

PIANC Workshop
13-14th September 2011



Innovation in Lock Filling and Emptying Systems

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Background

- New **lock designs** are being considered to **save construction, and operation and maintenance costs**
- 2 newest locks have used **innovative designs**
 - New McAlpine Lock, Ohio River
(11.3m, 37' lift)
 - New Marmet Lock, Kanawha River
(7.3m, 24' lift)

In-Chamber Longitudinal Culvert System (ILCS)



- ILCS design was briefly mentioned at the last PIANC workshop by Mr. Jerry Webb (Paper 5, Part A)
- Today's presentation will
 - Provide details of ILCS design
 - Describe project features found on Marmet and McAlpine ILCS Locks

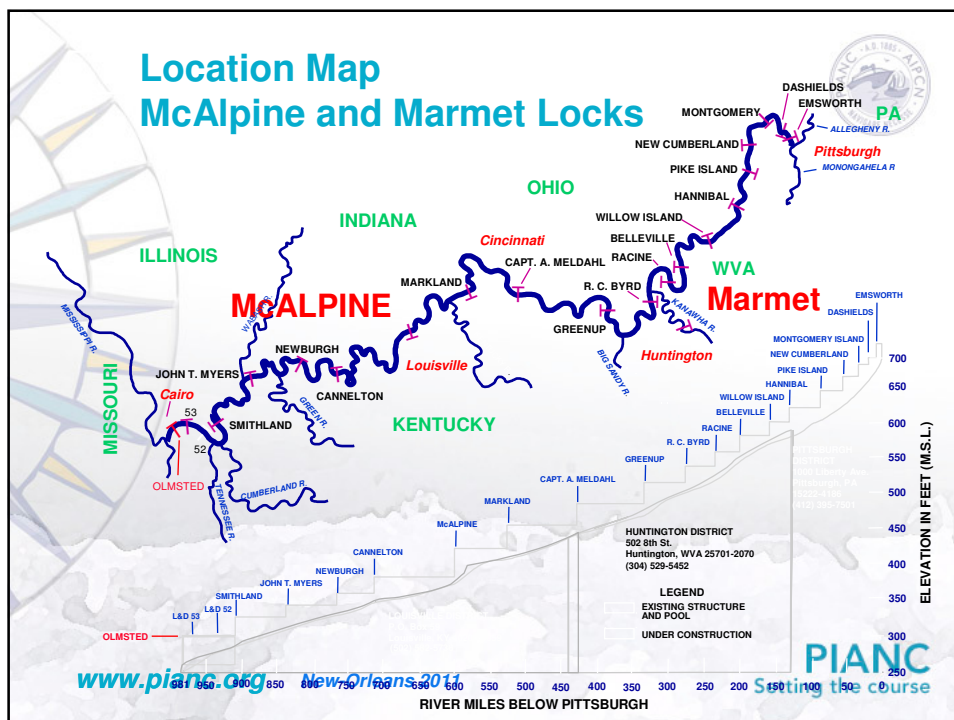
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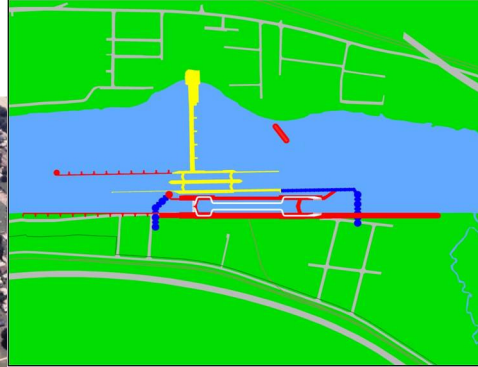
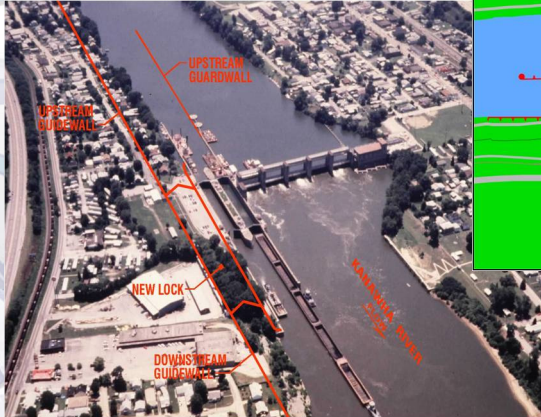
3

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Location Map McAlpine and Marmet Locks



Planned Marmet Lock



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Completed Marmet Lock



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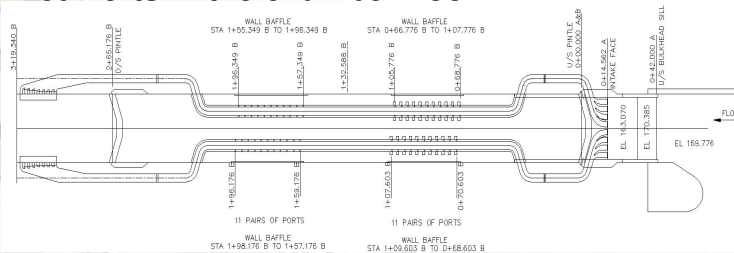
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ILCS Design Philosophy

- Develop a system nearly as efficient as the side-port filling and emptying system
- Culverts in the chamber walls are replaced by culverts in the chamber floor



Marmet Lock

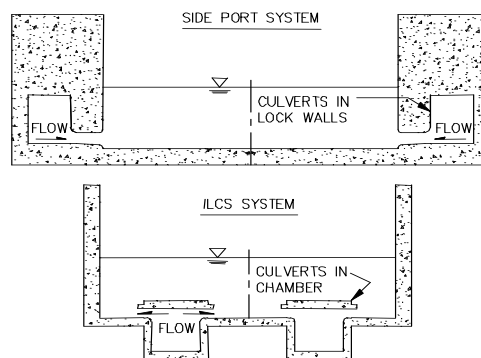
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ILCS Offers Potential Cost Savings in Wall Construction



Culvert Locations for the Side-Port and ILCS Filling and Emptying Systems

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In-Chamber Longitudinal Culvert System



Side-Port System



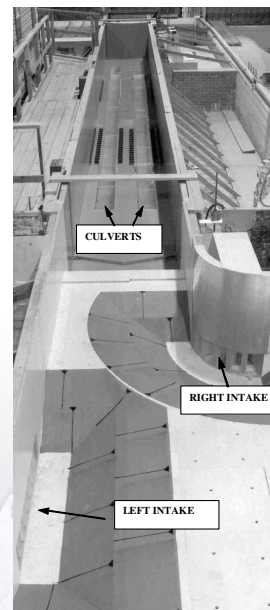
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Intake Manifolds McAlpine Lock



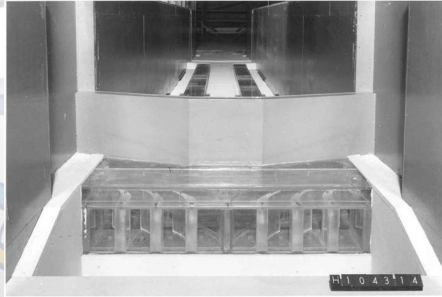
***Layout Fit
Existing Conditions***



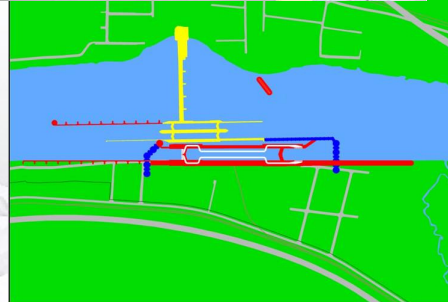
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Intake Manifolds Marmet Lock



**Through-the-Sill
Design Reduced
Cofferdam Size**



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Hydraulic Efficiency: Lock Coefficient

$$C_L = \frac{2A_L (\sqrt{H+d} - \sqrt{d})}{A_c (T - Ut_v) \sqrt{2g}}$$

Where:

- C_L = lock coefficient
- A_L = plan area of lock chamber
- H = initial head (i.e. lift)
- d = lock chamber water level over-travel (or under-travel)
- A_c = sum of culvert area at each operation valve
- T = operational time required to fill (or empty) the lock
- t_v = valve operation time
- U = valve coefficient ($0.45 \leq U \leq 0.55$)

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Lock Coefficients - Previous Model Studies

Filling: Side Port = 0.73, ILCS = 0.64



Project	Filling and Emptying System	Initial Head, m	Lock Coefficient		Reference
			Filling	Emptying	
Cannelton Model Type 45 Port Arrangement	Side Port	6.1	0.74	0.57	Ables and Boyd (1966a)
		7.9	0.74	0.60	
		9.1	0.73	0.61	
		12.2	0.74	0.60	
Cannelton Model Type 100 Port Arrangement	Side Port	6.1	0.71	0.56	Ables and Boyd (1966a)
		9.1	0.73	0.56	
		12.2	0.74	0.56	
Arkansas River Model	Side Port	3.0-15.2	0.73	0.67	Ables and Boyd (1966b)
Marmet Model Type 5 Chamber Design	ILCS	4.3	0.63		Hite (1999)
		7.3	0.63		
		10.4	0.63		
McAlpine Model Type 1 Chamber Design	ILCS	11.3	0.63	0.56	Hite (2000)
McAlpine Model Type 11 Chamber Design	ILCS	11.3	0.65	0.57	Hite (2000)

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ILCS Manifolds

- Allow for alternative lock wall construction, such as RCC or in-the-wet construction
- Port extensions and wall baffles provide uniform distribution of flow and dissipate energy



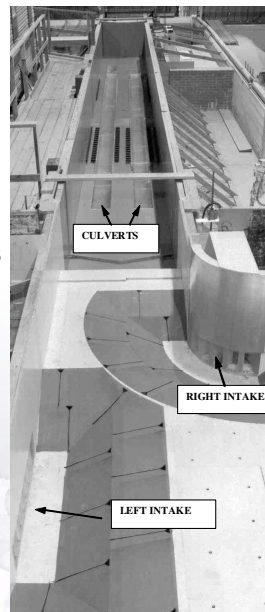
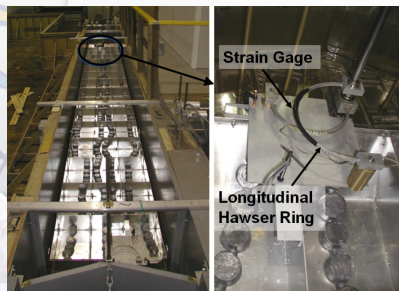
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ILCS Research

1:25-Scale Hydraulic Model

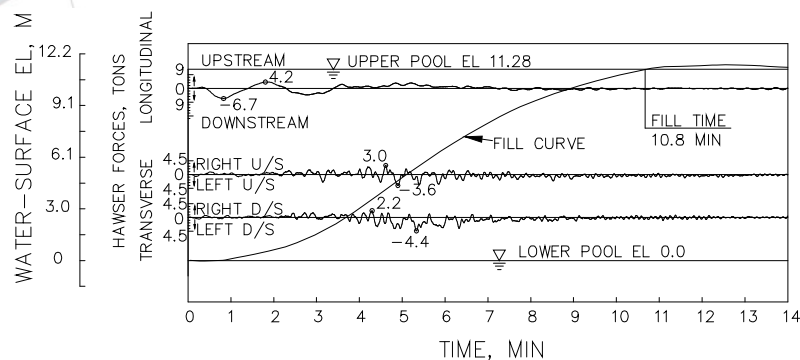
- Hawser Forces
- Filling & Emptying Times



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ILCS – Filling Characteristics

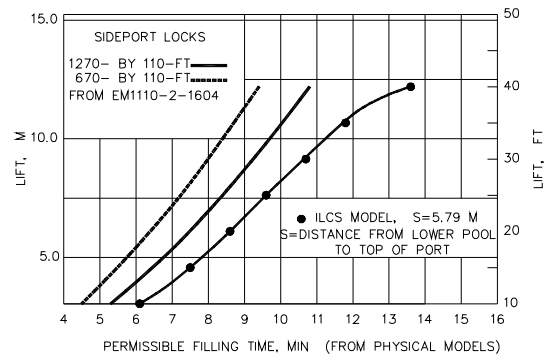


11.28-m lift, 5.79-m submergence, 5-min normal valve

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Permissible Filling Times



Side-Port System Allows Faster Filling than ILCS

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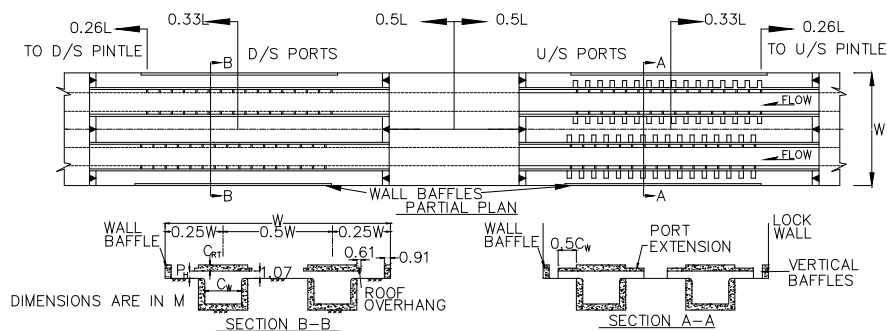
ILCS Design Guidance



Ports:

- Spacing – chamber width dependent (~ 12 m)
- Number – port-to-culvert ratio about 0.96
- 2 Groups – at 1/3 points of chamber length
- Extensions – needed on upstream group

Wall Baffles: diffuse port jets near lock floor and inhibit upwelling along walls



Questions?



Marmet Lock, Kanawha River

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