

Guidance for Using Passive Sampling Devices to Assess Federal Contaminated Sites

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IISD-Experimental Lakes Area

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Outline



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1 Objective

To identify passive sampling device (PSD) technologies that could be used reliably at federal contaminated sites to assess environmental risks

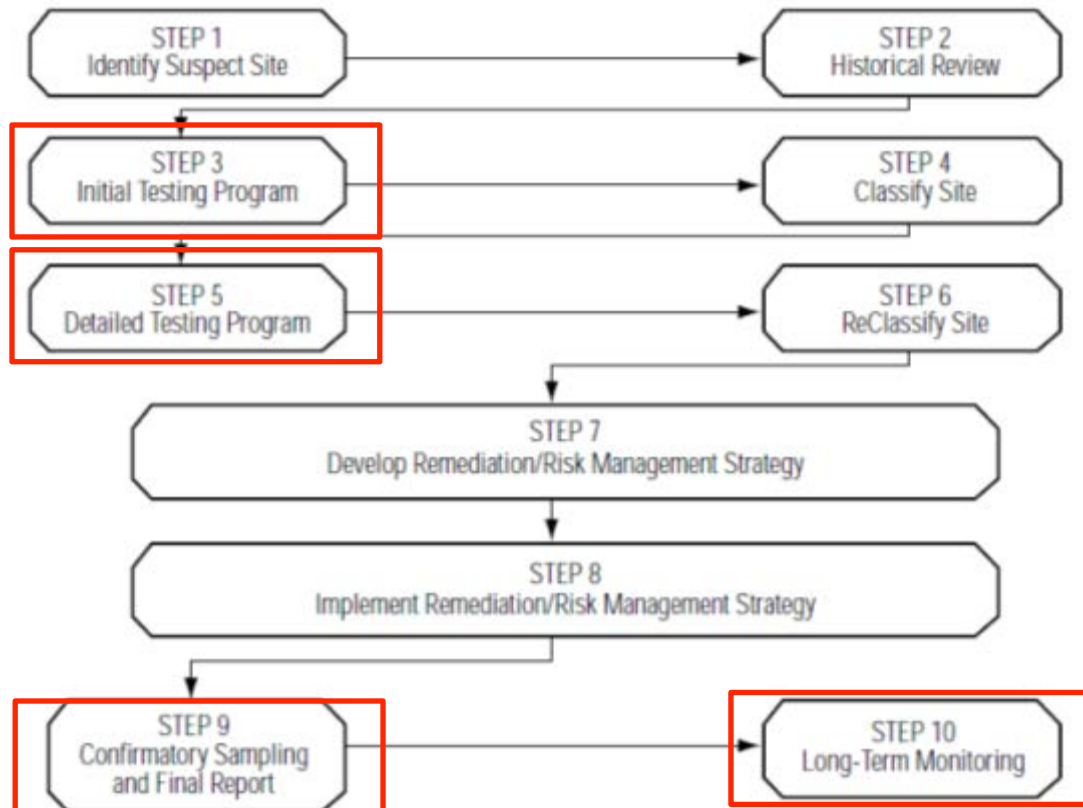
Passive Sampling Devices (PSDs)

- Accumulate contaminants into, or onto, a medium from the environment in which they are deployed, without active media transport, like pumping, purging, or extracting
- Serve as a surrogate for contaminant uptake by biota
- Can provide a better alternative to bulk contaminant analysis in sediments and/or biota

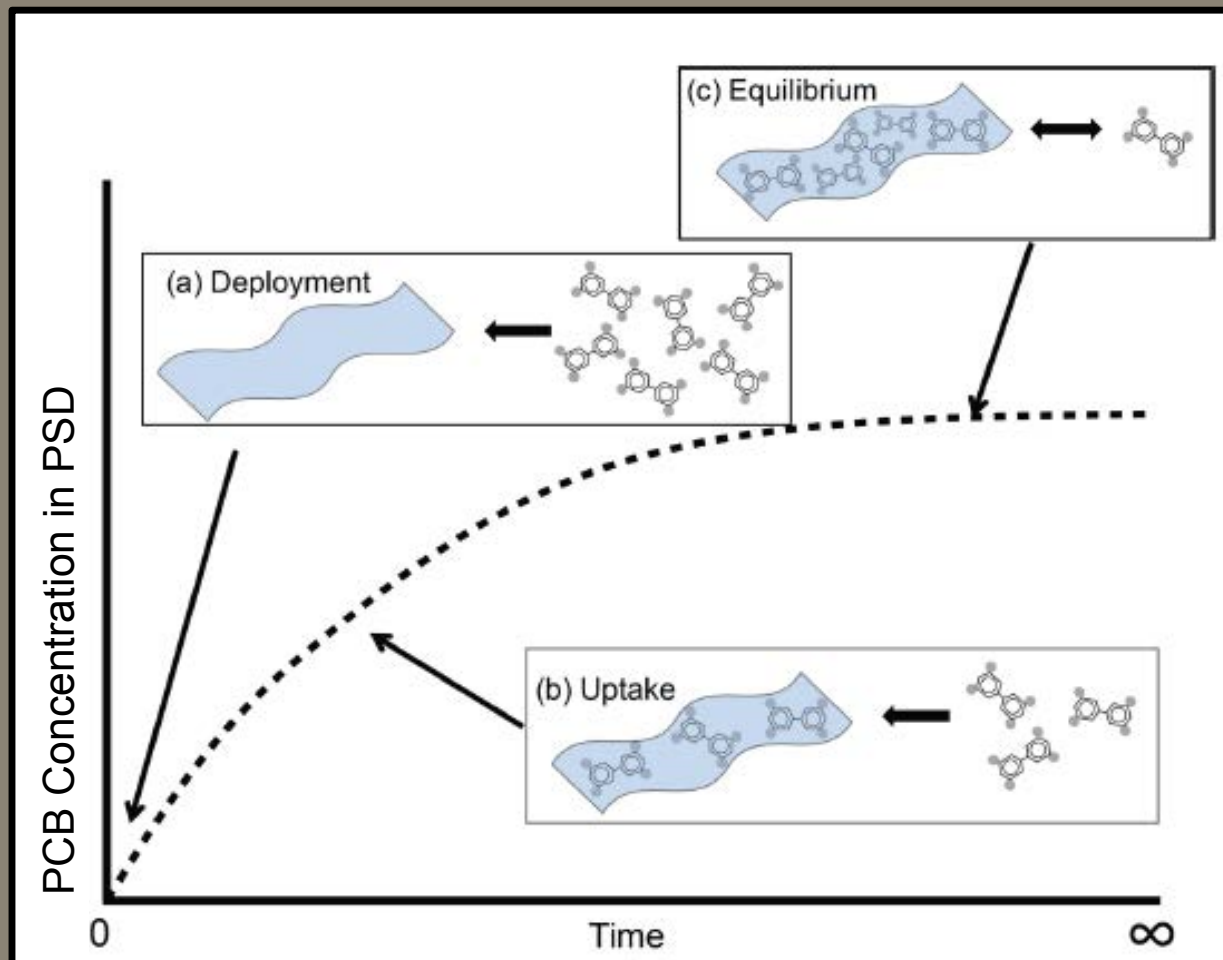


PSDs and FCSAP

10-Step Federal Approach to Contaminated Sites



2 PSDs for Organics



Semi-permeable Membrane Devices (SPMDs)

Polyethylene dialysis membrane filled with lipid



Source: EST 2015

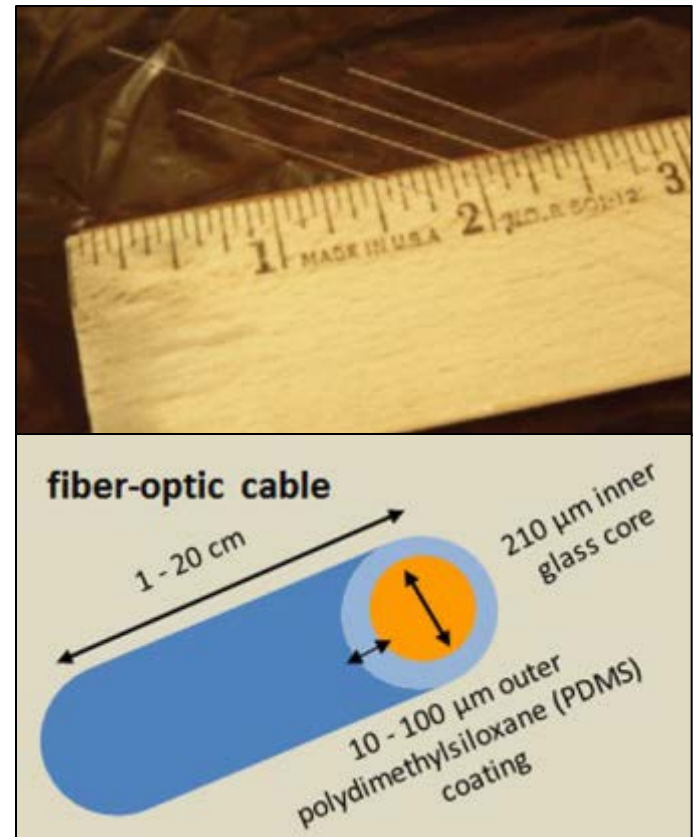
Organic contaminants in water:

- PCBs, PAHs
- Organochlorine, OP, and pyrethroid pesticides
- Dioxins, furans
- Other nonpolar organic contaminants

Esteve-Turrillas et al. 2007; USGS 2004

Solid-phase Micro-extraction (SPMEs)

- Based on fiber-optic cable, with a silicon core and polydimethylsiloxane (PDMS) coating
- Small size enhances confidence in non-depletive conditions and lowers time to equilibrium
- Available for semi-volatiles but not polar organics



Source: USEPA 2012

Polar Organic Chemical Integrative Sampling (POCIS)



Source: EST 2015



Source: EST 2015

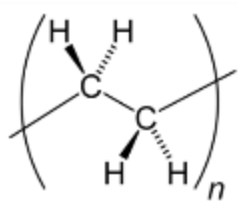
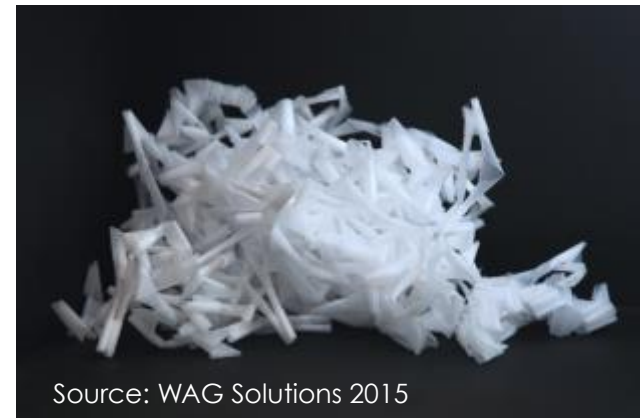
Contaminants with $\log K_{ow} < 3$

- Pharmaceuticals
- Polar pesticides
- Phosphate-based flame retardants
- Surfactants
- Steroid hormones
- Triclosan
- Alkylated phenols

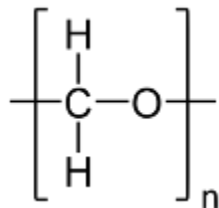
Other PSDs for Organics

LDPE, polyoxymethylene (POM), and polydimethylsiloxane (PDMS):

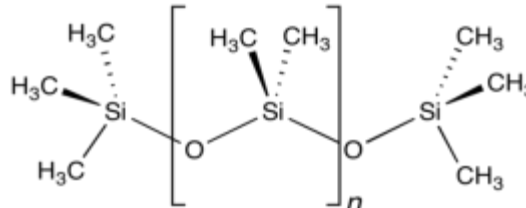
- PAHs
- PCBs
- Dioxins
- Organochlorine pesticides
- Triclosan
- Polybrominated diphenylethers (PBDEs)
- Other volatile compounds



LDPE



POM



PDMS

3 PSDs for Inorganics

Availability of PSDs for Measurement of Target Inorganic Analytes for the National Contaminated Sites Remediation Program (CCME 1993a) in Water and/or Sediment

Passive Sampling Available

Arsenic

Barium¹

Beryllium²

Cadmium

Chromium

Cobalt

Copper

Lead

Mercury

Molybdenum¹

Nickel

Selenium

Vanadium

Zinc

No Passive Sampling Available

Antimony

Boron

Cyanide (free, total)

Fluoride (total)

Silver

Sulphur (elemental)

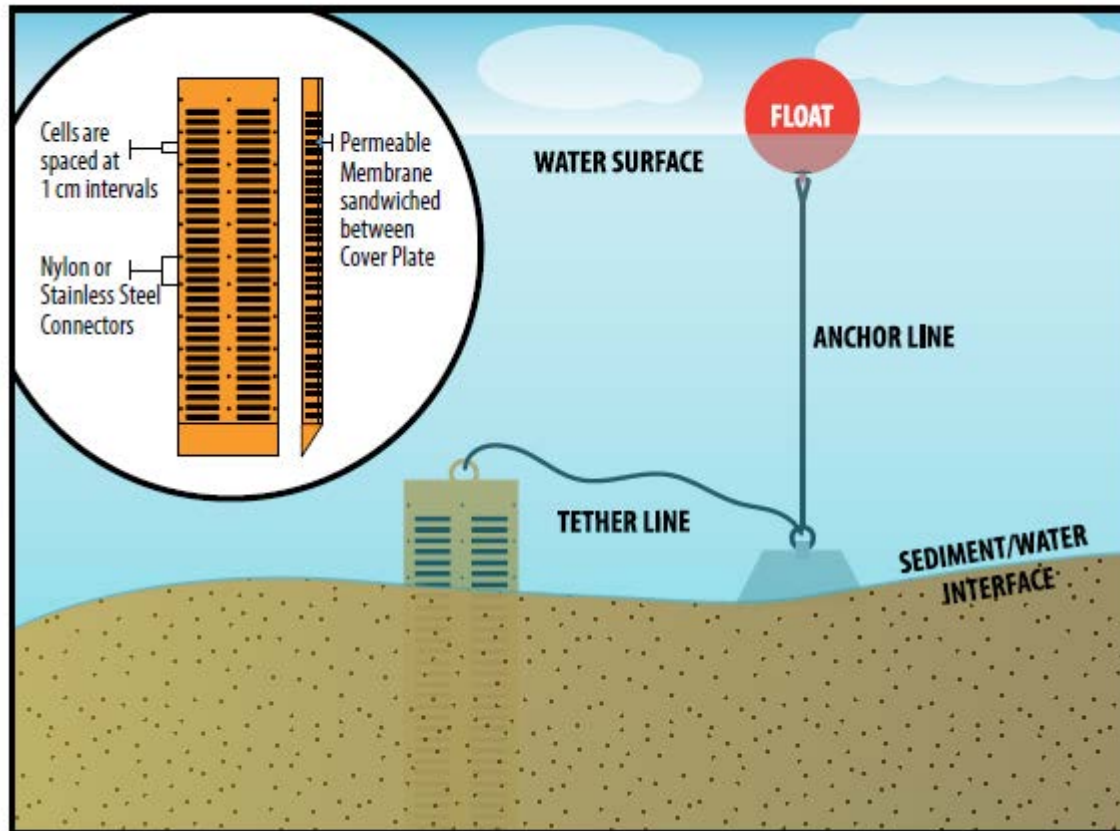
Thallium

Tin

¹ pH-dependent, limited research done to date (NIVA 2002)

² capacity-limited, little research done to date (NIVA 2002)

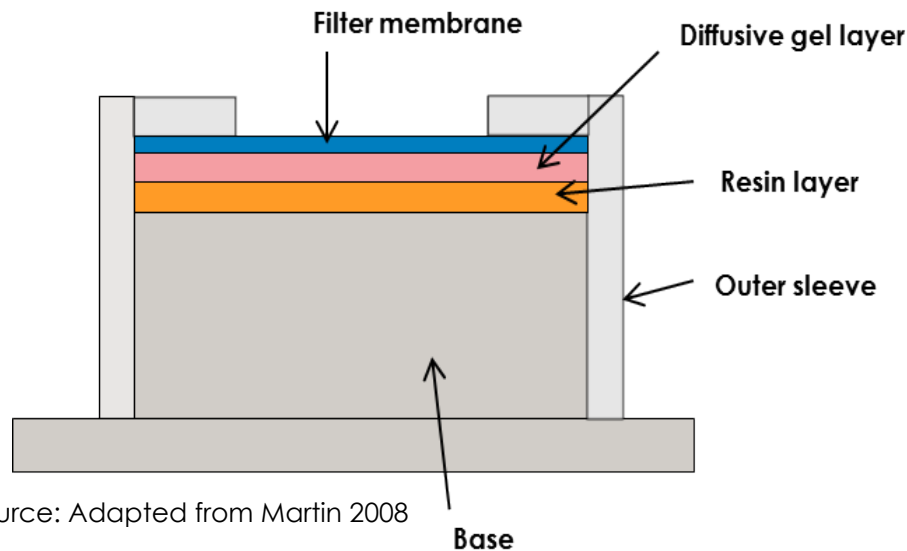
Pore Water Peepers



- Developed at ELA
- Examines vertical stratification of metals in pore waters
- Useful for examining redox zonation

Peijnenburg et al. 2014

Diffusive Gradient in Thin Film (DGT)

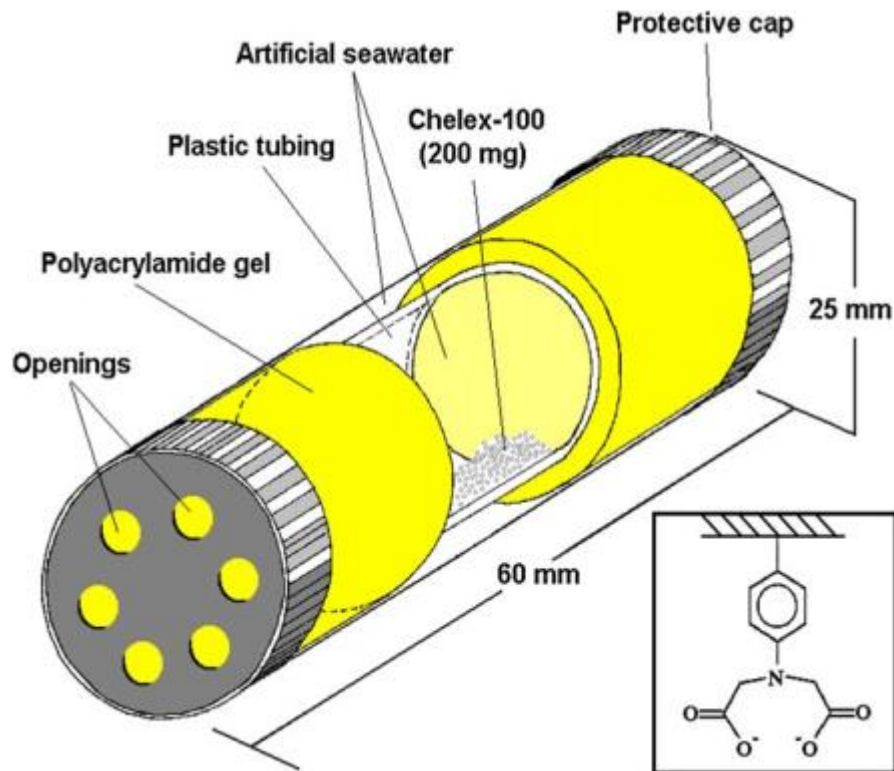


Source: Adapted from Martin 2008

- Can measure any dissolved species for which there is a selective binding agent
- Metals: Al, As, Cd, Co, Cr, Cu, Fe, Mn, Ni, Pb, Zn
- Cations: Ca, Mg, Ba, Sr
- Rare earth elements
- Sulphide
- Radionuclides
- Polar organics (e.g., antibiotics)

Biomimetic Applications

Example: Artificial Mussel (Wu et al. 2007)



May require further refinement to become widely available commercially (Parkerton et al. 2013)

4 Advantages of PSDs

“..passive sampling devices (PSDs) may have much to offer the analytical process by providing a time-integrated sample with low detection limits and in situ extraction of analytes.”

Advantages of PSDs

- Concentrations of non-degrading contaminants
- Lipid-weighted accumulation patterns
- Free or soluble contaminant concentrations
- Vertical profiles
- More consistent trend analysis than sediments or biota
- Lower detection limits for surface waters
- Mapping areas of freely-dissolved contaminants



Advantages of PSDs (cont'd)

- Screen for presence/absence
- Identify sources of pollution
- Support speciation analysis
- Develop site-specific water quality objectives
- Support toxicity testing or toxicological screening
- Model bioavailability and remobilization of contaminants



Source: RECETOX 2012

5 Limitations of PSDs

Uncertainties remain in terms of:

- Sampling selection
- Time to equilibrium
- Effects and prevalence of biofouling
- **Degree to which results from PSDs can be linked to specific endpoints in biological receptors**

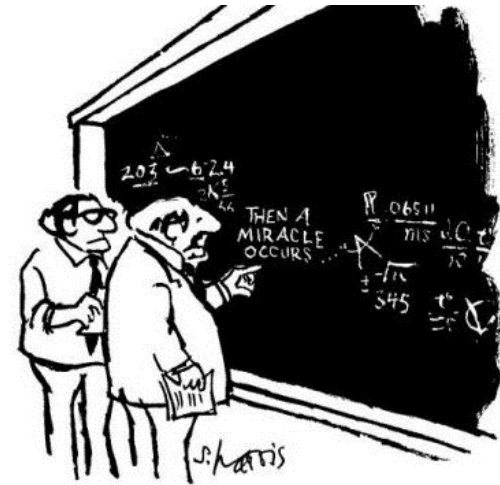
Limitations of PSDs

- Do not account for degradation
- May overestimate bioaccumulation
- Not clearly linked to toxicity endpoints
- Lack of technical and deployment expertise



Limitations of PSDs (cont'd)

- Few comparisons of C_{free} for different PSDs
- Interference from DOM
- PRC data lacking
- Shortage of high quality K values



"I THINK YOU SHOULD BE MORE EXPLICIT HERE IN STEP TWO."

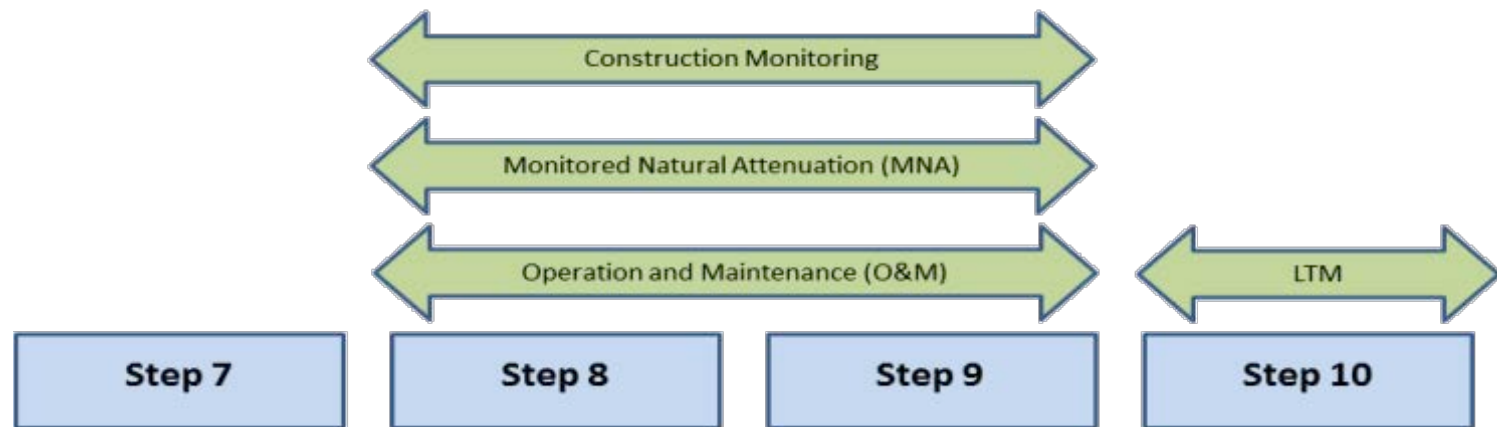
Source: Sidney Harris Science Cartoons 2016

6 Incorporation of PSDs into FCSAP Framework

Examples of acceptance by regulators:

- Oil sands and Great Lakes monitoring by Environment Canada, Ontario MOE, and Alberta Environment adopting use of PSDs (R. Grace, pers. comm. 2015)
- SPMDs used by USEPA, USGS, National Fish and Wildlife Service, and National Park Service (USGS 2004)
- PSDs used to monitor PCBs at Palos Verdes Shelf Superfund site in California (USEPA 2012)
- SPMDs adopted for use by the Environmental Agency of England and Wales (USGS 2004)

Incorporation of PSDs into FCSAP Framework



Key Factors for Success



1. Understanding site conditions and contaminants of concern
2. Developing objectives based on site-specific conditions
3. Validating PSDs technologies
4. Deploying PSDs technologies

7 Conclusions

- SPMD, POCIS, and DGT sampling has the greatest commercial availability and laboratory support at this time; others could become more widely used
- Specific PSD of choice will depend upon site-specific conditions and contaminant(s) of interest
- Recommend consulting with laboratories and other resources to receive site-specific guidance for programs using PSDs

Conclusions (cont'd)

- More support is currently available for organic contaminants than for metals; however, PSDs are available for many metals of interest for FCSAP sites
- For FCSAP sites, the ability to monitor contamination trends over extended time and spatial reaches could be very powerful and cost-effective

Questions?