

U.S. Army Corps  
of Engineers

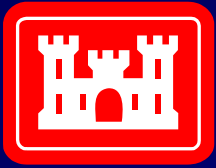
---

# **Savannah Harbor Expansion Project**

---

# **Savannah Harbor Ecosystem Restoration Project**

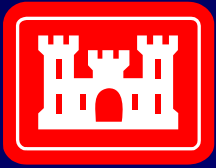
---



U.S. Army Corps  
of Engineers

MACTEC  
Engineering and  
Consulting, Inc.

# Identification and Screening Level Evaluation of Measures to Improve Dissolved Oxygen in the Savannah River Estuary

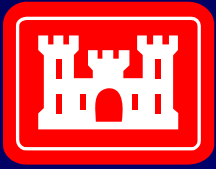


U.S. Army Corps  
of Engineers

# Savannah Harbor Expansion Project

## PURPOSE

- 1. Identify Dissolved Oxygen improvement techniques**
- 2. Evaluate feasibility of D.O. improvement techniques for use in Savannah Harbor**
- 3. Recommend best way to improve D.O. for several scenarios**

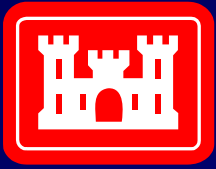


U.S. Army Corps  
of Engineers

# Savannah Harbor Expansion Project

## IMPROVEMENT TECHNIQUES

- 1. Started with list of list of conceptual mitigation actions for water quality presented to SEG in 2002**
- 2. Contractor was encouraged to add to the list from his experience and knowledge**



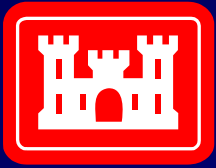
U.S. Army Corps  
of Engineers

# Savannah Harbor Expansion Project

## IMPROVEMENT TECHNIQUES

**Contractor grouped methodologies into 5 categories:**

- **Advanced Treatment**
- **Aeration**
- **Management**
- **Oxygen Injection**
- **Physical Modifications**

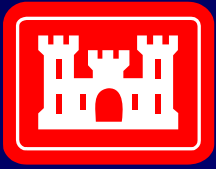


U.S. Army Corps  
of Engineers

# Savannah Harbor Expansion Project

## IMPROVEMENT TECHNIQUES

1. Membrane Filtration of Effluents
2. Cascade Aerator
3. CleanFlo-Natural Inversion
4. Coarse Bubble Diffuser
5. Fine Bubble Diffuser
6. Linde-Soaker Hose
7. Mechanical Surface Aerators
8. Rolling Maintenance Shutdown during Critical Season

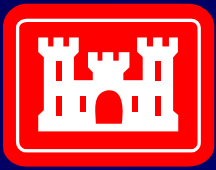


U.S. Army Corps  
of Engineers

# Savannah Harbor Expansion Project

## IMPROVEMENT TECHNIQUES

9. Increased Releases from Upstream Reservoirs
10. ECO<sub>2</sub>-SuperOxygenation (Speece Cone)
11. Fine Bubble Diffuser using High Purity Oxygen
12. Hydroflo-Aero Transfer System
13. Praxair-In-Situ Oxygenation
14. Sidestream Pressurized Oxygenation
15. U-Tube Oxygenation
16. Venturi Oxygenation
17. Aquatic Treatment Systems

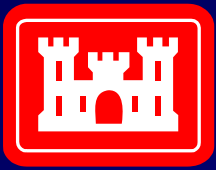


U.S. Army Corps  
of Engineers

# Savannah Harbor Expansion Project

## IMPROVEMENT TECHNIQUES

18. **Constructed Wetland Treatment Systems**
19. **Discharge Collection Network With Supplemental Oxygen Injection**
20. **Inflatable Weir**
21. **Land Treatment Systems/Water Reuse**
22. **Mechanical Mixing**
23. **Seaward Pipeline with Timed Tidal Discharge**
24. **Storage and Controlled Discharge System**
25. **Tidal Gate**



U.S. Army Corps  
of Engineers

# Savannah Harbor Expansion Project

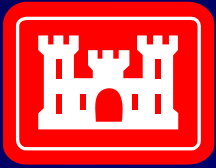
## IMPROVEMENT TECHNIQUES

### Two Levels of Assessment:

**Level I -- Site-specific conditions and requirements for either upstream or harbor implementation**

**Product =**

- (A) techniques that could feasibly achieve desired D.O. improvement goals, and**
- (B) be proven to be effective**



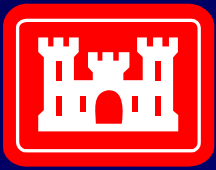
U.S. Army Corps  
of Engineers

# Savannah Harbor Expansion Project

## IMPROVEMENT TECHNIQUES

### Considerations:

- **Applicability to moving or stagnant water**
- **Zone of influence**
- **Ability to effectively add oxygen to water**
- **Interference with shipping traffic**
- **Required space to construct & operate**
- **Power needs**
- **Effluent treatment techniques at 5 largest contributors of BOD loads to Savannah River**



U.S. Army Corps  
of Engineers

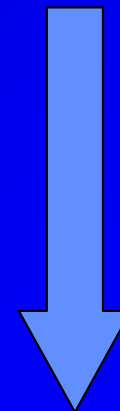
# Savannah Harbor Expansion Project

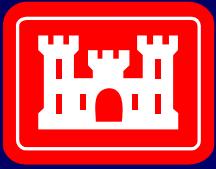
## IMPROVEMENT TECHNIQUES

### Techniques Eliminated:

2. Cascade Aerator
3. CleanFlo-Natural Inversion
4. Coarse Bubble Diffuser
5. Fine Bubble Diffuser
6. Linde-Soaker Hose
7. Mechanical Surface Aerators
11. Fine Bubble Diffuser using High Purity Oxygen

Require large surface area  
Interfere with shipping  
Interfere with dredging





U.S. Army Corps  
of Engineers

# Savannah Harbor Expansion Project

## IMPROVEMENT TECHNIQUES

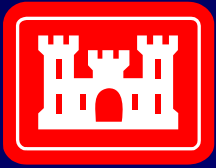
### Techniques Eliminated:

#### 9. Increased Releases from Upstream Reservoirs

No noticeable increase in D.O. at Clyo

Sufficient volumes for dilution not available

when needed to enhance summer low flows



U.S. Army Corps  
of Engineers

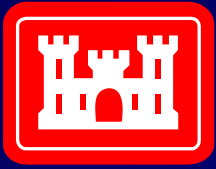
# Savannah Harbor Expansion Project

## IMPROVEMENT TECHNIQUES

### Two Levels of Assessment:

**Level II -- More detailed assessment of individual techniques**

**Product = ranking of techniques based on overall achievement of project goals**



U.S. Army Corps  
of Engineers

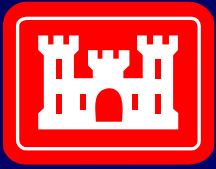
# Savannah Harbor Expansion Project

## IMPROVEMENT TECHNIQUES

### Level II Assessment

### Evaluation Criteria

- **Performance/Effectiveness**
- **Reliability**
- **BOD Reduction**
- **Capital Cost**
- **Constraints**
- **Seasonal Application**



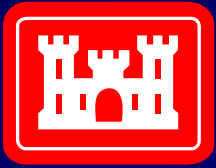
U.S. Army Corps  
of Engineers

# Savannah Harbor Expansion Project

## IMPROVEMENT TECHNIQUES

Contractor grouped methodologies into 5 categories:

- **Advanced Treatment**
- **Aeration** ---- **Eliminated in Level I**
- **Management**
- **Oxygen Injection**
- **Physical Modifications**



U.S. Army Corps  
of Engineers

# Savannah Harbor Expansion Project

## IMPROVEMENT TECHNIQUES

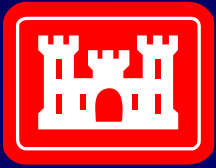
Technique

Score

Management

**Rolling maintenance shutdown  
of industrial discharges  
during critical months**

**16**

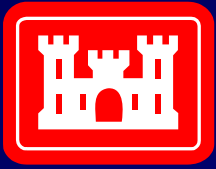


U.S. Army Corps  
of Engineers

# Savannah Harbor Expansion Project

## IMPROVEMENT TECHNIQUES

<u>Technique</u>	<u>Score</u>
<u>Physical Modifications</u>	
Inflatable weir	6
Mechanical mixing	6
Tidal Gate	6
Urban water reuse	10
Seaward pipeline with timed tidal discharge	18

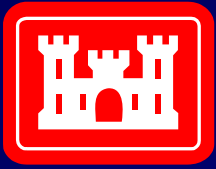


U.S. Army Corps  
of Engineers

# Savannah Harbor Expansion Project

## IMPROVEMENT TECHNIQUES

<u>Technique</u>	<u>Score</u>
<u>Physical Modifications</u>	
Discharge collection network with supplemental oxygen	14
Constructed wetlands	14
Storage pond with controlled discharge	17



U.S. Army Corps  
of Engineers

# Savannah Harbor Expansion Project

## IMPROVEMENT TECHNIQUES

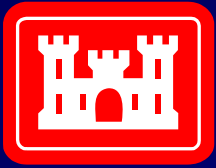
Technique

Score

Advanced Treatment

Membrane filtration  
of point source discharges

10



U.S. Army Corps  
of Engineers

# Savannah Harbor Expansion Project

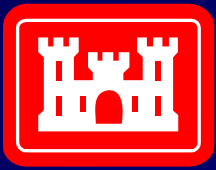
## IMPROVEMENT TECHNIQUES

### Technique

### Score

### Oxygen Injection

ECO2-SuperOxygenation (Speece Cone)	16
Hydroflow-Aero Transfer System	10
Praxair – In-Situ Oxygenation	13
Sidestream Pressurized Oxygenation	14
U-Tube	15
Venturi Nozzle	10

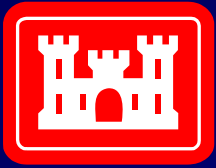


U.S. Army Corps  
of Engineers

# Savannah Harbor Expansion Project

## IMPROVEMENT TECHNIQUES

<u>Technique</u>	<u>Score</u>
<u>High Scores</u>	
ECO2-SuperOxygenation (Speece Cone)	16
Praxair – In-Situ Oxygenation	13
Sidestream Pressurized Oxygenation	14
U-Tube	15
Storage pond with controlled discharge	17
Seaward pipeline with timed discharge	18
Rolling maintenance shutdown	16

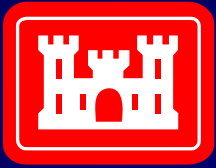


U.S. Army Corps  
of Engineers

# Savannah Harbor Expansion Project

## PURPOSE

- 1. Identify Dissolved Oxygen improvement techniques**
- 2. Evaluate feasibility of D.O. improvement techniques for use in Savannah Harbor**
- 3. Recommend best way to improve D.O. for several scenarios**



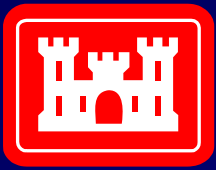
U.S. Army Corps  
of Engineers

# Savannah Harbor Expansion Project

## IMPROVEMENT SCENARIOS

### Phase I -- Compliance with D.O. Standards

- 1 Current BOD loads / Current GA D.O. standard
- 2 Permitted BOD loads / Current GA D.O. standard
- 3 Current BOD loads / Recommended GA D.O. standard
- 4 Permitted BOD loads / Recommended GA D.O. standard



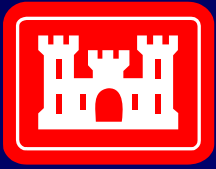
U.S. Army Corps  
of Engineers

# Savannah Harbor Expansion Project

## IMPROVEMENT SCENARIOS

### Phase I -- Compliance with D.O. Standards

- 1 1999 BOD loads / Current GA D.O. standard  
290,250 lbs/day
- 2 Permitted BOD loads / Current GA D.O. standard  
725,500 lbs/day
- 3 1999 BOD loads / Recommended GA D.O. standard  
68,250 lbs/day
- 4 Permitted BOD loads / Recommended GA D.O. standard  
503,500 lbs/day



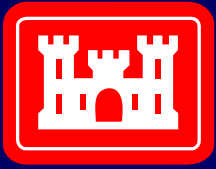
U.S. Army Corps  
of Engineers

# Savannah Harbor Expansion Project

## IMPROVEMENT SCENARIOS

### Phase II -- D.O. Improvement

1. 0.2 mg/L in harbor
2. 0.4 mg/L in harbor
3. 0.6 mg/L in harbor
4. 0.8 mg/L in harbor



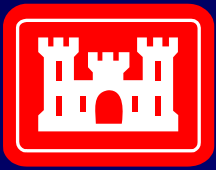
U.S. Army Corps  
of Engineers

# Savannah Harbor Expansion Project

## IMPROVEMENT SCENARIOS

### Phase II -- D.O. Improvement

1.	0.2 mg/L in harbor	72,800 lb/day
2.	0.4 mg/L in harbor	145,650 lb/day
3.	0.6 mg/L in harbor	218,450 lb/day
4.	0.8 mg/L in harbor	291,270 lb/day



U.S. Army Corps  
of Engineers

# Savannah Harbor Expansion Project

## IMPROVEMENT SCENARIOS

### Phase I -- Compliance with D.O. Standards

#### 1A. 1999 BOD loads / Current GA D.O. standard

29 Speece Cones

Capital Costs \$36 million

Operating Costs \$1.6 million/yr

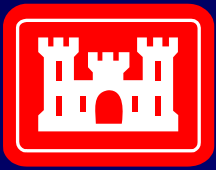
#### 1B. 1999 BOD loads / Current GA D.O. standard

29 Speece Cones

Scheduled maintenance shutdowns

Capital Costs \$36 million

Operating Costs \$1.4 million/yr



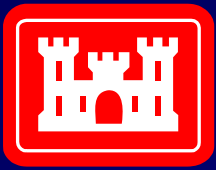
U.S. Army Corps  
of Engineers

# Savannah Harbor Expansion Project

## IMPROVEMENT SCENARIOS

### Phase I -- Compliance with D.O. Standards

- 1C. 1999 BOD loads / Current GA D.O. standard  
Discharge Collection Network with 60-day retention**
- |                        |                         |
|------------------------|-------------------------|
| <b>Capital Costs</b>   | <b>\$72 million</b>     |
| <b>Operating Costs</b> | <b>\$0.2 million/yr</b> |
- 1D. 1999 BOD loads / Current GA D.O. standard  
Discharge Collection Network with 30-day retention**
- |                        |                         |
|------------------------|-------------------------|
| <b>Capital Costs</b>   | <b>\$63 million</b>     |
| <b>Operating Costs</b> | <b>\$0.2 million/yr</b> |



U.S. Army Corps  
of Engineers

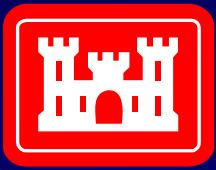
# Savannah Harbor Expansion Project

## IMPROVEMENT SCENARIOS

### Phase 1-1

### 1999 BOD loads / Current GA D.O. Standard

	<u>Capital Costs</u>	<u>Operating Costs</u>
1A	\$36 million	\$1.6 million/yr
1B	\$36 million	\$1.4 million/yr
1C	\$72 million	\$0.2 million/yr
1D	\$62 million	\$0.2 million/yr

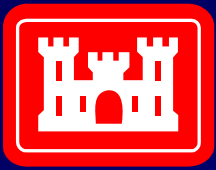


U.S. Army Corps  
of Engineers

# Savannah Harbor Expansion Project



**Speece Cone – Kentucky – 1 MGD**



U.S. Army Corps  
of Engineers

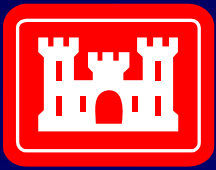


# Savannah Harbor Expansion Project

**Speece Cone**

**Indiana**

**5 MGD**



U.S. Army Corps  
of Engineers

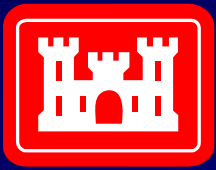
# Savannah Harbor Expansion Project



**Speece Cone**

**California**

**7 MGD**



U.S. Army Corps  
of Engineers

# Savannah Harbor Expansion Project

## IMPROVEMENT SCENARIOS

### Phase I -- Compliance with D.O. Standards

#### 2A. Permitted BOD loads / Current GA D.O. standard

73 Speece Cones

Capital Costs \$90 million

Operating Costs \$4.1 million/yr

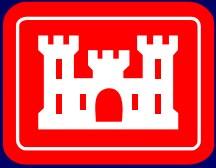
#### 2B. Permitted BOD loads / Current GA D.O. standard

73 Speece Cones

Scheduled maintenance shutdowns

Capital Costs \$90 million

Operating Costs \$3.9 million/yr



U.S. Army Corps  
of Engineers

# Savannah Harbor Expansion Project

## IMPROVEMENT SCENARIOS

### Phase I -- Compliance with D.O. Standards

#### 2C. Permitted BOD loads / Current GA D.O. standard

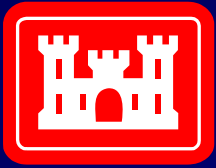
40 Speece Cones

Scheduled maintenance shutdowns

Discharge Collection Network with 30-day storage

Capital Costs \$115 million

Operating Costs \$2.3 million/yr



U.S. Army Corps  
of Engineers

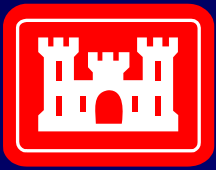
# Savannah Harbor Expansion Project

## IMPROVEMENT SCENARIOS

### Phase 1-2

### Permitted BOD loads / Current GA D.O. Standard

	<u>Capital Costs</u>	<u>Operating Costs</u>
2A	\$94 million	\$4.1 million/yr
2B	\$94 million	\$3.9 million/yr
2C	\$118 million	\$2.3 million/yr



U.S. Army Corps  
of Engineers

# Savannah Harbor Expansion Project

## IMPROVEMENT SCENARIOS

### Phase I -- Compliance with D.O. Standards

#### 3A. 1999 BOD loads / Recommended GA D.O. Standard

7 Speece Cones

Capital Costs

\$8.7 million

Operating Costs

\$0.4 million/yr

#### 3B. 1999 BOD loads / Recommended GA D.O. Standard

7 Speece Cones

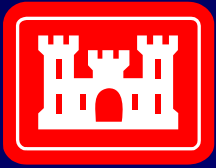
Scheduled maintenance shutdowns

Capital Costs

\$8.7million

Operating Costs

\$0.2 million/yr



U.S. Army Corps  
of Engineers

# Savannah Harbor Expansion Project

## IMPROVEMENT SCENARIOS

### Phase I -- Compliance with D.O. Standards

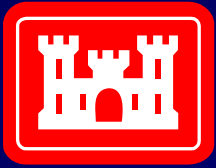
#### 3C. 1999 BOD loads / Recommended GA D.O. standard

##### Discharge Collection Network

with timed seaward discharge

Capital Costs \$55 million

Operating Costs \$0.2 million/yr



U.S. Army Corps  
of Engineers

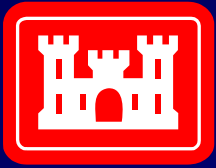
# Savannah Harbor Expansion Project

## IMPROVEMENT SCENARIOS

### Phase 1-3

### 1999 BOD loads / Recommended GA D.O. Standard

	<u>Capital Costs</u>	<u>Operating Costs</u>
3A	\$8.7 million	\$0.4 million/yr
3B	\$8.7 million	\$0.2 million/yr
3C	\$54.6 million	\$0.2 million/yr



U.S. Army Corps  
of Engineers

# Savannah Harbor Expansion Project

## IMPROVEMENT SCENARIOS

### Phase I -- Compliance with D.O. Standards

#### 4A. Permitted BOD loads / Recommended GA D.O. Standard

50 Speece Cones

Capital Costs

\$62 million

Operating Costs

\$2.8 million/yr

#### 4B. Permitted BOD loads / Recommended GA D.O. Standard

50 Speece Cones

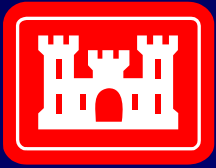
Scheduled maintenance shutdowns

Capital Costs

\$62 million

Operating Costs

\$2.6 million/yr



U.S. Army Corps  
of Engineers

# Savannah Harbor Expansion Project

## IMPROVEMENT SCENARIOS

### Phase I -- Compliance with D.O. Standards

#### 4C. Permitted BOD loads / Recommended GA D.O. Standard

24 Speece cones

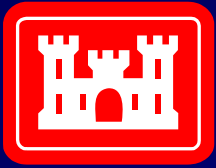
Scheduled maintenance shutdowns

Discharge Collection Network

with timed seaward discharge

Capital Costs \$85 million

Operating Costs \$1.4 million/yr



U.S. Army Corps  
of Engineers

# Savannah Harbor Expansion Project

## IMPROVEMENT SCENARIOS

### Phase I -- Compliance with D.O. Standards

#### 4D. Permitted BOD loads / Recommended GA D.O. Standard

24 Speece cones

Scheduled maintenance shutdowns

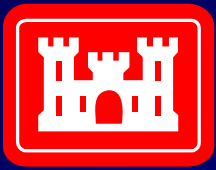
Discharge Collection Network

with 30-day storage

with timed seaward discharge

Capital Costs                      \$96 million

Operating Costs                    \$1.4 million/yr



U.S. Army Corps  
of Engineers

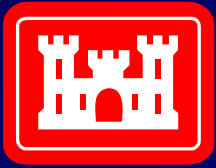
# Savannah Harbor Expansion Project

## IMPROVEMENT SCENARIOS

### Phase 1-4

### Permitted BOD loads / Recommended GA D.O. Standard

	<u>Capital Costs</u>	<u>Operating Costs</u>
4A	\$62 million	\$2.8 million/yr
4B	\$62 million	\$2.6 million/yr
4C	\$85 million	\$1.4 million/yr
4D	\$96 million	\$1.4 million/yr



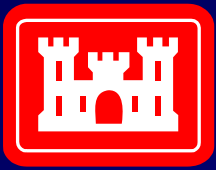
U.S. Army Corps  
of Engineers

# Savannah Harbor Expansion Project

## IMPROVEMENT SCENARIOS

### Phase II -- D.O. Improvement

1.	0.2 mg/L in harbor	72,800 lb/day
2.	0.4 mg/L in harbor	145,650 lb/day
3.	0.6 mg/L in harbor	218,450 lb/day
4.	0.8 mg/L in harbor	291,270 lb/day



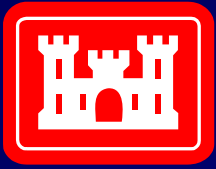
U.S. Army Corps  
of Engineers

# Savannah Harbor Expansion Project

## IMPROVEMENT SCENARIOS

### Phase II -- D.O. Improvement

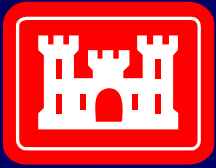
	<u># Speece Cones</u>	<u>Capital Costs</u>	<u>Operating Costs</u>
1.	8	\$ 10 million	\$ 0.4 million/yr
2.	15	\$ 19 million	\$ 0.8 million/yr
3.	22	\$ 28 million	\$1.2 million/yr
4.	29	\$ 38 million	\$1.6 million/yr



U.S. Army Corps  
of Engineers

# Savannah Harbor Expansion Project

## SUMMARY

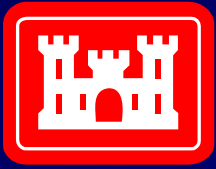


U.S. Army Corps  
of Engineers

# Savannah Harbor Expansion Project

## PURPOSE

- 1. Identify Dissolved Oxygen improvement techniques**
- 2. Evaluate feasibility of D.O. improvement techniques for use in Savannah Harbor**
- 3. Recommend best way to improve D.O. for several scenarios**

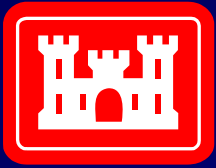


U.S. Army Corps  
of Engineers

# Savannah Harbor Expansion Project

## PURPOSE

1. **Identify Dissolved Oxygen improvement techniques**
  - **Identified 25 D.O. improvement techniques or technologies**



U.S. Army Corps  
of Engineers

# Savannah Harbor Expansion Project

## PURPOSE

### 2. Evaluate feasibility of D.O. improvement techniques for use in Savannah Harbor

#### Level II Assessment --- Evaluation Criteria

Performance/Effectiveness

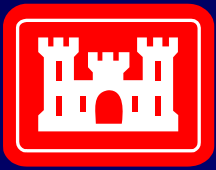
Reliability

BOD Reduction

Capital Cost

Constraints

Seasonal Application



U.S. Army Corps  
of Engineers

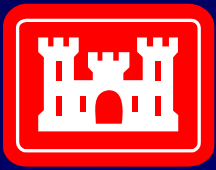
# Savannah Harbor Expansion Project

## PURPOSE

### 3. Recommend best way to improve D.O. for several scenarios

#### Phase I -- Compliance with D.O. Standards

- 1 Current BOD loads / Current GA D.O. standard
- 2 Permitted BOD loads / Current GA D.O. standard
- 3 Current BOD loads / Recommended GA D.O. standard
- 4 Permitted BOD loads / Recommended GA D.O. standard



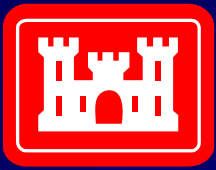
U.S. Army Corps  
of Engineers

# Savannah Harbor Expansion Project

## PURPOSE

### 3. Recommend best way to improve D.O. for several scenarios

	<u>Design</u>	<u>Initial Cost</u>
1-1B	29 Speece Cones Rolling maintenance shutdowns	\$37 million
1-2B	73 Speece Cones Rolling maintenance shutdowns	\$94 million
1-3B	7 Speece Cones Rolling maintenance shutdowns	\$8.9 million
1-4B	50 Speece Cones Rolling maintenance shutdowns	\$64 million



U.S. Army Corps  
of Engineers

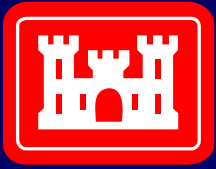
# Savannah Harbor Expansion Project

## PURPOSE

### 3. Recommend best way to improve D.O. for several scenarios

#### Phase II -- D.O. Improvement

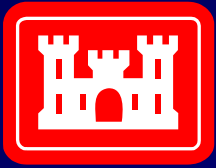
	<u>Increase</u>	<u>Design</u>	<u>Initial Cost</u>
2-1	0.2 mg/L	8 Speece Cones	\$10 million
2-2	0.4 mg/L	15 Speece Cones	\$19 million
2-3	0.6 mg/L	22 Speece Cones	\$28 million
2-4	0.8 mg/L	29 Speece Cones	\$38 million



U.S. Army Corps  
of Engineers

# Savannah Harbor Expansion Project

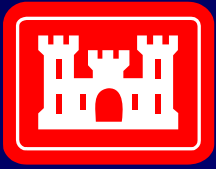
## THE PLAN FORWARD



U.S. Army Corps  
of Engineers

# Savannah Harbor Expansion Project

- **SH Expansion Project will pursue D.O. injection as the best technique to mitigate for any impacts to dissolved oxygen from a harbor deepening.**
- **The approved hydrodynamic and dissolved oxygen models will be used to identify impacts to dissolved oxygen.**
- **The models will also be used to design the D.O. injection system that would be needed to reduce/eliminate project effects on dissolved oxygen.**



U.S. Army Corps  
of Engineers

---

**QUESTIONS ?**

---