

---

# **Problem Formulation: Endpoints and Conceptual Models for Assessing and Managing Risks from Resuspension**

**Burton Suedel, Ph.D.**  
**burton.suedel@usace.army.mil**  
**DMAM Seminar – Day 3**  
**17 Sept 2009**



# Objectives

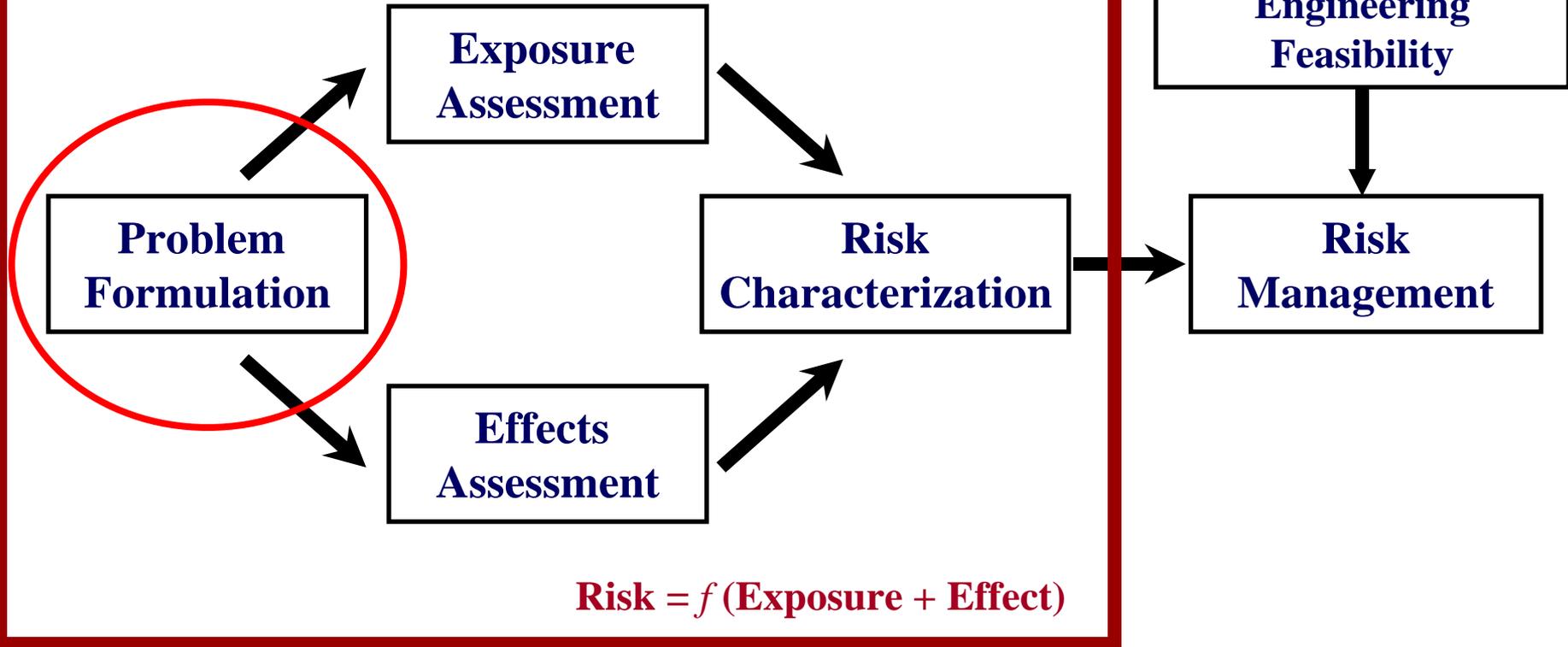
---

- Overview of problem formulation
- Overview of conceptual models



# Risk Assessment Overview

## RISK ASSESSMENT PARADIGM



$$\text{Risk} = f(\text{Exposure} + \text{Effect})$$



# **Problem Formulation Goal**

---

**The goal is to define the ecological relationships to be evaluated, then plan how to evaluate them. Any deficiencies in problem formulation will compromise all subsequent work on the risk assessment.**

**Defining the problem is extremely important.**



# **Problem Formulation Components**

- **Site characterization**
  - Document current conditions
  - Determine nature and extent of stressors
- **Identify receptors and endpoints**
- **Completed exposure pathways**
  - receptor can contact stressor
- **Conceptual model**



# **Assessment Endpoint:**

**An explicit expression of the environmental value that is to be protected, operationally defined by an ecological entity and its attributes**

## **Criteria:**

- **Ecological Relevance**
- **Societal Values**
- **Susceptibility to stressor**



# What are We Trying to Protect?

---

- **Level of biological organization**
  - **Species, community, ecosystem**
- **Which components of ecosystem could be adversely impacted (3 groups)**
  - **Organisms living in sediment**
  - **Pelagic organisms**
  - **Consumers of aquatic life**
- **Species (lethal and sublethal endpoints such as avoidance, growth, prey capture)**



# Assessment Endpoint Examples

---

- **Protection of fish eggs in spawning grounds from burial by resuspended sediments**
- **Protection of juvenile salmonids outmigrating through areas impacted by dredging resuspension**
- **Protection of endangered freshwater mussels from adverse impacts due to dredging resuspension**



# Measurement Endpoints for Resuspension

---

## Relative to assessing risk

- **Suspended solids concentration**
- **Light penetration**
- **Turbidity**
- **Sedimentation**
- **Net deposition**
- **Temp, salinity, flow speed and direction**
- **Chemical concentration in water column (dissolved and total)**



# Resuspension Effects

---

## Relative to assessing risk

- Physical abrasion of filtering and respiratory organs
- Clogging of filtering and respiratory organs
- Smothering (e.g., eggs)
- Shading
- Productivity
- Prey capture and avoidance
- Recognition of reproductive cues



# Conceptual Model

---

- **Written and visual representation of predicted relationships between ecological entities and the stressors to which they may be exposed**
- **Typically consist of**
  - **Source(s)**
  - **Release mechanism(s)**
  - **Transport mechanisms**
  - **Receptors**



# Resuspension Sources

---

## Primary Sources

- Dredge and attendant vessel movement
- Dredge-head movements
- Overflow
- Fall back of loosened sediments not captured
- Washing (e.g., sloughing of sediment from bucket)
- Silt curtain debris removal and management

## Secondary Sources

- Prop wash from dredge, tugs and other attendant vessels
- Spuds
- Anchors



# Contaminant Release Mechanisms

---

- **Desorption from suspended particles**
- **Sediment pore water expulsion**
- **Volatilization to air**
- **Particulate, colloidal, dissolved, volatile fractions**
- **Residuals**
  - **Densification of high solids concentration layer**
  - **Molecular diffusion**
  - **Advection of groundwater**
  - **Bioturbation**



# Resuspended Sediment Transport Mechanisms

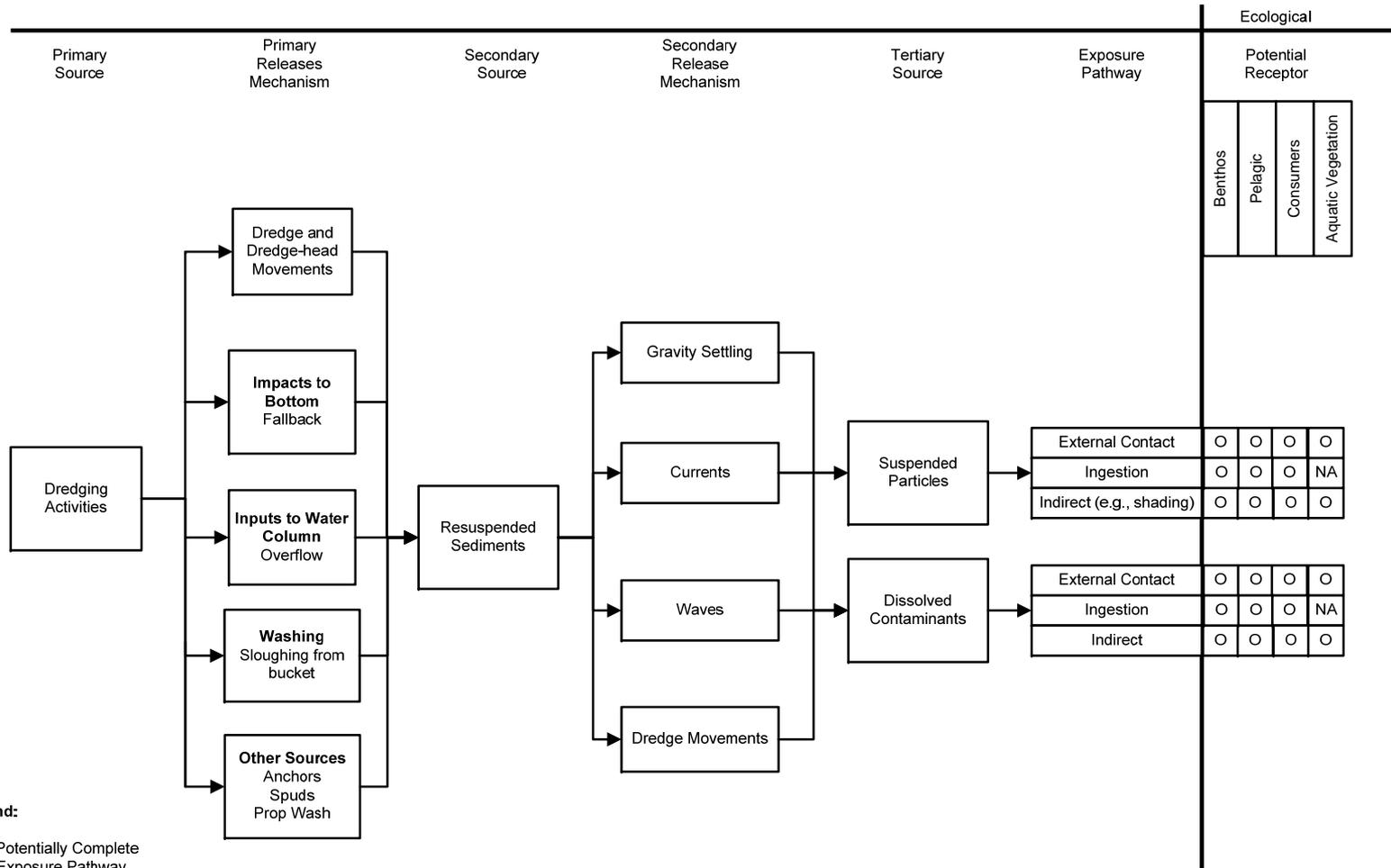
---

- **Transport (and Exposure) varies by zone:**
  - Initial mixing (minutes)
  - Near field (up to 1 hr)
  - Far field (hours)
- **Movements from dredging operations**
- **Gravity settling/deposition**
- **Currents**
- **Waves**
- **Exposure as a series of repetitive pulses**



# Conceptual Model for Resuspended Sediments

## Conceptual Model for Sediments Resuspended as a Result of Dredging Operations – Physical Stressors

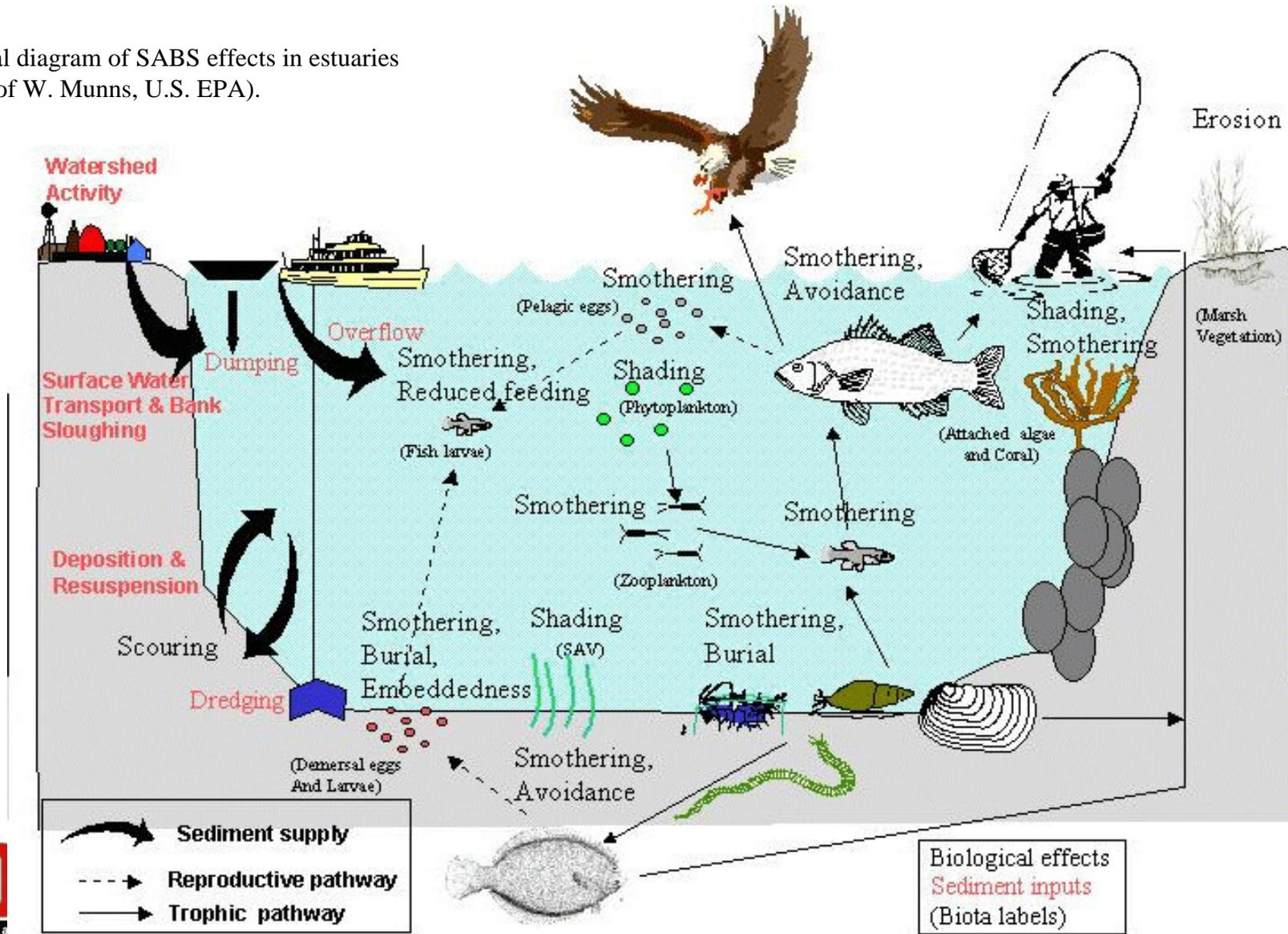


Exposure Pathway	Ecological Potential Receptor			
	Benthos	Pelagic	Consumers	Aquatic Vegetation
External Contact	O	O	O	O
Ingestion	O	O	O	NA
Indirect (e.g., shading)	O	O	O	O
External Contact	O	O	O	O
Ingestion	O	O	O	NA
Indirect	O	O	O	O



# Example Conceptual Model Diagram

Conceptual diagram of SABS effects in estuaries  
(courtesy of W. Munns, U.S. EPA).



---

# Hypothetical Example

## Problem Formulation and Conceptual Model



Spawning Habitat

Placement Site

Mussel Bed

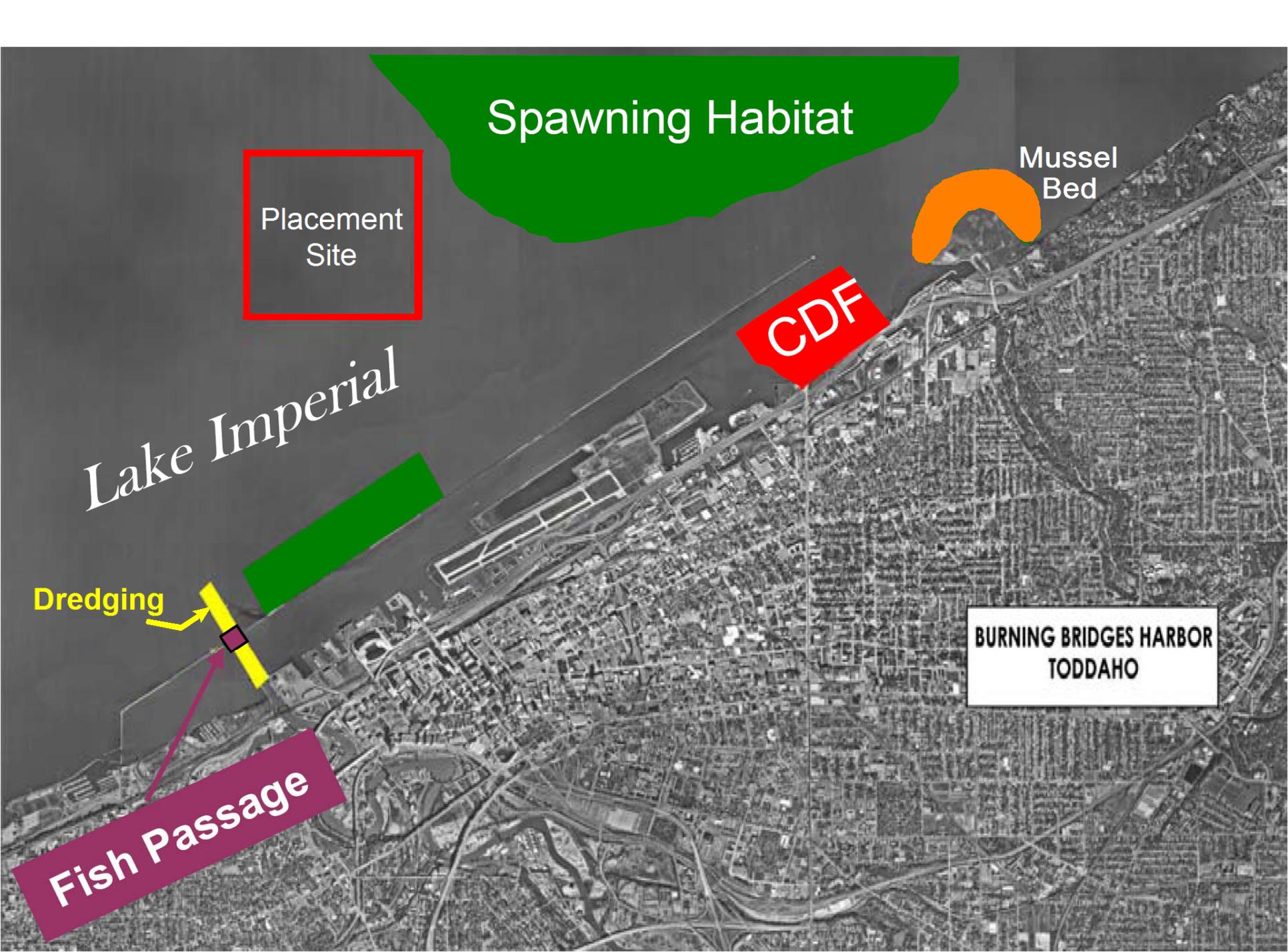
CDF

Lake Imperial

Dredging

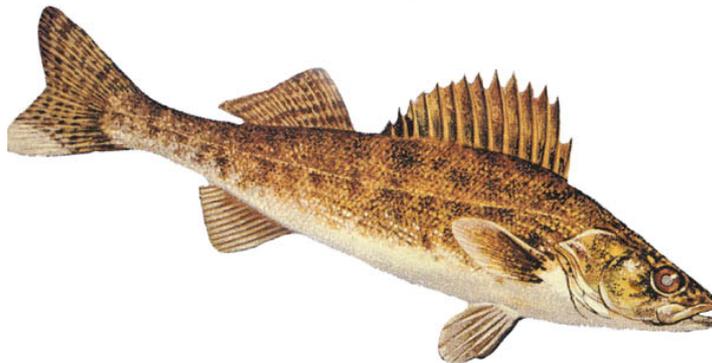
Fish Passage

BURNING BRIDGES HARBOR  
TODDAHO



# Problem Formulation

- **Problem statement**
  - **Protection of migrating juvenile salmonids, fish (e.g., walleye) eggs in spawning grounds and endangered freshwater mussels from adverse effects of resuspended sediments caused by dredging operations**



# Problem Formulation

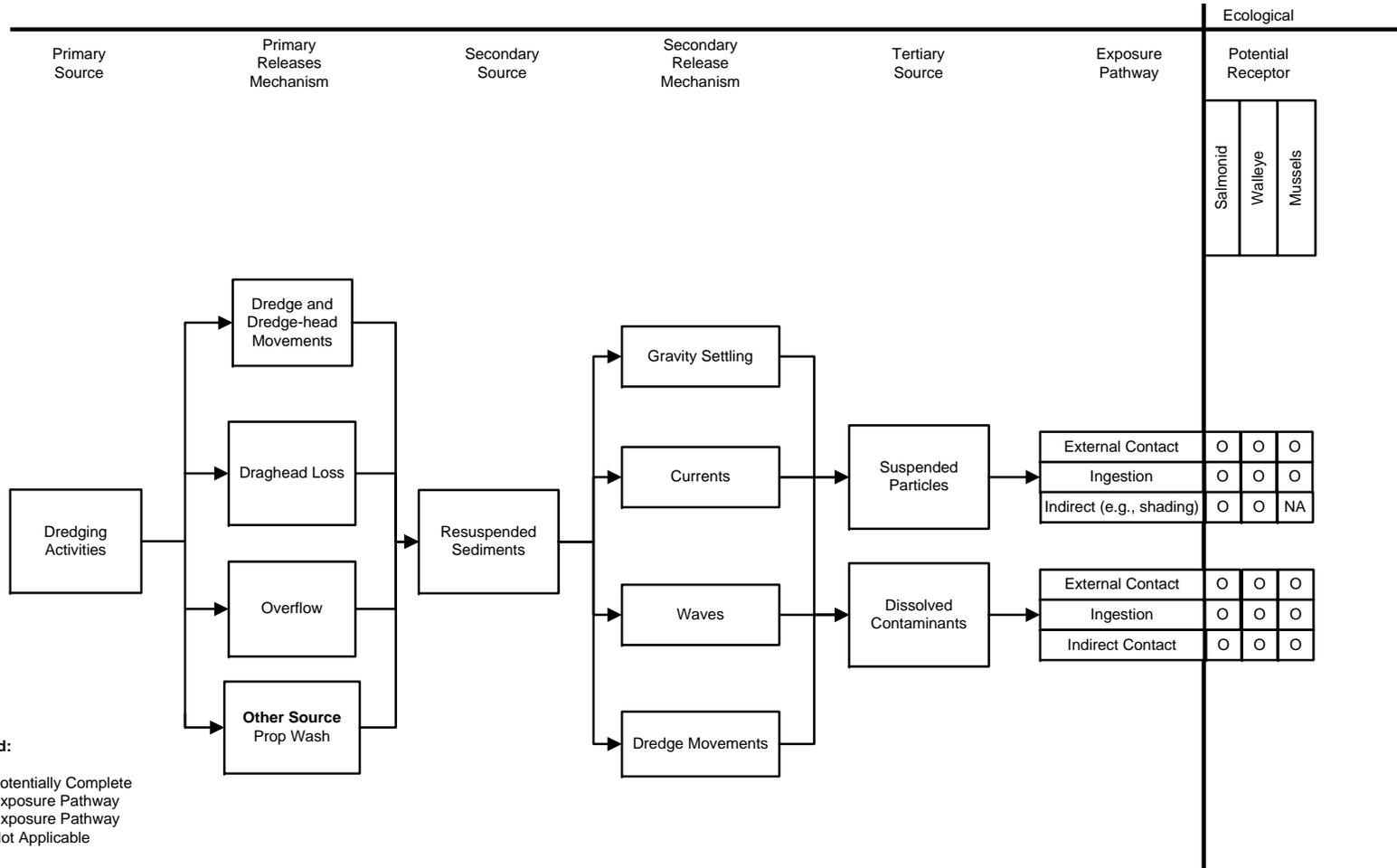
---

- **Receptors and endpoints related to suspension**
  - Juvenile salmonids outmigrating (physical abrasion, clogging of gills, plume avoidance)
  - Fish eggs in harbor (smothering)
  - Mussels (smothering)
- **Completed exposure pathways**
  - Salmonid pathway complete via potential abrasion of gills
  - Fish pathway complete via smothering of eggs during spawning
  - Mussel pathway complete via smothering
- **Develop conceptual model (scenarios)**
  - Hopper dredge without overflow – open water placement
  - Clamshell dredge with open water placement
  - Clamshell dredge with CDF placement



# Conceptual Model – Hypothetical Example

## Conceptual Model for Sediments Resuspended as a Result of Dredging Operations – Physical Stressors for Hypothetical Hopper Dredge Example



**Legend:**

- O = Potentially Complete Exposure Pathway
- NA = Exposure Pathway Not Applicable



# Take Home Message

---

- **Defining the problem is extremely important**
- **Stressors can be physical, not just chemical**
- **Successful conceptual model development critical to defining and understanding problem**
- **Leads to appropriate level of evaluation**

