Slopes

Maximum slopes for superimposed oscillations resulting from successive valve operations were computed assuming downstream inner gates open. A summary of maximum longitudinal water surface slopes is presented in Table N2-11-8.

Table N2-11-8 Estimated Maximum Longitudinal Water Surface Slopes (ILCS with Downstream Inner Gates Open)

Equalization	Operation Without WSBs	Operation With WSBs
	Maximum Slope (1/1000)	Maximum Slope (1/1000)
Lake Gatun to Upper Lock	0.27	0.47
Upper Lock to Middle Lock	0.22	0.48
Middle Lock to Lower Lock	0.20	0.46
Lower Lock to Atlantic Ocean	0.25	0.35

11.14.1.4. Ship Effects

Cursory computations were performed with the beta version of LOCKSIM, which accounts for the presence of a ship in the lock chamber. The design container ship was represented with downstream inner gates open. The estimated hawser forces are less than the recommended maximum of 209 t. Results are presented in Table N2-11-9.

Table N2-11-9 Estimated Maximum Longitudinal Hawser Forces for Design Container Ship (ILCS with Downstream Inner Gates Open using LOCKSIM Beta Version - Ship Effect Included)

Equalization	Operation Without WSBs		Operation With WSBs	
	Maximum Slope (1/1000)	Estimated Hawser (t)	Maximum Slope (1/1000)	Estimated Hawser (t)
Lake Gatun to Upper Lock	0.61	127	0.74	155
Upper Lock to Middle Lock	0.45	94	0.63	132
Middle Lock to Lower Lock	0.46	96	0.60	125
Lower Lock to Atlantic Ocean	0.40	84	0.86	180

11.14.2. Transverse Hawser Forces

The one-dimensional LOCKSIM model does not have the capability to estimate transverse hawsers. Designs have been developed based upon research findings and other similar designs to minimize the potential for adverse transverse hawsers. Future studies should include a physical hydraulic model testing program which includes the measurement of transverse hawsers.

11.15. Recommended Operation Plan

11.15.1. Without Water Saving Basins

Filling and emptying curves and end-to-end water surface slopes for equalizations without water saving basins using the recommended operating plan are shown in Figures N2-11-1 and N2-11-2. The recommended operating plan incorporates the previously adopted valve schedule. The downstream inner gates are assumed to be in a closed position to reduce end-to-end slopes.

Figure N2-11-1 Equalization Without Water Saving Basins (ILCS)

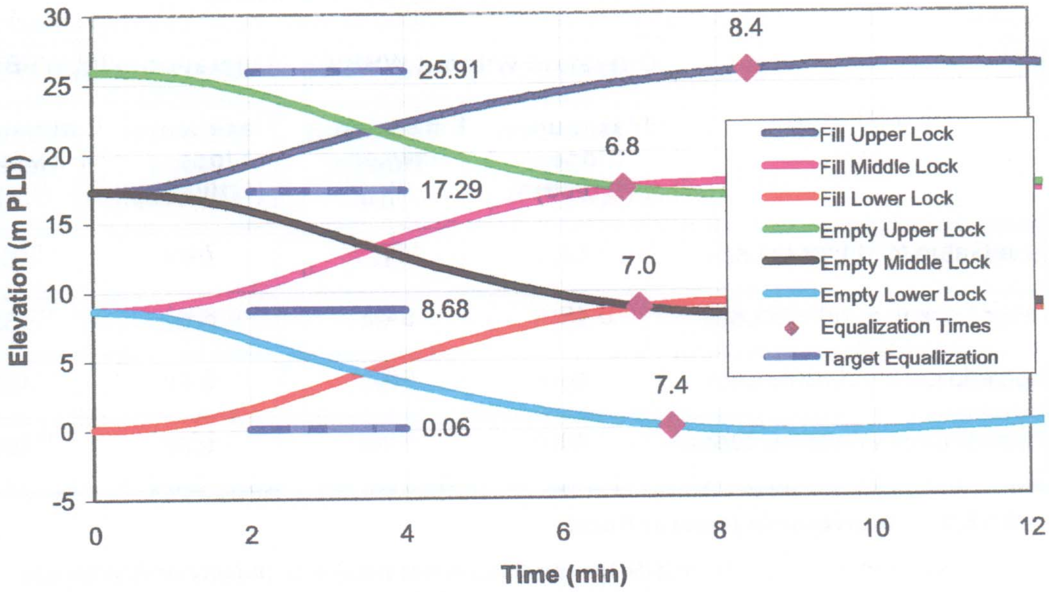
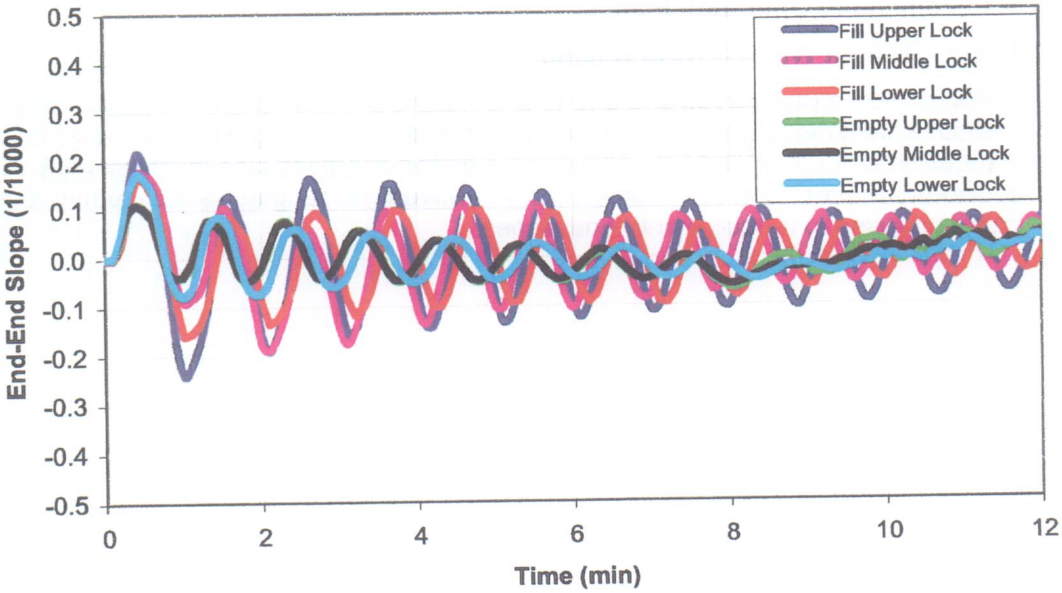


Figure N2-11-2 End to End Water Surface Slopes Without Water Saving Basins (ILCS)



11.15.2. With Water Saving Basins

Filling and emptying curves and typical end-to-end water surface slopes for equalization with water saving basins using the recommended operating plan are shown in Figures N2-11-3 and N2-11-4. The recommended operating plan incorporates the previously adopted valve times with a 0.2 minute overlap between successive valve operations. This reduces equalization times by 0.4 minutes. Equalization times would still be longer with the water saving basin as compared to operations without the water saving basins because of a 50% reduction in the initial driving head and the additional valve operations required with use of the basins. The downstream inner gates would be closed to reduce end-to-end slopes.

Figure N2-11-3 Equalization With Water Saving Basins (ILCS)

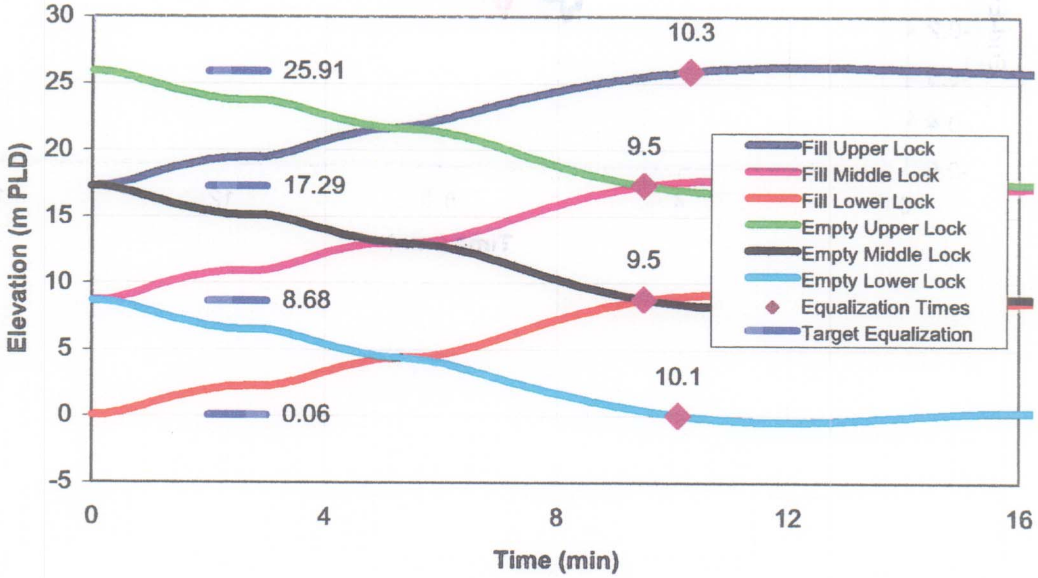
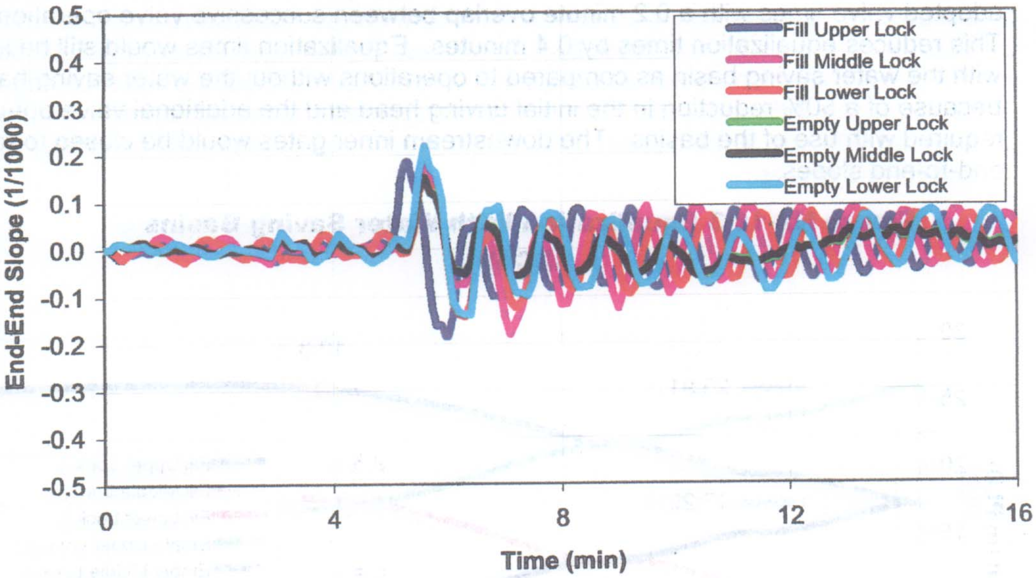


Figure N2-11-4 End to End Water Surface Slopes With Water Saving Basins (ILCS)



12. INTERLACED BOTTOM LATERAL

Prior to modification 2 to the terms of reference, preliminary designs had already been initiated for a triple-lift interlaced bottom lateral filling and emptying system. The following paragraphs provide a summary of this preliminary design.

Plate N2-5 shows a plan and profile of the interlaced bottom lateral filling and emptying system for the upper lock. The middle lock layout is presented in Plate N2-6. The lower lock layout is presented in Plate N2-7. Typical sections are shown on Plate N2-8.

12.1. Lock Components

The design of the triple-lift bottom lateral system is similar to the double-lift bottom lateral configuration with minor changes to the size of some features. Changes from the double-lift bottom lateral design are documented in the following paragraphs. Specific details related to the design of features are presented in Section 12.1 of Appendix E.

12.1.1. Culverts

A preliminary culvert size was determined using Equation N2-12-1.

$$A_c = \frac{A_s\left(\sqrt{H+d}-\sqrt{d}\right)}{C_L\sqrt{2g}\left(T-Ut_v\right)} \qquad \text{(N2-12-1)}$$

Parameters used in Equation N2-12-1 are summarized in Table N2-12-1. The estimated culvert size required for an equalization time of 9 minutes is 53 m^2. The culvert size selected for design is 7 m wide and 8 m high with an area of 56 m^2. The additional culvert area would allow target equalization times to be met when using the water saving basins.

The culverts are located in the same configuration as the double-lift design. The culvert invert was set at the lock chamber floor to maximize the use of RCC.

12.1.2. Intakes

A conventional manifold type intake is proposed for the upper lock. The intake has the same configuration as the double-lift design.

12.1.3. Valves

Vertical lift valves are proposed similar to the double-lift design. The culvert valves would be 7 m wide by 8 m high. The previously adopted valve schedule was used. The culverts could be made 8 m wide by 7 m high and bifurcated to use smaller valves, if desired, with little effect on equalization times.

Reverse tainter valves were considered but not recommended due to the relatively large recess required for this type of valve, and considering that they would not be suitable for the water saving basin control valves.

Table N2-11-1 Parameters to Estimate Culvert Size (IBLS)

Parameter	Description	Estimated Value
A_s	Surface area of lock (m^2)	32,140
H	Lift height (m)	8.61
d	Overtravel (m)	0.3
C_L	Lock coefficient	0.70
g	Gravity ($\mathrm{m/s}^2$)	9.81
T	Target equalization time (s)	540
U	Valve coefficient	0.50
t_v	Valve time (s)	120

12.1.4. Laterals

Twelve laterals per culvert were used in a configuration similar to the double-lift design. The laterals were scaled up to 3.75 m wide by 2.48 m high to be consistent with the increased culvert size.

12.1.5. Ports

Each port is 1.50 m by 0.78 m, which, again was scaled up from the double-lift design to be consistent with the larger culvert. The configuration of ports remains the same as the double-lift design.

12.1.6. Outlet

A diffusion chamber similar to that proposed for the double-lift design was assumed for the outlet.

Consistent with the double-lift design, recycling provisions could also be used to convey water to an alternate discharge channel.

12.2. Water Saving Basin Components

12.2.1. Conduits and Crossovers

The conduits from the basin intakes through the valves will be 8 m high by 7 m wide. The layout of conduits and crossovers is similar to the double-lift design. The conduit size will change from 8 m high by 7 m wide to 7 m high by 8 m wide near the vertical transition into the crossover.

12.2.2. Intakes

Intakes would have features similar to the double-lift design. The intake would be flared and lowered to improve hydraulic efficiency. Conduit roofs at the bottom of the intake shaft will be set to avoid strong vortices at the intakes.

12.2.3. Valves

The valves for the water saving basins are 8 m high by 7 m wide and would have features similar to the double-lift design.

12.3. Recycling

Culvert connections for possible recycling ponds were included on the east side near the upstream end of the upper lock and downstream end of the lower lock in a configuration similar to the double-lift design.

12.4. LOCKSIM Model

The LOCKSIM model represents the entire system including both locks and all water saving basins. The valve operations and starting water surface elevations determine the mode of operation. The head losses for various system components are consistent with the values used for the double-lift design.

12.5. LOCKSIM Analysis

Lock water surface elevations at the upper sill, middle of chamber, and lower sill were computed to evaluate slopes and equalization times. Basin water surfaces were also monitored in trial and error model runs to arrive at the correct valve timing for water saving basin operations. Computations were performed at the average lift with the downstream inner gates opened. Analyses were performed to determine baseline equalization times and maximum slopes.

12.6. Baseline Equalizations

Baseline equalizations were performed for operations with and without water saving basins. Results are summarized in Table N2-12-2. The valve times presented in Table E-11-2 of Appendix E were used. Equalization times generally satisfy the 8-10 minute criteria with the exception of filling the upper lock and emptying the lower lock with water saving basins, which are slightly over 10 minutes.

Table N2-12-2 Baseline Equalizations (ILCS)

Equalization	Time (Minutes)	
	With WSBs	Without WSBs
Lake Gatun to Upper Lock	8.7	10.5
Upper Lock to Middle Lock	7.8	9.7
Middle Lock to Lower Lock	7.9	9.9
Lower Lock to Atlantic Ocean	8.9	10.7

12.7. Maximized Slopes

Maximum slopes for superimposed oscillations resulting from successive valve operations were computed assuming downstream inner gates open. The slopes are less than the recommended maximum of 0.5/1000. A summary of maximum longitudinal water surface slopes is presented in Table N2-12-3.

Table N2-12-3 Estimated Maximum Longitudinal Water Surface Slopes (Bottom Lateral)

Equalization	Operation Without WSBs	Operation With WSBs
	Maximum Slope (1/1000)	Maximum Slope (1/1000)
Lake Gatun to Upper Lock	0.31	0.40
Upper Lock to Middle Lock	0.24	0.39
Middle Lock to Lower Lock	0.23	0.41
Lower Lock to Atlantic Ocean	0.23	0.41

12.8. Ship Effects

Cursory computations were performed with the beta version of LOCKSIM, which accounts for the presence of a ship in the lock chamber. The design container ship was represented with downstream inner gates open. The estimated hawser forces are less than the recommended maximum of 209 t. The forces presented are a relative indicator of lock performance and not necessarily a prediction of actual forces. Future studies should include a physical hydraulic model that would include measurement of longitudinal hawser forces. Results are presented in Table N2-12-4.

Table N2-12-4 Estimated Maximum Longitudinal Hawser Forces for Design Container Ship (Bottom Lateral - LOCKSIM Beta Version - Ship Effect Included)

Equalization	Operation Without WSBs		Operation With WSBs	
	Maximum Slope (1/1000)	Estimated Hawser (t)	Maximum Slope (1/1000)	Estimated Hawser (t)
Lake Gatun to Upper Lock	0.78	163	0.72	150
Upper Lock to Middle Lock	0.57	119	0.61	127
Middle Lock to Lower Lock	0.61	127	0.66	138
Lower Lock to Atlantic Ocean	0.36	75	0.63	132

12.9. Recommended Operation Plan

12.9.1. Without Water Saving Basins

Filling and emptying curves and end-to-end water surface slopes for equalizations without water saving basins using the recommended operating plan are shown in Figures N2-12-1 and N2-12-2. The recommended operating plan incorporates the previously adopted valve schedule. The downstream inner gates would be closed to reduce end-to-end water surface slopes.

Figure N2-12-1 Equalization Without Water Saving Basins (Bottom Lateral)

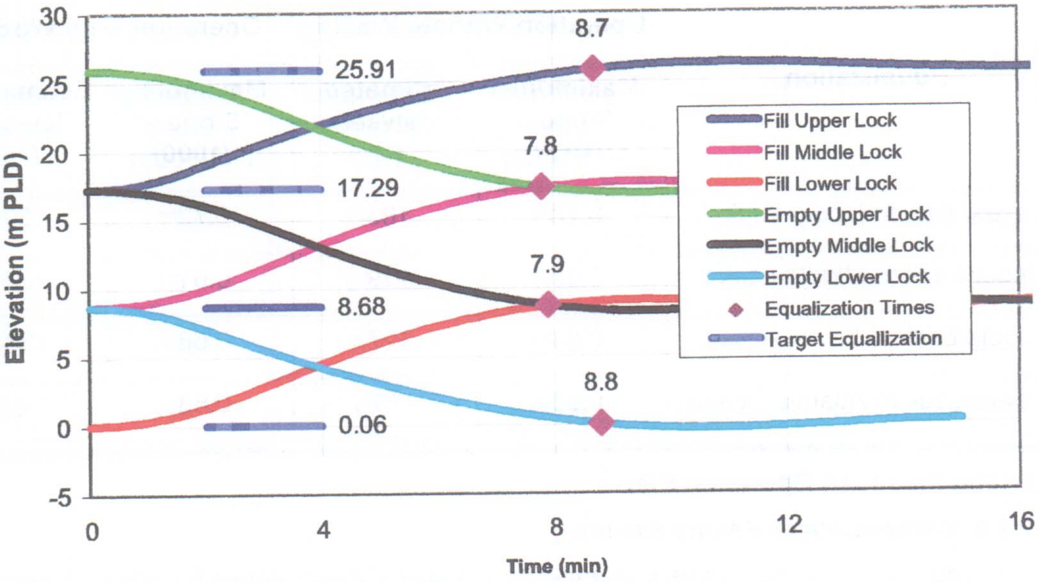
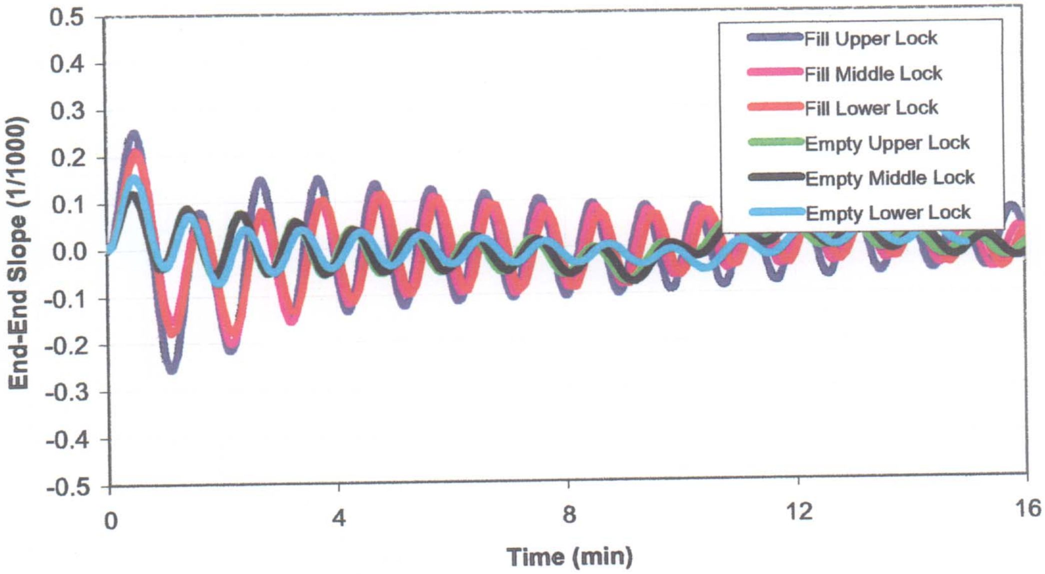


Figure N2-12-2 End to End Water Surface Slopes Without Water Saving Basins (Bottom Lateral)



12.9.2. With Water Saving Basins

Filling and emptying curves and typical end-to-end water surface slopes for equalization with water saving basins using the recommended operating plan are shown in Figures N2-12-3 and N2-12-4. The recommended operating plan incorporates the previously adopted valve times with a 0.2 minute overlap between successive valve operations to reduce equalization times by 0.4 minutes. Equalization times would still be longer with water saving basin use compared to the without water saving basin operations because of a 50% reduction in the initial driving head and the additional valve operations required with use of the basins. Again, the downstream inner gates are assumed to be in the closed position.

Figure N2-12-3 Equalization With Water Saving Basins (Bottom Lateral)

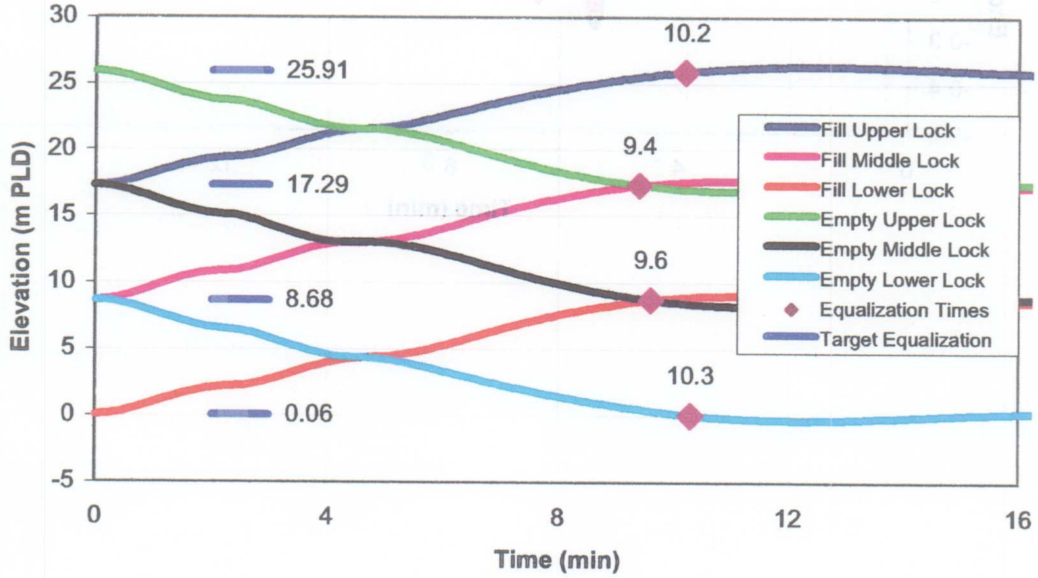
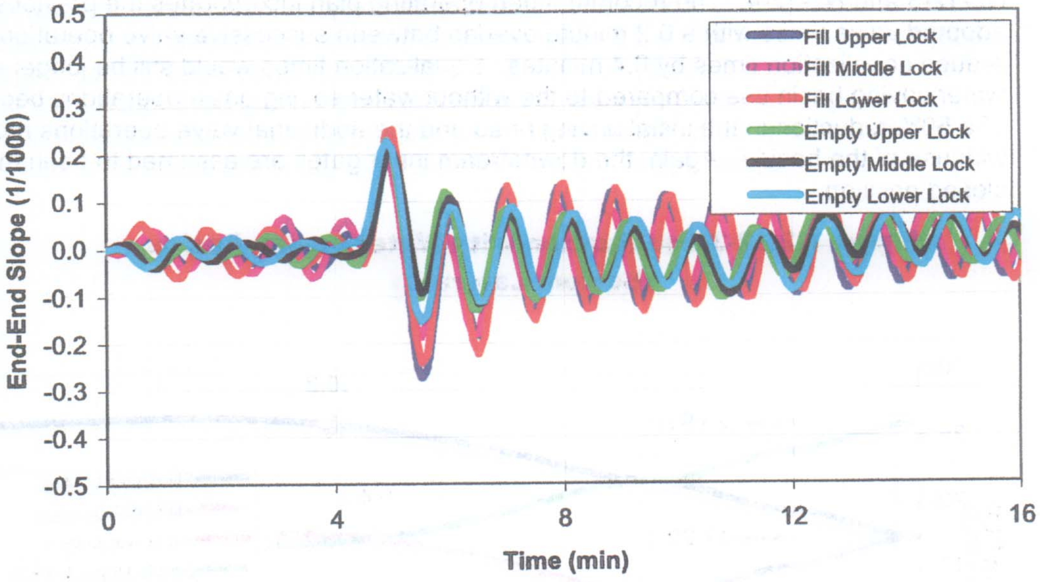
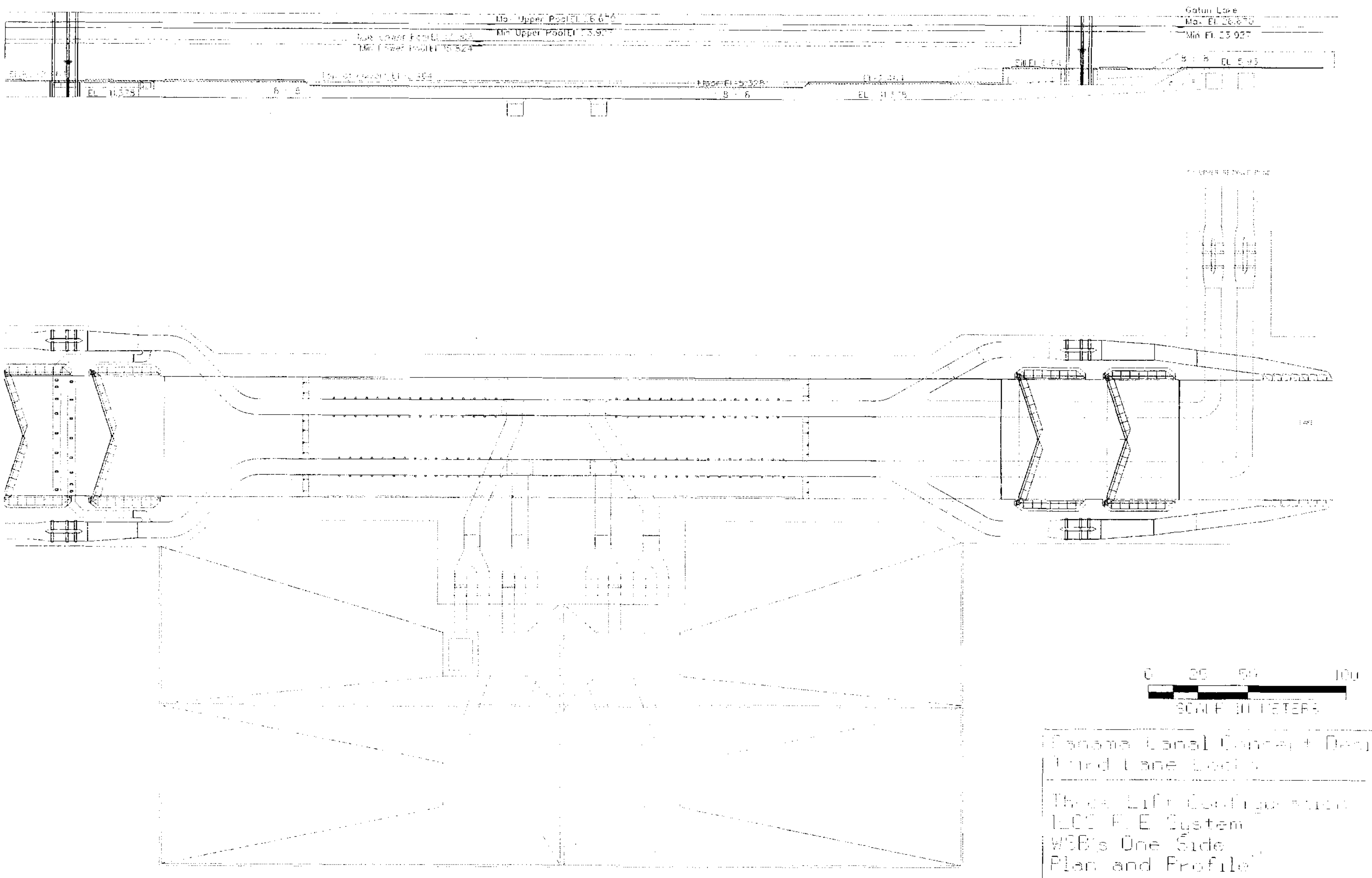


Figure N2-12-4 End to End Water Surface Slopes With Water Saving Basins (Bottom Lateral)



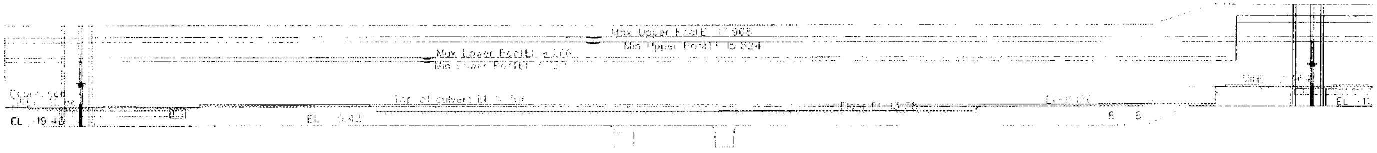
PLATES

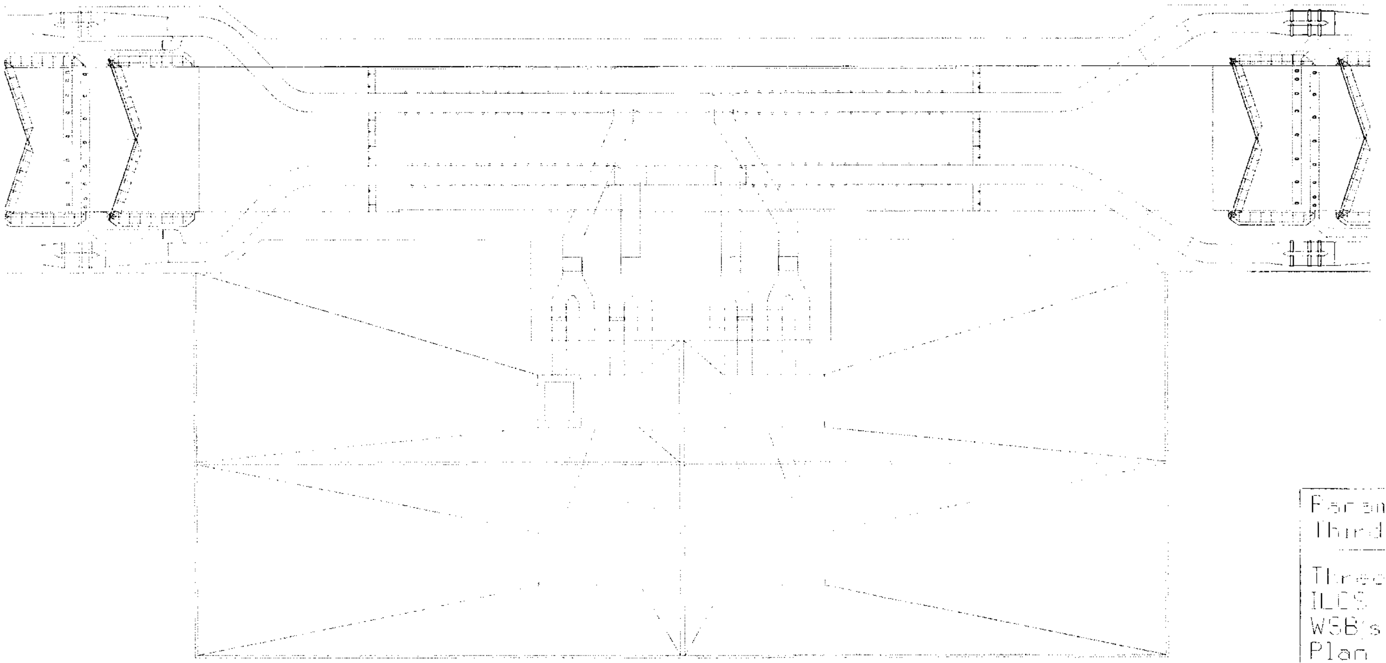


Panama Canal Concept Design
Third Lane Locks

Three Lift Configuration
1LC1 F. E. System
WSB's One Side
Plan and Profile
Upper Lock

Plate II2-1





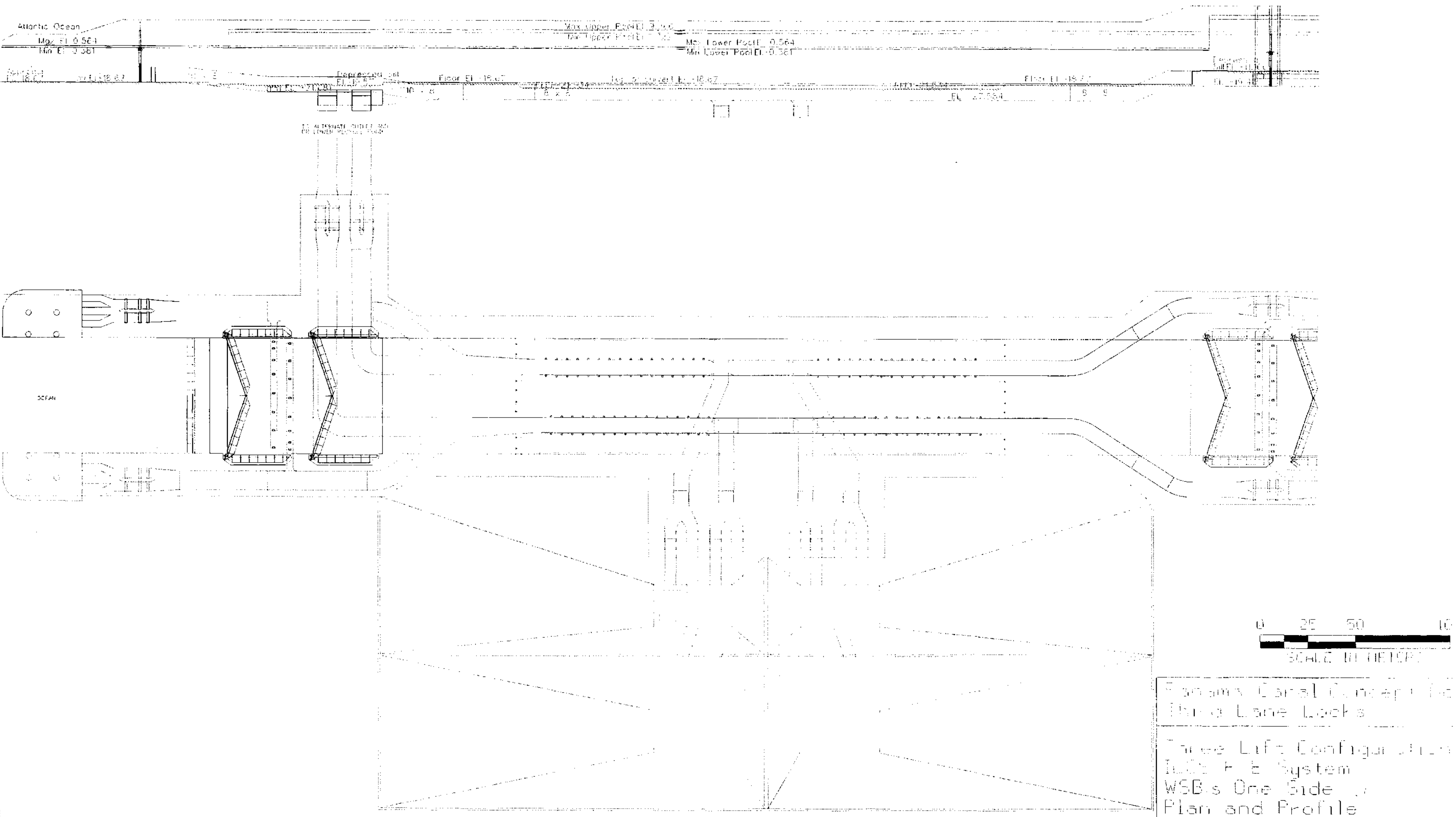
0 50 100

SCALE IN METERS

Panama Canal Concept Design
Third Lane Locks

Three Lift Configuration
ILCS F E System
WSB's One Side
Plan and Profile
Middle Lock

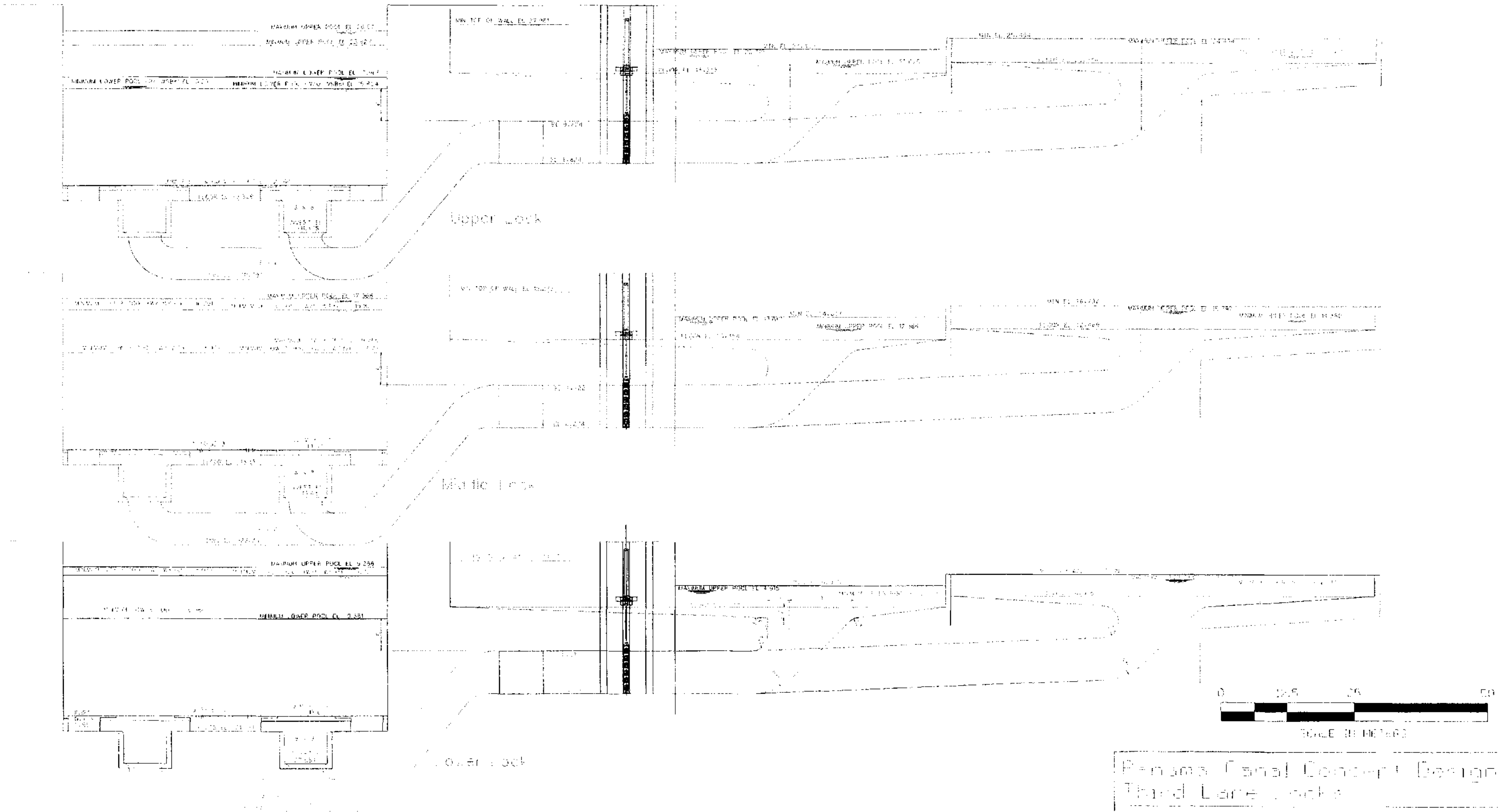
Plate II2-2



Panama Canal Concept Design
Three Lane Locks

Three Lift Configuration
ILCS F E System
WSBs One Side
Plan and Profile
Lower Lock

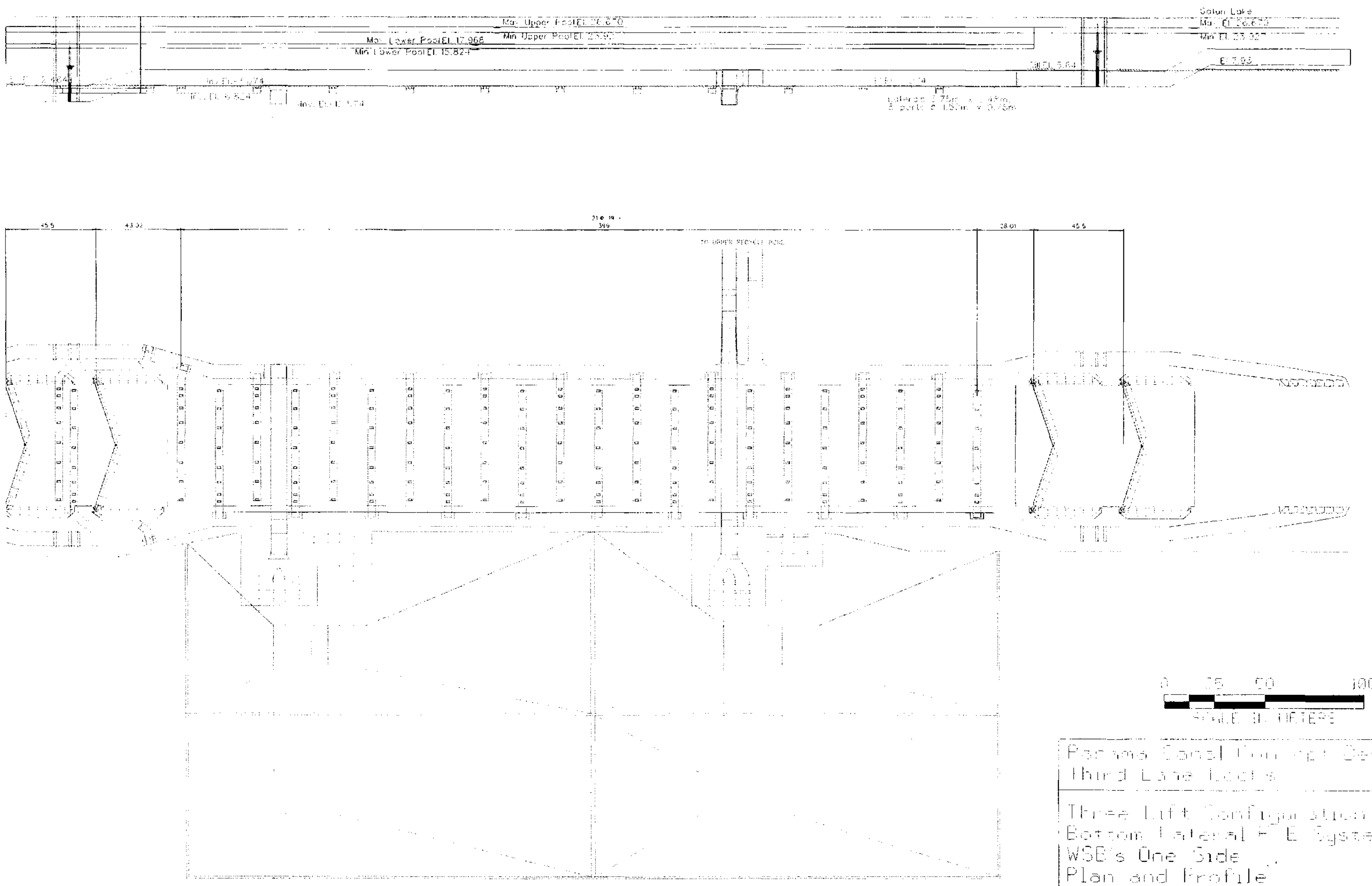
Plate II2-3



Panama Canal Concept Design
Third Lane Locks

Three Lift Configuration
U.S. F.E. System
WSB's One Side
Cross Sections
Upper, Middle, and Lower Lock

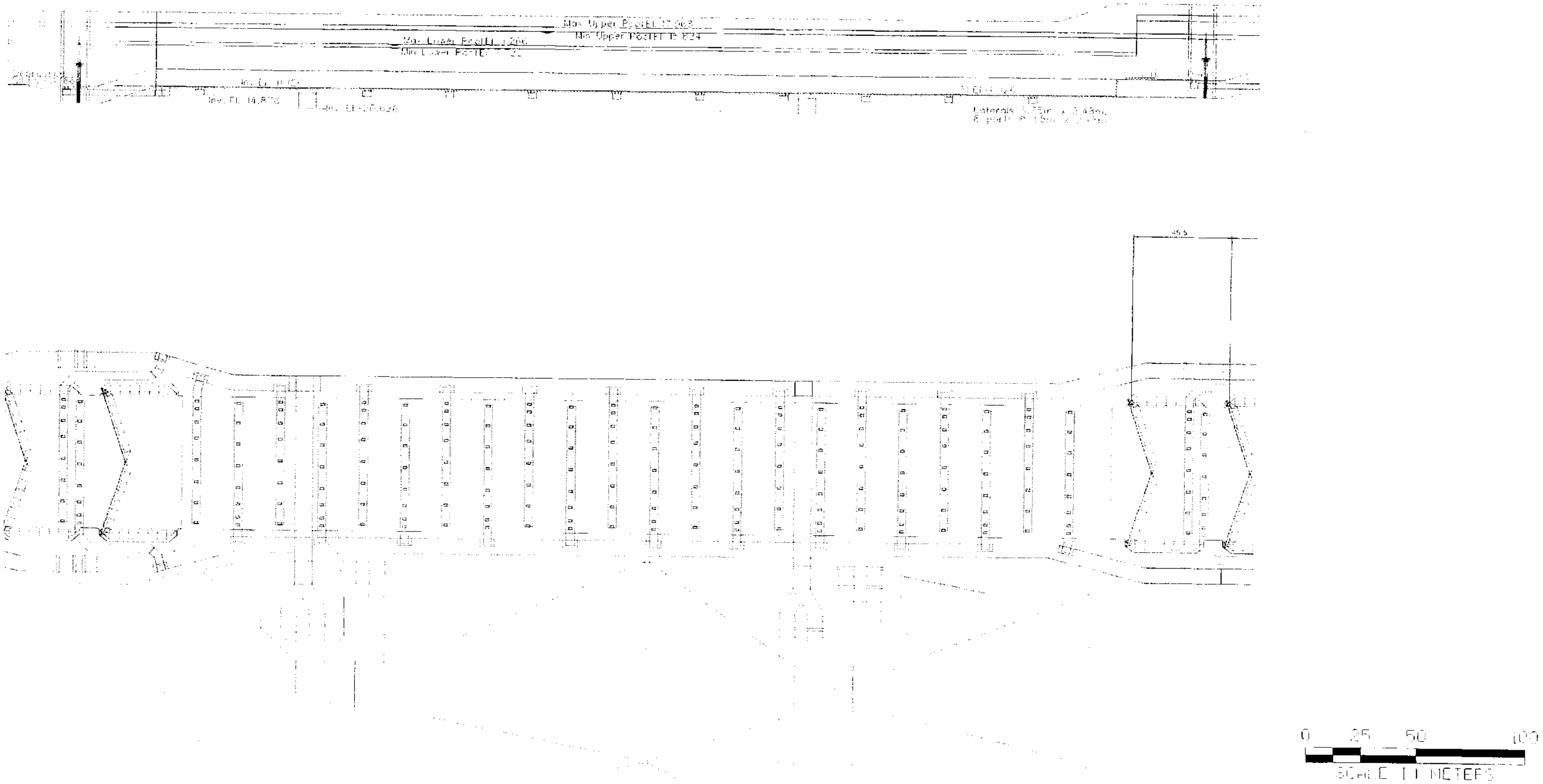
Plate II2-4



Panama Canal Concept Design
Third Lane Locks

Three Lift Configuration
Bottom Lateral F.E. System
WSB's One Side
Plan and Profile
Upper Lock

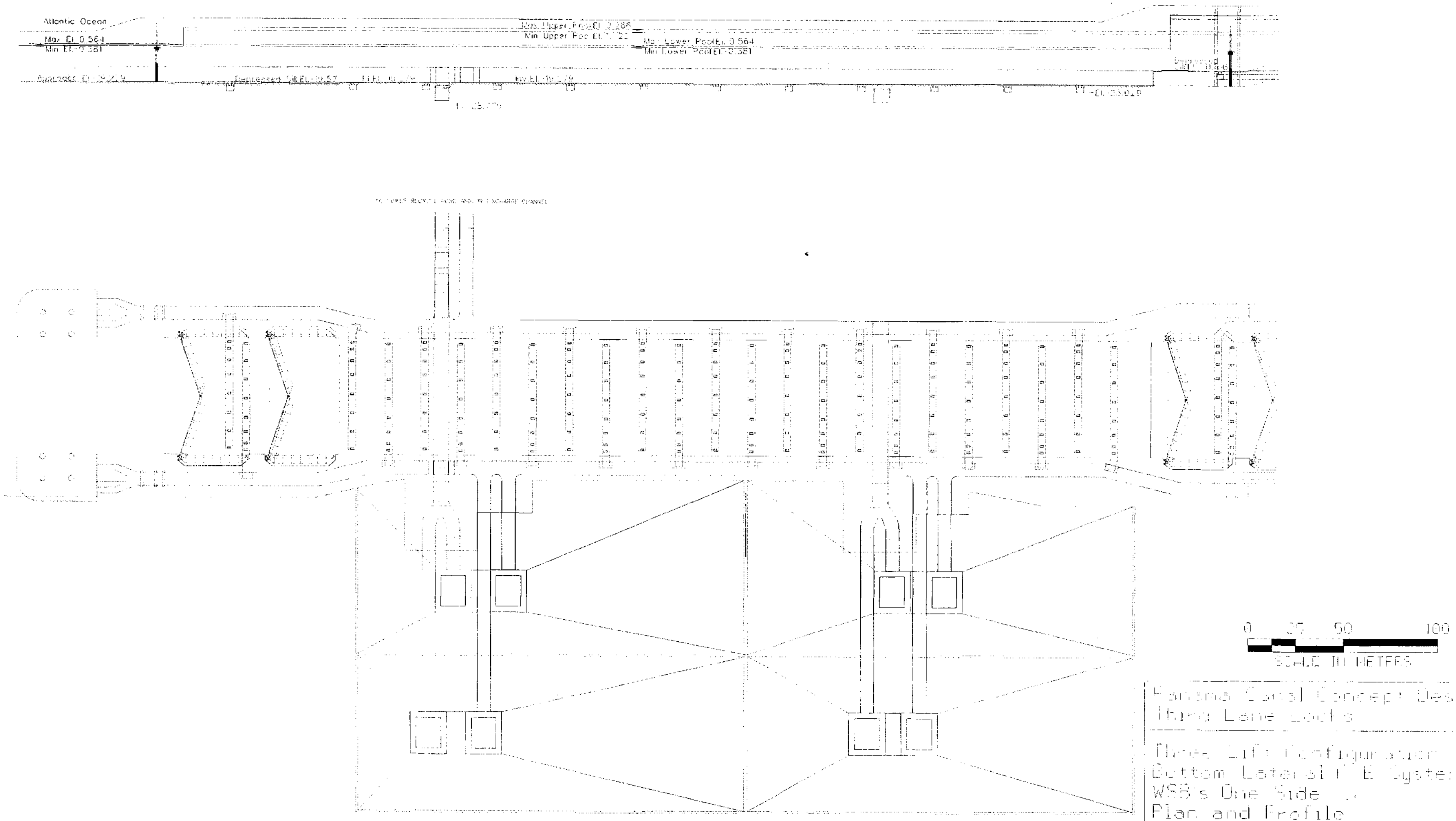
Plate H2-5



Panama Canal Concept Design
Third Lane Locks

Three Lift Configuration
Bottom Lateral F E System
WSB's One Side
Plan and Profile
Middle Lock

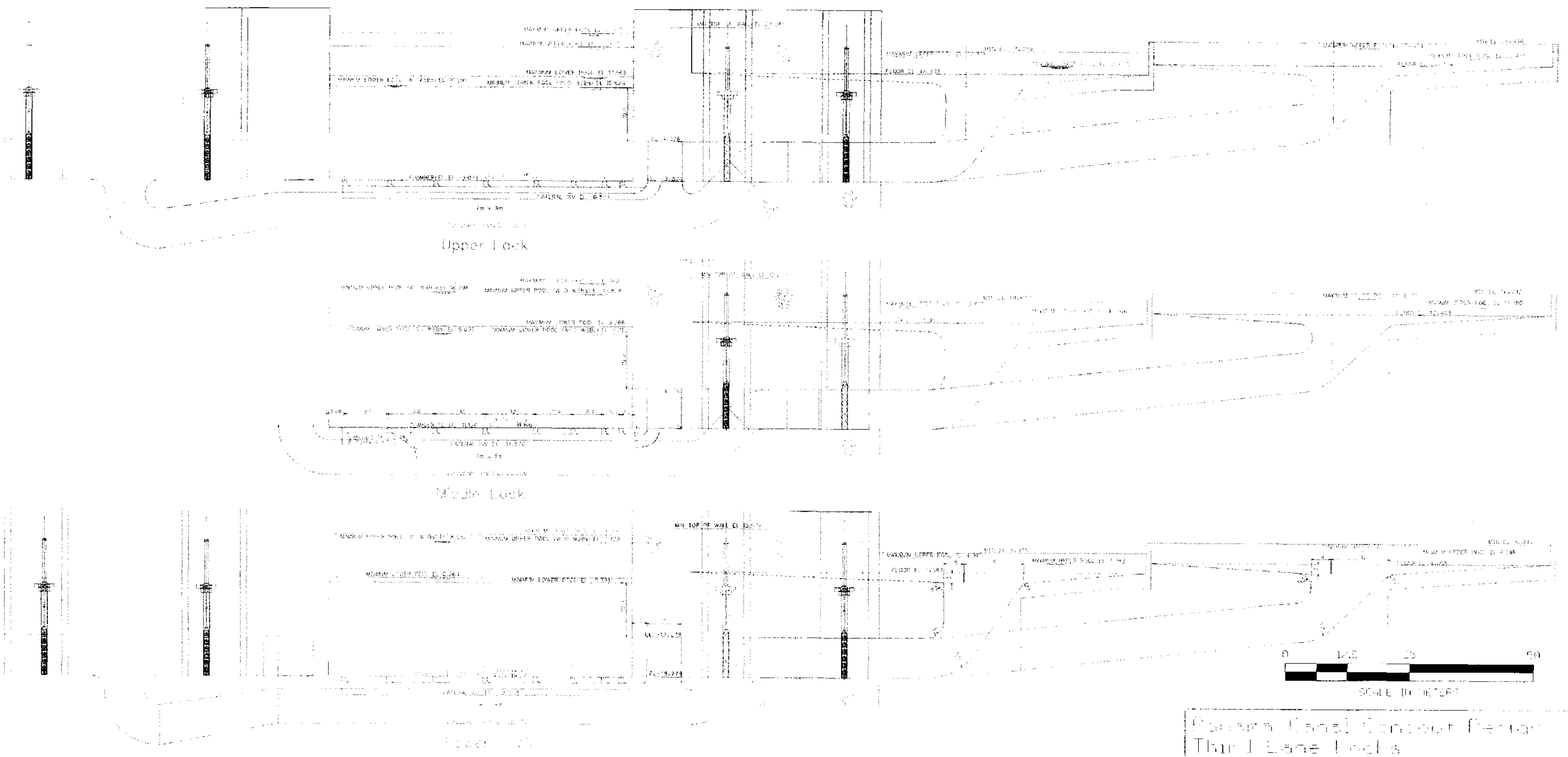
Plate II2-6



Panama Canal Concept Design
Third Lane Locks

Three Lift Configuration
Bottom Lateral F E System
WSB's One Side
Plan and Profile
Lower Lock

Plate II2-7



Panama Canal Contour Design
Third Lane Locks

Three Lift Configuration
Bottom Lateral F E System
WSB's One Side
Cross Sections
Upper. Middle. and Lower Lock

Plate II2-8

PANAMA CANAL CONCEPT DESIGN

Atlantic Locks Structure

Third Lift Lock

Appendix N, Attachment 3

Quantity Estimates

Prepared for

ACP

Canal Capacity Projects Office

By

US Army Corps
of Engineers®

Final Report

Triple-Lift Configuration

23 July 2003

US Army Corps
of Engineers
Pittsburgh District

Panama Canal Authority
Atlantic Locks
3rd Lane - Concept Design Study

COMPUTATION
Three Lift Concept Design (Cost Estimate)
Quantity Summary

Computed By: AHARKNESS Date 15-Mar-03
Checked By: RAALLWES Date 24-Mar-03

Three Lift Lock - ICLC F&E System, Gravity Monoliths, WSB to the West

							Concrete			*Type of Concrete*	
	Description	Station	to	Station	Reinforcing Steel kg/m	Reinforcing Steel kg	Area m^2	Volume m^3	RCC %	RCC m^3	Cast-in-Place (CIP) m^3
East Walls	***Atlantic East Entrance Wall***										
		12+140		12+334	2 500	484 625	506	98 049	90%	88 244	9 805
		12+334		12+381	2 500	119 100	463	22 076	90%	19 869	2 208
		12+381		12+877	2 500	1 238 578	421	208 576	90%	187 719	20 858
		12+877		12+935	2 500	144 450	463	26 775	90%	24 098	2 678
	Gatun East Entrance Wall	14+773		14+898	2 500	312 823	440	55 057	90%	49 551	5 506
		14+898		15+568	the wet construction - see separate quantity take-						
					Subtotal =	2 299 575			**Subtotal =**	369 481	41 053
	North Gate Bay Monoliths	13 043		13 134	10 000	908 000	1 078	97 882		39 153	58 729
	Gate Bay 2 Monoliths	13 558		13 649	10 000	908 000	1 078	97 882		39 153	58 729
	Gate Bay 3 Monoliths	14 074		14 165	10 000	908 000	1 078	97 882		39 153	58 729
	South Gate Bay Monoliths	14 590		14 680	9 721	882 667	796	72 277		28 911	43 366
					Subtotal =	3 606 667			**Subtotal =**	146 370	219 554
	Atlantic Outlet Structure - between entrance wall and lower gate monolith	12+935		13+043	5 400	584 550	580	62 785	50%	31 393	31 393
	Lower Chamber East Wall										
	Section 1	13+134		13+175	4 200	174 174	845	35 042	90%	31 538	3 504
	Section 2	13+175		13+428	4 200	1 063 650	741	187 658	90%	168 892	18 766
	Section 3	13+428		13+504	4 200	319 200	845	64 220	90%	57 798	6 422
	Section 4	13+504		13+558	4 200	226 842	947	51 164	90%	46 047	5 116
	Center Chamber East Wall										
	Section 1	13+649		13+691	4 200	174 174	876	36 328	90%	32 695	3 633
	Section 2	13+691		13+944	4 200	1 063 650	782	197 915	90%	178 123	19 791
	Section 3	13+944		14+020	4 200	319 200	876	66 576	90%	59 918	6 658
	Section 4	14+020		14+074	4 200	226 842	969	52 341	90%	47 107	5 234
	Upper Chamber East Wall										
	Section 1	14+165		14+206	4 200	174 174	945	39 189	90%	35 270	3 919
	Section 2	14+206		14+460	4 200	1 063 650	900	227 925	90%	205 133	22 793
	Section 3	14+460		14+536	4 200	319 200	945	71 820	90%	64 638	7 182
	Section 4	14+536		14+590	4 200	226 842	988	53 383	90%	48 045	5 338
	Gatun Intake Structure - between entrance wall and upper gate monolith	14+680		14+773	5 400	499 662	425	39 325	50%	19 663	19 663
					Subtotal =	6 435 810			**Subtotal =**	1 026 260	159 411
West Walls	***Atlantic West Entrance Wall***	12+780		12+935	2 500	387 750	506	78 450	90%	70 605	7 845
	Gatun West Entrance Wall	14+773		14+898	2 500	311 775	640	79 839	90%	71 855	7 984
					Subtotal =	699 525			**Subtotal =**	142 460	15 829
	North Gate Bay Monoliths	13+043		13+134	10 000	908 000	1 078	97 882	50%	48 941	48 941
	Gate Bay 2 Monoliths	13+558		13+649	10 000	908 000	1 078	97 882	40%	39 153	58 729
	Gate Bay 3 Monoliths	14+074		14+165	10 000	908 000	1 078	97 882	40%	39 153	58 729
	South Gate Bay Monoliths	14+590		14+680	9 721	882 667	796	72 277	50%	36 138	36 138
					Subtotal =	3 606 667			**Subtotal =**	163 386	202 538
	Atlantic Outlet Structure - between entrance wall and lower gate monolith	12+935		13+043	5 400	584 550	580	62 785	50%	31 393	31 393
	Lower Chamber West Wall										
	Section 1	13+134		13+175	3 600	149 292	733	30 398	90%	27 358	3 040
	Section 2	13+175		13+428	3 600	911 700	661	167 297	90%	150 567	16 730
	Section 3	13+428		13+504	3 600	273 600	733	55 708	90%	50 137	5 571
	Section 4	13+504		13+558	3 600	194 436	804	43 424	90%	39 082	4 342
	Center Chamber West Wall										
	Section 1	13+649		13+691	5 400	223 938	722	29 941	90%	26 947	2 994
	Section 2	13+691		13+944	5 400	1 367 550	651	164 866	90%	148 379	16 487
	Section 3	13+944		14+020	5 400	410 400	722	54 872	90%	49 385	5 487
	Section 4	14+020		14+074	5 400	291 654	793	42 808	90%	38 527	4 281
	Upper Chamber West Wall										
	Section 1	14+165		14+206	3 600	149 292	726	30 107	90%	27 096	3 011
	Section 2	14+206		14+460	3 600	911 700	653	165 372	90%	148 835	16 537
	Section 3	14+460		14+536	3 600	273 600	726	55 176	90%	49 658	5 518
	Section 4	14+536		14+590	3 600	194 436	797	43 051	90%	38 746	4 305
	Gatun Intake Structure - between entrance wall and upper gate monolith	14+680		14+773	5 400	499 662	576	53 316	50%	26 658	26 658
					Subtotal =	6 435 810			**Subtotal =**	852 769	146 352

Downstream Bulkhead Sill	12+927		12+935	4 102	32 816	270	2 160	90%	1 944	216
Downstream Paving	12+935		13+043	2 882	311 977	54	5 846	0%		
North Gate Bay Sill	13+043		13+134	4 102	372 462	295	27 815	80%	22 252	5 563
Lower Chamber Floor	13+134		13+558	2 837	1 204 959	41	17 202	0%		17202
Lower Chamber Culverts	13+134		13+558	2 585	1 097 825	36	15 290	0%	0	15 290
Gate Bay 2 Sill	13+558		13+591	4 102	135 120	528	17 891	80%	14 313	3 578
Gate Bay 2 Sill	13+591		13+649	4 102	237 342	355	21 011	80%	16 809	4 202
Center Chamber Floor	13+649		14+074	2 837	1 204 959	41	17 202	0%		17202
Center Chamber Culverts	13+649		14+074	2 585	1 097 825	36	15 290	0%	0	15 290
Gate Bay 3 Sill	14+074		14+107	4 102	135 120	528	17 891	80%	14 313	3 578
Gate Bay 3 Sill	14+107		14+165	4 102	237 342	355	21 011	80%	16 809	4 202
Upper Chamber Floor	14+165		14+590	3 140	1 333 652	38	15 927	0%		15927
Upper Chamber Culverts	14+165		14+590	2 585	1 097 825	36	15 290	0%	0	15 290
South Gate Bay Sill	14+590		14+622	3 140	103 432	636	21 915	80%	17 532	4 383
South Gate Bay Sill	14+622		14+680	3 140	181 680	187	11 278	80%	9 023	2 256
Upstream Paving	14+680		14+765	2 882	243 558	53	4 454	0%		4454
Upstream Bulkhead Sill	14+765		14+773	1 570	12 560	264	2 108	90%	1 897	211
Connecting Culvert Runs										
				Subtotal =	9 040 453			**Subtotal =**	114 891	128 844

	Item	*Total Length*	*Mass, kg/m*	*Mass*	*Length*	*Cross Sectional Area*	*Volume, m^3*
WSB 1A	***Exterior Wall Footing***	31,864.0	3.042	96.93	569.00	4.31	2 454
		26,713.0	2.235	59.70			
	Exterior Wall Stem	42,214.0	3.042	128.41	569.00	3.21	1 828
		27,141.0	2.235	60.66			
	Baffle Wall	6,073.0	1.552	9.43	80.50	1.68	135
	Floor Slab	260,400.0	2.235	581.99			15 500
WSB 1B	***Exterior Wall Footing***	9,310.0	3.042	28.32	166.25	4.31	717
		7,805.0	2.235	17.44			
	Exterior Wall Stem	12,263.0	3.042	37.30	166.25	3.16	526
		7,805.0	2.235	17.44			
	Baffle Wall	6,830.0	1.552	10.60	92.00	1.65	152
	Floor Slab	293,672.0	2.235	656.36			17 481
	Middle Wall Footing	23,393.0	3.042	71.16	406.00	7.44	3 021
		24,563.0	6.404	157.30			
	Middle Wall Stem	11,263.0	3.042	34.26	406.00	6.71	2 724
		20,794.0	2.235	46.47			
		18,778.0	6.404	120.25			
		20,300.0	3.973	80.65			
		7,335.0	3.973	29.14			
			Subtotal =	**2 243 847**		**Subtotal =**	**44 537**
WSB 2A	***Exterior Wall Footing***	31,864.0	3.042	96.93	569.00	4.31	2 454
		26,713.0	2.235	59.70			
	Exterior Wall Stem	41,207.0	3.042	125.35	569.00	3.01	1 713
		26,713.0	2.235	59.70			
	Baffle Wall	5,684.0	1.552	8.82	80.50	1.57	126
	Floor Slab	260,400.0	2.235	581.99			15 500
WSB 2B	***Exterior Wall Footing***	9,310.0	3.042	28.32	166.25	4.31	717
		7,805.0	2.235	17.44			
	Exterior Wall Stem	11,786.0	3.042	35.85	164.66	2.96	487
		7,225.0	2.235	16.15			
	Baffle Wall	6,830.0	1.552	10.60	92.00	1.65	152
	Floor Slab	293,672.0	2.235	656.36			17 481
	Middle Wall Footing	23,393.0	3.042	71.16	406.00	7.44	3 021
		24,563.0	6.404	157.30			
	Middle Wall Stem	11,263.0	3.042	34.26	406.00	6.71	2 724
		19,927.0	2.235	44.54			
		21,518.0	6.404	137.80			
		20,300.0	3.973	80.65			
		6,616.0	3.973	26.29			
			Subtotal =	**2,249,228**		**Subtotal =**	**44,374**

US Army Corps
of Engineers
Pittsburgh District

Panama Canal Authority
Atlantic Locks
3rd Lane - Concept Design Study

COMPUTATION
Three Lift Concept Design (Cost Estimate)
Quantity Summary

Computed By: AHARKNESS Date 15-Mar-03
Checked By: RAALLWES Date 24-Mar-03

WSB 3A	***Exterior Wall Footing***	31,864.0	3.042	96.93	569.00	4.31	2 454
		26,713.0	2.235	59.70			
	Exterior Wall Stem	41,207.0	3.042	125.35	569.00	3.01	1 713
		26,713.0	2.235	59.70			
	Baffle Wall	5,684.0	1.552	8.82	80.50	1.57	126
	Floor Slab	260,400.0	2.235	581.99			15 500
WSB 3B	***Exterior Wall Footing***	9,310.0	3.042	28.32	166.25	4.31	717
		7,805.0	2.235	17.44			
	Exterior Wall Stem	11,786.0	3.042	35.85	164.66	2.96	487
		7,225.0	2.235	16.15			
	Baffle Wall	6,830.0	1.552	10.60	92.00	1.65	152
	Floor Slab	293,672.0	2.235	656.36			17 481
	Middle Wall Footing	23,393.0	3.042	71.16	406.00	7.44	3 021
		24,563.0	6.404	157.30			
	Middle Wall Stem	11,263.0	3.042	34.26	406.00	6.71	2 724
		19,927.0	2.235	44.54			
		21,518.0	6.404	137.80			
		20,300.0	3.973	80.65			
		6,616.0	3.973	26.29			
			Subtotal =	**2,249,228**		**Subtotal =**	**44,374**

US Army Corps
of Engineers
Pittsburgh District

Panama Canal Authority
Atlantic Locks
3rd Lane - Concept Design Study

COMPUTATION
Three Lift Concept Design (Cost Estimate)
Quantity Summary

Computed By: AHARKNESS Date 15-Mar-03
Checked By: RAALLWES Date 24-Mar-03

	Main Features	RCC m^3	CIP m^3	Reinforcing Steel kg	Overburden Excavation, m^3	Rock Excavation, m^3	Structural Backfill, m^3	Random Fill, m^3
Summary Table	***Gate Monolith Construction***	309 755	422 093	7 213 334				
	Chamber Monolith Construction	1 879 029	305 764	12 871 620				
	Floor and Sill Construction	114 891	128 844	9 040 453				
	Entrance Wall Construction	511 941	56 882	2 999 100				
	Water Saving Basins	—	133 285	6 742 303				
	Total	2,815,700	1,046,900	38,866,900	5,772,119	8,401,582	717,308	1,116,709

QUANTITIES: PANAMA THIRD LANE ATLANTIC LOCKS, ENTRANCE WALLS

US Army Corps
of Engineers
Pittsburgh District

Panama Canal Authority
Atlantic Locks
3rd Lane - Concept Design Study

COMPUTATION

Three Lift Lock - Gatun Entrance Wall (In the Wet Construction)
Quantity Summary

Computed By: AHARKNESS Date 15-Mar-03
Checked By: RAALLWES Date 24-Mar-03

CASINGS: 50.8 mm WALL THICKNESS for 2.44 M			Lake Gatun Walls		TOTAL	UNITS
Number of shafts			72			
Caisson Length, l =			40			*meters*
Outside diameter of Caisson, d_o =			2.440			*meters*
Inside diameter of Caisson, d_i =			2.338			*meters*
Diameter of #18 (#57 metric) reinforcing bar, db=			57.3			*mm*
Number reinforcing bars, n_b=			47			
Caisson Wall Thickness, t=			50.8			*mm*
Volume of Steel in Caisson Wall, $v_s = \{[p(d_o^2 - d_i^2)]/4\}\ l =$			15.25			*cubic meters*
Weight of Steel in Caisson Wall, $w_s = v_s * 7.8483$ tonnes/m³ =			119.70			*metric tons*
Volume of Reinforcing in Caisson, $v_r = [(p(d_b)^2)/4]\ l\ n_b =$			4.85			*cubic meters*
Weight of Reinforcing Steel in Caisson Wall, $w_r = v_r * 7.8483$ tonnes/m³ =			38.05			*metric tons*
Volume of Concrete in Caisson, $v_c = [(pdi^2)/4]l - v_r =$			166.94			*cubic meters*
Weight of steel casing, total			8618.55		8618.5494	*metric tons*
Volume of Reinforced Concrete in Drilled Shafts			12019.53		12019.532	*cubic meters*
Weight of reinforcing steel, total			2739.46		2739.4606	*metric tons*

(63 shafts under Cap Beam, and 12 under the Lake Gatun Nose Pier)

FENDERS:	Quantity	Unit Cost	TOTAL COST	Comments and discussion
Metso/Trellex MV1450 x 1000A fender systems, with closed-box frontal frames ancillary hardware and UHMW pads; assumed to sized 6.10-m by 3.66-m by 37.5-cmm thick, with 51 mm gap between each frame.	106	$36,782.00	$3,898,892.00	*Price quote from John Rector and Tara Perry, Metso Minerals Trellex Fender, 3 October, 2002*
Wheel Fender Model # 114-2-FX (metso), including the heavy duty steel casing, sliding axle, idler rollers and protective "eyebrows". The Nose Piers each have 9 in plan view; the Lake Gatun Fenders are stacked two high; there is a single height of fenders on the Atlantic Nose Piers.	54	$218,462.00	$11,796,948.00	*Price quote from John Rector and Tara Perry, Metso Minerals Trellex Fender, 13 Nov 2002*
TOTAL			$15,695,840.00	

CONVENTIONAL REINFORCED CONCRETE FOR CAP BEAMS:

	Lake Gatun Walls			
	Cross-Sectional Area (M²)	Length (M)	Volume (m³)	
11.800 M wide section	59	432	25488.00	
22.501 M wide section	112.505	238	26776.19	
Transitions	85.7525	46	3944.62	
Transitions				
SUBTOTAL VOLUME (M³)			56208.81	56208.81 plus

Subtract for drilled shaft embedment into Cap Beams

	Cross-Sectional Area (M²)	Height (M)	Number of Shafts	Volume (m³)	
2.44 M	4.68	2.5	72	841.67	
SUBTOTAL VOLUME (M³)				841.67	841.67 minus
Total Volume (M³) =					55367.13 cubic meters

TOTAL VOLUME of REINFORCED CONCRETE, Lake Gatun Entrance Wall (M³) = 67386.67 cubic meters

US Army Corps
of Engineers
Pittsburgh District

Panama Canal Authority
Atlantic Locks
3rd Lane - Concept Design Study

COMPUTATION

Three Lift Concept Design
Excavation Quantities

Computed By: AHARKNESS Date 15-Apr-03
Checked By: RAALLWES Date 24-Apr-03

Lock Excavation

Sta.	Overburden Excavation m²	Rock Excavation m²	Structural Backfill m²	Random Fill m²	Overburden Excavation m³	Rock Excavation m³	Structural Backfill m³	Random Fill m³
12+100	-	-	-	-	-	-	-	-
12+140	8,125	303	366	1,964	162,500	6,060	7,320	39,280
12+200	8,125	303	366	1,964	487,500	18,180	21,960	117,840
12+300	3,150	883	233	561	563,750	59,300	29,950	126,250
12+400	3,478	1,138	324	1,520	331,400	101,050	27,850	104,050
12+500	2,780	956	408	780	312,900	104,700	36,600	115,000
12+600	913	772	220	470	184,650	86,400	31,400	62,500
12+700	1,757	951	295	748	133,490	86,150	25,750	60,900
12+780	3,289	496	316	853	201,832	57,880	24,440	64,040
12+800	3,289	496	316	853	65,780	9,920	6,320	17,060
12+900	280	567	460	1,341	178,450	53,150	38,800	109,700
13+000	120	528	473	1,334	20,000	54,750	46,650	133,750
13+043	1,170	2,122	131	314	27,735	56,975	12,986	35,432
13+100	1,170	2,122	131	314	66,690	120,954	7,467	17,898
13+134	1,170	2,122	131	314	39,780	72,148	4,454	10,676
13+135	3,720	1,301	200	270	2,445	1,712	166	292
13+200	3,720	1,301	200	270	241,800	84,565	13,000	17,550
13+275	2,830	3,240	128	175	245,625	170,288	12,300	16,688
13+300	2,830	3,240	128	175	70,750	81,000	3,200	4,375
13+395	2,830	3,240	128	175	268,850	307,800	12,160	16,625
13+400	2,109	3,505	206	46	12,348	16,863	835	553
13+500	2,817	3,675	50	39	246,300	359,000	12,800	4,250
13+588	1,647	2,505	79	188	196,416	271,920	5,676	9,988
13+600	1,647	2,505	79	188	19,764	30,060	948	2,256
13+649	1,647	2,505	79	188	80,703	122,745	3,871	9,212
13+649	1,892	4,045	187	12	-	-	-	-
13+700	1,892	4,045	187	12	96,492	206,295	9,537	612
13+795	1,892	4,045	187	12	179,740	384,275	17,765	1,140
13+800	2,420	4,267	190	-	10,780	20,780	943	30
13+900	2,243	5,487	182	-	233,150	487,700	18,600	-
13+910	2,243	5,487	182	-	22,430	54,870	1,820	-
14+000	1,840	6,030	33	-	183,735	518,265	9,675	-
14+074	752	3,182	22	113	95,904	340,844	2,035	4,181
14+100	752	3,182	22	113	19,552	82,732	572	2,938
14+165	752	3,182	22	113	48,880	206,830	1,430	7,345
14+166	1,997	3,071	224	112	1,375	3,127	123	113
14+200	1,997	3,071	224	112	67,898	104,414	7,616	3,808
14+300	1,193	4,846	164	40	159,500	395,850	19,400	7,600
14+305	944	5,203	175	20	5,341	25,123	846	150
14+400	694	5,560	185	-	77,781	511,243	17,076	950
14+420	694	5,560	185	-	13,880	111,200	3,700	-
14+500	1,585	3,120	40	-	91,160	347,200	9,000	-
14+589	1,585	3,120	40	-	141,065	277,680	3,560	-
14+590	78	1,903	27	30	832	2,512	34	15
14+600	78	1,903	27	30	780	19,030	270	300
14+680	78	1,903	27	30	6,240	152,240	2,160	2,400
14+681	385	500	562	95	232	1,202	295	63
14+700	385	500	562	95	7,315	9,500	10,678	1,805
14+800	374	580	581	68	37,950	54,000	57,150	8,160
14+898	374	802	572	74	36,652	67,718	56,497	6,968
14+900	374	4,019	572	74	748	4,821	1,144	148
15+000	374	802	572	74	37,400	241,050	57,200	7,400
15+100	374	6,508	-	-	37,400	365,500	28,600	3,700
15+200	374	2,500	-	-	37,400	450,400	-	-
15+525	374	1,250	-	-	121,550	609,375	-	-
				Sub Total	5,934,619	8,389,342	724,628	1,155,989
Culvert Cross Overs						18300		
				Total	5,934,619	8,407,642	724,628	1,155,989

US Army Corps
of Engineers
Pittsburgh District

Panama Canal Authority
Atlantic Locks
3rd Lane - Concept Design Study

COMPUTATION

Lock Gate (3 Lift) Quantity Estimate
Material Estimates for Double Skin Plate Miter Gates

Computed By: WAH Date 8-Apr-02
Checked By: RAA Date

Material Quantity Summary

Component	Material	Total, lbs	Total, t*
Fabricated Steel (Welded Construction)	ASTM A572M Grade 345	41,255,667	**18,753**
Fabricated Steel (Welded Construction)	ASTM A572M Grade 345	5,984,400	**2,720**
Casting (Pintle and Pintle Base)	ASTM A27 Class 65-35 Annealed	206,551	**94**
Pintle Bushing	ASTM B148, Alloy 954	38,356	**17**
Quoin and Miter Blocks	ASTM XM-25	2,422,817	**1,101**
Embedded Anchorage Frames	ASTM A572M Grade 345	1,940,032	**882**
Embedments for Quoin Blocks	ASTM A572M Grade 345	672,300	**306**
Gate Sill Embedded Metals	ASTM 304 Stainless Stl.	111,624	**51**
		52,631,747	**23,924**

* - Metric Ton

30.5m Tall Miter Gate Leaf

Component	Material	Each, lbs	# Required	Total, lbs
Fabricated Steel (Welded Construction)	ASTM A572M Grade 345	2,606,582	12	31,278,978
Fabricated Steel (Welded Construction)	ASTM A572M Grade 345	498,700	12	5,984,400
Casting (Pintle and Pintle Base)	ASTM A27 Class 65-35 Annealed	14,152	12	169,820
Pintle Bushing	ASTM B148, Alloy 954	2,710	12	32,519
Quoin and Miter Blocks	ASTM XM-25	162,170	12	1,946,038
Embedded Anchorage Frames	ASTM A572M Grade 345	121,252	12	1,455,024
Embedments for Quoin Blocks	ASTM A572M Grade 345	45,000	12	540,000
		3,450,565		**41,406,779**

22.34m Tall Miter Gate Leaf

Component	Material	Each, lbs	# Required	Total, lbs
Fabricated Steel (Welded Construction)	ASTM A572M Grade 345	2,494,172	4	9,976,689
Casting (Pintle and Pintle Base)	ASTM A27 Class 65-35 Annealed	9,183	4	36,730
Pintle Bushing	ASTM B148, Alloy 954	1,459	4	5,837
Quoin and Miter Blocks	ASTM XM-25	119,195	4	476,779
Embedded Anchorage Frames	ASTM A572M Grade 345	121,252	4	485,008
Embedments for Quoin Blocks	ASTM A572M Grade 345	33,075	4	132,300
		2,778,336		**11,113,343**

Gate Sills

Component	Material	Each, lbs	# Required	Total, lbs
Gate Sill Embedded Metals	ASTM 304 Stainless Stl.	13,953	8	**111,624**

Total (lbs) = **52,631,747**

US Army Corps
of Engineers
Pittsburgh District

Panama Canal Authority
Atlantic Locks
3rd Lane - Concept Design Study

COMPUTATION

Lock Gate Quanity Estimate
30.5m Tall Double Skin Plate Miter Gates

Computed By: WAH Date 16-Oct-02
Checked By: Date

Double Skin Plate Gate Weight

		Weights, Lbs
Upstream Skin Plate Systems		
Skin Plate		148,000
Intercostals		101,350
		249,350
Downstream Skin Plate Systems		
Skin Plate		148,000
Intercostals		101,350
		249,350
	Skin Plate Total =	498,700
Horizontal Girders		
Girder 1		67783.60
Girder 2		59268.50
Girder 3		59268.50
Girder 4		65565.20
Girder 5		78661.00
Girder 6		85706.40
Girder 7		90150.80
Girder 8		94042.00
Girder 9		95251.00
Girder 10		97132.50
Girder 11		99229.60
Girder 12		101419.90
Girder 13		103525.20
Girder 14		81536.00
	Girders Totals =	1,178,540
End Diaphragm Plates		236,000
Interior Diaphragms Plates		255,800
Thrust Diaphragm Plates		275,700
Thrust Diaphragm Stiffener Plates		151,000
Contact Plate Weight		210,300
	Diaphragm Total =	1,128,800
Diagonal Bars		-
Diagonal Bar Support Plates & Misc.		-
		-
Pintle Base		7,076
Pintle		7,076
Pintle Bushing		2,710
	Pintle Total =	16,862
Gudgeon Connection		5,507

US Army Corps
of Engineers
Pittsburgh District

Panama Canal Authority
Atlantic Locks
3rd Lane - Concept Design Study

COMPUTATION

Lock Gate Quanity Estimate
30.5m Tall Double Skin Plate Miter Gates

Computed By: WAH Date 16-Oct-02
Checked By: Date

Hydraulic Cylinder Connection	8,261
Miter and Quoin Contact Blocks	121,000
Walkway Framing	45,240
	180,008

Sum of Weights =	3,002,910	
Misc. (8%) =	240,233	
	3,243,143	Lbs

One Leaf	1474	Metric Ton
One Set	2948	Metric Ton

US Army Corps
of Engineers
Pittsburgh District

Panama Canal Authority
Atlantic Locks
3rd Lane - Concept Design Study

COMPUTATION

Lock Gate Quanity Estimate
22.34m Tall Single Skin Plate Miter Gates

Computed By: WAH Date 16-Oct-02
Checked By: Date

Single Skin Skin Plate Gate Weight

Upstream Skin Plate Systems		**Weights**
Skin Plate		99,969
Intercostals		70,389
		170,359
Downstream Skin Plate Systems		99,969
Skin Plate		70,389
Intercostals		170,359
	Skin Plate Total =	340,717
Horizontal Girders		
Girder 1		88,376
Girder 2		88,376
Girder 3		88,376
Girder 4		88,376
Girder 5		88,376
Girder 6		89,331
Girder 7		94,253
Girder 8		107,952
Girder 9		112,784
Girder 10		118,684
	Girders Totals =	964,885
End Diaphragm Plates		148,482
Interior Diaphragms Plates		261,128
Thrust Diaphragm Plates		234,657
Thrust Diaphragm Stiffener Plates		131,554
Contact Plate Weight		186,515
	Diaphragm Total =	962,336
Diagonal Bars		-
Diagonal Bar Support Plates & Misc.		-
		-
Pintle Base		4,591
Pintle		4,591
Pintle Bushing		1,459
		10,642

Gudgeon Connection		5,507
Hydraulic Cylinder Connection		8,261
Miter and Quoin Contact Blocks		127,162
Walkway Framing		45,240
		186,171
	Sum of Weights =	2,464,751
	Misc. (8%) =	197,180
		2,661,931

US Army Corps
of Engineers
Pittsburgh District

Panama Canal Authority
Atlantic Locks
3rd Lane - Concept Design Study

COMPUTATION

Triple Lift Concept Design
3 Lift Valve Quantity Estimate

Computed By: WAH 29-Apr-03
Checked By: RAA

Upper and Valves between Locks

	Two Lift Lock				Three Lift Lock				
Number	Width	Height	Hydrodynamic Head	Weight	Width	Height	Hydrodynamic Head	Proportioned Weight, Ea	Total Weight, kg
12	4.0	7.0	40.6	66,400	4.0	8.0	27.0	50,466	605,590

Lower Valves

	Two Lift Lock				Three Lift Lock				
Number	Width	Height	Hydrodynamic Head	Weight	Width	Height	Hydrodynamic Head	Proportioned Weight, Ea	Total Weight, kg
4	4.0	7.0	40.6	66,400	5.0	8.0	13.5	63,199	252,797

Water Saving Basins

	Two Lift Lock				Three Lift Lock				
Number	Width	Height	Hydrodynamic Head	Weight	Width	Height	Hydrodynamic Head	Proportioned Weight, Ea	Total Weight, kg
24	6.0	8.0	10.1	58,300	6.0	8.0	6.7	38,522	924,521

Total (kg) 1,782,908

PANAMA CANAL CONCEPT DESIGN

Atlantic Locks Structure

Third Lift Lock

Appendix N, Attachment 4

Cost Estimates

Prepared for

ACP

Canal Capacity Projects Office

By

US Army Corps of Engineers®

Final Report

Triple-Lift Configuration

23 July 2003

Panama Canal Concept Design
Atlantic Locks Structure
Third Lane Lock
Triple-Lift Configuration
Construction Cost Estimate - In-Chamber Longitudinal F/E System (ILCS)

Price Level: October 2002

ITEM #	Description	Quantity	Unit	Unit Price	Amount	Contin-gencies	Total
	Mobilization & Demobilization (4%)	1	ls	$35,000,000.00	**$35,000,000.00**	10.0%	**$38,500,000.00**
01-01	**Preparatory Work**				**$10,000,000.00**	20.0%	**$12,000,000.00**
01-02	**Relocations**				**$1,500,000.00**	25.0%	**$1,875,000.00**
01-03	**Care & Diversion of Water**				**$5,000,000.00**	25.0%	**$6,250,000.00**
01-04	**Earthwork for Structures**						
01-04001	Exploratory Drilling	1	ls	$1,980,000.00	$1,980,000.00	20.0%	$2,376,000.00
01-04002	Common Excavation (Dry)	3406640	m^3	$3.75	$12,774,900.00	20.0%	$15,329,900.00
01-04003	Rock Excavation (Dry)	4523320	m^3	$7.80	$35,281,896.00	20.0%	$42,338,300.00
01-04004	Common Excavation (In the Wet)	233750	m^3	$6.50	$1,519,375.00	20.0%	$1,823,300.00
01-04005	Rock Excavation (In the Wet)	1666325	m^3	$23.00	$38,325,475.00	20.0%	$45,990,600.00
01-04006	Pervious (Structural) Backfill	724628	m^3	$18.00	$13,043,304.00	25.0%	$16,304,100.00
01-04007	Random Backfill	1155989	m^3	$3.00	$3,467,967.00	20.0%	$4,161,600.00
01-04008	Foundation Prep	187500	m^2	$75.00	$14,062,500.00	20.0%	$16,875,000.00
				Subtotals	**$120,455,000.00**		**$145,199,000.00**
01-05	**Sitework**				**$2,104,500.00**	20.0%	**$2,529,000.00**

Panama Canal Concept Design
Atlantic Locks Structure
Third Lane Lock
Triple-Lift Configuration
Construction Cost Estimate - In-Chamber Longitudinal F/E System (ILCS)

Price Level: October 2002

ITEM #	Description	Quantity	Unit	Unit Price	Amount	Contin-gencies	Total
01-06	**Entrance Walls, Upper & Lower**						
01-06001	Soil Excavation (Caissons)	2015	m^3	$260.00	$523,900.00	30.0%	$681,100.00
01-06002	Rock Excavation (Caissons)	3705	m^3	$775.00	$2,871,375.00	30.0%	$3,732,800.00
01-06003	Caissons	2880	m	$3,000.00	$8,640,000.00	30.0%	$11,232,000.00
01-06004	Reinforcing Steel (Caissons)	2739460	kg	$0.90	$2,465,514.00	30.0%	$3,205,200.00
01-06005	Tremie Concrete	12020	m^3	$150.00	$1,803,000.00	30.0%	$2,343,900.00
01-06006	Testing/Monitoring Caissons	72	ea	$25,000.00	$1,800,000.00	30.0%	$2,340,000.00
01-06007	Concrete (Cap Wall)	55370	m^3	$335.00	$18,548,950.00	30.0%	$24,113,600.00
01-06008	Reinforcing Steel (Cap Wall)	446800	kg	$0.90	$402,120.00	30.0%	$522,800.00
01-06009	Sheet Piling (Cap Wall)	25750	m^2	$310.00	$7,982,500.00	30.0%	$10,377,300.00
01-06009	Conventional CIP	56882	m^3	$91.00	$5,176,262.00	20.0%	$6,211,500.00
01-06010	RCC	511941	m^3	$63.00	$32,252,283.00	20.0%	$38,702,700.00
01-06011	Reinforcing Steel (Dry Section)	2999100	kg	$0.90	$2,699,190.00	20.0%	$3,239,000.00
01-06012	Pervious (Structural) Backfill	0	m^3	$18.00	$0.00	25.0%	$0.00
01-06013	Fenders	1	Job	$11,200,000.00	$11,200,000.00	20.0%	$13,440,000.00
				Subtotals	**$96,365,000.00**		**$120,142,000.00**
01-07	**Lock Structure**						
01-07001	Concrete for Lock Walls, (Conv)	305764	m^3	$90.00	$27,518,760.00	20.0%	$33,022,500.00
01-07002	Concrete for Lock Walls, (RCC)	1879029	m^3	$56.00	$105,225,624.00	20.0%	$126,270,700.00
01-07003	Concrete in Place, Gate Monoliths, (Conv)	422093	m^3	$111.00	$46,852,323.00	20.0%	$56,222,800.00
01-07004	Concrete for Lock Gate Monoliths, (RCC)	309755	m^3	$49.00	$15,177,995.00	20.0%	$18,213,600.00
01-07005	Concrete for Lock Floors/Sills, (Conv)	74060	m^3	$203.00	$15,034,180.00	20.0%	$18,041,000.00
01-07006	Concrete for Lock Floors, (RCC)	175521	m^3	$45.00	$7,898,445.00	20.0%	$9,478,100.00
01-07007	Reinforcing Steel, Wall Monoliths	12871620	kg	$0.90	$11,584,458.00	20.0%	$13,901,300.00
01-07008	Reinforcing Steel, Floor/Sills	9040453	kg	$0.90	$8,136,407.70	20.0%	$9,763,700.00
01-07009	Reinforcing Steel, Gate Monoliths	7213334	kg	$0.90	$6,492,000.60	20.0%	$7,790,400.00
				Subtotals	**$243,920,000.00**		**$292,704,000.00**

Panama Canal Concept Design
Atlantic Locks Structure
Third Lane Lock
Triple-Lift Configuration
Construction Cost Estimate - In-Chamber Longitudinal F/E System (ILCS)

Price Level: October 2002

ITEM #	Description	Quantity	Unit	Unit Price	Amount	Contin-gencies	Total
01-08	**Lock Gates & Operating Machinery**						
01-08001	Furnish & Install 30.5m Tall Miter Gate Sets	6	sets	$19,402,500.00	$116,415,000.00	15.0%	$133,877,300.00
01-08002	Furnish & Install 22.34m Tall Miter Gate Sets	2	sets	$15,502,500.00	$31,005,000.00	15.0%	$35,655,800.00
01-08004	Furnish and Install Operating Machinery	16	ea	$715,000.00	$11,440,000.00	15.0%	$13,156,000.00
01-08005	Embedded Metals (Stainless Steel)	51000	kg	$6.50	$331,500.00	15.0%	$381,200.00
01-08006	Gate Anchorage (Structural steel)	1188000	kg	$2.50	$2,970,000.00	15.0%	$3,415,500.00
01-08007	Bridges over recesses	16	ea	$300,000.00	$4,800,000.00	20.0%	$5,760,000.00
01-08008	Emergency Closure	1	LS	$20,000,000.00	$20,000,000.00	15.0%	$23,000,000.00
				Subtotals	**$186,962,000.00**		**$215,246,000.00**
01-09	**Culvert Valves and Operating Machinery**						
01-09001	Upper Valves and Valves Between Locks	12	ea	$277,750.00	$3,333,000.00	15.0%	$3,833,000.00
01-09003	Lower Lock Emptying Valves	4	ea	$347,600.00	$1,390,400.00	15.0%	$1,599,000.00
01-09004	Embedded Metals (Stainless Steel)	5100	kg	$6.50	$33,150.00	15.0%	$38,100.00
01-09005	Valve Anchorage	52300	kg	$2.50	$130,750.00	15.0%	$150,400.00
01-09006	Bulkheads	1	ls	$920,000.00	$920,000.00	15.0%	$1,058,000.00
01-09007	Valves Operating Machinery	16	ea	$500,000.00	$8,000,000.00	15.0%	$9,200,000.00
				Subtotals	**$13,807,000.00**		**$15,879,000.00**
01-10	**Piping System**				**$2,250,000.00**	30.0%	**$2,925,000.00**
01-11	**Power and Lighting Systems**				**$28,750,000.00**	18.3%	**$34,000,000.00**
01-12	**Associated General Items**				**$4,122,000.00**	15.0%	**$4,740,000.00**
01-13	**Building, Project Operations**				**$1,000,000.00**	25.0%	**$1,250,000.00**
01-14	**Miscellaneous Items**				**$21,165,000.00**	15.8%	**$24,506,000.00**
01-15	**Maintenance Facility (Gates)**				**$2,781,000.00**	24.5%	**$3,463,000.00**

Panama Canal Concept Design
Atlantic Locks Structure
Third Lane Lock
Triple-Lift Configuration
Construction Cost Estimate - In-Chamber Longitudinal F/E System (ILCS)
Price Level: October 2002

ITEM #	Description	Quantity	Unit	Unit Price	Amount	Contin-gencies	Total
01-16	**Water Savings Basins**						
01-16001	Overburden Excavation	2294229	m^3	$3.75	$8,603,358.75	15.0%	$9,893,900.00
01-16002	Rock Excavation	2217998	m^3	$7.80	$17,300,384.40	15.0%	$19,895,400.00
01-16003	Concrete (Conventional)	131710	m^3	$150.00	$19,756,500.00	15.0%	$22,720,000.00
01-16004	Reinforcing Steel	6742303	kg	$0.90	$6,068,072.70	20.0%	$7,281,700.00
01-16005	Handrailing	2055	m	$50.00	$102,750.00	20.0%	$123,300.00
				Subtotals	**$51,831,000.00**		**$59,914,000.00**
01-17	**Conduits**						
01-17001	Overburden Excavation	0	m^3	$3.75	$0.00	15.0%	$0.00
01-17002	Rock Excavation	0	m^3	$7.80	$0.00	15.0%	$0.00
01-17003	Concrete	90000	m^3	$210.00	$18,900,000.00	15.0%	$21,735,000.00
01-17004	Reinforcing Steel	9810000	kg	$0.90	$8,829,000.00	20.0%	$10,594,800.00
				Subtotals	**$27,729,000.00**		**$32,330,000.00**
01-18	**Crossovers (Including with Lock Floor Costs)**						
01-19	**Conduit Valves and Operating Mach.**						
01-19001	Valves	24	ea	$211,750.00	$5,082,000.00	15.0%	$5,844,300.00
01-19002	Embedded Metals (Stainless Steel)	6000	kg	$6.50	$39,000.00	15.0%	$44,900.00
01-19003	Valve Anchorage (Structural Steel)	60000	kg	$2.50	$150,000.00	15.0%	$172,500.00
01-19004	Valve Operating Machinery	24	ea	$400,000.00	$9,600,000.00	15.0%	$11,040,000.00
01-19005	Electrical System/Controls	1	job	$2,250,000.00	$2,250,000.00	20.0%	$2,700,000.00
				Subtotals	**$17,121,000.00**		**$19,802,000.00**
				Totals	**$871,862,500.00**		**$1,033,254,000.00**
				Rounded	**$872,000,000.00**		**$1,033,000,000.00**

PANAMA CANAL CONCEPT DESIGN

Atlantic Locks Structure

Third Lift Lock

Appendix N, Attachment 5

Project Construction Schedules

Prepared for

Canal Capacity Projects Office

By

US Army Corps of Engineers®

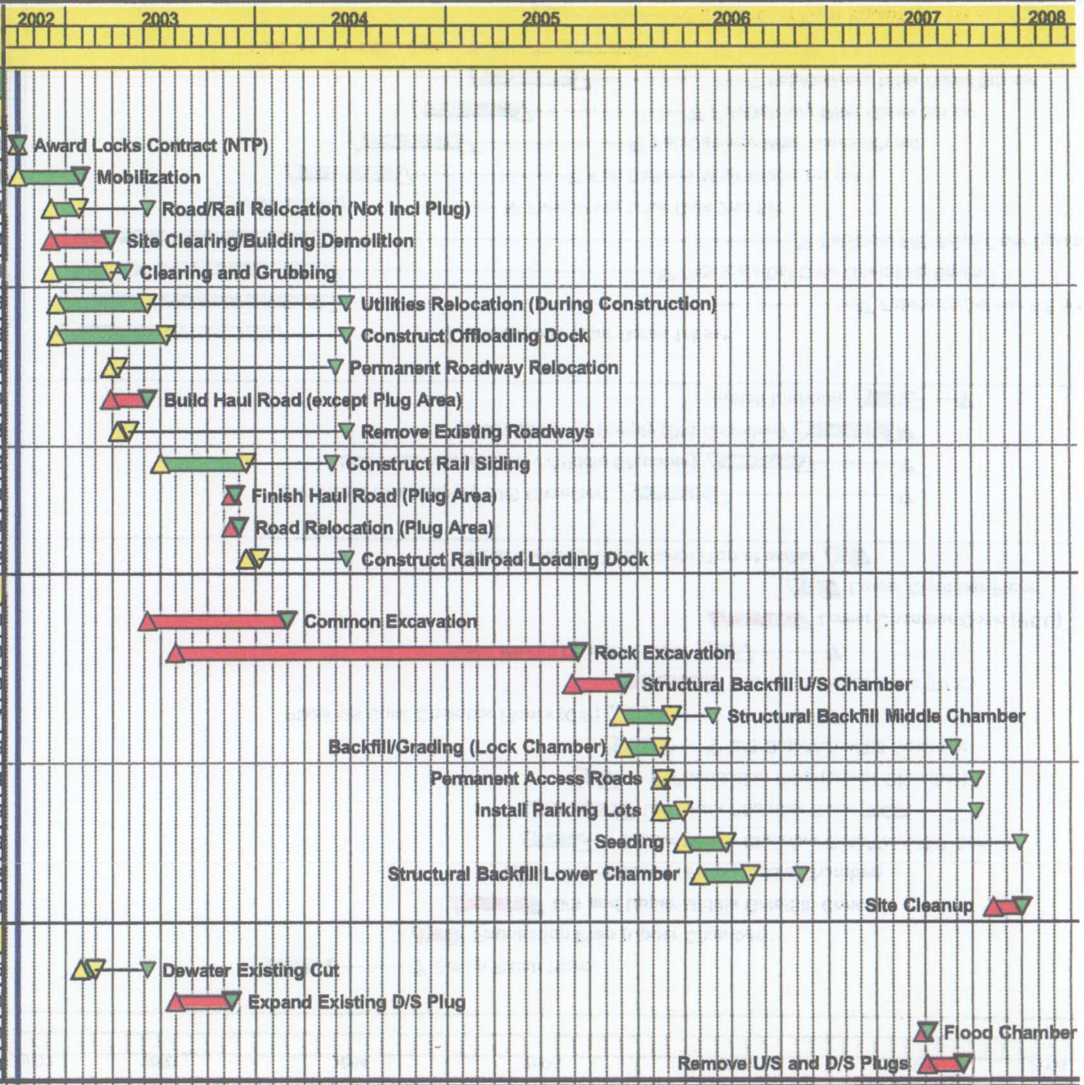
Final Report

Triple-Lift Configuration

23 July 2003

PANAMA CANAL CONCEPT DESIGN
ATLANTIC LOCKS STRUCTURE
TRIPLE-LIFT
CONSTRUCTION SCHEDULE

Activity ID	Activity Description	Orig Dur	Early Start	Early Finish	Total Float
Locks Contract					
Site Prep Work					
0330	Award Locks Contract (NTP)	1	01OCT02	01OCT02	1
0340	Mobilization	120	02OCT02	29JAN03	1
0050	Road/Rail Relocation (Not Incl Plug)	40	02DEC02	24JAN03	94
0010	Site Clearing/Building Demolition	100	02DEC02	27MAR03	0
0700	Clearing and Grubbing	100	02DEC02	27MAR03	24
0760	Utilities Relocation (During Construction)	150	16DEC02	07JUN03	326
0740	Construct Offloading Dock	180	16DEC02	12JUL03	296
0710	Permanent Roadway Relocation	10	28MAR03	10APR03	298
0020	Build Haul Road (except Plug Area)	60	28MAR03	05JUN03	0
0720	Remove Existing Roadways	15	11APR03	01MAY03	298
0730	Construct Rail Siding	140	02JUL03	11DEC03	142
0040	Finish Haul Road (Plug Area)	6	14NOV03	20NOV03	0
0970	Road Relocation (Plug Area)	10	14NOV03	27NOV03	0
0750	Construct Railroad Loading Dock	24	12DEC03	08JAN04	142
Earthwork					
0060	Common Excavation	230	06JUN03	28FEB04	0
0070	Rock Excavation	660	01AUG03	08SEP05	0
0360	Structural Backfill U/S Chamber	85	29AUG05	05DEC05	0
0150	Structural Backfill Middle Chamber	85	28NOV05	06MAR06	67
0180	Backfill/Grading (Lock Chamber)	60	06DEC05	13FEB06	479
0500	Permanent Access Roads	5	14FEB06	20FEB06	424
0430	Install Parking Lots	30	14FEB06	27MAR06	399
0520	Seeding	60	28MAR06	19JUN06	399
0370	Structural Backfill Lower Chamber	85	28APR06	04AUG06	82
0300	Site Cleanup	45	08NOV07	29DEC07	0
Water Diversion					
0130	Dewater Existing Cut	24	30JAN03	26FEB03	85
0030	Expand Existing D/S Plug	90	01AUG03	13NOV03	0
0270	Flood Chamber	7	28JUN07	04JUL07	0
0290	Remove U/S and D/S Plugs	60	05JUL07	12SEP07	0



Start Date	01OCT02
Finish Date	28FEB08
Data Date	01OCT02
Run Date	30APR03 09:20

🟩 Early Bar

▽ Float Bar

🟦 Progress Bar

🟥 Critical Activity

PAN3

Sheet 1 of 4

USACE

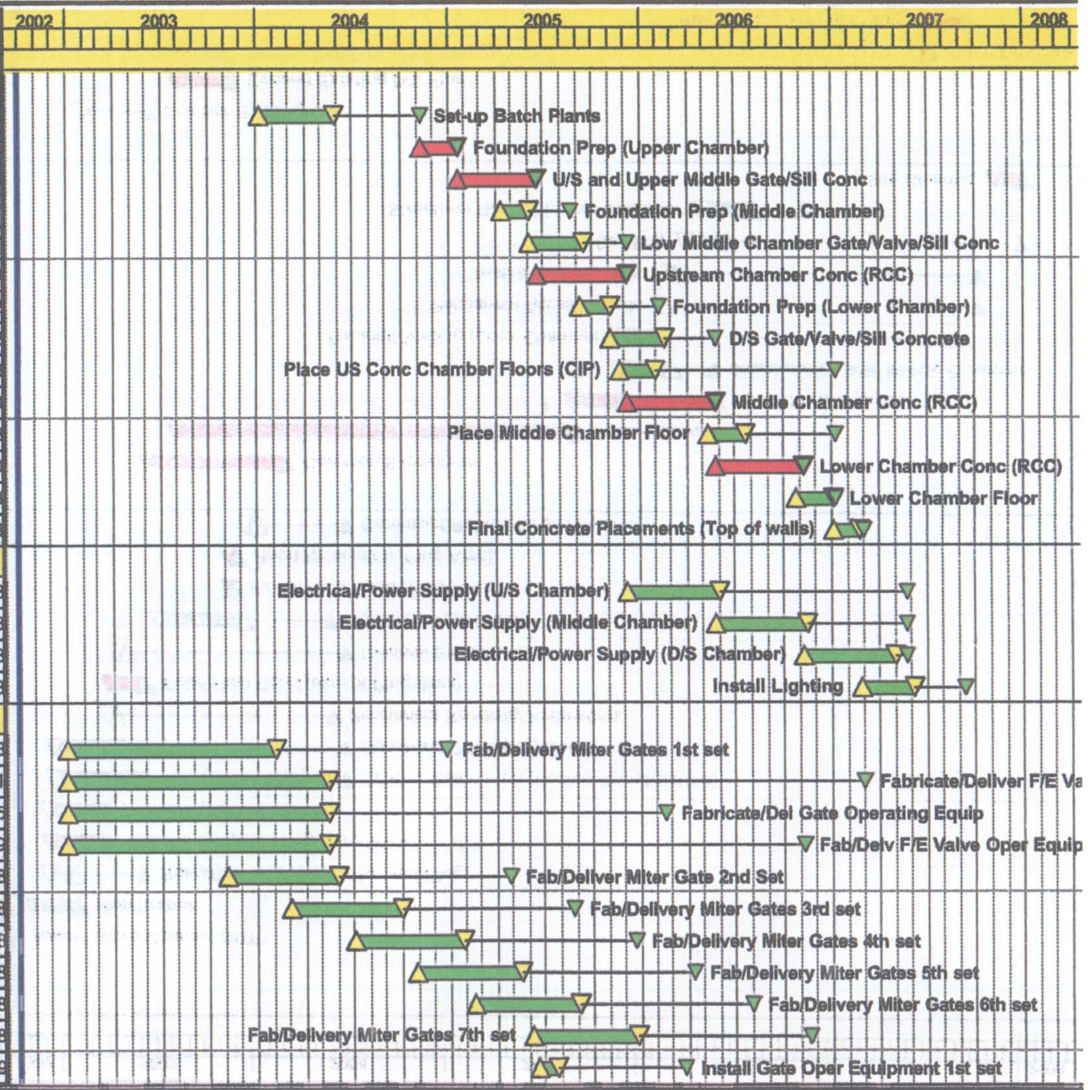
Panama Locks Study, 3 Lift

Classic Schedule Layout

Date	Revision	Checked	Approved
04APR29	ITR Draft		

PANAMA CANAL CONCEPT DESIGN
ATLANTIC LOCKS STRUCTURE
TRIPLE-LIFT
CONSTRUCTION SCHEDULE

Activity ID	Activity Description	Orig Dur	Early Start	Early Finish	Total Float
Lock Concrete					
0090	Set-up Batch Plants	120	09JAN04	27MAY04	142
0080	Foundation Prep (Upper Chamber)	60	10NOV04	18JAN05	0
0120	U/S and Upper Middle Gate/Sill Conc	130	19JAN05	18JUN05	0
0160	Foundation Prep (Middle Chamber)	48	11APR05	04JUN05	67
0170	Low Middle Chamber Gate/Valve/Sill Conc	90	06JUN05	17SEP05	67
0380	Upstream Chamber Conc (RCC)	145	20JUN05	06DEC05	0
0770	Foundation Prep (Lower Chamber)	48	09SEP05	03NOV05	82
0790	D/S Gate/Valve/Sill Concrete	90	04NOV05	16FEB06	82
0100	Place US Conc Chamber Floors (CIP)	60	22NOV05	30JAN06	293
0550	Middle Chamber Conc (RCC)	145	06DEC05	23MAY06	0
0320	Place Middle Chamber Floor	60	10MAY06	18JUL06	148
0780	Lower Chamber Conc (RCC)	145	24MAY06	08NOV06	0
0810	Lower Chamber Floor	60	26OCT06	03JAN07	3
0390	Final Concrete Placements (Top of walls)	45	04JAN07	24FEB07	3
Electrical Work					
0250	Electrical/Power Supply (U/S Chamber)	150	06DEC05	29MAY06	308
0350	Electrical/Power Supply (Middle Chamber)	150	24MAY06	14NOV06	163
0940	Electrical/Power Supply (D/S Chamber)	150	09NOV06	02MAY07	18
0240	Install Lighting	88	26FEB07	07JUN07	83
Mechanical					
0190	Fab/Delivery Miter Gates 1st set	400	31DEC02	03FEB04	328
0440	Fabricate/Deliver F/E Valves	500	31DEC02	13MAY04	1,021
0540	Fabricate/Del Gate Operating Equip	500	31DEC02	13MAY04	645
0580	Fab/Delv F/E Valve Oper Equip	500	31DEC02	13MAY04	909
0600	Fab/Deliver Miter Gate 2nd Set	210	06NOV03	02JUN04	328
0610	Fab/Delivery Miter Gates 3rd set	210	05MAR04	30SEP04	328
0620	Fab/Delivery Miter Gates 4th set	210	03JUL04	28JAN05	328
0630	Fab/Delivery Miter Gates 5th set	200	31OCT04	18MAY05	328
0640	Fab/Delivery Miter Gates 6th set	200	18FEB05	05SEP05	328
0830	Fab/Delivery Miter Gates 7th set	200	08JUN05	24DEC05	328
0210	Install Gate Oper Equipment 1st set	30	20JUN05	23JUL05	209



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🟥 Critical Activity

PAN3

Sheet 2 of 4

USACE

Panama Locks Study, 3 Lift

Classic Schedule Layout

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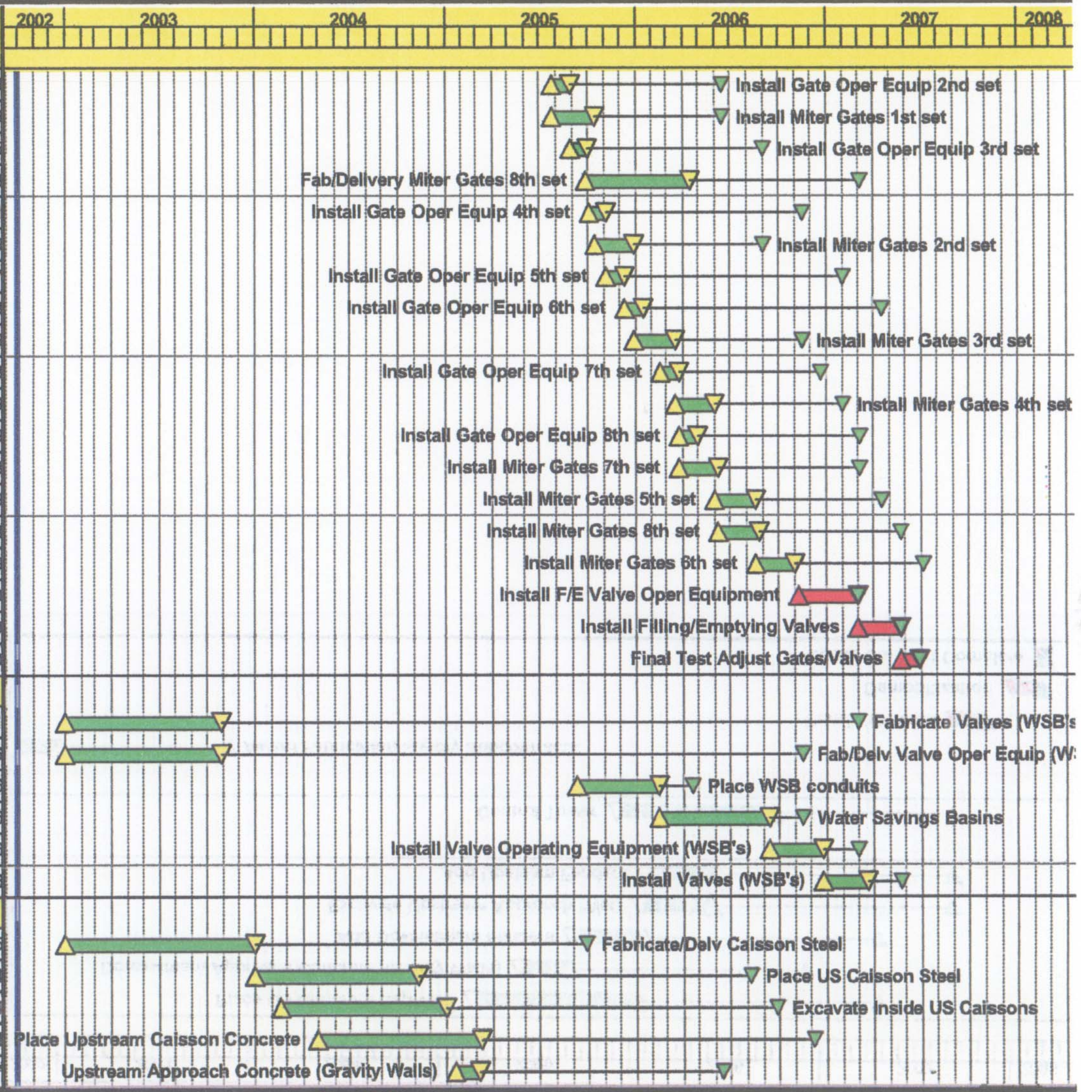
04APR29	ITR Draft		

PANAMA CANAL CONCEPT DESIGN
ATLANTIC LOCKS STRUCTURE
TRIPLE-LIFT
CONSTRUCTION SCHEDULE

Activity ID	Activity Description	Orig Dur	Early Start	Early Finish	Total Float
0280	Install Gate Oper Equip 2nd set	30	25JUL05	27AUG05	249
0200	Install Miter Gates 1st set	70	25JUL05	13OCT05	209
0450	Install Gate Oper Equip 3rd set	30	29AUG05	01OCT05	286
0890	Fab/Delivery Miter Gates 8th set	200	26SEP05	13APR06	328
0510	Install Gate Oper Equip 4th set	30	03OCT05	05NOV05	321
0650	Install Miter Gates 2nd set	66	14OCT05	29DEC05	209
0530	Install Gate Oper Equip 5th set	30	07NOV05	10DEC05	357
0570	Install Gate Oper Equip 6th set	30	12DEC05	14JAN06	393
0660	Install Miter Gates 3rd set	66	30DEC05	16MAR06	209
0950	Install Gate Oper Equip 7th set	30	17FEB06	23MAR06	233
0670	Install Miter Gates 4th set	66	17MAR06	01JUN06	209
0960	Install Gate Oper Equip 8th set	30	24MAR06	27APR06	269
0910	Install Miter Gates 7th set	66	24MAR06	08JUN06	233
0680	Install Miter Gates 5th set	66	02JUN06	17AUG06	209
0930	Install Miter Gates 8th set	66	09JUN06	24AUG06	233
0690	Install Miter Gates 6th set	66	18AUG06	02NOV06	209
0230	Install F/E Valve Oper Equipment	96	09NOV06	28FEB07	0
0220	Install Filling/Emptying Valves	72	01MAR07	23MAY07	0
0420	Final Test Adjust Gates/Valves	30	24MAY07	27JUN07	0
Water Savings Basins					
0460	Fabricate Valves (WSB's)	300	31DEC02	26OCT03	1,221
0480	Fab/Delv Valve Oper Equip (WSB's)	300	31DEC02	26OCT03	1,116
0110	Place WSB conduits	135	09SEP05	13FEB06	56
0140	Water Savings Basins	180	14FEB06	11SEP06	56
0470	Install Valve Operating Equipment (WSB's)	90	12SEP06	25DEC06	56
0490	Install Valves (WSB's)	72	26DEC06	19MAR07	56
Approach Walls					
0560	Fabricate/Delv Caisson Steel	365	31DEC02	30DEC03	636
0850	Place US Caisson Steel	270	31DEC03	09NOV04	544
0860	Excavate Inside US Caissons	270	21FEB04	31DEC04	544
0870	Place Upstream Caisson Concrete	270	01MAY04	11MAR05	544
0800	Upstream Approach Concrete (Gravity Walls)	42	19JAN05	08MAR05	397



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🟩 Early Bar
Float Bar
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🟥 Critical Activity

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Sheet 3 of 4

USACE

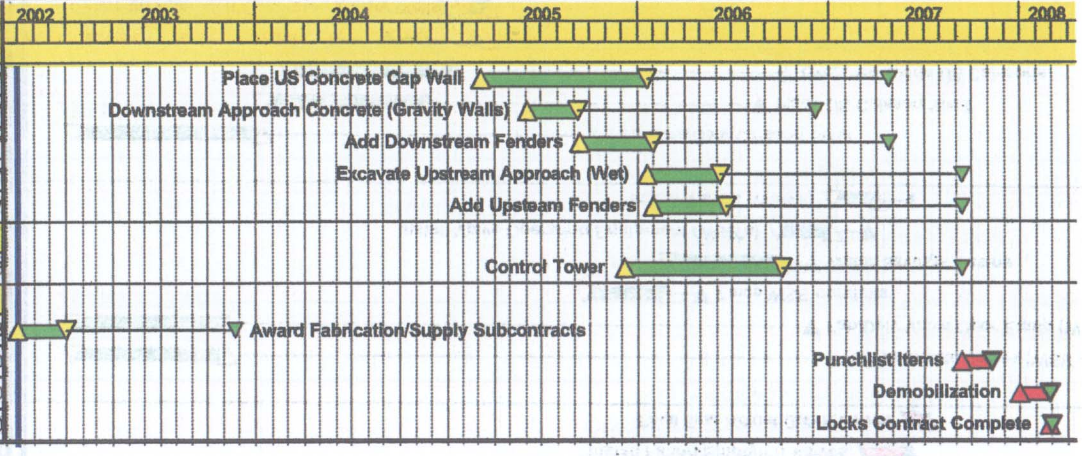
Panama Locks Study, 3 Lift

Classic Schedule Layout

Date	Revision	Checked	Approved
04APR29	ITR Draft		

PANAMA CANAL CONCEPT DESIGN
ATLANTIC LOCKS STRUCTURE
TRIPLE-LIFT
CONSTRUCTION SCHEDULE

Activity ID	Activity Description	Orig Dur	Early Start	Early Finish	Total Float
0880	Place US Concrete Cap Wall	270	09MAR05	17JAN06	397
0840	Downstream Approach Concrete (Gravity Walls)	84	06JUN05	10SEP05	387
0820	Add Downstream Fenders	120	12SEP05	28JAN06	387
0920	Excavate Upstream Approach (Wet)	120	18JAN06	06JUN06	397
0900	Add Upsteam Fenders	120	30JAN06	17JUN06	387
Control Building					
0260	Control Tower	300	06DEC05	01OCT06	346
General Work Locks Contract					
0590	Award Fabrication/Supply Subcontracts	90	02OCT02	30DEC02	328
0400	Punchlist Items	48	13SEP07	07NOV07	0
0310	Demobilization	60	30DEC07	27FEB08	0
0410	Locks Contract Complete	1	28FEB08	28FEB08	0



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USACE

Panama Locks Study, 3 Lift

Classic Schedule Layout

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04APR29	ITR Draft		

PANAMA CANAL CONCEPT DESIGN

Atlantic Locks Structure
Third Lift Lock
Appendix N, Attachment 6
Quality Control Certification

Prepared for

Canal Capacity Projects Office

By

US Army Corps
of Engineers®

Final Report

Triple-Lift Configuration

23 July 2003

COMPLETION OF INDEPENDENT TECHNICAL REVIEW

Draft Report, Modification 2

Triple-Lift Configuration

The Corps of Engineers has completed the draft report for Modification 2, Triple-Lift Configuration for the Concept Design Of Lock Structures, Atlantic Lock Structures. Notice is hereby given that an independent technical review has been conducted that is appropriate to the level of risk and complexity inherent in the project, as defined in the Quality Control Plan. During the independent technical review, compliance with established policy principles and procedures, utilizing justified and valid assumptions, was verified. This included review of assumptions; methods, procedures, and material used in analyses; alternatives evaluated; the appropriateness of data used and level of data obtained; and reasonableness of the results, including whether the product meets the customer's needs consistent with law and existing Corps policy. The design was accomplished by a team of Corps of Engineers personnel from various districts and centers, and the independent technical review was accomplished by an independent a team of Corps of Engineers personnel from various districts and divisions.

12 May 03

Technical Manager

Byron K. McClellan

5 MAY '03

Independent Technical Review Team Leader

PANAMA CANAL CONCEPT DESIGN

Atlantic Locks Structure

Third Lane Lock

Appendix O

Work Plan

Prepared for

ACP

Canal Capacity Projects Office

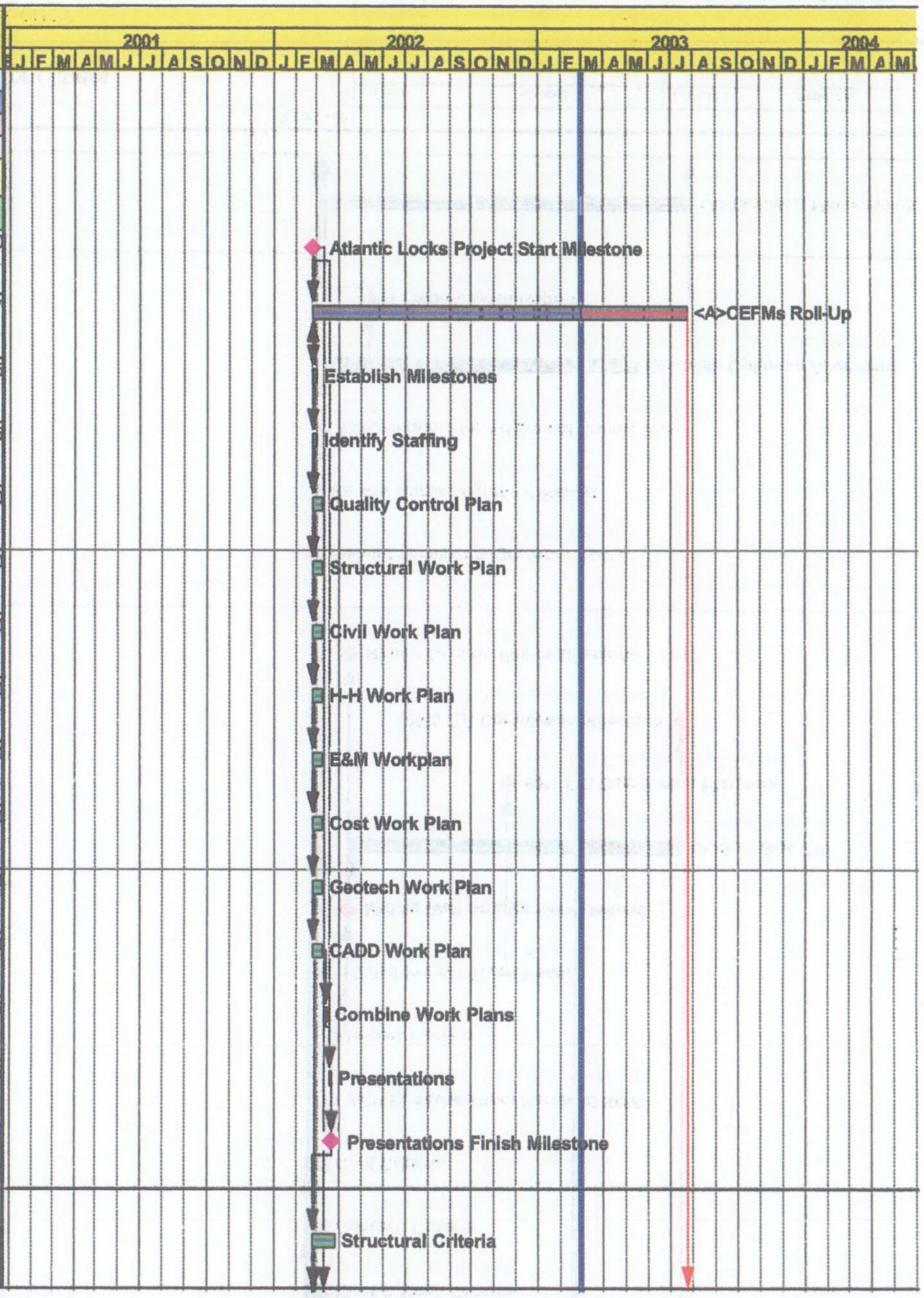
By

US Army Corps
of Engineers®

Final Report

23 July 2003

Project Manager	KEYT	Activity Description	Activity ID	Early Start	Early Finish	Orig Dur
Pittsburgh District						
Civil Works						
Support/Work for Others Projects						
Panama Canal Concept Design						
Atlantic Locks						
Atlantic - Work Plans and QC Plan - Task #1						
CAIN	ZOV	Atlantic Locks Project Start Milestone	Z5S0980	25FEB02A		0
CAIN	ZOV	<A>CEFMs Roll-Up	Z5S0990	25FEB02A	23JUL03	356*
CAIN	ZOV	Establish Milestones	Z5S1000	25FEB02A	01MAR02A	5
CAIN	ZOV	Identify Staffing	Z5S1100	25FEB02A	01MAR02A	5
CAIN	ANR	Quality Control Plan	Z5S1200	25FEB02A	08MAR02A	10
CAIN	HARK	Structural Work Plan	Z5S1300	25FEB02A	08MAR02A	10
CAIN	TDS	Civil Work Plan	Z5S1400	25FEB02A	08MAR02A	10
CAIN	LEP	H-H Work Plan	Z5S1500	25FEB02A	08MAR02A	10
CAIN	BUC	E&M Workplan	Z5S1600	25FEB02A	08MAR02A	10
CAIN	CARN	Cost Work Plan	Z5S1700	25FEB02A	08MAR02A	10
CAIN	BRO	Geotech Work Plan	Z5S1800	25FEB02A	08MAR02A	10
CAIN	HARK	CADD Work Plan	Z5S1900	25FEB02A	08MAR02A	10
CAIN	ZOV	Combine Work Plans	Z5S2000	15MAR02A	15MAR02A	5
CAIN	ZOV	Presentations	Z5S2100	20MAR02A	21MAR02A	5
CAIN	ZOV	Presentations Finish Milestone	Z5S2110		21MAR02A	0
Atlantic - Dev. of Design Criteria - Task #2						
CAIN	HARK	Structural Criteria	Z5S2200	25FEB02A	25MAR02A	21



Start Date	28FEB01	S03A - PAN5
Finish Date	23JUL03	
Data Date	28FEB03	
Run Date	25MAR03 14:32	

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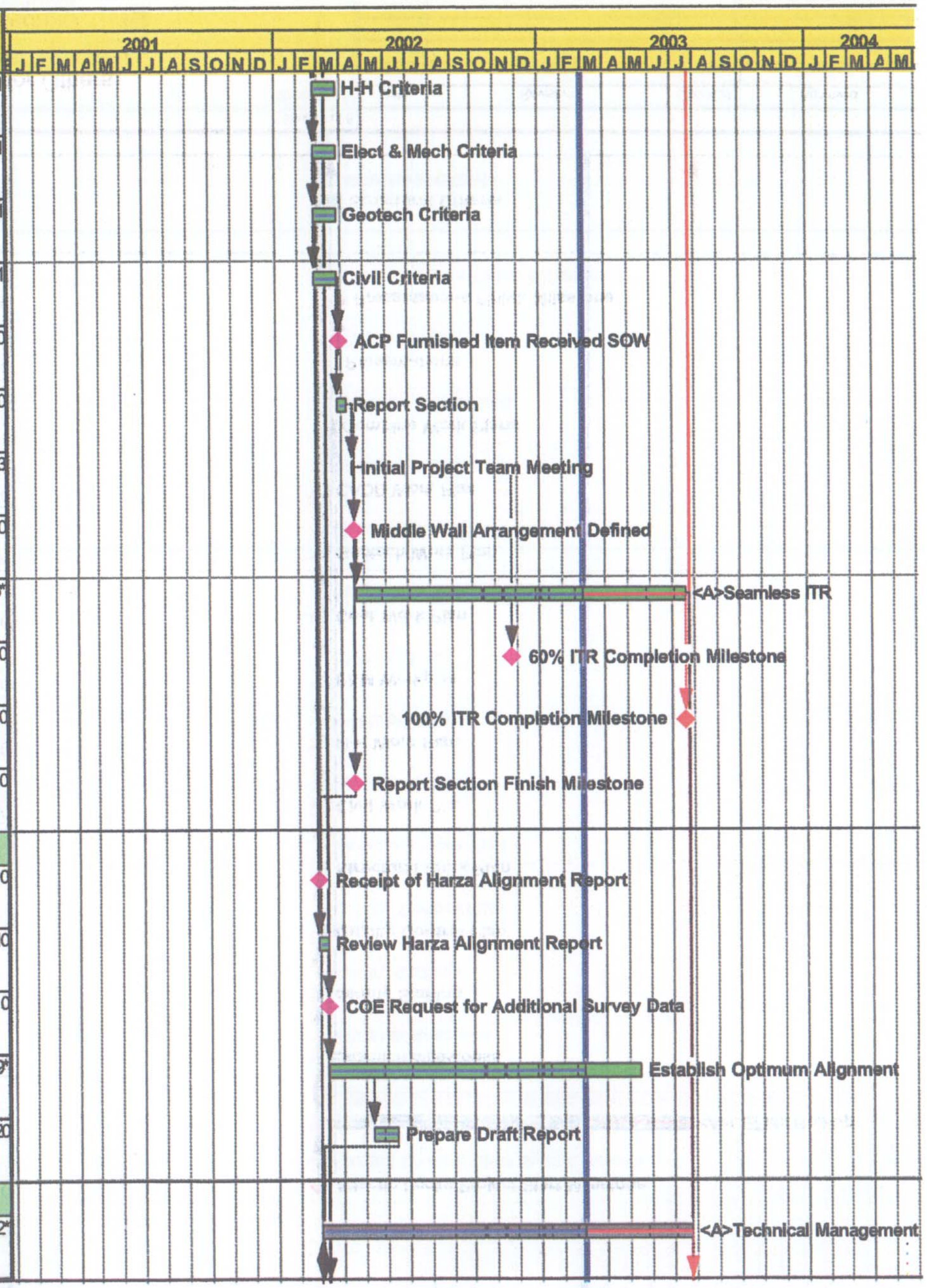
Support/Work for Others

Project Schedules

Date	Revision	Checked	Approved

Project Manager	KEYT	Activity Description	Activity ID	Early Start	Early Finish	Orig Dur
CAIN	LEP	H-H Criteria	Z5S2300	25FEB02A	25MAR02A	21
CAIN	BUC	Elect & Mech Criteria	Z5S2400	25FEB02A	25MAR02A	21
CAIN	BRO	Geotech Criteria	Z5S2500	25FEB02A	25MAR02A	21
CAIN	TDS	Civil Criteria	Z5S2600	25FEB02A	25MAR02A	21
CAIN	ZOV	ACP Furnished Item Received SOW	Z5S2610		29MAR02A	0
CAIN	ANR	Report Section	Z5S2700	26MAR02A	08APR02A	10
CAIN	ZOV	Initial Project Team Meeting	Z5S2705	17APR02A	19APR02A	3
CAIN	HARK	Middle Wall Arrangement Defined	Z5S2705.5		19APR02A	0
CAIN	ZOV	<A>Seamless ITR	Z5S2706	22APR02A	18JUL03	313*
CAIN	ZOV	60% ITR Completion Milestone	Z5S2707		22NOV02A	0
CAIN	ZOV	100% ITR Completion Milestone	Z5S2708		18JUL03	0
CAIN	ANR	Report Section Finish Milestone	Z5S2710		19APR02A	0
Atlantic - Optimize Alignments - Task #3						
CAIN	TDS	Receipt of Harza Alignment Report	Z5S2849		25FEB02A	0
CAIN	TDS	Review Harza Alignment Report	Z5S2850	26FEB02A	11MAR02A	10
CAIN	TDS	COE Request for Additional Survey Data	Z5S2855		11MAR02A	0
CAIN	TDS	Establish Optimum Alignment	Z5S2860	12MAR02A	16MAY03	299*
CAIN	TDS	Prepare Draft Report	Z5S2870	13MAY02A	14JUN02A	20
Atlantic - Design of Project Features - Task #4						
CAIN	ZOV	<A>Technical Management	Z5S2790	01MAR02A	23JUL03	352*



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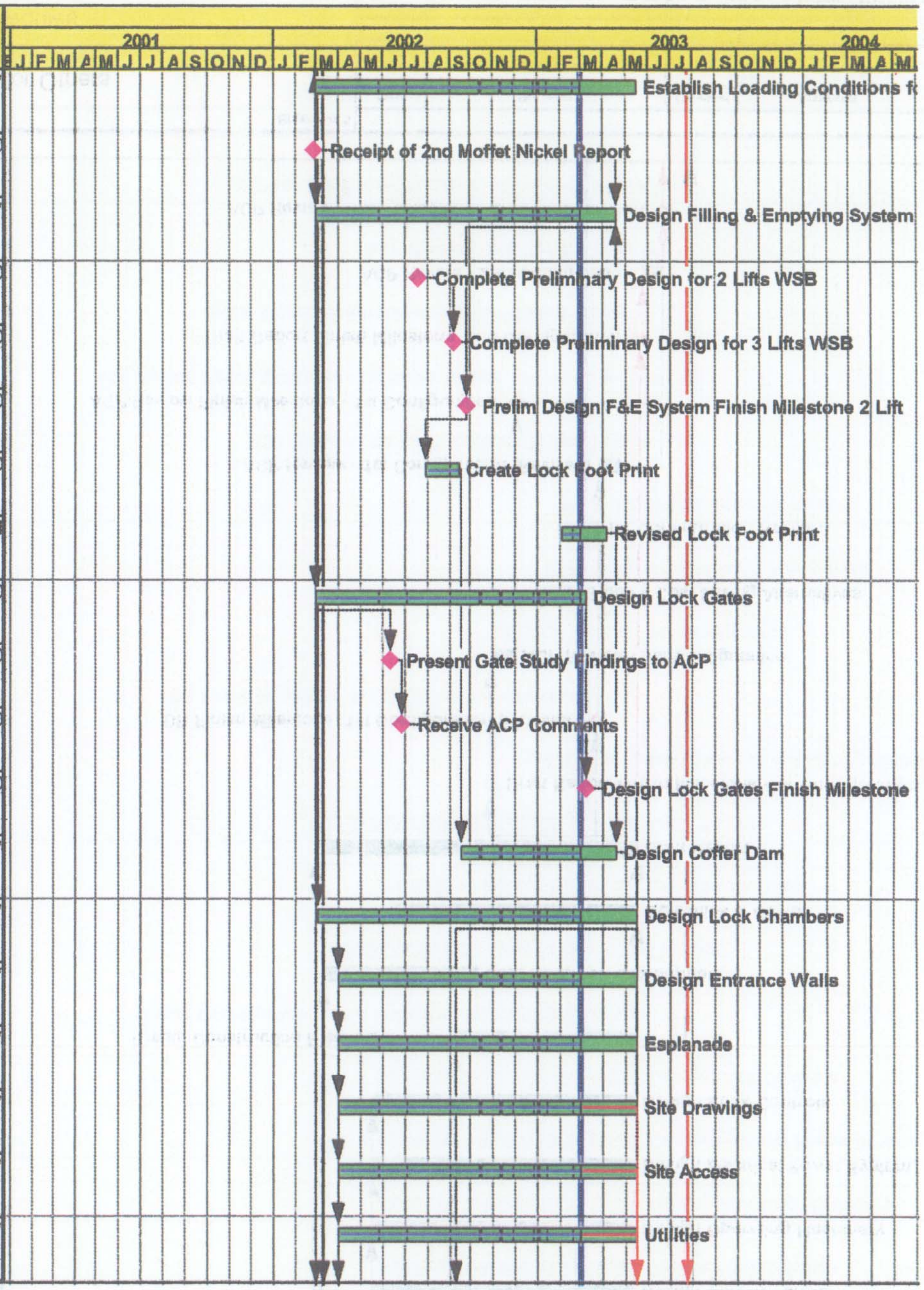
Support/Work for Others

Project Schedules

Date	Revision	Checked	Approved

Project Manager	KEYT	Activity Description	Activity ID	Early Start	Early Finish	Orig Dur
CAIN	BRO	Establish Loading Conditions for Design of Walls	Z5S2800	01MAR02A	16MAY03	306*
CAIN	ZOV	Receipt of 2nd Moffet Nickel Report	Z5S2806		25FEB02A	0
CAIN	LEP	Design Filling & Emptying System with WSBs	Z5S2810	01MAR02A	18APR03	286*
CAIN	LEP	Complete Preliminary Design for 2 Lifts WSB	Z5S2810.2		19JUL02A	0
CAIN	LEP	Complete Preliminary Design for 3 Lifts WSB	Z5S2810.4		06SEP02A	0
CAIN	LEP	Prelim Design F&E System Finish Milestone 2 Lift	Z5S2811		23SEP02A	0
CAIN	TDS	Create Lock Foot Print	Z5S2830	30JUL02A	13SEP02A	10
CAIN	TDS	Revised Lock Foot Print	Z5S2835	03FEB03A	04APR03	44
CAIN	HARK	Design Lock Gates	Z5S2840	01MAR02A	07MAR03	250
CAIN	HARK	Present Gate Study Findings to ACP	Z5S2842		10JUN02A	0
CAIN	HARK	Receive ACP Comments	Z5S2844		25JUN02A	0
CAIN	HARK	Design Lock Gates Finish Milestone	Z5S2848		07MAR03	0
CAIN	HARK	Design Coffer Dam	Z5S2900	16SEP02A	18APR03	148*
CAIN	HARK	Design Lock Chambers	Z5S3000	04MAR02A	16MAY03	306*
CAIN	HARK	Design Entrance Walls	Z5S3100	02APR02A	16MAY03	284*
CAIN	TDS	Esplanade	Z5S3500	02APR02A	16MAY03	284*
CAIN	TDS	Site Drawings	Z5S3600	02APR02A	16MAY03	284*
CAIN	TDS	Site Access	Z5S3700	02APR02A	16MAY03	284*
CAIN	TDS	Utilities	Z5S3800	02APR02A	16MAY03	284*



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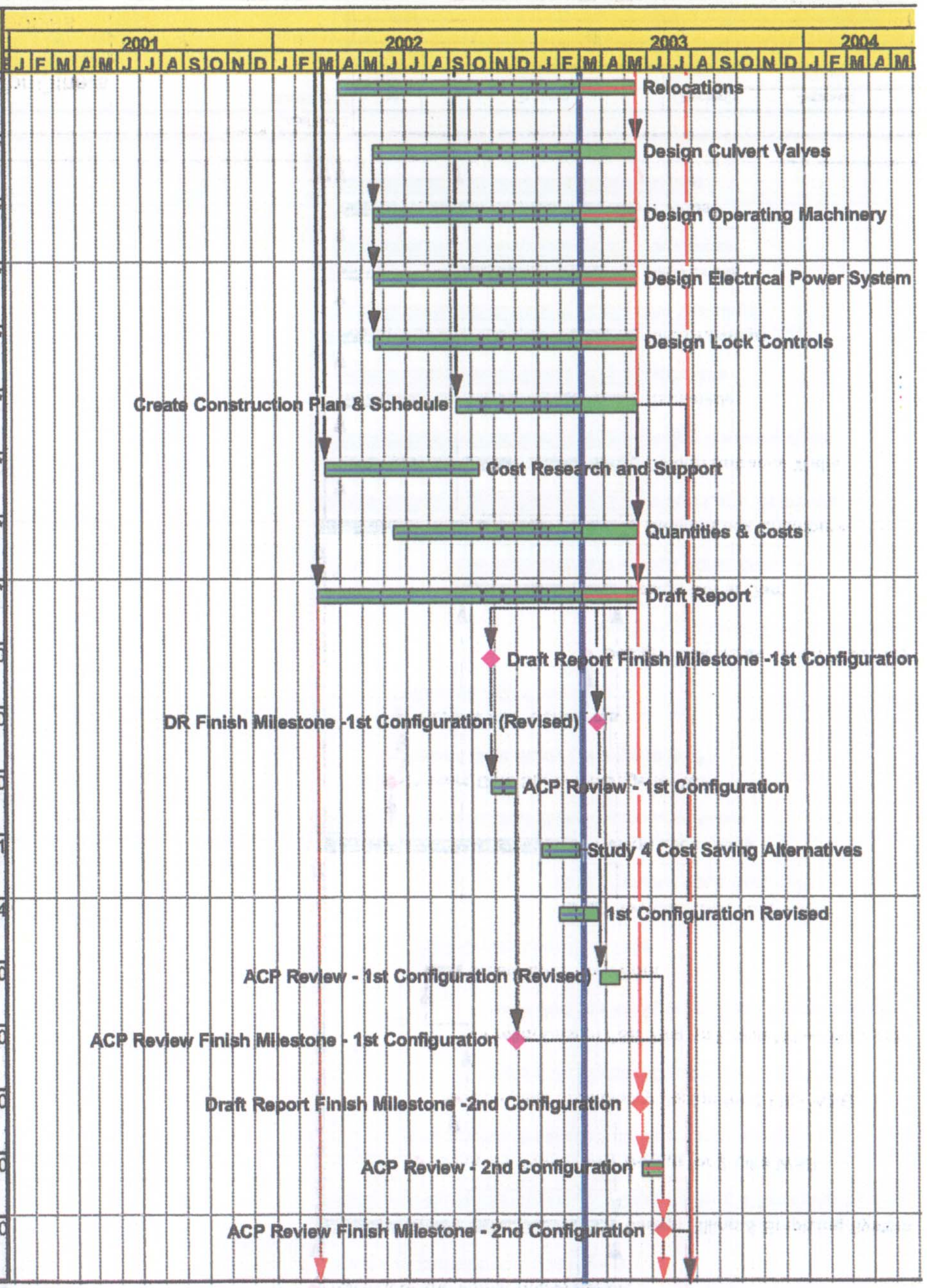
Support/Work for Others

Project Schedules

Date	Revision	Checked	Approved

Project Manager	KEYT	Activity Description	Activity ID	Early Start	Early Finish	Orig Dur
CAIN	TDS	Relocations	Z5S3805	02APR02A	16MAY03	284*
CAIN	HARK	Design Culvert Valves	Z5S3810	20MAY02A	16MAY03	250*
CAIN	BUC	Design Operating Machinery	Z5S3820	20MAY02A	16MAY03	250*
CAIN	NIT	Design Electrical Power System	Z5S3830	20MAY02A	16MAY03	250*
CAIN	GAD	Design Lock Controls	Z5S3840	20MAY02A	16MAY03	250*
CAIN	ANR	Create Construction Plan & Schedule	Z5S4600	10SEP02A	16MAY03	172*
CAIN	CARN	Cost Research and Support	Z5S4610	11MAR02A	09OCT02A	150*
CAIN	CARN	Quantities & Costs	Z5S4700	14JUN02A	16MAY03	232*
CAIN	ANR	Draft Report	Z5S4800	01MAR02A	16MAY03	306*
CAIN	ZOV	Draft Report Finish Milestone -1st Configuration	Z5S4810		25OCT02A	0
CAIN	ZOV	DR Finish Milestone -1st Configuration (Revised)	Z5S4815		21MAR03	0
CAIN	ZOV	ACP Review - 1st Configuration	Z5S4900	25OCT02A	27NOV02A	20
CAIN	HARK	Study 4 Cost Saving Alternatives	Z5S4902	02JAN03A	21FEB03A	21
CAIN	ZOV	1st Configuration Revised	Z5S4904	27JAN03A	21MAR03	34
CAIN	ZOV	ACP Review - 1st Configuration (Revised)	Z5S4906	24MAR03	18APR03	20
CAIN	ZOV	ACP Review Finish Milestone - 1st Configuration	Z5S4910		27NOV02A	0
CAIN	ZOV	Draft Report Finish Milestone -2nd Configuration	Z5S4920		16MAY03	0
CAIN	ZOV	ACP Review - 2nd Configuration	Z5S4930	19MAY03	16JUN03	20
CAIN	ZOV	ACP Review Finish Milestone - 2nd Configuration	Z5S4940		16JUN03	0



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Support/Work for Others

Project Schedules

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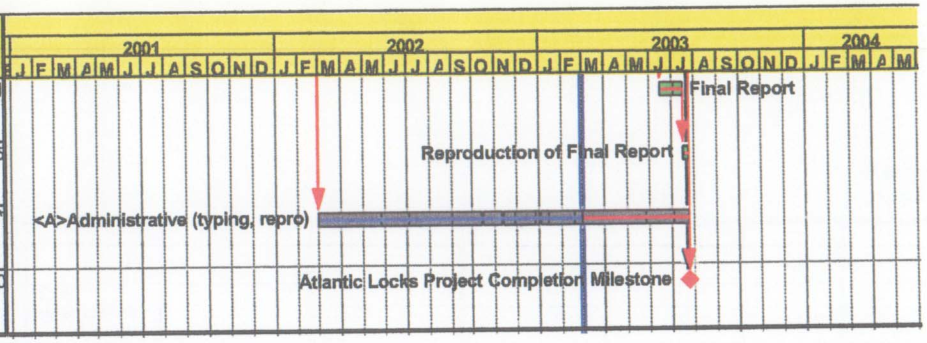
Project Manager	KEYT	Activity Description	Activity ID	Early Start	Early Finish	Orig Dur
CAIN	ANR	Final Report	Z5S5100	17JUN03	16JUL03	21
CAIN	ZOV	Reproduction of Final Report	Z5S5105	17JUL03	23JUL03	5
CAIN	ZOV	<A>Administrative (typing, repro)	Z5S5300	01MAR02A	23JUL03	352*
CAIN	ZOV	Atlantic Locks Project Completion Milestone	Z5S5400		23JUL03	0



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Support/Work for Others

Project Schedules

Date	Revision	Checked	Approved

Oversight Committee	**Larry Seals P.E., Byron Foster P.E., Anjana Chudgar P.E.**

Progect Manager	**Leo Cain**
Technical Manager	**Frank Zovack** (Andy Harkness - alternate)

Major Disciplines	**H&H**	**Structural**		**Geology**	**Soils**	**Civil**	**Mech**	**Elec**	**Costs**	**Tech/Writer**	**Arch**	**Operations & Maintenance**
Technical Lead	Walter Leput CELRP	William A. Harkness CELRP *Structural Systems*		James F. Brown CELRP	David Carlson CELRP	Terry Shilley CELRP	David Buccini CELRP	John Nites CELRP *Power Distribution*	Paula Boren CELRP	Thomas Andre CELRP	Larry Cozine CELRL	
Production Team Members	Raymond Povirk CELRP *F/E System Lead*	Richard Allwes CELRP *Lock Masonry Design*	Bob Ebeling ERDC *Design Wall Loading Conditions*	Andrew Schaffer CELRP *Rock Mechanics*	Carol Tasillo CELRP *Concrete & Mtrls*	Silvio Iera CELRP *In-Roads*		Ronald Gadomski CELRP *Electronics & Controls*	Craig Carney CELRP *Cost/Navigation*			
	David Margo CELRP *F/E System*	Kenneth Hull CELRN *General Structural Engineering*	Robert Hall ERDC *Design Wall Loading Conditions*	Brian Greene CELRP *Foundations*		*Dee Marciniak* *CELRP* *In-Roads Specialist*		Andy Schimpf CEMVS *Electronics & Controls*	Frank Likar CELRP *Cost/Navigation*			
	Mark Zaitsoff CELRP *F/E System WSB*	Doug Kish CELRH *Lock Gates*	Robert Patev CENE *Design Wall Loading Conditions*	Kathleen Bensko CELRP *Geologic Site Characterization*					Gary Stinson CELRN *Cost/Navigation*			
	John Hite ERDC *F/E System*	Pedro Luciano CELRH *Valves*	Terry Sullivan CELRL *Approach Walls, Design Wall Loading Conditions*						Joseph H. Ellsworth Jr CESAM *Cost/Central America*			
	Richard Stockstill ERDC *LOCKSIM*	Marine Design Center *Naval Architecture*	Carl Johnson CEMVR *Steel Structures, Gates*						Bill Griffin CESAM *Cost/Central America*			
	Steve Maynord ERDC *Ship Movement*											
	Gerald A. Schohl TVA-WES *Consultant* *LOCKSIM*											

ITR Team	Gordon Lance CENWK	John Clarkson CELRH		Stephen Hornbeck CELRL	Jeffrey Schaefer CELRL *Soils*	Byron McClellan CELRL	James Pace SAD	Robert Fulton SAD	Martin Lockard CELRL			Bob Willis CELRL
	Coy Miller CELRH	Bryon McClellan CELRL			Bill Halczak CESPL *Concrete & Mtrls*	William Ddorsch CELRL						
		Thomas Sully CEMVP										

2/28/2003

Brief resume of key persons, specialists, and individual consultants anticipated for this project:

a. Name & Title:
Richard A. Allwes
Structural Engineer

b. Project Assignment:
Structural Design Team Member

c. Organization:
Structural Section, CELRP-ED-DS, Engineering Division, Pittsburgh District, U.S. Army Corps of Engineers

d. Years Experience: 21 1/2

With This Organization: 6 1/2 With Other Organizations: 15

e. Education: Degree(s)/Year/Specialization
BS Mathematics 1978 University of Pittsburgh, BS Mining Engineering 1981 University of Pittsburgh, MS Civil Engineering Carnegie-Mellon University 1989

f. Active Registration:
EIT 1996

First Year Registered/Discipline

g. Other Experience and Qualifications Relevant to the Proposed Project:

Arch Canopy Research Project, US Bureau of Mines, 1982-88: Developed a plastic design procedure for arch canopies constructed of steel liner plate and steel arch sets to resist the impact of massive roof falls occurring in underground coal mines. Full-scale arches were designed and dynamically tested to verify the design procedure.

Mine Shaft Remediation, US Bureau of Mines, 1992-94: Served as Technical Consultant to the Borough of North Arlington, NJ and provided assistance in the development of plans to remediate problem shaft areas, reviewed engineering designs for accuracy and code compliance, and field supervised the remediation work of 20 shafts, including the support and repair of residential structures.

Roof-Support Design, US Bureau of Mines, 1994: Served as the design engineer to rehabilitate the USBM Lake Lynn Facility following a massive roof fall. Responsible for final design and specifications for foundations and structures, and supervising construction of two concrete crib structures and reinforced concrete foundations.

Braddock Dam Left Abutment Wall, USACE, 1997-98: Developed final design and plans for the 550-ft long tied-back secant-pile wall to protect two elevated railways and the left bank and to permit the in-the-wet construction of new Braddock Dam. Design the drilled shafts, rock anchors, rock socket, and wall facing.

Johnstown LFPP, USACE, 1995-97: Designed gravity and tied-back concrete flood walls for the channels. Floodwalls were designed for both gravity and seismic loadings. Developed a computer program to facilitate the design.

Mahoning Dam, USACE, 1996: Designed the concrete replacement wall for the 36-in ring-jet valve.

ORMSS, USACE, 1997-2000: Developed reliability models for both gravity and anchored lock chamber monoliths for the Ohio River Main Stem Study. Provided technical support for in-house development of reliability models for miter gates and sills and for A/E development of reliability models for vertical lift gates. Participated on ITR team to assess the useful life of Chickamauga L&D, TVA. Assessed the reliability of the 52-strand rock anchors used in the Chickamauga Lock and Dam, TVA.

Charleroi Middle Wall Concept Study, USACE, 2001: Developing concept design and construction for the new middle lock wall using in-the-dry and in-the-wet construction methods.

Experience in steel design, concrete design, and foundation design, and rock anchor design. Experienced in using concrete and steel design codes. .Proficient in the use of the computer programs Microstation, Ansys & Algor (finite element analysis), Staad/Pro, Excel, @Risk, PCA COL, Visual Basic, and CASE Programs in design.

Brief resume of key persons, specialists, and individual consultants anticipated for this project:

a. Name & Title:
Thomas E. Andre
Civil Engineer

b. Project Assignment:
Technical Writer

c. Organization:
Design Branch, Technical Contract Support Section (CELRP-ED-DT)
Pittsburgh District, U.S Army Corps of Engineers

d. Years Experience:
With This Organization: 27 With Other Organizations:

e. Education: Degree(s)/Year/Specialization
BS Civil Engineering, Geneva College 1974
MS Industrial Engineering, Univ. of Pittsburgh, 1983

f. Active Registration:
Professional Engineer, Pennsylvania

First Year Registered/Discipline 1980/Engineering

g. Other Experience and Qualifications Relevant to the Proposed Project:

Twenty-six years experience as a Specifications Engineer. Responsible for preparing, correcting and reviewing construction specifications, including construction and rehabilitation of navigation structures; reviewing specifications prepared by A-E's and other Corps of Engineers Districts for the District. Major specification projects have included Rehabilitation of Locks and Dam 3, Monongahela River (1978), Emsworth Locks and Dams (1981), Montgomery Locks and Dam (1985), and Dashields Locks and Dam (1987), Ohio River; Construction of Stonewall Jackson Dam (1983), Grays Landing Lock (1990), Point Marion Lock (1990), Grays Landing Dam (1993), Monongahela River.

Previous experience with updating and reviewing of guide specifications and other technical criteria include, preparation of a model specification for maintenance painting for Ohio River Division (1986) based on Civil Works guide specifications to address conditions unique to the Division facilities; review of Draft ER 1110-2-1200 "Engineering Design Plans and Specifications" (1991); review of EC 1110-1-79 "Environmental Protection Guide Specifications" (1994); review with of Draft EM 1110-2-3400 "Painting: New Construction and Maintenance" (1994); and review of Corps of Engineers Advanced Materials Selection Guide (2001).

Participated in Quality Assurance review for Construction of North Fork Hughes River Dam for US Soil Conservation Service (1994). Independent Technical Review Coordinator for Construction of Braddock Dam (1998-99)

Currently Key Team Member for preparation of Unified Facility Guide Specifications for Soil and Rock Anchors and Concrete Rehabilitation.

Brief resume of key persons, specialists, and individual consultants anticipated for this project:

a. Name & Title:
Kathleen Bensko, P.G.
Construction Geologist

b. Project Assignment:
Geologic Site Characterization

c. Organization:
Pittsburgh District, US Army Corps of Engineers

d. Years Experience:
With This Organization: 16 With Other Organizations:

e. Education: Degree(s)/Year/Specialization
The University of Pittsburgh at Johnstown, 1982
BS Natural Sciences (Geology)

f. Active Registration:
Professional Geologist – 1995/Pennsylvania

First Year Registered/Discipline:

g. Other Experience and Qualifications Relevant to the Proposed Project

CONSTRUCTION DIVISION

Construction of New Gated Dam, Braddock Float-In Construction: Resident Geologist. Examined exploratory borings in order to determine final tip elevations of the drilled shafts to ensure competent rock foundations based on site-specific rock quality and features. Analyzed the geologic data from the exploratory drilling and sheet pile programs and developed the top of rock profiles at two cross-sectional locations. Determined the expected sheet pile refusal elevations and provided the required sheet pile lengths along the upstream and downstream cutoff walls. Provided geologic guidance to the contractor during drilled shaft drilling operations. Technical leader in post-tensioning of the bottom slabs of the dam segments, instrumentation, drilling operations, and analysis of drilled shaft Crosshole Sonic Logging test results

Construction of New Dam Abutments, Braddock Dam: Resident Geologist. Examined exploratory borings to fine-tune the final tip elevations of the drilled shaft elevations to ensure that the structural caissons were founded in competent rock. Developed and determined the top of rock profiles along both abutments to provide guidance to the contractor for casing refusal for the left abutment lagging caissons, the right abutment structural caissons, the right abutment sheet pile cutoff wall, and drilling operations. Oversaw the installation of 71 rock anchors through the left abutment structural drilled shafts and determined their acceptability based on the results of the proof and performance tests. Key player in determining necessary tolerance adjustments in order to avoid intersection with adjacent and future, lower row anchor locations. Responsible for overseeing the instrumentation program.

Johnstown Local Flood Protection Project: Resident Geologist. Provided technical guidance for acceptable rock bond zone material based on anchor core borings, drilling and installation procedures, and determined the acceptability of the results of proof and performance tests for 390 "passive" rock anchors installed under three separate contracts.

PEWARS New Dock Front Project: Resident Geologist. Provided technical guidance for the drilling methods and installation procedures for 22 "passive" rock anchors in the first phase of the project. Played an active role in determining an alternate method of stressing procedures in order for the job to progress when the contractor had a 50% failure rate of the anchors in the "passive" state, and offered the geologic analysis as to why these anchor casings had failed.

Gray's Landing Dam Construction, Point Marion Lock Construction, and Gray's Landing Lock Construction Projects: Resident Geologist. Responsible for all geologically related work features, and problems encountered during the construction process. Examined rock anchor core borings to determine the top of the anchor bond zone per monolith group, and the exploratory core borings to finalize the founding elevations for the rock foundation excavation limits of the lockwalls and dam. Recognized a sub-surface water feature resulting in adjusted rock anchor lengths, performed remedial grouting to stabilize a portion of the existing lockwall utilized as part of the cofferdam, and identified intersection points of 45 drilled caisson with respect to subsurface rock anchor locations. Directed the preparation of foundation rock surfaces including any additional rock removal and dental areas, reviewed and offered suggestions to blasting plans, offered solutions to water seepage problems (notably artesian flow problems), and directed stabilization methods for slope failures. Performed geologic mapping of all monolith foundations prior to concrete placement. Compiled all foundation data and records, and prepared comprehensive foundation reports

ENGINEERING DIVISION

East Branch Dam Foundation Seepage Analysis. Provided on-site rock core logging and interpretation and determined the locations of piezometers for the water seepage study. Developed cross sections and profiles correlating rock features and information gained from the piezometer borings, and prepared a written report with conclusions and recommendations concerning the seepage flows through the underbase rock strata.

Construction of New Dam Abutments, Braddock Dam. Designed the instrumentation program, and the secant wall weep holes for the Braddock Dam Left Abutment contract, prepared the pertinent specifications and cost estimate for this work. Provided guidance on constructability matters especially in the rock anchor construction sequencing.

Design of Braddock Dam and Charleroi Projects. Standardized the rock classifications for both projects to establish consistency in the rock type descriptions. Developed project cross-sections depicting the specific site geology that was utilized throughout the design process for both of these projects.

Brief resume of key persons, specialists, and individual consultants anticipated for this project:

a. Name & Title:
Paula G. Boren, P.E., C.C.E.
Chief, Cost Engineering & Support Branch

b. Project Assignment:

Senior Cost Engineer

c. Organization:
Cost Engineering & Support Branch
Pittsburgh District, US Army Corps of Engineers

d. Years Experience:
With This Organization: 21, With Other Organizations: 1

e. Education: Degree(s)/Year/Specialization
The Pennsylvania State University, 1979
BS Civil Engineering

f. Active Registration:
Professional Engineer

First Year Registered/Discipline
1985 – Pennsylvania/ Civil

g. Other Experience and Qualifications Relevant to the Proposed Project:

Ms. Boren has extensive experience in the Civil Works Cost Engineering Field. Specific areas of cost engineering expertise related to Lock and Dam design include: miter gates, tainter gates, dredging, various filling and emptying systems, bulkheads, mass concrete, pre-cast concrete, pre-stressed concrete, cofferdams, in-the-wet construction, rock anchors, and pile and caisson foundations. She is a Certified Tri-Service Cost Engineer and a member of the AACE International Cost Engineering organization. She also serves as an Instructor for the Cost Engineering Basics course taught under the Corps of Engineers PROSPECT program.

Ms. Boren currently holds the position of Chief, Cost Engineering & Support Branch, in the Engineering Division, U.S. Army Corps of Engineers, Pittsburgh District. In this position she supervises 6 professional and technical engineering personnel engaged in preparing all construction cost estimates in the District. She formulates policies, procedures, develops criteria, schedules and integrates the entire District cost engineering effort. Ms. Boren has served as an expert on cost engineering providing advisory service to all District elements on complex or controversial matters. She has been responsible for conceptual, feasibility, competitive bid, and negotiated estimates for numerous navigations locks, navigation dams, flood control dams, flood protection projects and other civil works activities.

US Army Corps of Engineers, New Gated Dam, Braddock Locks and Dam, Monongahela River. Ms. Boren served as the senior cost engineer for this $130,000,000 innovative navigation dam on the lower Monongahela River. The project was designed for "float-in" construction methods where large concrete shells (106'x340'x30') are constructed at a remote site in dry conditions and then floated to the project site on the inland navigation system. Ms. Boren prepared the concept design cost estimates for this work applying contingencies as appropriate. She supervised a four-member estimating team that produced detailed schedules and estimates for the final design and provided support for the Best Value Procurement Process.

US Army Corps of Engineers, Lock and Dam 4 on the Monongahela River. She is the senior cost engineer responsible for estimating support for design of new twin lock chambers. Project construction cost is approximately $265,000,000. Provided cost assistance during the investigation of the use of innovative design features such as "float-in" and "lift-in" precast concrete lock walls founded on high capacity drilled shaft foundations constructed in the wet without cofferdams. This effort has reduced project costs by minimizing the need for construction of cofferdams.

US Army Corps of Engineers, Point Marion Lock and Grays Landing Lock and Dam. Ms. Boren was the senior cost engineer responsible for estimating these projects from feasibility stage through detailed bid opening estimates. She also provided estimating support throughout construction by preparing modification estimates over $100,000.

US Army Corps of Engineers, Emsworth Lock and Dam Rehabilitation Evaluation Report. Supervised development of estimates for reliability analysis and rehabilitation of the mechanical features of the Dam.

Brief resume of key persons, specialists, and individual consultants anticipated for this project:

a. Name & Title:
James F. Brown

b. Project Assignment:
Engineering Geologist

c. Organization:
Geotechnical Branch, Pittsburgh District

d. Years Experience: 33
With This Organization: 23 With Other Organizations: 10

e. Education: Degree(s)/Year/Specialization
Bachelor of Science, Geology 1967
University of Pittsburgh
Groundwater Hydrology, Wright State University (correspondence) 1998
GIS Certification Coursework 1998 Pennsylvania State

f. Active Registration:
Registered Professional Engineer, Pennsylvania
Registered Professional Geologist, Pennsylvania

First Year Registered/Discipline 1975

g. Other Experience and Qualifications Relevant to the Proposed Project:

September 1967 to June 1978- Geotechnical Engineer with the Pennsylvania Department of Transportation in Pittsburgh, PA. Conducted geotechnical engineering site investigations at varying levels of detail for highway and bridge projects. These projects ranged from final design of shorter sections of highway to corridor studies of proposed highway relocations. The studies involved field geologic investigations, planning and supervising drilling operations and writing final reports for cut slope and foundation design.
Conducted site investigations and subsurface exploration planning for a large number of landslide repair projects

June 1968 to June 1970- Soils Analyst in U.S. Army in Fort Carson CO. and Republic of South Vietnam. Quality control testing on airfield and roadway projects in the Republic of South Vietnam.

June 1978 to September 1978- Geotechnical Engineer with Pittsburgh Testing Laboratory, Pittsburgh, PA. Performed geotechnical investigations for small commercial structures and stability analyses for coal company disposal areas.

September 1978 to Present- Geotechnical Engineer with the U.S. Army Corps of Engineers. Served in the Soils Section and Geology Section of the Geotechnical Branch at various positions with increasing levels of responsibility. Currently, as senior staff geologist, functions as a project engineering geologist responsible for developing geotechnical design studies, analyses, computations, boring programs and final foundation design for major navigation and flood control projects. Plan and supervise the preparation of boring log drawings, geologic sections and coordinate the work of subordinate geologists and other technical employees engaged in the design of major projects. Prepare the geotechnical sections of contract specifications for major navigation and flood control structures. Acts as chief of the section in the absence of the Section Chief.

SIGNIFICANT ASSIGNMENTS

Foundation Design 1986 – 1990:Grays Landing Lock and Dam. Included geologic mapping, subsurface exploration planning and fieldwork and cut slope design. 1996-1999:Charleroi Locks and Dam Geology and Foundations Design Memorandum: Work included initial geologic mapping, preparation of boring plans for several phases of work, analysis of the boring information, layout of sections and profiles for final report and overall foundation characterization for final report. 1998 Lake Girard Dam Geologic investigation of old concrete dam for upgrade to meet current safety criteria. Review of existing plans and layout of initial subsurface investigation.

Geologic Site Characterization:1991-Lower Monongahela River Navigation System Feasibility Study, Geotechnical Appendix. Feasibility level characterization of six potential dam locations, preparation of limited boring program, analysis of results and preliminary foundation recommendations for final report. 1996 National Park Service Friendship Hill Historic Site Geotechnical Foundation Investigation. Work involved planning remedial measures to save an historic structure from slope failure. Include site characterization, potential mine subsidence and rock slope failure.
1999 Panama Western Watershed Prepared boring plans and the drilling contract for the initial studies of three large dams and three associated saddle dams in Panama. This work involved review of existing geologic data on the study area, a field visit to proposed locations, and submission of the completed plans to the Panama Canal Authority.

Concrete Materials Memoranda:1982 Stonewall Jackson Dam 1987 Grays Landing and Point Marion Locks 1997 Locks and Dam 2, 3 and 4 Monongahela River. Work included regional assessment of stone sources, field investigation and sample selection of individual quarries, analysis of test results and final reports with recommended stone sources.

Brief resume of key persons, specialists, and individual consultants anticipated for this project:

a. Name & Title:
David L. Buccini
Senior Mechanical Engineer

b. Project Assignment:
Mechanical Engineering – Technical Lead

c. Organization:
Design Branch, Engineering Division,
Pittsburgh District, US Army Corps of Engineers

d. Years Experience:
With This Organization: With Other Organizations:

e. Education: Degree(s)/Year/Specialization
Bachelor of Science, Mechanical Engineering West Virginia University, Morgantown, WV

f. Active Registration:

g. Other Experience and Qualifications Relevant to the Proposed Project:

Developed plans and specifications of mechanical features for the major rehabilitation of Montgomery Locks and Dam.

Developed plants and specifications of mechanical features for the major rehabilitation of Dashields Locks and Dam.

Developed plans and specifications of mechanical features for the construction of Point Marion Lock.

Developed plans and specifications of mechanical features for the construction of Grays Landing Lock and Damn.

Developed plans and specifications for the mechanical rehabilitation of Lock #4 on the Allegheny River. This is the first lock to use self-contained hydraulic actuators for the operating machinery. These actuators incorporate the hydraulic power unit and hydraulic cylinder into a single submersible unit that is connected directly to the miter gate.

Developed plans and specifications for retrofitting state of the art ring-jet valves used for throttling low flow discharges at Mahoning, Tygart and Berlin flood control dams.

Developed plans and specifications for the mechanical rehabilitation of Lock #5 on the Allegheny River.

Developed plans and specifications for innovative vertical lift gate machinery for Emsworth Dam. This machinery utilizes an automatic staging system for each hydraulic cylinder that allows cylinders with a 20-foot stroke to raise the lift gates forty feet vertically.

Key team member on lock automation study to evaluate the feasibility of automation and remote control of Locks 2 thru 9 on the Allegheny River. Visited locks and ship lifts with state of the art automation and remote control.

Brief resume of key persons, specialists, and individual consultants anticipated for this project:

a. Name & Title:

David E. Carlson

Chief, Soils Section, Geotechnical Branch

b. Project Assignment:

Geotechnical Engineer

c. Organization:

Pittsburgh District, U.S. Army Corps of Engineers

d. Years Experience:

With This Organization: 17 With Other Organizations:

e. Education: Degree(s)/Year/Specialization

B.S.E.M 1982 Engineering of (Surface) Mines , West Virginia University

M.S.C.E 1992 Civil Engineering (Geotechnical) University of Pittsburgh, PA

f. Active Registration: First Year Registered/Discipline

1995 Professional Engineer #PE-048769-E Pennsylvania

g. Other Experience and Qualifications Relevant to the Proposed Project:

Throughout my 17 year career with the Corps of Engineers, I have been directly involved in all planning and design efforts related to the construction of Pittsburgh District water resources projects, including Navigation Locks and Dams, Flood Control Reservoirs, Local Flood Control Projects, and Environmental Restoration Projects. My involvement in these projects include geotechnical investigations, subsurface explorations, geotechnical design, preparation of geotechnical reports and appendices, for Concept Studies, Reconnaissance Studies, Feasibility Reports, Design Memorandums, contract plans and specifications, and O&M rehabilitations. I have conducted Dam Safety Inspections, and provided extensive E&D during construction. Specific Projects Include:

Braddock Dam: Design activities included evaluation of alternatives for Feasibility Study, selection of site access routes, off-loading and staging areas, disposal sites, and concrete batch plant areas, formulation of subsurface investigations for drilled shaft foundation system along dam alignment, geotechnical oversight of instrumented caisson load test, stability analysis and instrumentation of elevated railroad embankment adjacent to deep abutment excavation in soil, development of soil parameters and backfill requirements for anchored wall on abutment, design of granular filter for seepage and piping control, design of scour protection requirements below dam, and E&D support to resident engineer during construction for contractor work plan reviews, technical clarifications, and coordination with State Environmental Protection Office for permit compliance related to Erosion and Sediment Control and Storm water run-off from the concrete plant and construction areas.

Grays Landing L/D: Design activities included formulation and oversight of subsurface explorations, slope stability analysis for Lock Approach excavations and approach channel dredging, design and layout of upstream navigation approach dikes, design of lockwall backfill requirements, computation of material quantities for stone riprap, backfill, excavation, stability analysis of the 3-stage cellular cofferdam system, design of cofferdam instrumentation system, design of steep hillside cut on abutment, design of concrete plug and clay seepage barrier for abutment mine seal, design and layout of 2 disposal sites, preparation of NPDES permit applications for earth disturbance activities, and geotechnical design support for all highway and railroad relocations and riverbank stability monitoring, and preparation of plans and specifications for all contract activities listed above.

McAlpine Lock: Geotechnical ITR Team Member for review of Lock Design Memorandum, Cofferdam construction contract, and Lock Construction Contract. Also assumed role as Pittsburgh District liaison for coordination of review work with between LRL Design Team and LRP ITR members.

Brief resume of key persons, specialists, and individual consultants anticipated for this project

a. Name & Title:
Craig R. Carney
Cost Engineer,

b. Project Assignment:
Cost and Value Engineering Team

c. Organization:
Cost Engineering and Support Branch, Engineering Division, Pittsburgh District, U.S. Army Corps of Engineers

d. Years Experience:
With This Organization: 8 With Other Organizations:

e. Education: Degree(s)/Year/Specialization
BS Degree in Civil Engineering, 1994, University of Pittsburgh, Pittsburgh, PA

f. Active Registration:

Engineer-In-Training, 1995, Civil Engineer, Pennsylvania

f. Other Experience and Qualifications Relevant to the Proposed Project:

- Recently served as the team leader of the Cost Engineering and Value Engineering Team, overseeing and supporting the work efforts of 3 cost engineers, 1 value engineer, 1 co-op student, and 1 engineer technician. Had to review numerous cost estimates, provide assistance in preparing cost estimates, as well as distributing work and budgeting labor costs as part of this assignment.

- As a Civil/Cost Engineer I have had to plan, coordinate, and prepare all phases of cost estimates for complete conventional projects, and larger and more complex construction projects. I have also prepared technical analyses and participated as a team member for construction contract and modifications negotiations.

- Have prepared cost estimates (individual or as part of a team) for the following Projects:

Construction of New Gated Dam at Braddock Locks and Dam – part of a team that prepared the Construction Estimate and Schedule for this innovative project involving float-in construction. Estimated the cost of the structural caisson foundation system for the dam, as well as the access tower and various other items.

Mon River L/D 2 Abutment and Upper Guard Wall – Served as the lead cost engineer. Prepared the Construction Estimate for the modifications to the existing Upper Guard Wall.

Emsworth Dam Rehabilitation Evaluation Report – Served as the lead cost engineer in preparing the fully funded Total Project Cost Estimate for rehabilitating the Dam and Stilling Basin at Emsworth.

Nine Mile Run Ecosystem Restoration Report – Serving as the lead cost engineer. Work included preparing the fully funded Total Project Cost Estimate for this innovative ecosystem restoration project. Project involves restoring an urban stream by realigning it and controlling the flow to minimize spikes in flow.

Nanty Glo Ecosystem Restoration Report – Served as the lead cost engineer. Prepared the fully funded Total Project Cost Estimate for this acid mine drainage abatement project.

Electrical and Mechanical Rehabilitation and Concrete Repair, L/D 5 Allegheny River – Served as the lead cost engineer and prepared the Construction Cost Estimate for this lock rehabilitation project.

Serving as the cost team member on the Pittsburgh District ORMSS team. The Pittsburgh District ORMSS (Ohio River Main Stem Study) team is studying the District's three aging lock and dam facilities on the Ohio River to determine what is required (rehabilitation/replacement) to keep the Ohio River navigable.

Prepared concept level estimates for the Allegheny River Lock Automation Study. Study looked into automating the locks on the Allegheny River to allow for control from a remote location.

Have prepared various procurement estimates for items such as miter gates and floating mooring bits.

Brief resume of key persons, specialists, and individual consultants anticipated for this project:

a. Name & Title:

Anjana K. Chudgar
Subject Matter Expert

b. Project Assignment:
Structural Engineer and Technical Specialist

c. Organization:
Louisville District, U.S. Army Corps of Engineer

d. Years Experience: 23
With This Organization: 22 With Other Organizations: 1

e. Education: Degree(s)/Year/Specialization
B.E. Civil Engineering 1968
M.E. Civil Engineering 1973

f. Active Registration:
YES

First Year Registered/Discipline 1983 P.E. Civil Engineering

g. Other Experience and Qualifications Relevant to the Proposed Project:

I have worked with Corps of Engineer since 1979 at Louisville District and Ohio River Division. During my career with Corps I have been responsible to develop design criteria and design procedures for highly specialized, complex structural features. Performed quality assurance, quality control, and independent technical review (ITR), and ITR team leader of design, plans and Specification and design analyses for civil and military projects. Coordinate, consult, and advise structural design with the functions of other organizational segments. Recommend and coordinate action with expert consultants and maintains liaison and correspondence with scientists and engineers in other organization.

HQUSACE Guidance Program:
Develop, review, manage and coordinate HQUSACE guidance programs on: Navigation Locks Design (1995); Earthquake Design and Evaluation for Civil Work Projects (EQEN –1995); Seismic Design of Reinforced Concrete Locks (Chair – 1995); Response Spectra and Seismic Analysis for Concrete Hydraulic Structure (1999); Time History Dynamic Analysis of Concrete Hydraulic Structure (2000); Structural Design and Evaluation of outlet works (2001); Innovation in navigation structures (INP – 1993 & 1996); Innovation in Navigation Structures (INP – 1993 & 1996); Soil structural interaction, Pile Foundation and Load Factor for Seismic Load (work in progress); Nonlinear incremental structural analysis (1994); Barge impact (BI – 2001).
Providing guidance and review on BI, INP AND EQEN to the districts in CELRD and CEMVD. Member or massive concrete structure task group, Chair of SSI task group and field review group member for R&D in EQEN and INP.

Olmsted Locks and Dam:
Develop structure design criteria for GDM and FDM for locks and dam. Developed W-Frame type locks structure. Performed response spectra analysis for locks and dam. Involve with WES and AE for the earthquake ground motion, probabilistic seismic hazard analysis, barge impact, soil structural interaction, instrumentation for pile load testing, seismic and dynamic analyses including time history and response spectra analyses, innovative design and construction and nonlinear incremental structural analysis. Review cofferdam design.

Review, Guidance, Develop design criteria and design procedure for the following Locks and Dam projects:
McAlpine Lock Replacement, Kentucky Lock Addition, Braddock Lock and Dam, Grace Landing Lock Addition, Point Marion Lock Addition, R.C. Byrd Locks, Winfield Locks and Dam, Marmet Lock Addition, Kentucky and Wabash River Locks, Upper Mississippi River Locks, Inner Harbor Navigation Lock.

Special Assignments:
San Francisco – Oakland Bay Bridge. COE were asked by the White House National Development Council to perform the review of the highly technical an earthquake related controversial issues raised by the City of San Francisco, California State, Federal Highway, and Navy. Lead the retrofit team, outline the report and coordinated both phase of the report with all the disciplines.

Chickamauga Lock Study. Lock has a long history of problems associated with concrete expansion form Alkali-Aggregate Reaction. The COE was asked to perform an independent technical review of TVA's analysis of the lock condition and predicted closure date. Lead finite element modeling and analysis review.

Professional Development Assignment HQUSACE. Develop engineering policy and guidance memorandums for ER 1110-2-1806, Completed report on safety inspection and evaluation of dewatering stoplogs and bulkhead, Develop an outline and first draft for EP on design and construction of INP including a letter on innovative R&D needs for the three division directors to signed, outline revision to BI ETL.

Brief resume of key persons, specialists, and individual consultants anticipated for this project:

a. Name & Title:
John D. Clarkson, P. E.
Chief, Structural Section

b. Project Assignment:
Independent Review Team - Structural

c. Organization:
Huntington District, US Army Corps of Engineers

d. Years Experience:
With This Organization: 18 With Other Organizations: 1

e. Education: Degree(s)/Year/Specialization:
Masters of Science in Engineering Management, 1992, College of Graduate Studies, Institute, WV
Bachelor of Science in Civil Engineering, 1980, West Virginia University

f. Active Registration:
Registered Professional Engineer (PE), West Virginia, June 1987, #010247

g. Other Experience and Qualifications Relevant to the Proposed Project:
AWARDS
PIANC Congress – Paper on Innovative Navigation Design – 2002
Great Lakes and Ohio River Division Designer of the Year - 1999.
Hammer Award awarded by Vice President Gore - 1997.
Named in the Top 25 Engineers by Engineering News Record - 1996.
Ohio River Division Designer of the Year – 1996

1. Nov 1992 - Present, Chief Structural Engineer, GS-0810-13, US Army Corps of Engineers, Huntington District, Engineering Division, Design Branch, Structural Section, 502 Eighth Street, Huntington, WV 25701, Coy W. Miller, 304-529-5202. As Chief of the Structural Section I direct and coordinate the work of 28 employees in the section. I am responsible for all job assignments, establishment of schedules, manpower projections and conceptualization of major features of projects. I assign all work to subordinates based on priority, difficulty, and individual capabilities and assure timely performance of a satisfactory amount and quality of work. I resolve issues and make interpretations on overall policy. I review all outgoing work for compliance with established principles and regulations and advise the Design Branch Chief on planning and programming during preliminary development of projects and establishing scopes or work. I supervise and review the work completed by other districts or A-E's. I provide periodic work progress to superiors and senior staff, coordinate the section's work relationship to broader programs, and independently carry out assignments through to completion. I interview candidates for positions and recommend selections for employment. I am also serving on the Army Performance Improvement Criteria Team to guide the District's senior leaders on large scale organizational change.

2. Nov 1988 - Nov 1993, Structural Engineer, GS-0810-12, William D. Barnes, retired. I directed, coordinated, and performed design work to prepare design memoranda and contract plans and specifications for all structural navigation features of District projects. I directed work (drafting and computations) of lower graded employees assuring they have sufficient guidance to work. I performed layout of navigation features. I assisted construction personnel with technical field problems. I worked with other engineering disciplinary fields to determine, coordinate, and review design requirements. I was the lead engineer writing the Engineering Appendix for Marmet L&D.

3. May 1985 - Nov 1988, Structural Engineer, GS-0810-11, Joesph Bozzay, retired. I performed many scheduling and coordinating functions that the Life Cycle Project Managers now perform as my section was the lead element on Gallipolis and Winfield Lock Replacement Projects. My work involved performing structural analysis and design including applying different loading cases to determine the critical condition for each portion (or all) of the lock wall monoliths, computing overturning stability analyses, working 3-D stability analyses, performing sliding stability analyses, and designing reinforcement steel according to ACI and Corps criteria. I was the lead engineer writing the DM for Winfield L&D.

4. Jul 1984 - May 1985, 40 HPW, Structural Engineer, GS-0810-7 & 9, Joesph Bozzay, retired. Worked in planning and design of navigation projects within the fields of civil and structural engineering. I performed design analysis computations for reinforced concrete, structural steel, and timber members for the Gallipolis L&D. I hand checked calculations completed by other engineers. I reviewed and made recommendations on plans, details, and analyses computed by others. I used various types of computer programs and operated Computer Aided Design and Drafting (CADD) systems. I hand checked and debugged computer programs. I prepared bid schedules and quantities for cost estimates. I prepared written correspondence.

Brief resume of key persons, specialists, and individual consultants anticipated for this project:

a. Name & Title:
Larry M. Cozine, R.A.
Chief, Architectural Design Section

b. Project Assignment:
Senior Architect

c. Organization:
Louisville District, US Army Corps of Engineers

d. Years Experience:
With This Organization: 20 With Other Organizations: 5

e. Education: Degree(s)/Year/Specialization
B. Architecture, The University of Kentucky, 1974
M. Architecture, Cornell University, 1976, Urban Design,

f. Active Registration:
Professional Architect, 1982 - Kentucky

First Year Registered/Discipline:

g. Other Experience and Qualifications Relevant to the Proposed Project

General. Mr. Cozine currently holds the position of Chief, Architectural Section, Design Branch for the US Army Corps of Engineers, Louisville District. In this position he is responsible for development and coordination of building design endeavors for inland navigation and flood control projects within the Louisville District Boundaries.

Regional Design Team Architect. Serves as the US Army Corps of Engineers Regional Architect, which is charged with the advancement of architectural design enhancement within the Ohio and Great Lakes Division. In this capacity he represents, promotes, develops, evaluates, and distributes Architectural related construction techniques, materials, and design innovations across the Corps of Engineers.

Member of US Army Corps of Engineers Architectural Design Advisory Committee (ADAC). This group is comprised of select senior individuals across the Corps of Engineers to enhance the overall quality of design in the USACE and provide professional commentary, recommendations, and guidance regarding but not limited to delivery and acquisition of design and construction services, transfer of industry technologies & electronic commerce, and development of standards and criteria.

Visitor Center Design for McAlpine Locks and Dam, Ohio River. Responsible as the supervisory Architect to oversee the design and construction documents preparation for visitor center facility and a variety of related exterior site features. Design included incorporation of mitigated historical features removed by new lock construction.

US Army Corps of Engineers, Olmsted Locks and Dam, Ohio River. Mr. Cozine served as the project supervisory Architect for design of all land-side visitor features, maintenance support facilities and Offices. Lock facilities include the operations tower located on the lock. Mr. Cozine performed and coordinated the concept design of this tower, containing electronic controls and instrumentation for locks and dam tainter gates. He supervised the multi-discipline design team, and coordinated project assignments. He was responsible for materials selections and integration, the review of contract drawings, and specifications for technical accuracy, adherence to design criteria, and incorporation of fire and building safety standards. Mr. Cozine provided field engineering support during construction, resolved technical issues as they arose during construction with solutions driven by consideration of potential contractor claims.

Operations and Maintenance. Mr. Cozine has been responsible for design of building additions, upgrades, and conversions of all type facilities located at existing lock and dam complexes throughout the District geographic area. This includes preparation of contract documents in simplified format to accommodate unique cost saving contracting methods.
Development of Design Criteria and Guide Specifications. Mr. Cozine has Co-authored the current specifications such as CEGS 07612, Non-Structural Metal Roofing; CEGS 06714, Structural Standing Seam Metal Roof; CEGS 13120, Standard Metal Building Systems; CEGS, 13121, Metal Building Systems (Minor Requirements). He has and TI 809-29, Structural Considerations for Metal Roofing; TI 809-30, Metal Building Systems. These documents give state of the art guidance and specifications to assist designers in proper design criteria selection, detailing, and quality assurance requirements associated with manufacturer supplied metal roofing systems and pre-engineered structural framing/building components and systems.

Brief resume of key persons, specialists, and individual consultants anticipated for this project:

a. Name & Title:
William Michael Dorsch, PE
Civil Engineer

b. Project Assignment:
Civil Engineer

c. Organization:
Civil Section, Civil Engineering Branch
Louisville District, US Army Corps of Engineers

d. Years Experience:
With This Organization: 2 With Other Organizations: 7

e. Education: Degree(s)/Year/Specialization
Purdue University, 1992
BS Civil Engineering

f. Active Registration:
Professional Engineer, Indiana - 1996

g. Other Experience and Qualifications Relevant to the Proposed Project:
General. Mr. Dorsch has a broad academic background in the Civil Engineering discipline, well rounded practical experience in the field of Civil Engineering, and reputable computer application skills in the use of Civil Engineering design software. Specific areas of expertise related to Lock and Dam design include: development of construction contract documents that include construction drawings, specifications, technic reports and real estate drawings for the following project aspects: cofferdam construction; site planning, design, and construction; roadway design and construction; storm sewer and storm water management design and construction. He has knowledge and experience in the use of the following Civil Engineering software design packages: Bentley's Microstation, Intergraph's Inroads, Hydrain Hydra and Hydro, Microsoft Excel and Word.

Mr. Dorsch currently holds the position of Civil Engineer in the Civil Section, Civil Engineering Branch for the US Army Corps of Engineers, Louisville District. In this position he is responsible for development and coordination of design endeavors for both Civil Works and Military Design projects within the Louisville District Boundaries. He is directly responsible for Development of construction contract documents that include construction drawings, specifications, technical reports, and relocation agreements. He prepares project budgets, schedules and quality control plans, and coordinates work efforts of civil design technicians. He is responsible for the review of drawings, design computations and contract specifications for technical accuracy and adherence to design criteria and design standards.

Other work experience:
Nov 95 – Aug 99, Employed with Skees Engineering, Inc., Louisville, KY. Performed roadway design and supervised roadway plan development. Produced construction plans using computer aided design software. Created Digital Terrain Models from survey data. Developed horizontal and vertical alignments, and intersection layout designs. Designed drainage systems associated with roadway design. Produced erosion control, traffic striping, and right-of way plans. Wrote property deed descriptions for affected parcels. Calculated bid quantities and performed cost estimating. Developed design specifications. Corresponded with clients and other consultants regarding design issues. Developed budgets and scopes of work as related to design change order requests.

Mar 94 – Nov 95, Employed with Hazelet & Erdal / Dames & Moore, Louisville, KY. Prepared roadway plans and specifications. Performed geometric design, roadside drainage design, intersection design, and development of miscellaneous details. Coordinated roadway design work with other design disciplines.

July 92 – Mar 94, Employed with the Regional Airport Authority of Louisville and Jefferson County, Louisville, KY. Supervised a team of technicians in the planning and preparation of plans and specifications for a variety of airport related maintenance and capitol improvement projects. Reviewed the consultant's designs for airport improvement projects during the expansion of the Louisville International Airport.

Brief resume of key persons, specialists, and individual consultants anticipated for this project.

a. Name & Title:
Dr. Robert Ebeling
Civil Engineer

b. Project Assignment:
Vessel Impact Consultant; Dynamic SSI of Lock Walls Retaining Earth Consultant;Tieback/Multi-Anchor Wall Consultant

c. Organization:
Engineering Research and Development Center
Information Technology Laboratory, Vicksburg, MS

d. Years Experience: 25 years

With This Organization: 13 With Other Organizations: 12

e. Education: Degree(s)/Year/Specialization
Ph.D. Civil Eng./1989/Geotech. & Structures
Masters of Eng. in Civil Eng/1980/ Geotech. & Structures
B.E. Civil Engineering/1976/Structures

f. Active Registration:
P.E. State of California

First Year Registered/Discipline: 1983/Civil Eng.

g. Other Experience and Qualifications Relevant to the Proposed Project

Participated in a variety of geotechnical, structural and earthquake engineering projects and research projects involving the design and construction of new structures or the analysis of the stability of existing structures. Experienced in the static and dynamic aspects of hydraulic structures (e.g., locks, earth and concrete dams, intake towers, cantilever walls), soil-structure interaction, stability evaluations of earth retaining structures and earth dams, soil behavior and material characterization, linear and nonlinear finite element analyses, fracture/cracking analysis of concrete structures, numerical modeling of base separation of gravity structures, numerical modeling of geoinclusions, slope stability analyses, multi-anchored/tieback earth retaining structures, uplift in rock foundations for concrete dams, settlement evaluations, liquefaction hazard evaluations, the characterization of seismic ground motions, and seismic hazard (probabilistic) evaluations, barge flotilla impact loading of hydraulic structures, and statistical (probabilistic) methods of analysis.

Current Principal Investigator (PI) of the Innovations for Navigation Projects (INP) R&D work unit on Barge Impact developing a numerical model to predict the maximum impact force that a flotilla of barges imparts on lock walls and co-author of ERDC technical teport on this subject (in preparation).

PI of the INP R&D work unit on SSI studies of retaining walls with multiple rows of anchors (i.e., tieback walls) and co-author of four ERDC technical reports on this subject (in publication & preparation).

Dr. Ebeling is a nationally recognized expert in the static and dynamic SSI of steel, reinforced and unreinforced concrete structures in contact with the earth. This includes all types of retaining walls, flexural walls, and lock walls that retain earth. Dr. Ebeling is PI of the Earthquake Engineering R&D work unit entitled “Seismic Design of Cantilever Retaining Walls.” He is principal author of the nationally recognized ERDC technical report ITL-92-11 “The Seismic Design of Waterfront Retaining Structures.” He has consulted with numerous Districts (e.g., Louisville, Los Angeles, New England, etc.) on static and dynamic SSI issues on a variety of types of the Corps earth retaining structures. He developed the Corps first seismic design procedures for anchored sheet pile retaining walls and for permanent cellular steel structures.

Brief resume of key persons, specialists, and individual consultants anticipated for this project:

a. Name & Title:

Joseph H. Ellsworth Jr.
Civil / Cost Engineer

b. Project Assignment:
Cost Estimating and Cost Engineering Production Team

c. Organization:
Cost Engineering Branch, CESAM-EN-E U.S. Engineering Division Mobile District, Army Corps of Engineers

d. Years Experience:
With This Organization: 28 With Other Organizations: 1

e. Education: Degree(s)/Year/Specialization:
BS Degree in Civil Engineering, 1973, University of South Alabama

f. Active Registration:
Engineering-In-Training (ET 1818), 1973, Civil Engineer
Certified Cost Consultant, Jan 96 to Present
First Year Registered/Discipline :

g. Other Experience and Qualifications Relevant to the Proposed Project:

- As a Civil/Cost Engineer, specializing in Cost Engineering involving heavy earthwork and equipment requirements for a wide variety of Civil, Military, Dredging, HTRW, and Other projects, Mr. Ellsworth is responsible for the supervision, coordination, preparation, review & technical accuracy of cost estimates. This includes the wide range estimates required in Planning, Conceptual, Preliminary and Final Design stage.

- Assist in Value Engineering Studies as a team member making recommendations and providing guidance for acceptable Cost Savings.

- Prepared cost estimates for the following specialized Projects:
Powerhouse - Richard B. Russell
Locks and Dams (**TTWW 10 projects**)
Aliceville Resource Mgt.& Visitors Complex
J-6, Large Rocket Test Facility, AEDC, Tn
SPIF, Cape Canaveral, Fl
Chemical Demil Projects – Anniston Army Depot, Al
Navy Homeport Projects – Mobile, Al – Pascagoula, Ms
Savannah River Site - Georgia
Painting of Powerhouses, Locks & Dams
Central America Projects - Bldgs, Bridges, Roads, Runways, Water Control & Rehabs in Panama, Honduras, Costa Rica & Guatemala.
Puerto Rico - Arched Concrete Dam
Navigational Projects - Rivers, Harbors, Canals (Mobile, Pascagoula, Gulfport, Panama City, and Houston.
Dredging Projects- Maintenance & New Work (includes such dredges as Hopper, Cutterhead, Bucket, Mechanical and Small Pipelines)

- Served as a Team Member on TDY assisting the countries of Saudia Arabia, Republic of Panama, Honduras, Puerto Rico.

- Served as a Federal Disaster Representative on Tornado, Hurricane & Flood disasters.

- Assist in negotiations of settlement of change orders, claims and cost analysis of proposals.

- Served as a Project Manager/Engineer in Mobile Corps Site Office managing dredging and disposal area projects.

- Effective in work involving Computer Aided Cost Engineering Systems, such as MCACES, CEDEP, HAG, PC-COST as well as ding Parametric Modeling programs, PACES.

Brief resume of key persons, specialists, and individual consultants anticipated for this project:

a. Name & Title:
Robert H. Fulton
Electrical Engineer, Dam Safety Program Manager

b. Project Assignment:
Independent Technical Review Team

c. Organization:
CESAD-MT-ET South Atlantic Division, U.S. Army Corps of Engineers

d. Years Experience:
With This Organization: 23 With Other Organizations: 8

e. Education: Degree(s)/Year/Specialization
Bachelor/1970/Electrical
Credits toward Masters

f. Active Registration:
EIT, Mississippi, 1981
Electrical Contractor/Class 2 Electrician, Unrestricted, Georgia, 1995

First Year Registered/Discipline

g. Other Experience and Qualifications Relevant to the Proposed Project:

SKILLS

Electrical Design, Electrical system testing, software testing, DOS, Windows (3.1 thru 98), Cathodic Protection systems, Hydroelectric Generation, Electric power and control systems, Dam Safety, fire detection and alarm systems, certified Instructor, public speaker

WORK EXPERIENCE

After graduating from Mississippi State University in 1970, I began my professional career as a Field Service Engineer for Westinghouse Electric Corporation, where I was responsible for construction, installation, maintenance, troubleshooting, training, technical oversight, and contract engineering services for specialized electrical equipment for the generation, transmission, distribution, control and protection of electrical power, as well as stationary and rotating equipment and systems for the manufacturing industries. My duties required extensive travel throughout the United States, South America, the Middle East, and Europe, during my seven years with Westinghouse.

WORK EXPERIENCE (Con't.)

After serving over a year as a Plant Engineer with GAF Corporation, responsible for all engineering, construction and maintenance by a staff of over 60 electrical and mechanical engineers and technicians for a paper and roofing mill in Savannah, GA, I joined the Corps of Engineers in Savannah District in November, 1978, as a Design Engineer. In Savannah, I was responsible for electrical design and review of major Civil Works (Hydropower) and Military projects, such as the St. Stephen and Richard B. Russell Power Plants, and the Steel Creek Outlet Works for the Department of Energy at the Savannah River Plant. Since 1985, I have been in the South Atlantic Division Office (SAD), responsible for electrical design and review for major civil and military projects performed by the Districts within SAD. I served as the Division Electrical Engineer, providing direct electrical design and technical support to the Transatlantic Division during the Desert Shield/Desert Storm operations, and, in 1995 I lead the team that designed the electrical distribution upgrade for a Saudi National Guard Base, while on temporary assignment in Riyadh.

I have been responsible for the South Atlantic Division Dam Safety Program since February 1996, with responsibility for the Dam Safety Assurance Program and coordinating all efforts relating to safety of the dams within the jurisdiction of the Charleston, Jacksonville, Mobile, Savannah, and Wilmington Districts. In the fall of 1998, I prepared the update/rewrite of major Dam Safety guidance documents, while on temporary assignment in the HQUSACE Dam Safety Office.

I am a licensed Electrical Contractor in the State of Georgia, and as such, a Class 2, Unrestricted, Electrician, and, I am also a member of the Association of State Dam Safety Officials (ASDSO), and was a long-time committee member of the Institute of Electrical and Electronic Engineers (IEEE). I also co-Chair the Corps of Engineers National Energy Team (CENET), have served as the Chairperson for the Corps of Engineers National Dam Safety Working Group, and provide support to the Corps-wide Corrosion Control/Cathodic Protection Experts in the Mobile District.

Brief resume of key persons, specialists, and individual consultants anticipated for this project:

a. Name & Title:
Ronald R. Gadomski
Electronics Engineer

b. Project Assignment:
Electronics & Controls

c. Organization:
US Army Corps of Engineers, Pittsburgh District, Engineering Division, Electrical & Mechanical Section.

d. Years Experience:
With This Organization: 1.75 With Other Organizations: 7

e. Education: Degree(s)/Year/Specialization:
BSEE, 1992, Electrical Engineering

f. Active Registration:
EIT, Commonwealth of Pennsylvania

First Year Registered/Discipline

g. Other Experience and Qualifications Relevant to the Proposed Project:

Performed professional electronic engineering duties related to the concept and detail design, application, selection, installation, failure analysis, replacement, rehabilitation, and repair of electrical and electronic control systems. Developed PLC/PC based electronic control systems as utilized in navigation locks and flood control dams, local protection projects, and related civil works projects. Designed detailed electronic control system plans and specifications using Allen-Bradley SLC500 and Allen-Bradley ControlLogix programmable logic controllers. Trained to program the SLC500 system using RSLogix500 software. Developed and implemented standard guidelines and specifications for the design of PLC/PC based supervisory control and data acquisition electronic control systems.

Modernized and improved efficiency of controls using state of the art equipment for control of miter gates, gate hoisting machinery on moveable crest dams, power, lighting, gate valves and sluices on navigation and reservoir projects.

Utilized manual and computer aided design techniques to size and select equipment components, to determine costs, to develop and analyze alternate solutions to operation and maintenance problems, to perform technical computations, and to develop systems.
Trained in and proficient using MicoStation CADD, computer aided drafting and design.

Reviewed and recommended for approval architect-engineer and contractor submittals and shop drawings in connection with the design and installation of electronic control systems. Proposed and submitted contract modifications to insure conformance with contract plans and specifications. Reviewed electronic control system designs for technical accuracy and functionality.

Assisted in the start-up, commissioning, and trouble shooting of new or rehabilitated electronic control system equipment installed at various navigation locks and flood control dams. Able to trouble shoot electronic control systems using various equipment and standard industry accepted practices.

Conducted field visits to projects and manufacturing plants to determine status and operating condition of existing electrical and electronic control system equipment, to determine design requirements, to inspect projects under construction and finished jobs, to assure conformance with contract plans and specifications, and to witness equipment acceptance tests.

Supervised and advised lower grade engineers completed designs and computations for technical accuracy, adequacy, and conformance with policies and regulations.

Prepared and reviewed studies and analysis of design alternatives and determined electronic control system design features to be proposed in various planning level studies, and in general and detailed design memoranda.

Prepared operation and maintenance manuals, technical reports and presented papers relating to electrical and electronic control systems designed for navigation locks and flood control projects.

Brief resume of key persons, specialists, and individual consultants anticipated for this project:

a. Name & Title:
Brian H. Greene, Ph.D., P.G.
Chief, Geology Section

b. Project Assignment:
Engineering Geologist

c. Organization:
Geotechnical Branch
Pittsburgh District

d. Years Experience: 23
With This Organization: 23 With Other Organizations: 0

e. Education: Degree(s)/Year/Specialization
B.S. Geology, 1975
M.A. Geology, 1977
Ph.D., Engineering Geology, 2001

f. Active Registration:
Pennsylvania

First Year Registered/Discipline 1995 Professional Geologist

g. Other Experience and Qualifications Relevant to the Proposed Project:

Buffalo District:
Spent 10 years (between 1978 and 1988) as an engineering geologist with the Buffalo District and was involved with the engineering design of small boat harbors and beach replenishment projects. Extensive work experience in geotechnical site investigation including core drilling & sampling, test pits, pressure testing and geophysical exploration. Spent 5 years in the evaluation of quarried stone materials including aggregates, riprap and armor stone for diked disposal areas and harbor breakwaters. Conducted field inspections of quarries, prepared laboratory test reports and recommended approval / disapproval. Wrote several technical reports on the geologic site characterization of project sites. Served as Project Geologist and prepared geotechnical portions of Design Memoranda for the rehabilitation design of the Dashields Locks and Dam. Work on this project was conducted for the Pittsburgh District.

St. Paul District:
January to May 1984. Acting Assistant Chief of the Geotechnical / Hydraulics and Hydrology Branch. On Corps sponsored executive development assignment, assisted in the management of a multidisciplinary workforce including geotechnical engineers, engineering geologists, hydraulic engineers, surveyors, drillers and technicians.

Ohio River Division Laboratory:
In 1987, as Acting Laboratory Director, oversaw the management of the geotechnical/environmental laboratory and the conduct of testing in the areas of rock mechanics, soil mechanics, construction stone materials and water quality. Provided quality control review of outgoing laboratory test reports primarily in the area of rock mechanics.

Pittsburgh District:
From 1988 to present have served in the capacity of Chief, Geology Section managing all aspects of engineering geologic design work conducted by a staff of six. In 2001, selected by Corps Headquarters a Corps of Engineers National Technical Expert in the field of Rock Mechanics.

Charleroi Locks Project: Currently overseeing the foundation design for the Charleroi Locks Project, which involves the replacement of two navigation locks on a weak rock foundation. Oversaw the execution of extensive subsurface exploration programs conducted to characterize site conditions. Foundations are currently being designed as drilled shafts in rock. Performing technical review of completed geotechnical work for plans & specifications.

Braddock Dam: For the past 3 years I have overseen the engineering geology investigations conducted for the Braddock Dam Project. These included borings, quarried materials investigations and preparation of design reports and Plans & Specifications. Braddock Dam involves unique in-the-wet construction of a new concrete gated navigation dam founded on drilled shafts in rock. Co-authored a paper in Civil Engineering magazine titled "Testing the Load". The paper described a unique axial and lateral in-river load tests on two prototype-drilled shafts constructed during the late design stage of the Braddock Dam project.

Point Marion Lock: During the period of 1987 thru 1994, I was project geologist involved with the foundation design for this new navigation lock project. Wrote the Geology & Foundations Design Memo for the new lock which involved defining foundations in weak rock formations and the design of a unique cofferdam that required stabilization with nearly 500 rock anchors. Developed site stratigraphy, rock shear strength, rock compressive strength and rock anchor bond strength needed for design. Co-authored 3 professional papers on this project and, in 1994, the project received the Outstanding Civil Engineering Achievement Award for the Pittsburgh Section of ASCE.

Grays Landing Lock & Dam: During the period 1988 thru 1995, oversaw the extensive exploration programs undertaken to define the foundations in rock for new lockwalls and a gated dam. All collected data was complied on drawings and included in design memos and plans and specifications. Reviewed the results of foundation excavations and coordinated with construction staff on making adjustments to founding elevations

Brief resume of key persons, specialists, and individual consultants anticipated for this project:

a. Name & Title:
William J. Griffin
Chief, Cost Engineering Branch

b. Project Assignment:
Consultant to Cost Engineering production team

c. Organization:
Cost Engineering Branch, CESAM-EN-E Engineering Division, Mobile District, U.S. Army Corps of Engineers

d. Years Experience:
With This Organization: 27 With Other Organizations: 13

d. Education: Degree(s)/Year/Specialization
BS in Mechanical Engineering,'61 Auburn University, AL

f. Active Registration:
1967 Registered Professional Engineer #7842 in State of Alabama
Tri-Service Certified Cost Engineering Professional

g. Other Experience and Qualifications Relevant to the Proposed Project:

As Chief of the Cost Engineering Branch have authoritative responsibility for the preparation and technical accuracy of all construction cost estimates for Military, Civil including Civil Dredging, HTRW, MEDCOM, and Support to Others programs. Also served as the Senior Mechanical Engineering Specialist for all programs. Responsible as a Senior Specialist, for preparing, assembling, managing, and defending cost estimates and to teach, coach and assist other cost engineers. Currently manage two Cost Consultant firms on contract to the Mobile District. Have been involved in numerous major process plant type design projects with complete cradle to grave responsibility for all cost engineering functions. Experienced in handling large dollar construction projects from the conceptual stage through final design.

Involved in the following major projects:

Numerous Hydropower projects
All Locks and Dams on the Tennessee-Tombigbee Waterway
Major facility projects at Cape Canaveral, Florida
Provided cost estimating support on numerous DOE projects, such as: Inter-Area Line Upgrade, Burial Ground II, Plant-Wide Fire Protection Project, Upgrade Separation Area Safeguards, Co-Generation Program Assessment, Upgrade Reactor Safeguards, and Health Protection & Environmental Monitoring Laboratory.
Chemical Demil Projects at numerous locations.
Large Rocket Test Facilities at Arnold AFB, TN.
Numerous HTRW projects, such as: Groundwater Treatment System, Toxic Munitions Change House, Industrial Waste Treatment Facilities, Hazardous Material Control Facilities, Explosive Ordnance Disposal Training Facilities, Various Asbestos Abatement Projects, Pollution Abatement and Explosive Waste Incinerator projects.
Disaster support.
Handle all projects in Latin America.
Cost estimating support on EPA's new Research and Administrative Facility, RTP, NC.

Involved in the preparation and validation of Military programming estimates, A-E oversight, change orders, claims, cost analysis, Value Engineering, etc.

Brief resume of key persons, specialists, and individual consultants anticipated for this project:

a. Name & Title:
William Halczak
Civil Engineer GS-0810-12

b. Project Assignment:
Concrete Materials Engineer

c. Organization:
Los Angeles District CESPL-ED-GD, US Army Corps of Engineers

d. Years Experience:
With This Organization: 23 With Other Organizations: 4

e. Education: Degree(s)/Year/Specialization
BSE (Civil Option) 1977

f. Active Registration:
Registered Civil Engineer, California

First Year Registered/Discipline 1981/Civil Engineering

g. Other Experience and Qualifications Relevant to the Proposed Project:
Principal Concrete Materials Engineer for the Seven Oaks Dam. Construction included a 200 foot high intake tower, 800 foot long 18 foot diameter reinforced concrete pressurized tunnel, designed for 550 feet of head. The outlet tunnel was designed for flow velocities greater than 160 feet per second. I was the lead engineer on all of the concrete materials studies. Those studies included borrow site analysis for production of aggregates, processing and production plans for aggregates for construction, finite element analysis of thermal and construction control studies for the various classes of concrete to be placed, design of the laboratory program for all concrete materials studies required for the planned construction. Additionally, I performed design studies and analysis for production of high strength abrasion resistant concrete for the tunnel lining. Specific job tasks also included preparation of plans and specifications and field instructions for all concrete construction; preparation of the Government estimate for the design of the production and processing scheme for the 550 foot high, 40 million cubic yard earthfill dam; and supplied direct field support to the Resident Office for most concrete placement during construction

Brief resume of key persons, specialists, and individual consultants anticipated for this project:

a. Name & Title:
Dr. Robert L. Hall
Research Structural Engineer Chief, Geosciences & Structures Division

b. Project Assignment:
Structural Production Team - Panama Canal Project

c. Organization:
Geotechnical & Structures Laboratory, Engineer Research and Development Center, U.S. Army Corps of Engineers Currently

d. Years Experience:

With This Organization: **30** With Other Organizations: 1

e. Education: Degree(s)/Year/Specialization
Auburn University, B.S. Civil Engineering, 1971
Mississippi University, M.S., Civil Engineering, 1976
Oklahoma University, Ph.D., Structural Engineering, 1985

f. Active Registration:
None

First Year Registered/Discipline:

g. Other Experience and Qualifications Relevant to the Proposed Project

Dr. Hall leads research and development activities in the areas of computational mechanics, soil-structure interaction, dynamic analysis, and earthquake engineering. Experience in seismic analysis of concrete dams: include Folsom Dam, Ca; Seven Mile Dam, Canada; Hugh Keenleyside Dam , Canada; Strathcona Dam, Canada, Three Gores Dam ,China and the Gatun Dam , Panama. Current dynamic projects include critical facilities in the Washington D.C. area and the retrofit analysis/design for the Pentagon. He has more than 100 technical publications in various journals and referee papers in proceeding, international conferences, and symposiums. Other experiences: past member of ACI's technical committee on blast response of structures, a past member of ASCE's technical committee on Seismic Effects, a member of the Society of America Military Engineers. Served on seismic evaluating teams after the Loma Prieta , North Ridge and Kobe Earthquakes.

Brief resume of key persons, specialists, and individual consultants anticipated for this project.

a. Name & Title:

William Andrew Harkness, PE

Chief, Structural and Architectural Design Section

b. Project Assignment:

Senior Structural Engineer

c. Organization:

Engineering Division, Pittsburgh District, US Army Corps of Engineers

d. Years Experience:

With This Organization: 11 With Other Organizations: 6

e. Education: Degree(s)/Year/Specialization

The University of Pittsburgh, 1997
MS Civil & Environmental Engineer

The Pennsylvania State University, 1986
BS Civil Engineering

f. Active Registration:

Professional Engineer, 1992 - Pennsylvania

First Year Registered/Discipline:

g. Other Experience and Qualifications Relevant to the Proposed Project

General. Mr. Harkness has broad academic background in the Structural Engineering discipline as well as significant computer programming and application skills. Specific areas of expertise related to Lock and Dam design include: miter gates, tainter gates, reverse tainter valves, bulkheads, mass concrete, precast concrete, prestressed concrete, cofferdams, in-the-wet construction, and pile and caisson foundations. He has specialized experience coordinating and optimizing the design of large moveable steel structures with the mechanical engineering discipline. He has used Bentley's MicroStation, MicaPlus Analysis and Design, STAAD, and Algor Finite Element Software as well as software that he developed to assist in design endeavors.

Mr. Harkness currently holds the position of Chief, Structural and Architectural Design Section, Design Branch for the US Army Corps of Engineers, Pittsburgh District. In this position he is responsible for development and coordination of design endeavors for inland navigation and flood control projects within the Pittsburgh District Boundaries.

Regional Navigation Design Team Member. Serves on the US Army Corps of Engineers Regional Navigation Design Team, which is charged with the coordinated advancement of innovative design within the Ohio and Great Lakes Division. This organization promotes, develops, evaluates, and distributes cost saving construction techniques, materials, and designs across the Corps of Engineers.

Member of US Army Corps of Engineers Steel Structures Group. This group is comprised of select individuals across the Corps of Engineers to address and recommends solutions to problems common with steel structures across the Corps of Engineers. The steel structures group also reviews design criteria and recommends and develops new computer software. One of the products of the steel structures group was a new computer program (CMITER) that designs and analyzes miter gates using the latest Corps of Engineers Load and Resistance Factor Design criteria.

Bulkhead Designs for the Panama Canal Commission. Responsible as a supervisory structural engineer to oversee the design of replacement of all culvert bulkheads used at the Panama Canal.

Welded fabricated structural steel bulkheads were designed to replace existing riveted bulkheads. The replacement bulkheads were detailed to fit and seal in existing slots.

Development of Design Criteria for Navigation and Spillway Tainter Gates. Co-author of US Army Corps of Engineers new Engineering Manual 1110-2-2702. This document provides state-of-the-art design guidance for tainter and spillway gates. Guidance for Load and Resistance Factor Design, fracture control of structural components, criteria for design of trunnion girders and gate anchorages, material selection for corrosion consideration, and considerations for design to minimize operational problems is included. Specific guidance is provided for best practices for structure fabrication and mechanical layout and discipline coordination.

US Army Corps of Engineers, New Gated Dam, Braddock Locks and Dam, Monongahela River. Mr. Harkness served as the project structural engineering manager for this $130,000,000 innovative float-in construction project on the lower Monongahela River. This project was a highly unique navigation dam. The project was designed for "float-in" construction methods where large concrete shells (106'x340'x30') are constructed at a remote site in dry conditions and then floated to the project site on the inland navigation system. Mr. Harkness performed the concept design for this work using finite element analysis and initiated float-in construction methods within the US Army Corps of Engineers. He supervised a 12-member design team, and planned and coordinated project assignments. He was responsible for the review of drawings, design computations and contract specifications for technical accuracy and adherence to design criteria and design standards. He was also responsible for the preparation and administration of A/E contract and annual operating budgets.

US Army Corps of Engineers, Lock and Dam 4 on the Monongahela River As a Technical Manager for design of new twin lock chambers he was responsible for developing and maintaining project schedules, coordinating design efforts, resolving technical issues, preparing and reviewing technical reports. Project construction cost of approximately $265,000,000. Investigated the use of innovative design features such as "float-in" and "lift-in" precast concrete lock walls founded on high capacity drilled shaft foundations constructed in the wet without cofferdams. This effort has reduced project costs by minimizing the need for construction of cofferdams.

Development of Design Criteria for Precast and Prestressed Hydraulic Concrete Structures, EC1110-2-6162. Principal Investigator for development of Engineering Circular 1110-2-6162, for the US Army Corps of Engineers. This document provides state-of-the-art design guidance for lift-in, float-in and permanent floating precast and prestressed concrete structures. This document addresses material selection, design conditions, loading requirements and serviceability criteria.

US Army Corps of Engineers, Point Marion Lock and Grays Landing Lock and Dam. Mr. Harkness designed several features for these projects including cofferdam arms and Hoist Structures. Provided field engineering support during construction, resolved technical issues as they arose during construction with solutions driven by consideration of potential contractor claims.

Rehabilitation of Historic Tygart Dam. Responsible for design and contract drawing preparation for replacement of existing sluice gate bulkheads, water intakes and replacement of gate valves with new ring jet valves

Rehabilitation Berlin Dam, Ohio. This project involved installation of two new low flow ring jet valves and replacement of existing slide gates with large ball valves. Localized concrete preparation and demolition was performed to reconfigure existing dam geometry to accept new machinery components and valve anchorage assemblies.

US Army Corps of Engineers, Allegheny River, Lock 7. Supervised development of plans and specifications for resurfacing lock walls with precast concrete panels. A unique sequence of work for concrete removal and panel installation was required to allow the use of cross-chamber struts to maintain lock wall stability while the chamber is dewatered. This contract was recently awarded (June 1999) for construction.

Brief resume of key persons, specialists, and individual consultants anticipated for this project:

a. Name & Title:
John E. Hite, Jr.
Research Hydraulic Engineer

b. Project Assignment:
Lock Filling and Emptying System Design

c. Organization:
U.S. Army Engineer Research and Development Center
Coastal and Hydraulics Laboratory, Navigation Branch
Office Symbol: CEERD-HN

d. Years Experience:
With This Organization: 22 With Other Organizations: 2

e. Education: Degree(s)/Year/Specialization
BS/1977/Civil Engineering
MCE/1988/Civil Engineering
PhD/1991

f. Active Registration:
Professional Engineer – Mississippi no. 08641

First Year Registered/Discipline: 1982/Civil Engineering

f. Other Experience and Qualifications Relevant to the Proposed Project:

General. Dr. Hite has served as the Group leader for the Locks Group of the Coastal and Hydraulics laboratory since September 1998. He has planned, directed, and conducted navigation studies with special emphasis on innovative lock design. His specific areas of expertise include filling and emptying system design including intakes and discharge outlets, modeling of Hydraulic Structures, and repair and rehabilitation of Navigation Locks and Dams.

Lock Filling and Emptying Systems. Dr. Hite has been the principal investigator on hydraulic model studies to evaluate and develop filling and emptying designs.

J. T. Myers Lock Extension. An innovative supplemental filling and emptying system was developed specifically for the Myers navigation improvement project located on the Ohio River. The smaller auxiliary lock was enlarged to match the dimensions of the existing main chamber. A through- the-sill intake and in chamber longitudinal culvert design developed in the Ohio River Main Stem Study was refined to create the filling and emptying system.

Ohio River Main Stem Filling and Emptying Design. Member of the Corps of Engineers team selected to develop general lock design guidance for future lock extension projects on the Ohio River Main Stem. Through the use of analytical, numerical, and laboratory models, the team developed an efficient and cost effective design. The innovative design consisted of a supplemental filling and emptying system with a through-the-sill intake, in chamber longitudinal culverts, and a discharge diffuser.

Inner Harbor Navigation Canal Lock Replacement. Principal investigator for the model study to evaluate and develop the filling and emptying system design for the shallow- and deep-draft lock replacement project on the IHNC in the New Orleans District of the Corps of Engineers. A combination end filling and emptying and side port filling and emptying design was developed for the project.

McAlpine and Marmet Lock Improvements. Principal investigator for the model studies of the lock addition at McAlpine lock on the Ohio River and the lock addition at Marmet lock on the Kanawha River. Innovative in chamber longitudinal culvert designs were developed for both of these projects. These designs were much less expensive than conventional lock designs and were also hydraulically efficient.

Lock Design Research. Member of the Corps of Engineers team to develop innovative lock designs. Principal investigator for the research on development of the in chamber longitudinal culvert filling and emptying system and consultant for the research on lock extension design.

Recent Publications

Hite, J. E., Jr. "New McAlpine Lock Filling and Emptying System, Ohio River, Kentucky, Hydraulic Model Investigation," Technical Report ERDC/CHL-00-24, Engineer Research and Development Center, Vicksburg, MS, September 2000.

Hite, J. E., Jr. "Model Study of Marmet Lock Filling and Emptying System, Kanawha River, West Virginia, Hydraulic Model Investigation," Technical Report CHL-99-8, Waterways Experiment Station, Vicksburg, MS, May 1999.

Hite, J. E., Jr. "Low-Head Navigation Dam Stilling Basin Design, " Technical Report HL-99-4, Waterways Experiment Station, Vicksburg, MS, March 1999.

Stockstill, R. L. and Hite, J. E., Jr. "Application of a Two-Dimensional Model of Hydrodynamics to the Lower Approach of the New Kentucky Lock, Tennessee River, Kentucky, Numerical Model Investigation" Technical Report CHL-98-9, Waterways Experiment Station, Vicksburg, MS, April 1998.

Brief resume of key persons, specialists, and individual consultants anticipated for this project:

a. Name & Title:
Stephen T. Hornbeck, PG
Lead Geologist

b. Project Assignment:
Geotechnical – Functional Analysis
Independent Technical Review

c. Organization:
Louisville District, US Army Corps of Engineers

d. Years Experience:

With This Organization: 29 With Other Organizations:

e. Education: Degree(s)/Year/Specialization
University of Minnesota
Rock Mechanics, Post Graduate Work

West Virginia University BS, Geology

f. Active Registration:
Professional Geologist, 1989 – Arkansas

First Year Registered/Discipline:

g. Other Experience and Qualifications Relevant to the Proposed Project

General. Mr. Hornbeck has a wide variety of experience in construction and design of embankment and concrete structures. Construction experience includes earthfill and rockfill embankments as well as concrete gravity dams and walls. Specific areas of foundation design experience include rockfill and earthfill embankment foundations as well as foundations for gravity and thin arch concrete structures. Specific items of experience associated with general design and construction experience includes the following: cement and chemical grouting, cutoff walls, slurry trenches, mechanical and resin anchored rock bolts, rock anchors, foundation preparation, foundation treatment, foundation and borrow excavations, blasting, vibration control, rock testing and interpretation, tunnel design, tunnel excavation, and tunnel lining, Mr. Hornbeck holds the position of Lead Geologist for the Louisville District of the Corps of Engineers. In his current position he serves as the District's technical expert in the areas of rock mechanics, foundation treatment and preparation, and also serves as the Dam Safety Program Manager for the Louisville District. He has been recognized as one of the Corps of Engineers' "National Technical Experts" in the fields of rock mechanics and foundation treatment. He serves on the Field Review Group for the Corps of Engineers' research program into Risk Assessment for Dam Safety. Mr. Hornbeck is a member of the Association of Engineering Geologists, the Association of State Dam Safety Officials, the United States Society on Dams, and is registered as a Professional Geologist in Arkansas and Kentucky.

Construction Experience. Mr. Hornbeck's experience consists of over 4 years of on-site construction experience involving earth and rockfill dams, and concrete gravity dams. He served as Resident Geologist on each of the following projects. R.D. Bailey Dam is a 4 million cubic yard rock fill dam with concrete paving on the upstream face to serve as a water cutoff. He was responsible for foundation excavation, foundation treatment, borrow excavation, grouting, foundation approvals, rock reinforcement, and blasting, and assisted in all portions of the work including quality control of embankment operations. Martins Fork Dam is a concrete gravity structure. Mr. Hornbeck was responsible for foundation excavation, foundation treatment, foundation approval, blasting, rock reinforcement, grouting, and assisted in other operations including quality control of batch plant and concrete placement operations

Design Experience. Mr. Hornbeck's design experience includes 17 years of foundation design on a wide variety of projects including embankment dams, concrete gravity locks and dams, and feasibility work on a double curvature thin arch dam. He served as the primary designer of the foundation for Yatesville Dam. Work on Yatesville included excavation, foundation preparation, foundation treatment, grouting, tunnel loadings, tunnel excavation and lining, diversion, materials distribution, and instrumentation. He served as the primary designer of the foundation for the Gallipolis Locks and Dam Replacement Project. Work included determination of foundation loadings, excavation, setting final foundation elevations, foundation preparation, foundation treatment, grouting, blasting, and rock anchors. Other foundation design work has included earth tunnels at Chillicothe, Ohio and Williamson, Kentucky, rock anchors for Charleston LPP, cement and chemical grouting of Leesville and Clendening Dams, chemical grouting of Burnsville Dam, concrete excavation and repair and rock anchors at Delaware Dam, spillway widening at Bolivar and Mohawk Dams, He served as the District's specialist in rock testing and interpretation for Winfield and Marmet Locks and Dams and other small projects. He also served as the District's specialist in problems related to construction geology on Paintsville, Alum Creek, Delaware, and Winfield, He served as the primary foundation designer during feasibility studies on a double curvature thin arch dam in Virginia. In 1994, at the request of Headquarters of the Corps of Engineers, he served as the geologic analyst for the Cerrillos Dam seepage investigation task force. This work for the Jacksonville District re-evaluated all data relating to the foundation of the dam to determine whether the seepage experienced following construction presented a threat to the stability or safety of the dam.

Dam Safety Experience. Mr. Hornbeck has extensive experience in the field of dam safety and served as the project coordinator for 10 of the Louisville District's projects. He currently serves as the Dam Safety Program Manager for the Louisville District's 34 projects. In addition to his normal dam safety duties he has served as the Project Engineer for the District's remediation programs at Patoka and Mississinewa Dams. The Patoka seepage remediation successfully incorporated the use of balanced and stabilized cement grouts with real time computer monitoring of permeabilities for the first time in the Corps of Engineers. The Mississinewa Foundation Remediation consists of a concrete cutoff wall through embankment, overburden foundation, and limestone rock to depths up to 180 feet. He serves as an instructor for the Waterways Experiment Station Dam Safety Training Course offered each year.

Brief resume of key persons, specialists, and individual consultants anticipated for this project:

a. Name & Title:
Kenneth Dale Hull, P.E.
Civil Engineer

b. Project Assignment:
Senior Structural Engineer

c. Organization:
Structural Engineering Section, Engineering Division
Nashville District, US Army Corps of Engineers

d. Years Experience:
With This Organization:18 With Other Organizations:13

e. Education: Degree(s)/Year/Specialization
Vanderbilt University 1970
BS Civil Engineering/ Specialized in Structures

f. Active Registration: First Year Registered/Discipline

Professional Engineer, 1981 Tennessee / Civil Engineering

g. Other Experience and Qualifications Relevant to the Proposed Project:

General. Mr. Hull has a broad background in the Structural Engineering discipline as well as field experience in fabrication and construction. Specific areas of expertise related to Lock and Dam design include: miter gates, tainter gates, reverse tainter valves, bulkheads, mass concrete, lock approach walls, bridges, and stability analysis.

US Army Corps of Engineers, Robert C. Byrd Lock and Dam, Ohio River. Responsible charge for on-site evaluation and preparation of plans and specifications for the rehabilitation of the dam and decommissioning of the lock. Performed stability analysis and designed anchorage system for the dam piers. Designed cellular cofferdam closures for the lock. Designed maintenance bulkheads and poiree dam trestles for the dam.

US Army Corps of Engineers, Melvin Price Lock, Mississippi River. Responsible charge for the design of the lock upper guidewall. The guidewall consists of reinforced concrete beams supported by steel caissons and was designed and detailed to be installed in-the-wet.

US Army Corps of Engineers, Old Hickory Lock and Dam, Cumberland River. Designed anchored sheet pile mooring cells.

US Army Corps of Engineers, Olmsted Lock and Dam, Ohio River. Technical Lead for Nashville Design Effort. Designed cellular cofferdams for dewatered construction site. Designed downstream approach walls. One of the walls was a concrete gravity wall, the other was built-in-the-wet reinforced concrete beams supported on concrete filled sheet pile cells. Detailed reinforcing and lock appurtenances for typical lock monoliths.

US Army Corps of Engineers, Kentucky Lock Addition, Tennessee River. Performed stability analyses of new and existing lock walls. Designed replacement reverse tainter culvert valves for existing lock.

US Army Corps of Engineers, Local Flood Protection Projects for West Virginia. Technical Lead for Nashville Design Effort. Designed lock-type miter gates for closure structure.

US Army Corps of Engineers, Hurricane Mitch Reconstruction for Nicaragua. On-site inspection of 4 damaged highway bridges and design of replacement bridges. Conceptual design of tainter-gated spillway, concrete ogee weir, non-overflow concrete gravity abutments and concrete u-frame stilling basin for Mancotal Dam spillway modifications.

Brief resume of key persons, specialists, and individual consultants anticipated for this project:

a. Name & Title:
Silvio Iera, P.E., P.L.S.
CADD Functional Manager

b. Project Assignment:
In-Roads

c. Organization:
Technical Contracts Support Section, Design Branch,
Engineering Division, Pittsburgh District Corps of Engineers

d. Years Experience: 30
With This Organization: 30 With Other Organizations:

e. Education: Degree(s)/Year/Specialization
Bachelor of Science, Civil Engineering 1972
University of Pittsburgh, Pittsburgh, PA

f. Active Registration:
Registered Professional Engineer, 1976 – Pennsylvania
Registered Professional Land Surveyor, 1981 - Pennsylvania

g. Other Experience and Qualifications Relevant to the Proposed Project:

General. As District CADD Functional Manager, Mr. Iera oversees the development and use of the CADD system to support the planning, design, operation and maintenance effort of the District. Mr. Iera coordinates with A/Es and District CADD users in the implementation and compliance of the District CADD standards.

Monongahela River Corridor Mapping and Flood Hazard Study. Mr. Iera coordinated and worked on the Monongahela River (129 Miles) Corridor Mapping and Flood Hazard Study. This study was a cost shared effort between the Corps and the Federal Emergency Management Agency (FEMA). Utilizing InRoads Mr. Iera developed a horizontal and vertical alignment for 129 miles of stream. A 3-D surface model was created and used to cut sections for Hydraulics to run a backwater model and develop 10, 50, 100, and 500-yr flood plains, and a floodway. Using InRoads, Mr. Iera used the flood plain elevations to delineate the 100 and 500-yr flood plain and the floodway on topographic maps for the entire length of the Monongahela River. This method of delineating the flood plains had never been used before.
Co-authored and presented paper (Monongahela River Corridor Mapping and Flood Hazard Study) at the American Society of Civil Engineers Conference (1993)

Allegheny River Flood Insurance Study. Utilizing InRoads, Mr. Iera developed the Allegheny River (24 Miles) Flood Insurance Study (1997). The procedures as used for the Monongahela River Corridor Mapping and Flood Hazard Study were used for this study.

Hydrology Board Charts. Utilizing InRoads Mr. Iera prepared board charts for the Hydrology Section. These charts required a semi log paper format in order to plot and show the profile of the yearly storage and discharges of the District's 17 reservoirs. In order to accomplish this, groups of profile windows were developed at different scales and matched together in a continuous vertical profile. Once the profile windows were completed the profile data was imported and displayed on the profile widow without any hand drafting.

Dredging Projects. Mr. Iera has worked on various dredging projects such as the Monongahela River Pool 3 Dredging, Hannibal L/D Dredging, Hildebrand L/D Dredging, Wheeling Creek Dredging. Using InRoads Mr. Iera has computed cut and fill dredging volumes.

Lock 4 Access Road. Utilizing InRoads Mr. Iera has created the alignment and developed cut and fill volumes for the different designs of the access road at the Monongahela River Lock 4 project.

Brief resume of key persons, specialists, and individual consultants anticipated for this project:

a. Name & Title:
Carl H. Johnson
Structural Engineer

b. Project Assignment:
Structural Engineer
Panama Canal - Concept Design of Lock Structures

c. Organization:
Structural Section, Engineering Division
Rock Island District, U.S. Army Corps of Engineers
Clock Tower Building

d. Years Experience: 33
With This Organization: 32.5 With Other Organizations: 0.5

e. Education: Degree(s)/Year/Specialization
B.S. 1968 – Civil Engineering - University of Illinois

f. Active Registration:
1974 Professional Engineer - Illinois
1980 Structural Engineer - Illinois

g. Other Experience and Qualifications Relevant to the Proposed Project:

Served on the US Army Corps of Engineers CASE Task Group on Miter Gates.
This group established the design criteria and was involved in writing the computer program to design lock miter gates.

Member of US Army Corps of Engineers Steel Structures Group.
This group is trying to address some of the inherent problems that we have been experiencing and to develop better methods of building steel structures.

Member of US Army Corps of Engineers Field Advisory Committee for Construction Underwater.
This group reviews innovative underwater construction methods.

Mississippi River – Auxiliary Lock No. 14
Designed new replacement miter gates.

Illinois Waterway – Lockport Lock
Designed new replacement miter gate.

Illinois Waterway – Brandon Road Lock
Designed new replacement miter gate and served as a technical assistant during construction.

Illinois Waterway – Dresden Island Lock
Designed new replacement miter gate and served as a technical assistant during construction.

Illinois Waterway – Marseilles Lock
Designed new replacement miter gate with a roadway bridge on top and served as a technical assistant during construction.

Illinois Waterway – Marseilles Dam
Did the original layout for the rehabilitation, and did the final design for the new submergible tainter gates.

Illinois Waterway – Peoria Dam
Did the original layout for the rehabilitation, and did the final design for the new submergible tainter gate.

Illinois Waterway – LaGrange Dam
Did the original layout for the rehabilitation, and did the final design for the new submergible tainter gate.

Seabrook - Lock Study
Involved in design of the gatebays and the sector gates.

Big Sandy River – Lock and Dam Study
Involved in a study to locate and layout locks and dams on this river.

Soo Lock - Sault Ste Marie - Lock Study
Involved in layout a replacement lock for the old Sabin and Davis Locks.

Upper Mississippi River Navigation Study
Involved in a system wide study of the navigation of the Upper Mississippi River. Was involved in laying out new locks and adding on to existing locks.

Brief resume of key persons, specialists, and individual consultants anticipated for this project:

a. Name & Title: **Douglas A. Kish, P. E.**
Structural Engineer
304-529-5724 W dougk@mail.orh.usace.army.mil

b. Project Assignment: Panama Canal

c. Organization: Huntington District, Corps of Engineers
502 Eighth Street
Huntington WV 25701

d. Years Experience:
With This Organization: 10 With Other Organizations:

e. Education: Degree(s)/Year/Specialization: BS/1989/Civil, MS/1991/Structural, West Virginia University

f. Active Registration:
Registered Professional Engineer (Civil), West Virginia, 1996

g. Other Experience and Qualifications Relevant to the Proposed Project:
Designed a miter gate for New Cumberland L&D. Responsible for the design and Plans & Specifications for the replacement upper miter gate. Utilized the case program "CMITER-LRFD" to design the replacement gate. Incorporated the use of a special nut on the upper end of the diagonal straps which should allow the diagonals to be stressed using standard torque wrenches or air tools. The diagonal design also incorporated clearances to allow hydraulic tensioners to be used to stress the diagonals if the special nuts do not perform as intended.

Performed ITR of the McAlpine L&D Miter Gate Plans & Specifications.

Designed a lifting reinforcement system for the Huntington District's Ohio river miter gates when utilizing the Ohio River Division's Heavy Gate Lifter. The system incorporated the use of bolted on members which significantly reduced the amount of preparation time for the repair fleet when removing an existing miter gate with the Ohio River Division's Heavy Gate Lifter.

Designed the Miter Gates, and checked the Culvert Bulkhead calculations and drawings for the Marmet Lock Replacement Project. Responsible for the design and Plans & Specifications for the upper and lower miter gates. Utilized the case program "CMITER-LRFD" to size the main members of the gates. For interchangeability between the Marmet L&D and Winfield L&D, the lower gate for Marmet was designed to also be used as the upper or lower gate at Winfield L&D. The calculations included the design of the pintle ball, top anchorage, diagonal straps, gudgeon pin hood, strut connection box, and lifting reinforcement for picking the gate up with the Ohio River Division's Heavy Gate Lifter. The diagonals included torquenuts for stressing the diagonals similar to those proposed on the replace miter gate for New Cumberland L&D. Was responsible for the review of the culvert bulkhead calculations and Plans & Specifications.

Checked various calculations for the Winfield L&D Miter Gates. Checked calculations for the inclusion of a "direct-action" operating strut. These calculations included the investigation of the pintle ball, top anchorage, diagonal straps, gudgeon pin hood and strut connection box.

Hydraulic Steel Structure Program Coordinator. Responsible for analyzing and inspecting a number of existing steel structures (miter gates, tainter gates, bulkheads, service gates, etc.) for signs or potential for fracture and/or fatigue failure. Also responsible to ensure new steel structures are designed, constructed and operated in accordance with current COE criteria in EM 1110-2-2105 and ER 1110-2-8157.

Certified Bridge Inspector. Have been trained to inspect steel bridges for signs of distress which has lead to a better understanding of fracture & fatigue detailing to reduce the potential for failure.

Brief resume of key persons, specialists, and individual consultants anticipated for this project.

a. Name & Title:
Gordon R Lance, P.E.
Hydraulic Engineer

b. Project Assignment:
Independent Technical Review
Filling and Emptying System

c. Organization:
Engineering and Construction Division,
Kansas City District, US Army Corps of Engineers

d. Years Experience: 41
With This Organization:20 With Other Organizations:21

e. Education: Degree(s)/Year/Specialization
BS Civil Engineering 1961, 41 yrs specialization

f. Active Registration:
P.E. Ohio 1966
P. E. Indiana 1967

First Year Registered/Discipline:

g. Other Experience and Qualifications Relevant to the Proposed Project:

Olmsted Locks and Dam. I was the Engineer responsible for the hydraulic design of Olmsted Locks and Dam, including the design of the filling and emptying system. I modified the filling and emptying design that had been used at Smithland Locks and Dam (twin 1270' x 110' locks) to effect a major reduction in the width of the middle, with a consequent major reduction in cost. I developed an unsteady flow model of the Olmsted pool in order to evaluate the proposed hinged pool operations at that project (the critical operating point is 52 miles upstream of the dam). I have presented a paper at an ASCE specialty conference on the proposed operations of Olmsted Dam.

McAlpine Locks and Dam. I designed a split lateral filling and emptying system for the new lock McAlpine Locks and Dam. This design was replaced by an innovative design based on the configuration of the lock walls.

Locksim. I was the principal COE staff member responsible for the introduction of the FLOWSYM (and its successor LOCKSIM) computer model to the USACE organization. This program has made it possible to evaluate and screen alternate filling and emptying system configurations prior to testing in a physical model.

Navigation Modeling. I was either the lead engineer or served in an advisory capacity for the navigation model studies at Olmsted and Cannelton Locks and Dams, and on the lock model studies at Kentucky and McAlpine Locks.

Brief resume of key persons, specialists, and individual consultants anticipated for this project:

a. Name & Title:
Walter P. Leput, P.E. & P.L.S.
Chief Hydraulics & Hydrology Section

b. Project Assignment:

Lock filling and emptying system designs.

c. Organization:
Water Resources Engineering Branch, Engineering Division,
Pittsburgh District, US Army Corps of Engineers

d. Years Experience: 30
With This Organization: 30 With Other Organizations:

e. Education: Degree(s)/Year/Specialization
Master of Science, Civil Engineering (Water Resources)
University of Pittsburgh, Pittsburgh, PA (1975)
Bachelor of Science, Civil Engineering
West Virginia University, Morgantown W Va (1971)

f. Active Registration:
Registered Professional Engineer, Pennsylvania (1975)
Registered Professional Engineer, West Virginia (1976)
Registered Land Surveyor, Pennsylvania (1974)
Registered Land Surveyor, West Virginia (1978)
Member, ASCE (20 years)

g. Other Experience and Qualifications Relevant to the Proposed Project:

Member, Corps of Engineers Navigation Hydraulics Research Program Review Committee (14 years overseeing, developing and guiding COE navigation physical/numerical research on various topics at the Waterways Experiment Station).

Member, Corps of Engineers Ice Engineering Research Program Review Committee (14 years overseeing, developing and guiding COE ice/debris physical/numerical research on various topics at the Cold Regions Research Lab).

Member, Ohio River Main Stem Study, Innovative Lock Extension Filling and Emptying Committee (participated in a team that developed an innovative lock filling and emptying design concept to be utilized at twelve sites on the Ohio river, presently being tested at WES). Ohio River Main Stem Study Meldahl Project Lock Extension Prototype Hawser Study (overseen a multi district team that conducted lock prototype filling and emptying tests to obtain Hawser forces for a lock extension design).

Ohio River Main Stem Study Initial Thru-The-Sill Fill & Emptying System Design/Analysis Team (participated in a team that developed thru the sill designs for various locks on the Ohio/Mon Rivers, included overseeing WES modeling).

Panama Canal – Miraflores Upper West Lock, Measurement Of Pressures Related to Vessel Movement Study (overseen the prototype lock testing and report of wave generation within the lock during ship movement).

Ohio River Main Stem Study (overseen the hydraulic analysis of new locks for three Projects which utilized f&e systems that could use float in construction concepts)

Lower Monongahela River L/D 2,3 &4 Project (overseen all Hydraulics & Hydrologic aspects of the Feasibility, GDM and P&S for a new navigation system on the Monongahela River, which included extensive numerical and physical modeling).

Monongahela River Lock #4 Project – Hook Gate Filling & Emptying System (over seen the hydraulic analysis and design for an innovative lock fill and emptying system for the Mon 4 project).

Monongahela River Damn 2 Float-In Dam (Construction, Deliver and Hydraulic Forces Study) (overseen and guided all numerical and physical analysis and testing for the delivery and set down of the float in dam segments).

Emsworth Lock/Dam Rehab Study (guided the risk analysis of the downstream dam protection).

Grays Landing Lock/Dam Project (overseen the hydraulic design of the side port f&e system, fixed crest dam, navigation pass and WES modeling).

Point Marion Lock Project (overseen the hydraulic design of the side port f&e system, dam modifications and WES navigation modeling).

Hydraulics & Navigation Studies for Six Add-On-Hydropower Plants at Pittsburgh District Navigation Projects (overseen the physical navigation modeling and independent testing of hydropower additions to various navigation projects).

Hildebrand L/D Upper Approach Sedimentation Mitigation Dike Study (guided the WES physical modeling of a dike system to reduce sediment within the upper lock approach without negatively influencing navigation).

Maxwell L/D Prototype Hawser Force Study (overseen the prototype lock f&e measurement of water slopes and Hawser Forces for a bottom lateral system).

Brief resume of key persons, specialists, and individual consultants anticipated for this project:

a. Name & Title:
Frank J. Likar
Assistant Deputy District Engineer for Programs & Project Management

b. Project Assignment:
Consultant to Cost Engineering production team

c. Organization:
U.S. Army Corps of Engineers, Pittsburgh District

d. Years Experience: In excess of 30
With This Organization: 30+ With Other Organizations:

e. Education: Degree(s)/Year/Specialization:
B.S. Civil Engineering, 1971

f. Active Registration:
P.E., Pennsylvania

First Year Registered/Discipline 1975, Civil Engineer

g. Other Experience and Qualifications Relevant to the Proposed Project:
USACE subject matter expert in developing training course in Construction Cost Engineering.

Lead instructor in 2 training courses – Construction Cost Engineering and Estimating for Construction Modifications in excess of 10 years.

Senior Cost Engineer, Pittsburgh District, 15 years.

Responsible for conceptual, feasibility, competitive bid, and negotiated estimates for numerous navigation locks, navigation dams, flood control dams, flood protection projects and other civil works activities.

Participated in team that drafted USACE regulations on cost engineering.

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Guest lecturer to other agencies on preparation of cost estimates.

Certified cost engineer.

Engineering oversight member of current Ohio River Mainstem Study

Brief resume of key persons, specialists, and individual consultants anticipated for this project:

a. Name & Title:

Martin L Lockard

b. Project Assignment:

c. Name of Firm with which associated:
Louisville District
US Army Corps of Engineers

d. Years experience: With this Firm 23 **With other Firms** 12

e. Education: Degree(s)/Year/Specialization
B.S. Civil Engineering, 1987, University of Kentucky, Lexington, KY, USA

f. Active Registration: Year First Registered/Discipline
DOD Tri-Services Certified Cost Consultant – Jan 1996
USACE Prospect Instructor – Dec 1994

g. Other Experience and Qualifications relevant to the proposed project:

Overall Experience:

May 2001 to Present:
Civil Engineer Regional Technical Specialist, GS-810-13, US Army Corps of Engineers Lakes & Rivers Division and Louisville District, 600 Martin Luther King Jr. Place, Louisville, KY 40202, Cost Engineering Section.

I serve as a regional technical specialist in cost engineering for civil works projects. Assignments involve work in a broad range of specialized activities related to cost engineering functions. Project features are commonly large and complex with some features that may be without precedent. Projects include navigational locks and dams; canals and channels; sheet pile cellular and/or earthen cofferdam structures; dredging and dredged material disposal area design; large earthfill or rockfill dams; foundations for large concrete dams; including appurtenant features such as power plants, spillways, outlets works, and intake structures; foundations for concrete flood walls; levees and dikes; soft ground tunnels; retaining structures; and landslides/slope failures.

I serve on independent technical review (ITR) teams, and quality assurance (QA) teams. In this capacity, I review/recommend approves Decision/Implementation documents, consult on matters in area of specialization with engineers in Districts, Division, and other Agencies, provide technical direction consistent with Corps policy to Districts and Architect-Engineer firms (AE). I serves as a technical expert in field of specialization within the region. I serve on District planning/design Teams upon request, and on regional (Division) Technical Discipline Teams.

The geographical area of operations for the region includes 7 districts and over 335,000 square miles that include the States of Tennessee, Kentucky, Indiana, Illinois, Michigan, Wisconsin, Minnesota, Ohio, New York, Pennsylvania, Maryland, Virginia, North Carolina, West Virginia, South Carolina, Georgia, Alabama, and Mississippi. Complex and diverse climate, hydrologic and geotechnical conditions characterize the area. Terrain is highly diverse. Parts of the region are prone to flash flooding as well as drought conditions. The total program is on the order of $ 1.5 Billion per annum.

I served as the cost engineering team member on selected design teams. I developed preliminary and budget estimates given preliminary plans, sketches, ideas and/or quantities and developed detailed final cost estimates using final plans and specifications for both civil works and military construction programs. I prepared cost estimates for change orders, contract modifications and negotiated contracts. I reviewed the work of other specialists both inside and outside of the organization including lower graded personnel and A/E firms. I provided leadership, instruction, format and guidance to in the preparation of cost estimates to lower graded personnel and A/E firms. I served as Team Leader within the section to coordinate the work of different disciplines into a complete estimate

July 89 to May 1993:
Cost engineering team member on selected design teams. Developed preliminary and budget estimates given preliminary plans, sketches, ideas and/or quantities and developed detailed final cost estimates using final plans and specifications for both civil works and military construction programs. Developed cost estimate for change orders, contract modifications and negotiated contracts. Reviewed work of other specialists both inside and outside of the organization including lower graded personnel and A/E firms. Provided instruction, format and guidance to in the preparation of cost estimates.

August 1988 to July 1989:
Served as field engineer for a firm specializing in highway construction. Responsible for construction layout, line and grade for various public and commercial projects. My office duties included weekly cost reporting, quantity verification and cost estimating

SPECIALIZED TRAINING
Design/Build Contracting course, Jan 2000; M32 Micro Computer Aided Cost Engineering System (MCACES) software, May 1999; Estimating for Construction Contract Modifications course, Feb 1998; MCACES Advanced course, Apr 1997; HTRW Cost Estimating course, Apr 1996; CEFMS, Nov 1996; LEAD training, May 1994; Instructional Methods course, Dec 1994; Negotiations for Construction Contract Modifications course, Apr 1993; Introduction to Supervision course, Dec 1992; Effective Briefing Techniques course, Oct 1991; Composer Gold Software course, May 1990; Value Engineering course, Feb 1990.

Brief resume of key persons, specialists, and individual consultants anticipated for this project:

a. Name & Title:
Pedro J. Luciano,P.E.
Structural Engineer

b. Project Assignment:
Panama Canal

c. Organization:
Army Corps of Engineers
502 Eighth St.
Huntington, WV 25701

d. Years Experience:
With This Organization: 20 With Other Organizations:1

e. Education: Degree(s)/Year/Specialization
1989 to 1993 M.S. Engineering Management
1978 to 1982 B.S., Civil Engineering

f. Active Registration:
1987 Registered Professional Engineer in the State of West Virginia

g. Other Experience and Qualifications Relevant to the Proposed Project:

1988 to Present –Structural Engineer
Supervise design and analysis of hydraulic structures such as lock monoliths, miter gates, bulkheads, culvert valves, pump stations, and floodwalls. Develop plans and specifications for floodwalls, major components of locks and dams, and masonry buildings. Conduct VE studies and QC and QA reviews of designed projects, and provide technical assistance in form of inspections, reviews of shop-drawings, contract modifications, repair procedures, and structural investigations. Provide structural assessments and construction supervision during local, regional, national, and international emergencies, including temporary components of infrastructure. (Served as Spanish-language translator and coordinator for engineering work during 2000 disaster in Nicaragua and Dominican Republic for example.)

Performs and reviews 3D overturning and sliding analyses of locks monoliths and floodwalls, using sophisticated computer programs and Corps of Engineers Design Criteria. Completes plans of the designed projects in Microstation Computer Aided Design and Drafting (CADD) program. Writes scopes of work, completes cost estimates and negotiates A/E Contracts. Participates in the A/E selection.

Recent assignments:
*Completed plans and specifications of mayor structural components of Winfield Locks and Marmet Locks
*Lead Engineer for the R.C Byrd Dam Rehabilitation. Dam rehabilitation included the anchoring of dam monoliths and installation of eight 125 ft. long roller gates. The installation of the roller gates and the anchors was performed in the wet.
*Lead Engineer Bluestone Drift and Debris Tower, Bluestone Dam, Hinton, WV

Awards:
2001 Exceptional Performance Appraisal, Army Corps of Engineers, Huntington, W.V.
2001 Hispanic Engineer of the Year, Army Corps of Engineers, Great Lakes and Ohio River Division
1993 Hispanic of the Year Award, Sigma Delta Pi, Marshall University, Huntington, W.V

***1982 to 1988* Structural Engineer**, U. S. Army Corps of Engineers' Huntington District, Huntington, WV.
Performed analysis and design of major structural components of locks, dams, floodwalls, and masonry buildings; provided technical assistance during project construction, including reviews of shop drawings; performed inspections of operating projects to identify opportunities for correction and general improvement.

Brief resume of key persons, specialists, and individual consultants anticipated for this project.

a. Name & Title:

Dolores J. Marciniak

Civil Engineering Technician

b. Project Assignment:

Lead Technician Charleroi Project

c. Organization:

Pittsburgh District, US Army Corps of Engineers

d. Years Experience:

With This Organization: 9 With Other Organizations: 3

e. Education: Degree(s)/Year/Specialization

Community College of Allegheny County, 1992

AS Engineering Technology

f. Active Registration:

First Year Registered/Discipline:

g. Other Experience and Qualifications Relevant to the Proposed Project

General. Ms. Marciniak has expert knowledge of MicroStation SE and MicroStation J for the purpose of compiling digital maps and related files and drawings to support planning, engineering design and construction, navigation, flood control, and project operations activities. Experienced use of MDL commands, user commands, dimension settings, reference files, cell libraries, plot settings, including pen tables, and color tables.

Ms. Marciniak has expert knowledge utilizing computer based software applications, i.e. InRoads, Comstar System, Kermit, and Digital ASCII File format to develop topographic and hydrographic feature data, volumetric and other data. Accessed the USGS Topographic Mapping to prepare the pre-survey data for specific survey areas.

Ms. Marciniak used advanced features of MicroStation J and Modeler Software to produce 3D models of the locks and project sites for use in an animation or fly-through presentation by applying materials to the digital terrain model (DTM).

Ms. Marciniak works with AE Contractors by checking shop drawings, contract drawings, aerial photography, etc. for Quality Control (QC) and Quality Assurance (QA).

Ms. Marciniak completes assignments within schedules and budgets. She also takes an active role in seeking new ways to improve productivity through participation in a regional CADD Users Group.

Charleroi Locks and Dam Currently serving as the Lead Civil Engineering Technician for the Site Development portion of the project. Incorporated the survey control data, the property descriptions and other survey datum onto existing mapping. Responsible for the overall technical accuracy of all cadd/digital files. Coordinate with the Louisville District to assure technical accuracy and compliance to the new district standards. Assist other engineers and engineering technicians. Compile all files for duplication and distribution for the technical review.

Navigation Charts. Ms. Marciniak provided technical CADD support for converting/reformatting the District Navigation Charts to Division Standards. These tasks required comprehensive technical knowledge in the use of MicroStation and InRoads software applications. Prepare Navigation Charts for placement on the Internet using a .pdf format. Delineate Flood Plains for flood plain management projects and provide hydrographic contours, and a 6'/9' shoreline contour for Federal Emergency Management Agency (FEMA) by utilizing the hydrographic software Comstar System, Kermit, and InRoads. Plot survey notes from field books or digital formatted data from electronic data collectors that are downloaded into MicroStation. Plan sheet layouts, views, limits of orientation on finished maps, plot baselines, indicate work limits, define survey control, and characteristics of the terrain. Use InRoads software to create 3D models of the locks, create alignments, and assign river mile markers to the channel centerline.

Ms. Marciniak has expert use of the File Management System as well as maintaining all CADD Project Files and up-to-date hardcopy records of all assignments. Uses IPLOT 9 to plot all digital files, Color Plots as well as Gray Shaded Plots, with extensive knowledge of Pen Tables, Color Tables, and Line Weights. Ms. Marciniak created new Navigation Cell Libraries with Dimension Driven Cells compliant with NOAA Standards that were adopted Corps wide throughout the nation.

Braddock Locks and Dam. Merged and digitized current construction site mapping with drawings of historical significance into a map used for formal presentations by Project Management . Used hydrographic sounding data to create the centerline profile and location of several pipeline crossings. Ms. Marciniak's expert knowledge of InRoads enabled her to create contours at 1' intervals to define the navigable channel for transporting the newly constructed dam from the construction site on the Ohio River to the temporary mooring site on the Monongahela River. Use of this information enabled the contractor to transport the dam segment without incident. Contours generated from hydrographic data delineated the dredge areas on the Monongahela River and identified areas on the Allegheny River where the dredged material could be placed.

Conversion to MicroStation J. As the Lead Civil Engineering Technician Ms. Marciniak worked in conjunction with the Information Management Center to prepare Engineering Division for the conversion from MicroStation SE to MicroStation J. This encompassed loading the software as prescribed by the U.S. Army Engineer Research and Development Center, Waterways Experiment Station/Tri-Service CADD/GIS Technology Center. All the Pittsburgh District defaults were set and beta tested. Implementation also included installing the new software on all PC's. Ms. Marciniak combined with the Information Management Specialist performed several in-house training sessions for all CADD users.

Additional support information was placed on the Pittsburgh District Intranet to facilitate any problems or questions in the future. Ms. Marciniak was the POC in Design Branch of the Pittsburgh District for any future CADD assistance. As a result of the major MicroStation upgrade, all other software had to be restructured i.e. InRoads and IPLOT, resulting in a change in the plotting process and additional in-service for the users. New scopes of work were also initiated to comply with the new standards as set forth by WES. This was a major endeavor that was highly successful because of the experience and expertise of Ms. Marciniak.

Brief resume of key persons, specialists, and individual consultants anticipated for this project:

a. Name & Title:
David A. Margo, P.E.
Hydraulic Engineer

b. Project Assignment:
Lock filling and emptying design

c. Organization:
Hydraulics and Hydrology Section, Water Resources Engineering Branch, Engineering Division, Pittsburgh District, US Army Corps of Engineers

d. Years Experience: 6
This Organization: 1 Other Organizations: 5 (Huntington District, USACE)

e. Education: Degree(s)/Year/Specialization
Bachelor of Science in Civil Engineering, University of Pittsburgh, 1993
Master of Science in Civil Engineering, University of Pittsburgh, 1995

f. Active Registration:
Registered Professional Engineer, West Virginia No. 14336 (2000)
Member ASCE (1993)

g. Other Experience and Qualifications Relevant to the Proposed Project:

Marmet Locks and Dam. Designed innovative lock filling and emptying systems. Utilized numerical models (LOCKSIM) to design features of filling and emptying systems. Determined fill times, empty times, hawser forces, and pressures at key points in the culvert system. Evaluated results of physical modeling of filling and emptying systems. Collaborated with Waterways Experiment Station on physical modeling of navigation conditions during construction.

London Locks and Dam. Performed hydraulic analysis for extension of the existing riverward lock chamber using LOCKSIM. The extended lock was designed to utilize the existing filling and emptying system. Collaborated with Waterways Experiment Station on physical modeling of navigation conditions during construction.

Ohio River Mainstem Systems Study. Collaborated with Pittsburgh District to collect prototype filling and emptying data at Meldahl Locks and Dam for evaluation potential lock extension alternatives. Validated prototype measurements using the numerical model LOCKSIM. Performed concept level hydraulic analysis and design of filling and emptying systems using LOCKSIM.

Brief resume of key persons, specialists, and individual consultants anticipated for this project:

a. Name & Title:

Stephen T. Maynord, PhD, PE
Research Hydraulic Engineer

b. Project Assignment:
Hydraulic Engineer-ship movement in locks

c. Organization:
US Army Engineer Research and Development Center
Coastal and Hydraulics Laboratory, Navigation Branch

d. Years Experience:
With This Organization: 29 With Other Organizations:

e. Education: Degree(s)/Year/Specialization
PhD/1987/Civil Engineering/Colorado State University
MS/1977/Civil Engineering/U of Texas at Arlington
BS/1972/Civil Engineering/U of Texas at Arlington

f. Active Registration: First Year Registered/Discipline:
1976/Professional Engineer, Mississippi#6956

g. Other Experience and Qualifications Relevant to the Proposed Project

General. Dr. Maynord has conducted physical model and numerical studies of tow and ship movement in locks and navigation channels. He has been principle investigator on projects concerning lock entry and exit times and required sill depth. He developed a 1D model "NAVEFF" for water level and velocity changes in navigation channels that includes vessel resistance and propulsion. He is currently involved in the application of 2D numerical models to evaluate water level changes due to ship movement in confined channels

Lock entry/exit times, required sill depth. As the principle investigator, he evaluated the entry and exit times of tows on the Upper Mississippi and Ohio Rivers. Techniques were developed for estimating the entry/exit time as a function of sill depth and guidance was developed for required sill depth to prevent vessels from striking the sill. He conducted a study on Lock 52 on the Ohio River to define required sill depth at an existing lock that had to be temporarily taken out of service because of vessels striking the sill.

NAVEFF Model for Vessel Effects The aspect of NAVEFF pertinent to the lock study is the development of resistance and propulsion techniques that will be important in evaluating entry and exit times for the Panama locks.

Application of 2D Numerical Models Dr Maynord is conducting studies of deep draft ship effects Houston Ship Channel, Chesapeake Bay at Tolchester Channel, and Sabine-Neches Waterway.

Selected Studies Related to Navigation:

Maynord, Stephen T. "Effects of Lock Sill and Chamber Depths on Transit Time of Shallow Draft Navigation", ERDC/CHL TR-00-13, August 2000.

Maynord, Stephen T. "Physical Forces near Commercial Tows", ERDC ENV Report 19, July 2000.

Maynord, Stephen T. "Power versus Speed for Shallow Draft Navigation", ASCE J of Waterway, Port, Coastal, and Ocean Engineering, Vol 126, No 2, Mar/Apr 2000.

Maynord, Stephen T. "Inflow Zone and Discharge Through Propeller Jets", PIANC Bulletin No 102, 1999.

Maynord, Stephen T. "Return Velocity and Drawdown in Navigable Waterways", ERDC TR HL-96-7, August, 1996.

Maynord, Stephen T. "Safe Navigation Speeds and Clearance at Lower Sill, Temporary Lock 52, Ohio River", ERDC TR HL-87-3, April 1987.

Brief resume of key persons, specialists, and individual consultants anticipated for this project:

a. Name & Title:
Byron K. McClellan,
Chief, Design Branch, Louisville District

b. Project Assignment:
Structural /Civil

c. Organization:
U.S. Army Corps of Engineers, Louisville District

d. Years Experience:
With This Organization: 31 With Other Organizations:

e. Education: Degree(s)/Year/Specialization
Master of Science, Civil Engineering (Structures), 1976, University of Louisville
Bachelor of Science, Civil Engineering, 1970, Purdue University

f. Active Registration:
Professional Engineer, Kentucky and Indiana

First Year Registered/Discipline: 1974, Civil Engineering

g. Other Experience and Qualifications Relevant to the Proposed Project:

-Member of team which produced Concepts Study for Canal Alternatives, 1997 (Independent Study for the Panama Canal Commission)

-Active member of Field Review Groups for "Innovations for Navigation Projects Research Program" and "Navigation Systems Research and Development Programs"

-Member CELRD Regional Navigation Design Team

-Served on Design and Construction Innovations for Locks and Dams Task Force, formed by Director for Civil Works

-Experience includes structural engineering (including structural and stability design, seismic analysis and design, nonlinear incremental structural analysis which addressed thermal stresses in concrete and resteel, lock filling and emptying system conceptual layout , innovative concept development for design and construction of locks and dams, planning, design and construction associated with major Ohio River navigation structures including Olmsted, McAlpine, J.T.Myers, Newburgh, Smithland, Cannelton and Markland. All projects included hands-on effort as a designer and or reviewer.

- Developed conceptual design concepts for construction of railroad bridge which was built beside existing track and rolled into place with one day track outage.

-Contributing author to the following Corps Guidance Documents:
Engineering for Prefabricated Construction of Navigation Projects(1999),
Earthquake Design and Evaluation for Civil Works Projects(1995),
Seismic Analysis and Design for Reinforced Concrete Locks(1995),
Planning and Design of Navigation Dams(1995),and
Report of the Task Force on Design/Construction Innovations for L&D(1993)

-Patents: (assigned to U.S.A., Secretary of the Army)
Patent No. 5,277,517, titled "Mobile Cofferdam"
Patent No. 5,199,812, titled "Hydraulic Fixed Strut Gate"
Patent No. 5,211,700, titled "Movable Dam Gate for Regulating Water in a Navigable Pass"

-1995 Researcher of the Year Award, U.S. Army Corps of Engineers, Ohio River Division

-Masters Degree Thesis, "An Analysis of Sheet Pile and Cell Fill Stresses in a Circular Cofferdam

Brief resume of key persons, specialists, and individual consultants anticipated for this project:

a. Name & Title:
Coy W. Miller, PE
Chief, Design Branch

b. Project Assignment:
Independent Technical Review
Hydraulic Design

c. Organization:
Engineering Division, Huntington District, US Army Corps of Engineers

d. Years Experience:
With This Organization: 23 With Other Organizations: 0

e. Education: Degree(s)/Year/Specialization
University of Iowa, 1990
MS Civil & Environmental Engineering – Hydraulics

West Virginia Institute of Technology, 1982 - BS Civil Engineering

f. Active Registration:
Professional Engineer, West Virginia

First Year Registered/Discipline: 1988/Civil Engineering

g. Other Experience and Qualifications Relevant to the Proposed Project:

General. Mr. Miller has broad academic background in the Hydraulic Engineering discipline. Specific areas of expertise related to Lock and Dam design include: filling and emptying systems (conventional and innovative), layout of navigation structures pertaining to approach conditions, stream bank protection, maintenance dredging requirements, hydraulic design of dam gates, etc. He has extensive experience in both physical modeling (filling and emptying and navigation conditions) and numerical modeling (1 and 2-D modeling).

Mr. Miller currently holds the position of Chief, Design Branch for the US Army Corps of Engineers, Huntington District. In this position, he is responsible for the development and coordination of design endeavors for inland navigation and flood control projects within the Huntington District Boundaries. Prior to selection for his current position, Mr. Miller held the position as Chief, Hydrology and Hydraulics Section. In that position, he was responsible for the hydraulic design of all navigation projects in Huntington District.

Member of USACE Field Review Group for Navigation. This group is comprised of select individuals across the Corps of Engineers to recommend and review new and on-going USACE research efforts in the area of navigation. These efforts include innovative filling and emptying systems, approach wall criteria, etc.

US Army Corps of Engineers, Winfield Locks and Dam, Kanawha River. Mr. Miller served as the lead hydraulic engineer for this $236,000,000 project on the Kanawha River. The project involved the addition of a new 110' x 800' lock chamber landward of the existing chambers. The project also included the first application in Huntington District of long span, pre-cast beams for construction of the guard wall. Mr. Miller was responsible for the physical model testing and development of the side-wall port filling and emptying system. He was also responsible for the review of drawings, design computations and contract specifications for technical accuracy and adherence to design criteria.

Marmet Lock Replacement Project, Kanawha River. Mr. Miller served as the lead hydraulic engineer for this $313,000,000 project on the Kanawha River. The project involved the addition of a new 110' x 800' lock chamber landward of the existing chambers. The project also included the development of an innovative filling and emptying system that included a through the sill intake with culverts located in the floor. This innovative filling and emptying system allowed for the use of RCC for construction of the lock walls. Mr. Miller was responsible for the physical model testing for navigation conditions and for development of the innovative filling and emptying system. The filling and emptying system development involved the use of the LOCKSIM numerical model and physical model testing. He was also responsible for the review of drawings, design computations and contract specifications for technical accuracy and adherence to design criteria.

Ohio River Mainstem – Greenup Lock Extension, Ohio River (Feasibility Study). Mr. Miller served as the lead hydraulic engineer for the study of this $200,000,000 project on the Ohio River. The project involves the extension of the existing 110' x 600' lock chamber to 1,200'. The study required the development of an innovative filling and emptying system that allowed for the use of "float-in" and "lift-in" precast concrete lock walls. Mr. Miller was responsible for the use of the LOCKSIM numerical model and the physical model testing required for the development of the innovative filling and emptying system.

Upper Mississippi Navigation Study. For St. Louis District, served as a hydraulic engineer on the Upper Mississippi Study ITR team. Study was to determine the viability of replacing or rehabbing 25 lock structures on the Mississippi River. Primary responsibilities included review of all design decisions and processes concerning the projects.

Kentucky Lock Replacement Study. For Nashville District, served as the hydraulic engineer on the Lock Replacement ITR team. ITR responsibilities included review of all design documents and plans and specifications.

Brief resume of key persons, specialists, and individual consultants anticipated for this project:

a. Name & Title:
John E. Nites, P.E.
Senior Electrical Engineer

b. Project Assignment:
Electrical Engineer – Technical Lead

c. Organization:
U.S. Army Corps of Engineers
Pittsburgh District, Engineering Division, Design Branch

d. Years Experience: 17
With This Organization: 17 With Other Organizations: 0

e. Education: Degree(s)/Year/Specialization
The Ohio State University, 1983
BS Electrical Engineering

f. Active Registration:
Professional Engineer, 1989 - Pennsylvania

g. Other Experience and Qualifications Relevant to the Proposed Project:

General. Seventeen years experience in the design of electrical power distribution, control, and lighting systems for navigation locks and dams, and flood control reservoirs. Extensive experience in the design of power distribution and solid state controls for direct connected hydraulic cylinders for valves, miter gates and tainter gates. Mr. Nites currently hold the position of Senior Electrical Engineer in the Electrical and Mechanical Design Section, Design Branch for the U.S. Army Corps of Engineers, Pittsburgh District. In this position he is responsible for coordination and the development of plans and specifications, and design criteria, for inland navigation and flood control projects. Assumes the technical lead for various projects of significant scope.

Remote gate controls Ohio and Mon Rivers. Developed plans and specifications for automating the controls for nine gated dams. The design included a PLC based real-time distributed control system allowing the tainter gates to be operated from a remote location. The Mon River design included the use Human Machine Interface software for remote centralized operator control from industrial computers.

Lead Electrical Engineer Grays Landing and Point Marion Lock and Dam. Designed the power distribution, lighting and control systems. Design included power and controls for a four corner hydraulic system. Implemented high mast lighting design for the locks. Support provided during construction and furnished critical correspondence resolving all technical issues.

Lead Electrical Engineer Lock #4 Allegheny River E/M Rehab. Design included power distribution and controls for direct connected hydraulic cylinders and the innovative use of variable frequency drives for controlling the speed of the miter gates.

Panama Canal Operations and Maintenance Study team member. Lead electrical engineer. Authored the electrical portions of the study which included an extensive assessment of the canals electrical distribution systems, control and lighting systems, transmission lines and various medium and high voltage power systems. Reviewed maintenance programs. Made various recommendations to the capital program in the interests of reducing costs and increasing reliability. Also authored electrical portions of the study for the Miraflores Power Plant. Gained institutional knowledge of the canal after spending approx 3 months in the field at Panama.

Saint Lawrence Seaway Development Corporation Study team member. Selected to the team by the SLSDC. Similar to the Canal O&M study. Authored the electrical portions of the study. Assessed the overall condition of the electrical power distribution and control systems for Eisenhower and Snell Locks. Several improvement recommendations to the maintenance and capital program were offered.

Lead Electrical Engineer Braddock design team. Developed plans and specs for a gated dam utilizing PLC technology for control of the direct connected hydraulic cylinders. Controls included state of the art computer controls for gate position and operator control. Gate synchronization considerations were included into the control system. Designed a fiber optic communications and remote I/O network. Power distributed utilizing motor control centers and hydraulic power unit controller cabinets.

Lead Electrical Engineer Lock #5 Allegheny River E/M Rehab. Design included power and controls for miter gate direct connected hydraulic cylinders and the innovative use of variable frequency drives for controlling the speed of the miter gates. Design included a real-time PLC based control system for lock operation. Industrial computers were utilized with integral touchscreen on an industrial network for control of the system. Power distribution centralized with all components including VFD's located in the motor control centers. Support provided during construction and furnished critical correspondence resolving various technical issues.

Lead Electrical Engineer Charleroi Locks. Project currently in the design phase. Responsible for all phases of design including plans and specs, design documentation report and criteria, and coordination with all other disciplines. Power and PLC controls will be provided for directed connected hydraulic cylinders for miter gates and valves for a new two chamber lock. Centralized state-of-the-art computer controls will be implemented in a control tower.

Brief resume of key persons, specialists, and individual consultants anticipated for this project:

a. Name & Title:
James Pace
Mechanical engineer

b. Project Assignment:
South Atlantic Division

c. Organization:
Military and Technical Directorate

d. Years Experience:
With This Organization: 20 With Other Organizations: 16

e Education: Degree(s)/Year/Specialization
BS in ME, 1965

f. Active Registration:
Georgia, 14133

First Year Registered/Discipline
1982, ME

g. Other Qualifications Relevant to the Proposed Project:

Responsible for planning, directing and coordinating the mechanical engineering activities in the South Atlantic Division. The work previously involved design review of the locks and dams on the Tenn-Tom Waterway and the feasibility design studies for the proposed locks on the Coosa Waterway. We also did the review of the Richard B Russell Pump storage project (600 mw) and was on the team that approved the model test. We presently provide technical support to the operations Division in support of their major rehab program. They have several projects that have required turbine and generator replacements. We have accomplished several reviews of pump stations that were in excess of 5000cfs for the Jacksonville District.

We support the PICES program and presently we conduct spot reviews of studies, designs, plans, specifications and cost estimates prepared by AE's and Districts for the purpose of assuring adequate quality control. We make site inspections of proposed projects, review the planning documents, and inspect projects under construction.

I am a member of the HQ field advisory group on lock operating controls and equipment.

Brief resume of key persons, specialists, and individual consultants anticipated for this project:

a. Name & Title:
Robert C. Patev
Senior Civil Engineer

b. Project Assignment:
Structural Design - Third Lock Design Study

c. Organization:
New England District, CENAE-EP-HG, U.S. Army Corps of Engineers

d. Years Experience:
With This Organization: 2 years with the New England District
With Other Organizations: 9 years with the Engineering Research and Development Center - Waterways Experiment Station, Vicksburg, MS

e. Education: Degree(s)/Year/Specialization
B.S Framingham State College – Geology
B.S. Worcester Polytechnic Institute – Civil Engineering (Structural/Geotechnical)
MCE – Mississippi State University – Civil Engineering (Structural/Geotechnical)
MCE Johns Hopkins University – Civil Engineering (Structural)
PhD Candidate – University of Maryland (Structural)

f. Active Registration:
Engineer-in-Training 1991

First Year Registered/Discipline:

g. Other Experience and Qualifications Relevant to the Proposed Project

Research/Design:

-Principal Investigator for Design of Innovative Lock Walls for Barge Impact under the Innovations for Navigation Projects R&D Program

- Conducted full-scale barge impact experiments
- Developed and tested full-scale prototype fendering system for guide walls
- Patents on two types of navigation fendering system for navigation projects
- Numerical model development for barge impact and fendering design

-Developing USACE Engineering Design Manuals for Barge/Vessel Impact for Navigation Structures

-Concept work with other USACE Districts on developing fendering systems and barge/vessel impact design for navigation projects

- Louisville District –Fendering concepts for protection structures
- Chicago District – Fendering concepts for quay structures

Publications:

Technical Reports/Papers:

- Prototype Barge Impact Experiments, ERDC/WES ITL-01-XX(in printing)
- Full-Scale Barge Impact Experiments, ERDC/WES ITL-01-XX (in printing)
- Full-Scale Barge Crushing Experiments, ERDC/WES ITL-01-XX (under Fiscal Year 02 development)
- Transportation Research Circular Number 491, "Inland Waterway Technical Studies". December 1999.

Conference Papers/Technical Presentations:

- AASHTO Committee on Research and Development, "Barge Impact Research and Development Program", 1998
- Transportation Research Board/National Research Council- "Full-Scale Barge Impact Experiments", 1999
- Inland Waterways User's Board Meetings #33 and #37, Presentation of Barge Impact Experiments, Aug 1999 and Feb 2001
- University of Florida – Crom Lecturer- "Design of Innovative Lock Walls for Barge Impact", May 2001

Engineering Manuals:

- Engineering Technical Letter 1110-2-XXX – Design of Rigid Walls for Barge/Vessel Impact (under Fiscal Year 02 development)

EM 1110-2-XXX – Barge Impact Design for Navigation Structures (under Fiscal Year 02/03 development)

Brief resume of key persons, specialists, and individual consultants anticipated for this project:

a. Name & Title:
Raymond A. Povirk, P.E.
Hydraulic Engineer

b. Project Assignment:
Design lock filling and emptying systems

c. Organization:
Hydraulics and Hydrology Section, Water Resources Engineering Branch,
Engineering Division, Pittsburgh District, US Army Corps of Engineers

d. Years Experience: 33
This Organization: 32 Other Organizations: 1

e. Education: Degree(s)/Year/Specialization
Bachelor of Science in Civil Engineering, University of Pittsburgh, 1969
Master of Science in Civil Engineering (Water Resources), University of Pittsburgh, 1976

f. Active Registration:
Registered Professional Engineer, Pennsylvania (1975)
Registered Land Surveyor, Pennsylvania (1980)

g. Other Experience and Qualifications Relevant to the Proposed Project:

Grays Landing Lock and Dam. Designed portions of the lock filling and emptying system using a numerical model (WES H5320). Developed optimal cofferdam staging with a navigable pass during construction. Developed a plan and procedure for using the lock as a floodway. Collaborated with the Waterways Experiment Station on physical modeling of navigation conditions.

Maxwell Locks. Collected prototype water surface data for various locations within the lock during operation of the bottom-lateral filling and emptying system analyzed it for driving hawser forces.

Point Marion Lock. Designed portions of the lock filling and emptying system using a numerical model (WES H5320). Collaborated with Waterways Experiment Station on physical modeling of navigation conditions. Collected prototype data for the prototype side-port filling system and analyzed it to determine driving hawser forces.

Braddock Dam. Served as the hydraulic expert throughout the concept, design and construction phases of Braddock Dam. Designed the new gated dam and stilling basin and coordinated the physical modeling at the Waterways Experiment Station. Coordinated the design and modeling of a new upstream approach wall and training dikes. Developed the hydraulic plan for an innovative method in which the dam shell is floated in and sunk in two very large segments. Used LOCKSIM to develop a flow by-pass procedure using the lock culverts to facilitate construction.

Ohio River Mainstem Systems Study. Developed a new procedure for measuring prototype differential lock water surfaces levels during filling and emptying. Directed a field effort to collect prototype data at Meldahl Locks and Dam for evaluation of potential lock extension alternatives. Verified prototype measurements using the numerical model LOCKSIM and analyzed the effects of pre-existing water surface oscillations on hawser forces. In collaboration with the Huntington District developed a method of predicting the hawsers and movement of vessels within a lock chamber resulting from longitudinal slopes in the water surface. Used LOCKSIM to determine the effects of adding in-chamber supplemental filling conduits to an extended lock.

Miraflores Pressure Study. Directed a prototype study of the pressures at various locations within Miraflores Upper West Lock resulting from vessel movements. Reduced the data to produce a continuous record of pressures over several consecutive days that show the effects of lockages as well as ship movements. Analyzed the pressure data and produced a report containing suggested explanations for the observed phenomena plus predictive equations. Derived typical filling and emptying curves from the data.

Charleroi Locks. Served as the hydraulic expert throughout the concept, design and early construction phases to date of the Charleroi Locks. Designed and directed testing of a floating lower guard wall and excavation plan at the Waterways Experiment Station to solve a difficult approach problem. Designed an innovative filling and emptying system using the LOCKSIM numerical model that employs through-the-sill filling and readily accessible slide gates. Directed testing and verification of the system in a physical model at the Waterways Experiment Station.

Brief resume of key persons, specialists, and individual consultants anticipated for this project:

a. Name & Title:
Jeffrey A. Schaefer
Geotechnical Subject Matter Expert

b. Project Assignment:
Geotechnical Independent Technical Reviewer

c. Organization:
US Army Corps of Engineers, Louisville District, Engineering Division, Civil Engineering Branch

d. Years Experience:
With This Organization: 12 With Other Organizations: 1

e. Education: Degree(s)/Year/Specialization -
B.S. 1987 Civil Engineering University of Louisville
M.Eng. 1988 Civil Engineering (Geotechnical) University of Louisville
Ph.D. 2000 Civil Engineering (Geotechnical) University of Kentucky

f. Active Registration: First Year Registered/Discipline

1992 Professional Engineer #17169 KY
1994 Professional Geologist #2133 KY

g. Other Experience and Qualifications Relevant to the Proposed Project:

Work Experience

October 1999 – Present, Geotechnical Subject Matter Expert, U. S. Army Corps of Engineers Louisville District, Serves as a technical expert in geotechnical/seismic design and construction. Acts as an authoritative source of technical leadership and guidance in the theoretical and practical geotechnical and seismic aspects for all projects and programs within the Louisville District. Performs quality verification reviews of design and construction documents on all major projects including the Olmsted Locks and Dam, McAlpine Locks, and J.T. Meyers Lock extension. Serves as the technical point of contact and the quality assurance team leader for the design of the Olmsted Dam. The $250- $300 million Olmsted Dam will utilize innovative techniques and will be constructed in-the-wet without cofferdams. Serves as the independent technical review team leader for the Mississinewa Dam Rehab project. This project consists of constructing a 2000 ft. long 150 ft. deep concrete cutoff wall in an existing embankment dam. Performs field inspections and maintains liaison with key members of the Construction and Operations divisions in connection with special problems involved during construction progress. Has provided continued support for the Olmsted Locks and Dam and the McAlpine Locks during construction related to foundation installations (large diameters shafts, H-piles, sheet piles) and cofferdam cellular sheet pile construction. Maintains awareness of current practices and latest advances in geotechnical/seismic engineering. Provides guidance and training to other Corps employees. Serves on the Corps CASE Soil Structure Interaction Committee and the Innovative Navigation Field Advisory Group.

Aug 1989 - Oct 1999, Geotechnical Engineer, U.S. Army Corps of Engineers Louisville District, Duties included geotechnical design, and technical review for a wide variety of civil and military projects. My design expertise includes: Subsurface investigations (including specialized methods), building foundations, cofferdams, pavements, lock and dam structures, mooring cells, retaining walls, anchored sheetpile walls, reinforced earth walls, wick drains, stone columns, landslide evaluations, borrow and disposal sites, pile foundations, pile load tests, drilled shaft foundations, soil and rock anchors, soil-structure interaction, slope stability analysis, seismic slope deformation analysis, dewatering systems, instrumentation systems, sinkhole stabilization, geophysical investigations, seismic design, seismic site evaluations, liquefaction analysis, seismic station installation, seismic site response, finite element seepage analysis, and finite element deformation analysis. Since 1992, I have been primarily responsible for all geotechnical design and construction problems associated with Olmsted Locks and Dam. This is one of the largest Civil works projects ever constructed by the Corps of Engineers with an estimated cost of 1.1 billion dollars. Performed as the Engineering Division team leader for the design and contract documents for the Slide Repair and Cofferdam Construction ($65 million) at Olmsted. As a result of my continued involvement throughout construction, one of the largest cofferdams ever built was successfully constructed in spite of a difficult Contractor. During the initial phase of the Locks portion of the project I developed and oversaw a detailed pile load testing program that resulted in a project savings of an estimated 10 million dollars. Other duties have included developing RFP selection criteria for the major construction contracts, along with serving on the selection boards for the Olmsted Dam Prototype and the Approach Wall Contracts. I served as a major government witness in two major litigations in the areas of subsurface boring evaluations, sheetpile driving, dewatering systems, landslide evaluations. Additionally, I served on board for a critical accident investigation at Olmsted. Work for other Districts includes technical review and assistance on the Little Rock District Montgomery Point Lock and Dam Project and the Pittsburgh District Braddock Dam Project.

Nov 1988 to Aug 1989, Geotechnical Engineer, ATEC Associates, Louisville, Ky, Supervisor- Bill Cutter, phone- 502 267-8355. I was responsible for geotechnical site investigations and preparation of geotechnical reports. Design responsibilities included: shallow footings, H-piles, auger-cast piles, drilled piers, retaining walls, basements, pavements, and slope stability analysis. Responsible for the production of plans and specifications for a clay liner system for a 100 acre ash pond at the LG&E Trimble County Power plant. Field inspections for H-piles, drilled piers, auger-cast piles, and large footing foundations were conducted.

Technical Courses and Seminars

Seepage, Piping, and Remedial Measures (May 5-7, 1991) at Virginia Tech University
Relief Well Design - USACE Professional Development Seminar (September 1993)
Seismic Deformation Analysis -WES (June 1993).
Ohio River Valley Soils Seminars (ORVSS):
  Construction In and On Rock (October 27, 1989)
  Design and Construction With Geosynthetics (October 18, 1991)
  Insitu Soil Modification (October 16, 1992).
  Recent Advances in Deep Foundations (October 21, 1994)
  Forensic Studies in Geotechnical Engineering (October 11, 1996)
  Unconventional Fills: Design, Construction, and Performance (October 10, 1997)
  Problematic Geotechnical Materials (October 16, 1998)
OCE National Geotechnical Conference (April 1990) in Nashville, Tennessee
ORD/SAD Geotechnical Conference in Orlando, Florida (June 1993).
ORD Geotechnical Conference (July 1995)
ASCE Geotechnical Conference Stability of Slopes and Embankments II (June 1992) at U.C. Berkeley
Thirteenth Annual USCOLD Lecture in Chattanooga Tennessee (May 1993).
Fourteenth Annual USCOLD Lecture, Phoenix, Arizona, June 1994
Design of Dewatering Systems (April 1994) University of Florida
Dynamic Pile Analysis, (March 1995) GRL Boulder, Co.
Shear Strengths (March 1996) Duncan and Wright, Denver, Co.
OCE National Geotechnical Conference (July 1997) in San Bernadino, California
AEG Seminar on Foundation Rehabilitation Techniques, Dr. Donald Bruce (9/12/98), Louisville, Ky
KGEG Seminar on Geo-Instrumentation, Dr. John Dunnicliff, (9/24/97), Frankfort, Ky
KGEG Distinguished Lecture Series - Multiple Lectures 1988-present
Soil Structure Interaction 2001 WES

Brief resume of key persons, specialists, and individual consultants anticipated for this project:

a. Name & Title:
Andrew Schaffer

b. Project Assignment:
Interdisciplinary Geologist/Civil Engineer

c. Organization:
CELRP-ED-GG

d. Years Experience:
With This Organization: 14 With Other Organizations 3:

e. Education: Degree(s)/Year/Specialization
M.S. Geological Engineering, 1985, University of Arizona,
B.S. Geological Engineering, 1981, University of Arizona

f. Active Registration:
Registered Geological Engineer, Arizona

First Year Registered/Discipline 1993

g. Other Experience and Qualifications Relevant to the Proposed Project:

Pittsburgh District: 11/89 – Present
Work for other agencies: Currently participating in the preparation of guide specifications for rock and soil anchors for HQUACE. Performed ITR review of plans and specifications and design memorandums for McAlpine Lock Cofferdam, Louisville District with emphasis on rock anchors, blasting, rock strength parameters, exploratory drilling, and dewatering. Performed ITR review for Lake Girard Dam, an aging buttress dam, for the city of Girard, Ohio. Recommended bearing capacity analysis and additional exploratory drilling. Reviewed the design for a roller compacted concrete gravity dam in W.Va. for the NRCS (formerly the SCS). Review of plans and specifications for the Erie Harbor East Canal Basin project for Buffalo District with emphasis on blasting.

Oversaw a large scale drilled shaft load test on the Mon River, Braddock, PA. Test results provided for the foundation design of an innovative float-in gated dam. Team member for Lower Mon Locks 4 design and Lower Mon Dam 2 design and plans and specifications. Emphasis on drilled shafts, pipe piles, rock anchors, rock strength parameters, exploratory drilling, and seepage cut-off walls.

Worked with Construction Division on determining drilled shaft tip elevations in rock, rock anchor bond zones, and seepage cut-off wall lengths at Dam 2, Braddock, PA. Provided rock strength parameters and geologic information for six locks on the Ohio River for the Ohio River Mainstem Study. Supervised pressuremeter testing of soft rock to determine Young's Modulus and bearing capacity parameters for Lower Mon Locks 4. Have developed exploratory drilling programs, selected rock samples, developed laboratory testing programs, and determined rock strength parameters for numerous projects in the District

Performed sliding stability analyses for Gray's Landing Dam cofferdams. Worked with Construction Division on the selection of final founding elevations of lock and dam monoliths, and interpreted instrumentation data for Gray's Landing Lock and Dam.

Supervised remedial foundation grouting and jet grouting, installation of an $800K instrumentation program, interpreted instrumentation data including the determination of allowable sliding limits, reviewed and made recommendations for blast designs and mechanical excavation, selected final founding elevations for lock monoliths, and participated in drilled shaft and rock anchor design and construction for Point Marion Lock project, PA.

Waterways Experiment Station: 9/86-10/89.
Performed deep seated sliding stability and bearing capacity analyses for an anchored cofferdam and oversaw a finite element analysis to predict wall displacements for Point Marion Lock, PA. Supervised a remedial grouting operation, Stonewall Jackson Dam, W. Va.
Reviewed a rock anchor design and performed a finite element analysis to determine stresses and strains on a concrete tunnel liner induced by hanging an overhead conduit with rock bolts, USACE, Baltimore District. Was Principal Investigator for REMR research work unit entitled, "Improved Performance of Rock Drains".

Rockwell Hanford Operations, WA: 8/85-8/86.
Developed a three-year rock mechanics laboratory testing program. Developed specifications for elevated-temperature creep testing and large-scale joint shear testing of basalt. Coauthored an intact rock properties summary report. Assisted in the over-coring of hollow inclusion cells for in-situ stress measurements in basalt.

University of Arizona: 1/83-8/85.
Research Assistant: Conducted research on the sealing effectiveness of rock fracture grouting using cement-based grouts.

Morrison-Knudsen Co.,ID: 6/81-1/83.
Performed slope stability analyses for multiple seam lignite mines, a mine reclamation project, and a slope improvement project.

Brief resume of key persons, specialists, and individual consultants anticipated for this project:

a. Name & Title:
Andy C. Schimpf, P.E.
Electrical/Electronics Engineer

b. Project Assignment:
Electronics/Controls Production Team

c. Organization:
Engineering Division, St. Louis District, US Army Corps of Engineers

d. Years Experience: 15
With This Organization: 13 With Other Organizations: 2

e. Education: Degree(s)/Year/Specialization
Bachelor of Science Electrical Engineering, 1988

f. Active Registration:
Missouri Registered Professional Engineer No. E-29752

First Year Registered/Discipline

g. Other Experience and Qualifications Relevant to the Proposed Project:

- Presented 6 lock automation workshops at the National Lock and Dam O&M Conference in 1994.
- Presented five 1-hour workshops and a closing summary to approximately 300 people on lock automation at the National O&M Conference for Locks and Dams and Hydropower Structures, 1996.
- St. Louis District Commanders Award for efforts on the commissioning of Mel Price Locks and Dam, in particular the area of the automated control system, 1992.
- Prepared Corps of Engineers guide specifications, CEGS-16900, CEGS-16910, CEGS-16920, on Instrumentation and Control, Programmable Logic Controller Systems, and Industrial Control Networks.
- Wrote Corps of Engineer Engineering Manual, EM-1110-2610 on Automated Controls for Locks and Dams, and Predictive Maintenance using Condition Monitoring

PANAMA CANAL - Made site visit to Panama Canal Locks in 1998. Made verbal recommendations to members of the Panama Canal Commission lock controls task force; followed up with report on more detailed recommendations for the upgrade of the control systems at the three lock sites.

MCALPINE LOCKS, Louisville District - Performed ITR for new control system design for McAlpine Locks for the Louisville District, 2001

LOCK AND DAM NO. 27 – Acted as technical manager and lead designer for P&S of new automated lock control system; performed start-up, debugging, and support for new system, 1996.

LOCK AND DAM NO. 24 – P&S for new automated control system; performed start-up, debugging, and support for new system, 1999.

LOCK AND DAM NO. 25 – P&S for new automated control system; performed start-up, debugging, and support for new system, 1999.

BARKLEY LOCK, Nashville District - Design and installed automated lock control system, 2000-2001.

CHEATHAM LOCK, Nashville District - Designed automated lock control system, 2000-2001.

HARVEY LOCK, IHNC LOCK, ALGIERS LOCK, and PORT ALLEN LOCK, New Orleans District – Prepared detailed P&S for new automated lock control systems, including new instrumentation and communication systems, 2001.

JACKSONVILLE DISTRICT - Currently working on conceptual design for automated controls and centralized operation of six locks, 2001 - 2002.

OLMSTEAD LCOK - Acts as control system consultant to Louisville District during construction of the Olmsted Locks by preparing construction design modifications, representing the Government at shop and field tests, review of shop drawings, 1998 - Present.

Brief resume of key persons, specialists, and individual consultants anticipated for this project:

a. Name & Title:
Gerald A. Schohl, PhD
Manager, Hydraulic Modeling & Analyses

b. Project Assignment:
Consultant for applications of LOCKSIM

c. Organization:
Tennessee Valley Authority
Engineering Laboratory

d. Years Experience: 22
This Organization: 20 Other Organizations: 2

e. Education: Degree(s)/Year/Specialization
PhD, 1985, Civil &Environmental Engineering, University of Iowa
MSE, 1975, Civil Engineering, University of Michigan
BSE, 1874, Civil Engineering, University of Michigan

f. Active Registration:
None

g. Other Experience and Qualifications Relevant to the Proposed Project:

General. Dr. Schohl developed LOCKSIM for simulating unsteady flow in navigation lock filling and emptying systems, including the lock chamber and, optionally, the upstream and downstream approach channels. He has prepared a comprehensive user's manual for LOCKSIM.

Dr. Schohl used LOCKSIM to design porthole manifolds for the proposed new locks at Kentucky Dam and at the Chickamauga Dam. He applied LOCKSIM to study filling and emptying conditions for the Wheeler Main Lock, Pickwick Main Lock, and Bay Springs Lock.

Dr. Schohl has conducted field tests at Wheeler Main Lock to verify the performance under emergency closure conditions of newly installed bulkhead-slot air seals and to collect data for comparison with LOCKSIM numerical predictions.

Dr. Schohl supervised the construction and testing of hydraulic models for the proposed Chickamauga Lock. He operated a 1:25-scale model of Pickwick Main Lock, the results of which have been published in a technical report.

Selected Publications Related to Navigation Lock Studies.

Schohl, G. A., 1999, "User's Manual for LOCKSIM: Hydraulic Simulation of Navigation Lock Filling and Emptying Systems," U.S. Army Engineer Waterways Experiment Station, Contract Report CHL-99-1, January.

Schohl, G. A., 1997, "Analysis of Connector Channel for Improving Navigation Below Wilson Dam," Tennessee Valley Authority, Engineering Laboratory, Report No. WR97-1-1-107, August.

Schohl, G. A., 1994, "Performance of Wheeler Main Lock With Air Seals Installed in Bulkhead Slots Downstream From Emptying Valves," Tennessee Valley Authority, Hydraulic Engineering, Engineering Laboratory, Report No. WR28-1-3-106, August.

Schohl, G. A., 1994, "Comparisons of Field Data from Wheeler Main Lock with Predictions from a Numerical Model," Tennessee Valley Authority, Hydraulic Engineering, Engineering Laboratory, Report No. WR28-1-3-107, August.

Schohl, G. A., 1992, "Numerical Model for Navigation Lock Filling and Emptying Systems," Tennessee Valley Authority, Engineering Laboratory, Report No. WR28-1-720-100, May.

Schohl, G. A., 1989, "Transient Flow and Pressures Resulting from Emergency Closure of Empty Valves at Wheeler Main Lock," Tennessee Valley Authority, Engineering Laboratory, Report No. WR28-1-3-103, July.

Schohl, G. A., 1978, "Determination of 1:25 Scale Port Diameter Needed to Compensate for Lack of Reynolds Number Scaling - Pickwick Landing 1000-Foot Lock," Tennessee Valley Authority, Water Systems Development Branch, Report No. WM28-2-4-101.

Schohl, G. A., 1978, "Model Test Results of Various Lock Design Modifications Pickwick Landing 1000-Foot Lock, "Tennessee Valley Authority, Water Systems Development Branch, Report No. WM28-2-4-100.

Brief resume of key persons, specialists, and individual consultants anticipated for this project:

a. Name & Title:
Terry D. Shilley
Civil Engineer

b. Project Assignment:
Civil Engineer Technical Lead

c. Organization:
Civil Engineering Section, Engineering Division
Pittsburgh District, US Army Corps of Engineers

d. Years Experience:
With This Organization: 15 3 With Other Organizations: 10

e. Education: Degree(s)/Year/Specialization
BSCE, 1976, Civil Engineering

f. Active Registration:
EIT, State of West Virginia, 1976
Professional Engineer, Commonwealth of Virginia, 1982
Professional Engineer, Commonwealth of Pennsylvania, 1984

g. Other Experience and Qualifications Relevant to the Proposed Project:

1. Project Engineer for Engineering Division for the preparation of a Rehabilitation Evaluation Report (RER) for the Main Channel and Back Channel Dams at the Emsworth Locks and Dams Project (Ohio River, RM 6.2), justifying the need for a Major Rehabilitation of both dams.

1a. Coordinated the preparation of drawings for the RER, including plans and elevations, sections of gate bays, machinery houses, service bridges, crane rails, concrete decks, entrance ways, stairwells, vertical lift gates and erosion protection systems. Computed quantities and coordinated with Cost Engineering to cost out the Construction Cost and Fully Funded Cost Estimate (detailed costs).

1b. Field Inspections with Operations, Construction and Engineering representatives to establish the Scope of the RER, limits of work, areas of concrete deterioration requiring saw cutting, removal and replacement, problems with crane rail expansion/contraction requiring correction, horizontal and vertical movement of service bridge spans (girder and deck) as evidenced by expanded or contracted deck joints, apparent over rotations of bridge bearings and cracking in bearing seats.

1c. Preparation of Draft and Final Reports, including write-ups for construction history, rehab history, materials used, problems discerned from Periodic Inspections, Diver's Inspections, results of structural analysis on gravity and anchored monolith stability and conclusions about dam components condition, expected life and required action.

2. Project Engineer for Engineering Division, on ORMSS, the Ohio River Main Stem System Study, a comprehensive Study to investigate the condition and problems associated with the 19 Lock and Dam Projects on the entire 981 miles of the main stem Ohio River. Interacted with Multi-District Engineering Team (members from Pittsburgh, Huntington, Louisville and others as needed) to produce a Draft "Systems Investment Report", a comprehensive report on the Locks and Dams within the Ohio River System, pointing out problems (structural and operational) and recommendations for needed actions (rehabs, replacements of lock chambers, other lock or dam components).

2a. Field Inspections of each of the 19 Lock and Dam projects on the Ohio River, beginning at Emsworth L/D, near Pittsburgh and covering the entire 981 miles of the Ohio River, to Cairo, Illinois. Member of a multi-district inspection Team, traveling to each L/D to inspect the major lock components which would directly influence lock outages (lock walls from the exterior and if possible from interior (pipe galleries), miter gates, culvert valves if chamber dewatered, emergency bulkhead piers and structure and dam components.

2a.1. Field Inspection Reports. Overall coordinator for preparation of Final Field Inspection Reports for 19 L/D Projects.

2b. Conceptual Drawings: Prepared plans, elevations, sections, details, and etc. for existing and proposed project features for Emsworth, Dashields and Montgomery L/D's.

2c. Without Project Condition and With Project Condition (refers to "No new authorization" or "Newly authorized" Projects. Prepared conceptual quantity take-offs for O&M maintenance, Major Rehabilitations and New Lock Chambers for Emsworth, Dashields, Montgomery, New Cumberland, Pike Island and Hannibal Locks and Dam Projects.

3. Production Engineer, working on the Lower Monongahela River, Locks and Dam 2,3,4 Project, for the Preparation of the Feasibility Report. Performed variety of Civil Engineering functions to ascertain optimum lock locations (lock and dam layout), optimum lock alignments, earthwork cuts and fills, foundation conditions, layout of lock chambers and approach walls (guide and guard walls). Interacted with Engineering Team and Planning Team to cost out approximately 40 alternatives for lock construction (concept level costs).

Brief resume of key persons, specialists, and individual consultants anticipated for this project:

a. Name & Title:
Gary J. Stinson
Civil Engineer, Cost Engineer

b. Project Assignment:
Senior Cost Engineer

c. Organization:
Cost Engineering and Management Support Branch (CELRN-EC-A)
Nashville District, U.S Army Corps of Engineers,

d. Years Experience:
With This Organization: 23 With Other Organizations: 6

e. Education: Degree(s)/Year/Specialization
BS Civil Engineering, Tennessee Technological University 1971

f. Active Registration:

g. Other Experience and Qualifications Relevant to the Proposed Project:

General. Mr. Stinson has extensive experience in cost engineering and construction cost estimating. He has significant computer skills with experience in using spreadsheets, word processing, and cost estimating software. Cost Engineering Experience includes: preparation of cost estimates for all types of civil works projects to include Locks and Dams, Levees and Floodwalls, Recreation, Environmental Restoration, and Hydroelectric Construction.

Mr. Stinson has specialized experience related to estimating Lock and Dam construction and project costs including: excavation, earth fill dams, mass concrete dams, locks including miter gates, spillway gates, culvert gates, electrical and mechanical systems, dewatering systems, cofferdams, roadway and utility relocations and foundation treatments. He has experience in developing construction schedules and contract time. He has worked closely with customers to deliver projects that are cost sensitive and has severed on value engineering teams studying construction designs and methods to effect project cost savings

Mr. Stinson currently holds the position of senior cost engineer in the Nashville District USACE. In this position he is responsible for development of project cost estimates for all types of Civil Works Construction to include Navigation and Flood Control Projects which are submitted to the United States Congress for funds appropriation

Chickamauga Lock and Dam. Responsible cost engineer for development of cost comparative estimates for 3 different lock sizes being studied for replacement of the existing lock at Chattanooga, Tennessee.

Bay Springs Lock and Dam. Responsible for quantity takeoffs and cost development of this concrete lock and zoned rock and earth-fill dam on the Tennessee Tombigbee Waterway. This project incorporated innovative design with the use of thin-sectioned tendon-anchored lock walls and an interlaced lateral emptying and filling system.

Lock and Dam 26-Mississippi River. Developed cost estimate for the Emergency Bulkhead Hoist and Crane to be used by St. Louis District, USACE for Government Estimate for Bid Opening.

Ohio River Main Stem Study. Severed on the Independent Technical Review Team for this study, which looked at the Ohio River System of Locks, and Dams for enlargement of existing locks. Involved review of lock estimates using float-in construction of lock components.

Wilson Auxiliary--Tennessee River. Involved in developing cost estimates for major rehabilitation of the double 60x292 and 60x300 ft locks. Estimated construction costs for mechanical, electrical, concrete, painting, and structural rehabilitation work.

Pickwick Lock--Tennessee River Estimated cost for rehabilitation of lock that included repairs to the miter gates, approach walls, lower miter sill, segmental valves, and gate machinery. Other costs estimated: painting, and miscellaneous electrical and mechanical repair.

Kentucky Lock--Tennessee River. Responsible for portions of total project cost estimate of the 110x1200 foot lock addition.

Brief resume of key persons, specialists, and individual consultants anticipated for this project:

a. Name & Title:
Richard L. Stockstill, PhD, PE
Research Hydraulic Engineer

b. Project Assignment:
Filling & Emptying System Evaluation using LOCKSIM

c. Organization:
Coastal & Hydraulics Laboratory, Navigation Branch,US Army Engineer Research & Development Center

d. Years Experience:
With This Organization:16 With Other Organizations: 2

e. Education: Degree(s)/Year/Specialization
PhD, 1995, Civil Engineering, Hydraulics, University of Washington
MS, 1989, Civil Engineering, Hydraulics, Mississippi State University
BS, 1983, Civil Engineering, Mississippi State University
BS, 1978, Management, Mississippi State University

f. Active Registration: First Year Registered/Discipline:
Professional Engineer, 1988 – Mississippi no. 10370

g. Other Experience and Qualifications Relevant to the Proposed Project

General. Dr. Stockstill has applied his engineering skills to many aspects of hydraulic design and evaluation of navigation locks. Those skills resulted from the academic studies associated with four university degrees. His doctoral work involved development of a finite-element flow model. He has been the principal investigator on several large-scale physical model studies of lock filling and emptying systems. He is actively involved in the development and application of 1D, 2D, and 3D numerical models with applications to lock approaches and lock culvert systems. Current research is directed toward developing guidance for guard wall configurations and the modeling of mooring system responses to hydraulic conditions.

Physical Model Studies of Lock Filling and Emptying Systems. As the principal investigator on the New Bonneville Locks' filling and emptying system model, he tested the high-lift lock design using a 1:25-scale physical model. Modifications to the Portland District's original design resulted in a navigation lock system characterized by fast operation times while maintaining safe navigation conditions. As the principal investigation on the Red River Locks revised outlets, Dr. Stockstill developed an innovative outlet manifold to address the problem of sediment accumulation at the low miter gates. Subsequent physical model testing showed that the design efficiently flushed material from the miter gates. The Olmsted project design incorporates a novel means of placing both locks' emptying culverts in a common outlet bucket. As the principal investigator on the physical model study, Dr. Stockstill made modifications to the Louisville District's design that produced an efficient lock emptying system that realized significant cost savings by constructing only one outlet bucket. Dr. Stockstill has served on the Innovative Lock Design team. He was the principal investigator responsible for the development and testing on the innovative In-Chamber Longitudinal Culvert System

Development of Numerical Flow Models. Dr. Stockstill co-developed a means of modeling tow-induced currents using a finite element representation of the flow equations (HIVEL2D). The model allows evaluation of the effects of barge passage on not only the main channel, but also backwaters and side channels. Dr. Stockstill developed a model that solves the flow conditions in manifolds given the total energy on the manifold. These research results have been incorporated in the numerical flow model, LOCKSIM. He has recently served as the leader for 3D-mesh generation of hydraulic structures such as navigation lock components. He has developed a modeling system that takes a CADD description of the structure, generates a 3D unstructured computational mesh, uses a flow solver designed for high-performance computers (ADH), and provides a means of displaying the solution using flow visualization.

Numerical Model Studies of Lock Systems and Approach Conditions. Dr. Stockstill has applied LOCKSIM, HIVEL2D, and ADH numerical flow models in the evaluation of flow conditions in the approaches to locks, the lock chamber, and within the culvert system of locks. The LOCKSIM model was coupled with optimization software to develop a lock operation strategy for pool lowering at Lock and Dam 1, Mississippi River. The HIVEL2D model was extended such that 2D effects of surges generated by the New Kentucky Lock within the lower approach could be evaluated. These evaluations assisted the Nashville District in their choice of outlet designs. The 3D modeling research has included simulations of flow in the approach and intake areas of the Poe and Marmet Locks, the outlet manifolds of the Arkansas River design, and the transition proposed as part of the J. T. Myers Lock extension design

Selected Publications Related to Navigation Lock Studies.

Stockstill, Richard L. "Revised Outlets for Red River Locks, Hydraulic Model Investigation," Technical Report HL-90-9, Waterways Experiment Station, Vicksburg, MS, August 1990.

Stockstill, Richard L., Neilson, Frank M., and Zitta, Victor L. "Hydraulic Calculations for Flow in Lock Manifolds," Journal of Hydraulic Engineering, ASCE, Vol. 117, No. 8, August 1991.

Stockstill, Richard L. "Olmsted Lock Outlet, Ohio River, Hydraulic Model Investigation," Technical Report HL-92-13, Waterways Experiment Station, Vicksburg, MS, November 1992.

Stockstill, R. L., Martin, S. K., and Berger, R. C. "A Hydrodynamic Model of Vessel Generated Currents," Regulated Rivers: Research and Management, Vol. 11, 1995.

Stockstill, Richard L. and George, John F. "Filling and Emptying System, New Bonneville Lock, Hydraulic Model Investigation," Technical Report HL-96-13, Waterways Experiment Station, Vicksburg, MS, September 1996.

Stockstill, Richard L. and Hite, John E., Jr. "Application of a Two-Dimensional Model of Hydrodynamics to the Lower Approach of the New Kentucky Lock, Tennessee River, Kentucky," Technical Report CHL-98-9, Waterways Experiment Station, Vicksburg, MS, May 1998.

Stockstill, Richard L. "Innovative Lock Design, Report 1: Case Study, New McAlpine Lock Filling and Emptying System, Ohio River, Kentucky, Hydraulic Model Investigation, Technical Report INP-CHL-1, Waterways Experiment Station, Vicksburg, MS, Dec 1998.

Stockstill, Richard L. "Modeling Surges in Navigation Lock Approaches," ERDC/CHL HETN-III-1, April 2000.

Stockstill, Richard L. and Berger, R. C. "Simulation of Flow in Hydraulic Structures using ADH," ERDC/CHL HETN-III-3, September 2000.

Stockstill, Richard L., Fagerburg, Timothy L. and Waller, Terry N. "Pool Lowering at Lock and Dam 1 using the Lock Filling and Emptying System, Mississippi River, Minnesota," ERDC/CHL TR- 01-8, U.S. Army Engineer Research and Development Center, Vicksburg, MS, May 2001.

Brief resume of key persons, specialists, and individual consultants anticipated for this project:

a. Name & Title:
Terry Michael Sullivan, PE
Structural Subject Matter Expert

b. Project Assignment:
Senior Structural Engineer

c. Organization:
Structural Section Engineering Division,
Louisville District, U.S Army Corps of Engineers

d. Years Experience:
With This Organization: 14 With Other Organizations: 5

e. Education: Degree(s)/Year/Specialization
Purdue University, 1990, MS Civil Engineer – Geotechnical Engineering
University of Kentucky, 1982, BS Civil Engineering

f. Active Registration:
Professional Engineer, 1987 – Kentucky
Professional Engineer, 1991 – California

First Year Registered/Discipline:

g. Other Experience and Qualifications Relevant to the Proposed Project:

. General. Mr. Sullivan has specialized experience coordinating and optimizing the planning, design, and preparation of plans and specifications for the many elements that make up a large locks project. His academic and experiential background have been focused for the past eight years on the Structural and Geotechnical Engineering aspects of Lock and Dam design and construction. His relevant design and construction experience features design and construction of floating approach walls for lock entrance and exit. This includes evaluation of vessel impact loadings, fendering, material selection, floatation, concrete design, reinforcement detailing, cold-weather and hot-weather concrete placement issues, concrete repair, precast concrete construction, post-tensioned concrete design and construction. Mr. Sullivan has also played very significant roles in design and construction of major navigation locks projects, including details such as reverse tainter valves, bulkheads, mass concrete, formwork, precast and prestressed concrete, cofferdams, in-the-wet construction, pile driving (both impact and vibration) and drilled shaft foundations. Mr. Sullivan currently holds the position of Subject Matter Expert in the area of Structural Design for the Design Branch of the US Army Corps of Engineers, Louisville District. In this position he is responsible for review and consultation on all structural issues relating to navigation and flood control projects within the Louisville District Boundaries

US Army Corps of Engineers, Olmsted Approach Walls, Ohio River. Mr. Sullivan served as the project manager for this $98,000,000 construction project on the lower Ohio River. The scope of this project truly has no precedence in navigation history. The Approach Walls are an innovatively designed series of structures with many unique features. The four floating walls altogether are approximately 4400 feet long, and one fixed wall is over 550 feet long. Mr. Sullivan developed the initial design concept in tandem with an A/E. The design approach was intended to conquer specific site problems, and to adapt to the many challenges offered by the seismic and flood events, which characterize the site. Mr. Sullivan supervised the Corps' and the navigation industry's review meetings, and met with contractors, fabricators, and engineers from various federal and state highway agencies numerous times to develop the design criteria. Within the Louisville District, Mr. Sullivan planned and coordinated project assignments. He was responsible for the review of all structural drawings and contract specifications. He also reviewed design computations for technical accuracy and adherence to design criteria and design standards. He was also responsible for the preparation and administration of the A/E scope of work and all subsequent modifications to the contracts.

US Army Corps of Engineers, Olmsted Locks, Ohio River. Mr. Sullivan served as the project structural engineering leader for this $250,000,000 construction project on the lower Ohio River. This project was a conventional navigation locks structure with many unique features. The locks consist of 26 individual monoliths founded on piles. Each monolith incorporated both lock chambers, including all three walls and the chamber floors. Each monolith is 325 feet wide. Mr. Sullivan lead a large diverse team of engineering firms and Corps Districts, each of whom contributed some part of the entire project. He supervised a design team of five engineering firms and four Corps Districts, and planned and coordinated project assignments. He was responsible for the review of all structural drawings and contract specifications. He also reviewed design computations for technical accuracy and adherence to design criteria and design standards. He was also responsible for the preparation and administration of A/E contracts.

US Army Corps of Engineers, McAlpine Lock Extension and Cofferdam. Mr. Sullivan designed several features for these projects including cofferdam bin walls and outlet structures. Provided field engineering support during construction, resolved technical issues as they arose during construction with solutions driven by consideration of potential contractor claims.

US Army Corps of Engineers, John T. Myers Locks Monolith Stabilization Project. Mr. Sullivan has supervised the design and analysis and development of plans and specifications for stabilizing existing lock monoliths with rock anchors. The existing river wall and land wall monoliths do not meet current Corps design criteria under revised maintenance scenarios. Design now nearly complete and construction is expected to begin in early 2002.

Member of US Army Corps of Engineers' CASE Soil-Structure Task Group. The acronym "CASE" stands for Computer-Aided Structural Engineering. This group is comprised of select individuals across the Corps of Engineers who meet periodically to analyze, address and recommend solutions to analysis and construction problems common with pile-founded structures. This group also develops and reviews design criteria and recommends and develops new computer software.

Brief resume of key persons, specialists, and individual consultants anticipated for this project:

a. Name & Title:
Thomas B. Sully
Chief, Structural, Mechanical, Electrical, Architectural Section

b. Project Assignment:
Supervisory Civil Engineer

c. Organization:
Design Branch, Engineering Division
St. Paul District, U.S. Army Corps of Engineers

d. Years Experience:
With This Organization: 16 With Other Organizations: 2

e. Education: Degree(s)/Year/Specialization
Bachelor/1983/Civil Engineering/ University of Nebraska – Lincoln
Master/1990/Civil Engineering/Structural Emphasis/ University of Minnesota

f. Active Registration:
Professional Engineer, State of Minnesota
Certificate No.19995

First Year Registered/Discipline: 1989/Civil Engineering

g. Other Experience and Qualifications Relevant to the Proposed Project:

General: Mr. Sully professional experience has been well rounded in the technical disciplines for the design and construction of major water resource projects for locks and dams on the Mississippi River as well as reservoir dams. Experience includes:

- Chief, Civil/Site Engineering Section, 1 year
- Chief, Structural Engineering Section, 11 years
- Structural Design, Omaha District, 2 years
- Technical Management of Plans & Specifications development
- Detail to Headquarters, USACE, Washington D.C.
- Project engineering/management of budgets and schedules of Lock and Dam "Inspection Program for Bridges" and "Hydraulic Steel Structures".

Mr. Sully holds the position of Chief, Structures-Mechanical-Electrical-Architectural Section, Engineering Division for the US Army, Corps of Engineers, St. Paul District. In this position he is responsible for the development of the technical designs for inland navigation projects and dam safety projects. In this position he has direct access to structural, mechanical, and electrical engineers familiar with all aspects of rehabilitation, design, and construction of lock and dam components.

Major Rehabilitation of Locks and Dams - This responsibility is for the development of Major Rehabilitation and Major Maintenance for the Locks and Dams in the St. Paul District. This includes the development of Plans and Specifications for the rehabilitation of locks 2-10 on the Upper Mississippi River. The Major Rehabilitation included management of the structural engineering effort for the design of the central control stations for the centralized operation of the locks. The rehabilitation of the dams included replacement of bridges across the control structures of three dams as well as replacement of mechanical operating equipment for dams 2-10 on the Mississippi river.

Lake Darling Dam, Flood Control Structure – Supervised the development of plans and specifications for construction of the dam control structure. This is a pile founded concrete structure with five tainter gates for controlled release of 100,000 cfs flow.

Souris River Flood Control, Rafferty and Alameda Dams – Served as the technical reviewer for structural design and construction of two large dams in Saskatchewan, Canada. The United States entered into an agreement with the Province to participate in the construction of two dams that would benefit flood control in North Dakota. Responsibility was to review designs and make recommendations for changes to ensure functionality and engineering integrity of the structural components including the control structures and spillways.

UMR-IWW Navigation Study - Mr. Sully has been a member of the Engineering Work Group for the Upper Mississippi River – Illinois Waterway System Navigation Feasibility Study. He oversaw the development of some of the in-the-wet concepts for lock extensions for both pile and rock founded structures. He also supervised the development of various reliability models, which attempted to determine the life expectancy on structural components.

US Army, Corps of Engineers, Innovations for Navigation Projects Research Program – Member of the Field Review Group responsible for setting priorities of the research program and review of development of the technical products. This program is tasked with developing innovative approaches to both design and construction of navigation structures including locks and dams. Some of the developments include Lock Floor Slab and Culvert Construction Underwater, and Contracting Methods for Innovative Design and Construction of Navigation Locks.

Brief resume of key persons, specialists, and individual consultants anticipated for this project:

a. Name & Title:
Carol L. Tasillo, P.E.
Civil / Materials Engineer

b. Project Assignment:
Civil Engineer

c. Organization:
Engineering Division, Geotechnical Branch
Pittsburgh District, U. S. Army Corps of Engineers

d. Years Experience:
With This Organization: 12 yrs. With Other Organizations: 8 yrs.

e. Education: Degree(s)/Year/Specialization
B.S. Civil Engineering – University of Pittsburgh (1981)
M.S. Civil Engineering Materials – Purdue University (1995)

f. Active Registration:
Professional Engineer, Pennsylvania (PE-039301-E), 1989 to present

g. Other Experience and Qualifications Relevant to the Proposed Project:

General Knowledge/Experience: Experienced in evaluating and selecting concrete material sources, including cementitious materials, aggregates, water and admixtures; developing and evaluating concrete and grout mixture designs; working with laboratories and ready-mix concrete producers on development of concrete mix designs; evaluating concrete batch plant capabilities; developing and directing materials and concrete investigations, including material aspects for structural and thermal analyses; evaluating aggregates based on petrographic results and assessment of mineralogical properties; evaluating concrete using crosshole sonic logging, other non-destructive test methods, and core inspection.

Charleroi Locks: (1999 to present) Currently providing guidance and support on design of twin lock chambers to replace existing locks without navigation interruption. Design support includes various aspects of drilled shaft foundation and lock wall design using a combination of conventional and in-the-wet construction techniques. Responsible for conducting structural and thermal analyses, and have provided initial investigation for concrete and material properties. Identified alternatives to conventional precast concrete panels for lock wall facing.

Braddock Dam: (1995 to present) Braddock Dam is a unique navigation project using a combination of float-in technology and in-the-wet construction to replace a dam built in 1902. Design team member providing guidance and support on various design features, including secant abutment wall constructed in-the-wet; lock wall modification using drilled shaft foundation and conventional mass concrete cap; and dam design using drilled shaft foundation, float-in dam segment fabrication, and underwater and dry dam segment infill concrete placed after positioning and setdown. Directed large-scale demonstration placement of infill concrete to evaluate concrete properties, flow patterns, effects of laitance and bleed, and placement techniques. In addition to design responsibilities, assigned to construction field office for two years. Construction responsibilities include guidance on all concrete related matters, evaluation of concrete methods, and liaison between design and construction offices. Served as acting field engineer for completion and float-out of first dam segment. Also responsible for tracking concrete quality control and assurance, and for identifying potential deficiencies.

Grays Landing Locks and Dam: (1990 to 1995) Supported design and construction of new navigation locks and dam. Responsible for various concrete and geotechnical aspects of the project, including tracking and evaluating concrete quality control and assurance, providing design support for various select fill materials, and for monitoring instrumentation used to assure the stability of the cofferdam and a railroad embankment effected by the change in pool elevation.

Point Marion Locks: (1990 to 1994) Supported design and construction of replacement locks. This project was unique in that the existing lock wall was used as a portion of the cofferdam while the lock remained in operation. Responsible for various concrete and geotechnical aspects of the project, including tracking and evaluating concrete quality control and assurance, and for monitoring instrumentation used to assure the stability of the cofferdam.

Allegheny River Locks and Dam Projects: (1992 to present) Responsible to provide guidance and support for the design and construction of several navigation rehabilitation projects on the Allegheny River. Responsibilities have included evaluation of concrete conditions, relating concrete conditions to structural integrity of locks and dams, design of dam scour repair, and design of lock wall repair.

Current Work for Other Agencies:
- Field Advisory Committee member for USACE, Engineer Research and Development Center, Innovations for Navigation Projects Research Program, in the areas of underwater concrete and grout, and low-density concrete.
- Consulting to various elements of the Engineer Research and Development Center, Louisville District, Huntington District, New Orleans District, St.Louis District, and public technical assistance to provide on-going assistance related to concrete and materials.
- Independent Technical Review member for Louisville District McAlpine Lock design memorandum, cofferdam plans and specifications, and lock plans and specifications.
- Consulting for underwater concrete of Louisville District Olmsted Dam.

Brief resume of key persons, specialists, and individual consultants anticipated for this project:

a. Name & Title: Robert M. Willis,
Chief, Operations Technical Support Branch
Assistant Chief, Operations Division, Louisville District

b. Project Assignment:
Independent Technical Review - Operation and Maintenance

Organization:
U.S. Army Corps of Engineers, Louisville District

d. Years Experience:
With This Organization: 27 With Other Organizations:

e. Education: Degree(s)/Year/Specialization

- Bachelor of Engineering, Marine, 1971, S.U.N.Y. Maritime College
- U.S. Coast Guard Merchant Marine Safety Course
- Environmental Laws & Regulations
- Contracting Officer Representative
- Business Law/Accounting
- Civil Works Program Development and Execution
- Managerial Negotiations
- Personnel Management for Executives
- Diving Supervisor Course

f. Active Registration:
U.S. C. G. Unlimited Steam and Diesel License

g. Other Experience and Qualifications Relevant to the Proposed Project:

- As Chief, Operations Technical Support Branch, responsible for directing major maintenance projects requiring multi-phased planning, covering flood control, navigation projects, lock and dam operations and recreational facilities located throughout a multi-state area.
- Maintain quality operational standards, policies and procedures.
- Direct and manage a highly diversified and trained group of engineers, biologists, technicians, dredging team and survey boat operators.
- Coordinate all maintenance and repairs to the floating, mobile and fixed land plant.
- Implement long-range plans for major repair and maintenance projects, insuring navigation and flood control facilities are operational at all times.
- Effectively direct the dredge team activities, insuring that the waterways of the District's rivers are navigable for the commercial industries.
- Interface with the United States Coast Guard on maintenance and operation of the inland navigation system.
- Oversee all design and engineering changes to enhance the projects as needed.
- Monitor all projects from inception to completion and establish milestones to satisfy completion dates.
- Major responsibility for completing Panama Canal O & M Study, 1996
- Direct financial planning, operating budgets, cost control, inventory control and work plans.
- Team Leader for regional acquisition of Corps of Engineers gate lifter crane
- Developed gate change out concept for Louisville District
- Presented Superior Civilian Service Award by Chief of Corps of Engineers General Flowers for efforts developing Lock Maintenance Efficiencies , 2002
- Member of Corps of Engineers review group for innovations to navigation structures.
- Supervised numerous emergency responses to clear or repair navigation structures.
- Developed conceptual designs and directed aquisition for specialized floating plant uniquely adapted to work on navigation structures.
- Chief, Maintenance Branch, Operations Division, Louisville District
- Executive assignment 1980 – Chief, Maintenance Branch, Pittsburgh District
- Member -- Ohio River Lock Closure Study Committee, 1988
- Member – Ohio River Division Navigation Maintenance Study, 1991
- Louisville District Engineer of Year 1985
- Ohio River Division Engineer of Year 1985
- Engineer in Charge, Louisville Repair Station / Fleet , 1975-1990

Ship Maintenance Officer, U.S. Army, 1973-1975

Brief resume of key persons, specialists, and individual consultants anticipated for this project:

a. Name & Title:
Mark P. Zaitsoff
Hydraulic Engineer

b. Project Assignment:
Filling and emptying system, lock culverts and valves, water savings basin culverts and valves

c. Organization:
Hydraulics and Hydrology Section, Water Resources Engineering Branch, Engineering Division, Pittsburgh District, US Army Corps of Engineers

d. Years Experience: 19
With This Organization: 19 With Other Organizations:

e. Education: Degree(s)/Year/Specialization
BSCE / 1975 / Civil Engineering
MSCE / 1982 / Water Resources

f. Active Registration:
PE – Pennsylvania – PE-039332-E

First Year Registered/Discipline: 1989 / Civil Engineering

g. Other Experience and Qualifications Relevant to the Proposed Project:

Charleroi Lock and Dam Project – use of LOCKSIM computer program for the hydraulic simulation of navigation filling and emptying systems, design of hydraulic features and determined fill and empty times, etc.

Hildebrand Lock and Dam Upper Approach Sedimentation Mitigation Dike Study – determination of physical and numerical model requirements, development of study criteria and alternatives, analysis of results and study management.

Tygart Dam Safety Assurance Study – determination of physical model requirements, development of study criteria and alternatives, analysis of results and study management.

Grays Landing Lock and Dam Project – hydraulic design of auxiliary culvert and scour protection.

Tygart Dam – inspection, collection and analysis of prototype data to determine discharge conditions causing cavitation problems in existing high head reservoir project.

Tygart Dam, Berlin Dam, Mahoning Dam – design of reservoir outlet modifications for medium and high head reservoirs, design of valves and sluice modifications, determination of gate and valve ratings, development of spreadsheet applications for design and analysis.

Brief resume of key persons, specialists, and individual consultants anticipated for this project:

a. Name & Title:
Frank Zovack
Chief, Electrical and Mechanical Section

b. Project Assignment:
Technical Manager

c. Organization:
CELRP-ED-DE, Pittsburgh District, US Army Corps of Engineers

d. Years Experience:
With This Organization: 30 With Other Organizations:2

e. Education: Degree(s)/Year/Specialization
Bachelor of Science, Mechanical Engineering, 1971 West Virginia University, Morgantown, WV

f. Active Registration:
Registered Professional Engineer, Pennsylvania

g. Other Experience and Qualifications Relevant to the Proposed Project:

Provided mechanical engineering services to the Bureau of Mines for design and construction of a unique lump coal, hydraulic transport facility.

Project Manager for design and construction of the Coal Preparation Laboratory for the Department of Energy.

Provided Engineering services for relocation and updating of a commercial gas compressor station and relocation of approximately 30 miles of interconnecting piping.

Provided design and start-up for a Station Hydropower Plant at Stonewall Jackson Dam.

Responsible for design and implementation of innovative direct connect hydraulic cylinder operation of miter gates at Lock #4 Allegheny.

Provided mechanical engineering services for the Panama Canal, Operations and Maintenance Study.

Provided mechanical engineering services for the Miraflores Power Plant, Operations and Maintenance Study

Provided mechanical engineering services for the Panama Canal, Concepts Study for Canal Alternatives, Initialized Application of ship lifts.

Responsible for design of innovative hydraulic cylinder operated 110' tainter gates for Monongahela River Dam #2.

Provided mechanical engineering services for the St. Lawrence Seaway, Condition Study.

Presently designing a no-culvert filling system for navigation locks utilizing double hook gates in lieu of upstream miter gates.

Presently serving on the U.S. Army Corps of Engineers INP2 group. The group implements innovative designs for Navigation.

PANAMA CANAL CONCEPT DESIGN

Atlantic Locks Structure

Third Lane Lock

Appendix P

Quality Control Plan

Prepared for

ACP

Canal Capacity Projects Office

By

US Army Corps
of Engineers

Final Report
23 July 2003

Table of Contents

List of Tables

1. QUALITY CONTROL PLAN

1.1. Purpose

This Quality Control Plan (QCP) addresses the procedures the Corps of Engineers will use for implementing quality control for preparation of the concept design for the lock structures for the Atlantic Side of the Panama Canal.

1.2. Applicability

This QCP applies to completion of all engineering products for the concept design of the lock structures.

1.3. References

a. ER 1110-1-12, Quality Management

b. ER 1110-1-8159, DRCHECKS

c. CELRPR 1110-1-1 Quality Management Plan

d. Scope Of Work For Concept Design Of Lock Structures, 6/20/01

e. Proposal For Concept Design Of Lock Structures, 1/31/02

1.4. General

The work consists of preparing concept level design for two configurations of lock structures at the Atlantic side of the Panama Canal. The work is being performed as a Task Order under a Memorandum of Agreement between the Panama Canal Authority (ACP) and the U.S. Army Corps of Engineers (USACE). The designs will be for a new triple-lift single lock structure and for a double-lift single lock structure, both with water saving basins to one side of the lock.

1.5. Management Philosophy

The Corps of Engineers will develop and implement Quality Control (QC) and Quality Assurance (QA) practices that ensure that technical products meet the requirements of the customer and appropriate laws, policies, and technical criteria, on schedule and within budget.

1.6. Technical Criteria Statement

The concept design will be completed in accordance with Corps of Engineers criteria contained in engineering regulations, manuals, and other guidance documents, commercial standards and ACP requirements. The technical criteria will be outlined in the Design Criteria Report and Draft and Final Design Reports.

1.7. Quality Control Structure

The quality control structure will consist of an Independent Technical Review (ITR) team and a Management Oversight/Quality Assurance (MO/QA) team.

1.8. Quality Control Approach

The general approach to QC is to implement a seamless ITR process concurrent with the design process throughout the project duration. Seamless review is the process of continual interaction, as appropriate, between the Design Team and the

ITR team throughout the development of the engineering product. During the development process, engineering products will be periodically posted to a secure web site (Bentley Viecon), where they will be available for review by the members of the ITR and MO/QA teams. ITR and MO/QA team members will access the web site at regular intervals and review and comment on the designs as they are developed. Comments from reviewers and responses from designers will be entered into the Dr. Checks system, which is a web-based database system designed specifically for quality review documentation. Reviewers will post their comments and designers will provide responses throughout the design/review period. This seamless process will be documented and become part of the Design Reports. Unresolved differences between the Design Team and ITR team members will be also be documented.

1.9. Design Team

The Design Team consists of discipline lead personnel from the Pittsburgh District and Design Team members from several Corps of Engineers Districts, Centers, and Headquarters. The members of the Design Team and their responsibilities are given in Table 1. Resumes of the Design Team members are included in the Work Plan. Other recognized experts in the respective fields of engineering may be used as sources of information as required.

1.10. Independent Technical Review Team

The Independent Technical Review Team consists of personnel from Corps of Engineers Districts and Divisions. The members of the Independent Technical Review Team are shown in Table 2. Resumes of the Independent Technical Review Team members are included in the Work Plan. Byron K. McClellan, CELRL-ED-D will be the Independent Technical Review Team leader. The ITR team members will attend the initial project team meeting to ensure that all design and review team members are provided consistent and complete information about the design criteria, the objectives of the ACP, and the logistics for working together to produce a quality product.

1.11. Management Oversight/Quality Assurance Team

The Management Oversight/Quality Assurance team shall consist of the following personnel:

Larry Seals, CELRD-MT-E, Great Lakes and Ohio River Division, Corps of Engineers

Gregory R. Baer, CESAD-MT-E, South Atlantic Division, Corps of Engineers

Anjana Chudgar, CECW-EWS, Headquarters, Corps of Engineers

This team will be given access to all engineering products, review comments, and responses throughout the design process to perform quality assurance reviews. This team will review products, comments and responses to ensure that the process is work as planned and that the requirements of the ACP are met during all phases of work.

1.12. Quality Management Procedures:

Quality Management will consist of design checks, independent technical review and quality assurance reviews as follows:

a. Design Check. Design checks of engineering products will be performed throughout the design process by design team members not directly involved in the particular aspect of design. In general, the design checks will be completed prior to making engineering products available for review. Design checks will consist of detailed evaluation of the engineering analyses and the documents as an extension of the design process prior to releasing the documents for review. The design checks will also include an evaluation of correct application of methods, adequacy of basic data, correctness of calculations (error free), completeness of documentation, and compliance with guidance and standards.

b. Independent Technical Review. A technical review of the engineering products will be performed by persons not involved directly in the development of the design. This review will be a continuing evaluation of the adequacy of the project design and formulation as the project progresses as well as a final evaluation of the completed decision and implementation documents. The technical review will ensure that the concepts, features, methods, analyses, and details are appropriate, fully coordinated among all disciplines, and correct; an appropriate range of feasible alternatives is evaluated; the problems/issues are properly defined and scoped; the analytical methods used are appropriate and yield reliable results; the results and recommendations are reasonable, within policy guidelines, and supported by the presentation; any deviations from policy, guidance, and standards are appropriately identified and have been properly approved; and the customer's interests, requirements, and concerns are adequately considered and addressed.

Engineering products will be placed on a secure web site for coordination among members of the Design Team and review by members of the ITR team and MO/QA team throughout the design process. Updated engineering products will be made available at various times in the design process as applicable for the particular engineering products.

Review comments may be made via e-mail at any time throughout each design phase, and designers will be expected to respond to review comments within 7 working days after the comment are posted. Review comments for the established phases of reviews will be made in Dr. Checks. Reviewers will have the opportunity to review the responses and provide additional comments using the Backcheck feature of Dr. CHECKS. Reviewers will either accept the response or provide backcheck comments within 7 working days of posting the response.

Two phases of review will be established for the design. The first phase will be from the commencement of work to 60% completion of design. The second phase will be from 60% completion of design to completion of design. At the end of each level of review, comments and responses will be assembled into review documents that will be incorporated as appendices to the design reports.

The first phase of review will end with comments and responses through 11 October 2002 to permit assembly of the comments and responses into the 60% review document. All unresolved comments will be documented separately with Design Team recommendations for proceeding with the final design phase. The project team will confirm all features of design with ACP at the 60% review.

The second phase of review will end with submission of the Draft Design Report to permit assembly of the comments and responses into the 100% review document and certification of the review. All comments will be resolved prior to submission of the Final Design Report.

1.13. Customer Involvement

Monthly progress reports will be submitted to the ACP during the design process. Nine site visits will be made by Design Team members as shown in the Work Plan for the purpose of gathering information and coordination with ACP personnel. The following products will be submitted to the ACP for comment and approval prior to finalizing the reports and continuing with design.

Work Plan

Design Criteria Report (Draft)

Alignment Optimization Report (Draft)

Lock Water Savings Basin Alternates Screening Study

Lock Gate Study

Additional coordination will be performed during the design process as required. Significant issues that arise during the design process will be coordinated and resolved with the ACP as needed.

1.14. Review Schedule

The ITR and MO/QA review will be performed continuously throughout the design process. Documentation of the review at the 60% completion of design is scheduled to be completed by October 22, 2002. Documentation of the review at the 100% completion of design is scheduled to be completed by 16 April 2003.

1.15. Review Budget

The budget for the seamless ITR of the product is included in the Work Plan.

1.16. Communications

Communications between team members and the respective discipline leaders will generally be informal. All communications with ACP will be coordinated through the Technical Manager, and will be documented using standard templates. All correspondence among team members will be copy-furnished to the Mobile District Program Manager. All official correspondence with the ACP will be signed and sent by the Mobile District Program Manager.

TABLE O-1 DESIGN TEAM

DISCIPLINE	NAME	ORGANIZATION	RESPONSIBILITIES
Structural Design	William A. Harkness	Pittsburgh District	Technical Manager and Technical Lead, Structural Systems
Structural Design	Richard Allwes	Pittsburgh District	Lock Masonry Design
Structural Design	Terry M. Sullivan	Louisville District	Approach Walls/Design Wall Loading Conditions
Structural Design	Carl H. Johnson	Rock Island District	Steel Structures/Gates
Structural Design	Kenneth D. Hull	Nashville District	General Structural Engineering
Structural Design	Robert M. Ebeling	ERDC	Design Wall Loading Conditions
Structural Design	Robert L. Hall	ERDC	Design Wall Loading Conditions
Structural Design	Robert C. Patev	New England District	Design Wall Loading Conditions
Structures	Douglas A. Kish	Huntington District	Lock Gates
Structures	Pedro J. Luciano	Huntington District	Valves
Structures		Marine Design Center	Naval Architecture
Hydraulics	Walter P. Leput	Pittsburgh District	Technical Lead, Hydraulics
Hydraulics	Raymond A. Povirk	Pittsburgh District	Lead, Filling and Emptying Systems
Hydraulics	David A. Margo	Pittsburgh District	Filling and Emptying Systems
Hydraulics	Mark P. Zaitsoff	Pittsburgh District	Filling and Emptying Systems and Water Storage Basins
Hydraulics	John E. Hite	ERDC	Filling and Emptying Systems
Hydraulics	Richard L. Stockstill	ERDC	LOCKSIM

Hydraulics	Stephen T. Maynord	ERDC	Ship Movement
Hydraulics	Gerald A. Schohl	TVA-WES Consultant	LOCKSIM
Geotechnical, Geology	James F. Brown	Pittsburgh District	Technical Lead, Geology
Geotechnical, Geology	Andrew Schaffer	Pittsburgh District	Rock Mechanics
Geotechnical, Geology	Brian Greene	Pittsburgh District	Foundations
Geotechnical, Geology	Kathleen Bensko	Pittsburgh District	Geologic Site Characterization
Geotechnical, Soils	David E. Carlson	Pittsburgh District	Technical Lead, Soils
Geotechnical, Soils	Carol Tasillo	Pittsburgh District	Concrete and Materials
Civil Design	Terry D. Shilley	Pittsburgh District	Technical Lead, Civil
Civil Design	Silvio Iera	Pittsburgh District	In-Roads
Civil Design	Dee Marciniak	Pittsburgh District	In-Roads Specialist
Mechanical Design	David L. Bucinni	Pittsburgh District	Technical Lead, Mechanical
Electrical Design	John Nites	Pittsburgh District	Technical Lead, Electrical
Electrical Design	Ronald R. Gadomski	Pittsburgh District	Electronics and Controls
Electrical Design	Andrew C. Schimpf	St. Louis District	Electronics and Controls
Cost Engineering	Paula G. Boren	Pittsburgh District	Technical Lead, Cost Engineering
Cost Engineering	Craig Carney	Pittsburgh District	Cost Engineering/ Navigation
Cost Engineering	Frank J. Likar	Pittsburgh District	Cost Engineering/ Navigation
Cost Engineering	Gary J. Stinson	Nashville District	Cost Engineering/ Navigation

Cost Engineering	Joseph H. Ellsworth, Jr.	Mobile District	Cost Engineering/ Central America
Cost Engineering	William J. Griffin	Mobile District	Cost Engineering/ Central America
Technical Writing	Thomas E. Andre	Pittsburgh District	Quality Control Plan/ Report Assembly
Architecture	Larry M. Cozine	Louisville District	Technical Lead, Architecture

TABLE O-2 INDEPENDENT TECHNICAL REVIEW TEAM

DISCIPLINE	NAME	ORGANIZATION	RESPONSIBILITIES
Structures	Byron K. McClellan	Louisville District	Independent Technical Review Team Leader, Lock Gates, Entrance Walls, Filling and Emptying Features, Water Saving Basins
Structures	John D. Clarkson	Huntington District	
Structures	Thomas B. Sully	St. Paul District	Lock Gates, Entrance Walls, Filling and Emptying Features, Water Saving Basins
Hydraulics	Gordon R. Lance	Kansas City District	Lock Design
Hydraulics	Coy W. Miller	Huntington District	Lock Design
Geotechnical, Geology	Stephen T. Hornbeck	Louisville District	Geology
Geotechnical, Soils	Jeffrey A. Scheafer	Louisville District	Soil Mechanics
Geotechnical, Soils	Bill Halczak	Los Angeles District	Concrete and Materials
Civil Design	Byron K. McClellan	Louisville District	Relocations, Utilities, Signage, Access
Civil Design	William M. Dorsch	Louisville District	In-Roads Specialist
Mechanical Design	James D. Pace	South Atlantic Division	Gate and Valve Operating Equipment
Electrical Design	Robert H. Fulton	South Atlantic Division	Controls, Power Distribution Systems
Cost Engineering	Martin Lockard	Louisville District	Cost Engineering
Operations & Maintenance	Bob Willis	Louisville District	

Sample Certification Document

COMPLETION OF INDEPENDENT TECHNICAL REVIEW

The District has completed the concept design for the Concept Design Of Lock Structures, Atlantic Lock Structures. Notice is hereby given that an independent technical review has been conducted that is appropriate to the level of risk and complexity inherent in the project, as defined in the Quality Control Plan. During the independent technical review, compliance with established policy principles and procedures, utilizing justified and valid assumptions, was verified. This included review of assumptions; methods, procedures, and material used in analyses; alternatives evaluated; the appropriateness of data used and level of data obtained; and reasonableness of the results, including whether the product meets the customer's needs consistent with law and existing Corps policy. The design was accomplished by a team of Corps of Engineers personnel from various districts and centers, and the independent technical review was accomplished by an independent a team of Corps of Engineers personnel from various districts and divisions.

(Signature) (Date)
Technical Manager

(Signature) (Date)
Design Team Member

(Signature) (Date)
Design Team Member

(Signature) (Date)
Independent Technical Review Team Leader

(Signature) (Date)
Independent Technical Review Team Member

(Signature) (Date)
Independent Technical Review Team Member

PANAMA CANAL CONCEPT DESIGN

Atlantic Locks Structure

Third Lane Lock

Appendix Q

Quality Control Certification and Documentation

Prepared for

ACP

Canal Capacity Projects Office

By

US Army Corps of Engineers

Final Report

23 July 2003

1. QUALITY CONTROL DOCUMENTATION

Quality control for the concept design has been conducted on a seamless basis in accordance with the Quality Control Plan (Appendix P). Documents were posted to a secure website at various times throughout the design process for review by designated Independent Technical Review (ITR) team members (Appendix O). Comments were provided to designers by telephone discussions and email. A formal ITR review was conducted upon completion of the Draft Double-Lift Report and again upon completion of the Revised Draft Double-Lift Report. A formal ITR review was also conducted upon completion of the Draft Triple-Lift Report and the formal reviews were provided by email and in Dr. Checks. The certification of the ITR reviews are enclosed.

COMPLETION OF INDEPENDENT TECHNICAL REVIEW

Revised Draft Report, Double-Lift Configuration

The District has completed the concept design for the Concept Design Of Lock Structures, Atlantic Lock Structures. Notice is hereby given that an independent technical review has been conducted that is appropriate to the level of risk and complexity inherent in the project, as defined in the Quality Control Plan. During the independent technical review, compliance with established policy principles and procedures, utilizing justified and valid assumptions, was verified. This included review of assumptions; methods, procedures, and material used in analyses; alternatives evaluated; the appropriateness of data used and level of data obtained; and reasonableness of the results, including whether the product meets the customer's needs consistent with law and existing Corps policy. The design was accomplished by a team of Corps of Engineers personnel from various districts and centers, and the independent technical review was accomplished by an independent a team of Corps of Engineers personnel from various districts and divisions.

, P.E. — 28 Mar '03

Technical Manager

Byron K. McClellan, P.E. — 27 MAR '03

Independent Technical Review Team Leader

COMPLETION OF INDEPENDENT TECHNICAL REVIEW

Draft Report, Modification 2

Triple-Lift Configuration

The Corps of Engineers has completed the draft report for Modification 2, Triple-Lift Configuration for the Concept Design Of Lock Structures, Atlantic Lock Structures. Notice is hereby given that an independent technical review has been conducted that is appropriate to the level of risk and complexity inherent in the project, as defined in the Quality Control Plan. During the independent technical review, compliance with established policy principles and procedures, utilizing justified and valid assumptions, was verified. This included review of assumptions; methods, procedures, and material used in analyses; alternatives evaluated; the appropriateness of data used and level of data obtained; and reasonableness of the results, including whether the product meets the customer's needs consistent with law and existing Corps policy. The design was accomplished by a team of Corps of Engineers personnel from various districts and centers, and the independent technical review was accomplished by an independent a team of Corps of Engineers personnel from various districts and divisions.

12 May 03

Technical Manager

Byron K. McClellan

5 MAY '03

Independent Technical Review Team Leader