State of Oregon Department of Environmental Quality

Monitoring Strategy to Support Implementation of the Willamette Mercury Total Maximum Daily Load

Executive summary

This strategy is a working document subject to change over time as DEQ expects to meet with Designated Management Agencies (DMAs), basin coordinators, and stakeholders to gain input on monitoring total mercury and methylmercury in fish tissue in the Willamette Basin in order to achieve TMDL targets. DEQ intends to take the lead on monitoring efforts unless otherwise indicated in this strategy, and will work with DMAs as future discussions clarify roles and capacities for monitoring and assessment. This monitoring and assessment approach is oriented toward adaptive management and focuses on evaluating administrative objectives as well as water quality objectives and lays out monitoring design guidance that may be incorporated by DMAs or a subset of DMAs.

Introduction

Starting in 1998, DEQ began identifying various waterbodies in the Willamette Basin as impaired due to elevated levels of mercury in fish tissue. This earlier work culminated in the development of the 2006 TMDL for mercury in the Willamette Basin (Oregon Department of Environmental Quality, 2006). In 2011, Oregon adopted human health criteria based on a revised fish consumption rate of 175 g/day (previously 17.5 g/day), which resulted in a mercury fish tissue criterion of 0.04 mg/kg, as methylmercury (previous TMDL target was 0.3 mg/kg). In 2012, EPA's approval of DEQ's Willamette Basin Mercury TMDL was challenged and in 2017, the U.S. District Court for Oregon ordered that the 2006 TMDL remain in place while EPA and Oregon evaluate the TMDL for reissuance consistent with the updated standard. The Willamette Basin Mercury TMDL was developed in cooperation between DEQ and EPA, along with EPA's watershed contractor, TetraTech, to address mercury impairments in the Willamette Basin to achieve the Oregon criterion for fish tissue concentrations of methylmercury, as well as the mercury in-stream aquatic life and narrative criteria.

Section 303(d) of the Clean Water Act requires states to identify waters where current pollution control technologies alone cannot meet the water quality standards set for that waterbody. Every two years, states are required to submit a list of impaired waters (i.e., 303(d) list) to EPA for approval. The latest water quality assessments relative to mercury for the Willamette Basin from Oregon's 2012 Integrated Report (https://www.oregon.gov/deq/wq/Pages/2012-Integrated-Report.aspx) identified 15 segments of the Willamette River and its tributaries as not meeting water quality standards. Those waters currently assessed as requiring a TMDL are shown in Table 1.

Table 1. 303(d) Listings for Mercury in the Willamette Basin.

Name	Miles	HUC 8	Assessed	Affected Use	Category	2006 TMDL
Amazon Diversion Canal (A3 Drain)	0 to 3.9	17090003	2010	Fishing	5	X
Amazon Creek Diversion Canal	0 to 6.6	17090003	2010	Fishing	5	X
Yamhill River	0 to 11.2	17090008	2012	Human health	5	
Coast Fork Willamette/ Cottage Grove Reservoir	28.5 to 31.3	17090002	2012	Resident fish and aquatic life; Anadromous fish passage; Drinking water	5	X
Row River/ Dorena Lake	7.3 to 11.9	17090002	2012	Drinking water; Resident fish and aquatic life; Anadromous fish passage	5	X
Clackamas River	0 to 83.2	17090011	2012	Human health	5	
Tualatin River	0 to 80.7	17090010	2012	Human health	5	
Multnomah Channel	0 to 21.7	17090012	2012	Human health	5	
Middle Fork Willamette River	0 to 82.2	17090001	2012	Human health	5	
Coast Fork Willamette River	0 to 38.8	17090002	2012	Human health	5	X
Coast Fork Willamette River	31.3 to 38.8	17090002	2012	Aquatic life; Human health	5	X
McKenzie River	0 to 84.8	17090004	2012	Human health	5	
Dennis Creek	0 to 1.4	17090002	2012	Aquatic life; Human health	5	X
Santiam River	0 to 26.2	17090005	2012	Human health	5	
Willamette River	0 to 186.6	17090003 17090007 17090012	2012	Human health	5	X

Notes: Information from 2012 Integrated Report as of May 2019. Category 5 = Water quality limited, TMDL needed.

Potential Ambient Monitoring Site Locations in the Willamette Basin

No.	Station ID	Site Description	Lat	Long	Basin Name	*Land Use
1	10332	Willamette R at SP&S RR Bridge (Portland)	45.57795	-122.748	Willamette - Lower	Urban
2	10456	Tualatin R at Boones Ferry Rd	45.38594	-122.757	Willamette - Lower	Urban
3	10458	Tualatin R at Elsner Rd	45.38834	-122.851	Willamette - Lower	Agriculture
4	10459	Tualatin R at HWY 210 (Scholls)	45.41478	-122.921	Willamette - Lower	Agriculture

No.	Station ID	Site Description	Lat	Long	Basin Name	*Land Use
5	10461	Tualatin R at Rood Bridge	45.48996	-122.951	Willamette - Lower	Agriculture
6	10469	Fanno Creek at Bonita Rd (Tigard)	45.41501	-122.754	Willamette - Lower	Urban
7	10480	Beaverton Creek at 216th (Orenco)	45.52087	-122.9	Willamette - Lower	Urban
8	10611	Willamette R at Hawthorne Bridge	45.51331	-122.67	Willamette - Lower	Urban
9	10801	Swan Island Channel (Willamette R)	45.56607	-122.714	Willamette - Lower	Urban
10	11201	Columbia Slough at Landfill Rd	45.61064	-122.755	Willamette - Lower	Urban
11	11233	Clackamas R at High Rocks	45.38001	-122.582	Willamette - Lower	Urban
12	11321	Johnson Creek at SE 17th Ave. (Portland)	45.44671	-122.643	Willamette - Lower	Urban
13	13070	Clackamas R at McIver Park (Upper Boat Ramp)	45.29939	-122.36	Willamette - Lower	Mixed
14	14008	Clackamas R at Memaloose Rd	45.15817	-122.151	Willamette - Lower	Forest
15	10339	Willamette R at Canby Ferry	45.29984	-122.692	Willamette - Middle	Agriculture
16	10344	Willamette R at Wheatland Ferry	45.09021	-123.045	Willamette - Middle	Agriculture
17	10363	Yamhill R at Dayton	45.22305	-123.072	Willamette - Middle	Agriculture
18	10366	S Santiam R at HWY 226 (Crabtree)	44.63065	-122.924	Willamette - Middle	Agriculture
19	10555	Willamette R at Salem	44.94439	-123.046	Willamette - Middle	Mixed
20	10637	Mollala R at Canby	45.2675	-122.71	Willamette - Middle	Agriculture
21	10640	Pudding R at HWY 211 (Woodburn)	45.15048	-122.793	Willamette - Middle	Agriculture
22	10792	N Santiam R at Greens Bridge	44.70814	-122.972	Willamette - Middle	Agriculture
23	10917	Pudding R at HWY 99E (Aurora)	45.23361	-122.75	Willamette - Middle	Agriculture
24	10929	N Yamhill R at Poverty Bend Rd	45.25195	-123.174	Willamette - Middle	Agriculture
25	10948	S Yamhill R at HWY 99W	45.16854	-123.208	Willamette - Middle	Agriculture
26	12553	N Santiam R at Gates School Rd	44.75244	-122.411	Willamette - Middle	Forest
27	12559	N Santiam R at Coopers Ridge Rd	44.69276	-122.05	Willamette - Middle	Forest
28	36875	Luckiamute River at Buena Vista Rd	44.73039	-123.163	Willamette - Middle	Agriculture
29	10350	Willamette R at Albany	44.63901	-123.105	Willamette - Upper	Agriculture
30	10352	Willamette R at Corvallis	44.56525	-123.257	Willamette - Upper	Agriculture

No.	Station ID	Site Description	Lat	Long	Basin Name	*Land Use
31	10355	Willamette R at HWY 99E (Harrisburg)	44.26738	-123.174	Willamette - Upper	Agriculture
32	10359	Willamette R at HWY 126 (Springfield)	44.04545	-123.028	Willamette - Upper	Mixed
33	10373	Mary's R at HWY 99W (Corvallis)	44.55672	-123.264	Willamette - Upper	Agriculture
34	10376	McKenzie R at Coburg Rd	44.112	-123.046	Willamette - Upper	Mixed
35	10386	Middle Fk Willamette R at Jasper Bridge	43.99849	-122.906	Willamette - Upper	Mixed
36	10662	McKenzie R at Hendricks Bridge	44.05594	-122.83	Willamette - Upper	Forest
37	10663	Mohawk R. at Hill Rd.	44.0928	-122.957	Willamette - Upper	Agriculture
38	11140	Long Tom R at Stow Pit Rd (Monroe)	44.34278	-123.295	Willamette - Upper	Agriculture
39	11180	Calapooia R at Queens Rd (Albany)	44.61973	-123.128	Willamette - Upper	Agriculture
40	11182	Calapooia Creek at HWY 99E	44.50434	-123.109	Willamette - Upper	Agriculture
41	11275	Coast Fk Willamette R at Mt. Pisgah Park	44.0123	-122.984	Willamette - Upper	Agriculture
42	12552	McKenzie R at McKenzie Bridge	44.17417	-122.161	Willamette - Upper	Forest
43	36788	Amazon Creek at High Pass Rd	44.21525	-123.25	Willamette - Upper	Agriculture
44	36790	Muddy Creek south of Corvallis at Airport Ave	44.49685	-123.331	Willamette - Upper	Agriculture

ODA funded site

* Land use type is determined based on the dominant land use in a five-mile buffer upstream of the monitoring site. The mixed land use type was assigned when none of the other four land use designations made up more than 50 percent of the five-mile buffer

Purpose and problem definition

The purpose of this water quality monitoring strategy is to inform adaptive management and assess progress toward attaining the water quality criteria during implementation of the Willamette Mercury TMDL by:

- Tracking implementation progress and assessing the effectiveness of implementation actions;
- Investigating the sources and processes of the mercury cycling system to better understand methylation processes within the basin and the bioaccumulation of methylmercury in fish;
- Measuring progress toward the TMDL total mercury target and reduction of methylmercury in fish tissue.

The Willamette Basin Mercury TMDL monitoring strategy is a guidance document that identifies monitoring objectives, guidelines and reporting requirements. This guidance document will be used as a starting point for work with stakeholders in the basin to develop more detailed monitoring programs during TMDL implementation. The Willamette monitoring strategy may be incorporated into site-specific Quality Assurance Project Plans developed and implemented by Designated Management Agencies and DEQ. Specific sampling designs constructed to meet each applicable monitoring objective will be discussed in the future and may be included in site-specific QAPPs.

Implementation of the TMDL is oriented toward an adaptive management approach. The adaptive management concept applies scientific methods in the design, implementation and evaluation of management strategies. The premise of adaptive management is that decisions about management strategies are based on knowledge gained throughout the implementation process. Decision-making informed by adaptive management is structured to allow for system response and incorporation of data generated from the implementation of this monitoring and assessment strategy, among other sources. This approach assumes that not all information is currently available, including responsibility and capacity for each objective.

Stakeholder involvement in adaptive management

Stakeholder involvement is a critical component of adaptive management and decision-making in natural resource management. Stakeholders are persons or organizations with a vested interest in the outcomes of management decisions and include a variety of groups including consumers and members of the general public, non-governmental organizations, natural resource management agencies, political appointees, businesses, landowners and scientists, among others. By involving stakeholders in the decision-making process, DEQ can help those with a vested interest better understand, and participate in, how decisions are made.

In order to identify the monitoring and data needed to support adaptive management, DEQ will develop with stakeholder participation a general influence diagram to identify objectives and the relationships between objectives (Conroy and Peterson, 2013). The influence diagram also identifies sources of uncertainty and how these sources will be addressed through monitoring.

DEQ will use the methods outlined by Conroy and Peterson (2013) to identify objectives and then sort them onto a continuum from fundamental to means objectives (Appendix A). Conroy and Peterson (2013) define fundamental objectives as what the decision-maker really wants to accomplish and means as the things that need to be accomplished to realize the fundamental objective. Stakeholders can be a vital part of the process of identifying both means and fundamental objectives, as well as potential conflicts, and assuring a more comprehensive analysis. By implementing a stakeholder-driven process, we build public support and ownership of the decision when the public is explicitly involved (Conroy and Peterson 2013).

The primary, fundamental objective for the Willamette Basin Mercury TMDL is to meet the fish tissue MeHg standard in the basin.

Monitoring objectives

Monitoring, assessment, and analysis conducted according to this monitoring strategy provide a key feedback mechanism to support adaptive management. This strategy aims to quantitatively track basin recovery, incremental progress and compliance of the TMDL, evaluate changes in mercury impairments in the basin and support accountability and corrective actions that improve assurance of implementation.

Willamette Basin Mercury monitoring strategy elements that support accountability include, but are not limited to:

- Track water quality status and trends concurrently as management actions are implemented.
    - Measure total Hg concentrations at HUC08 outlets
    - Measure MeHg concentrations in fish tissue in waterbodies listed for fish consumption impairment
- Conduct monitoring and analysis actions necessary to identify and reduce sources of unidentified mercury loads such as:
    - Investigating how reservoir management actions impact methylmercury production;
    - Monitoring groundwater mercury concentrations to estimate contributions to baseflow;
    - Identifying general sources of atmospheric deposition;
    - Measure total Hg concentrations in water and meHg concentrations in fish tissue in tributaries to assess mercury loading to HUC08 outlets.
- Estimation of response times for total mercury reductions and fish tissue concentrations at the HUC08 spatial scale and for the entire basin.
- Take necessary corrective action(s), including DEQ-led monitoring and reporting, if DMAs fail to develop or effectively implement their site-specific QAPP, monitoring or reporting requirements.

Monitoring objectives are statements that identify the reason(s) for collecting administrative and environmental quality data. Monitoring designs are then constructed to achieve objectives. Objectives relevant to the Willamette Basin Mercury TMDL reflect the complexities of assessing attainment of water quality standards, characterizing the performance of best management practices, evaluating compliance with TMDL allocations, better understanding unidentified sources of mercury and determining whether the underlying TMDL assumptions are correct or if the TMDL needs to be revised.

Draft conceptual model for identifying fundamental and means objectives used to inform Table 2 can be found in Appendix A.

Table 2. List of objectives for Willamette Basin Hg TMDL DRAFT. DEQ will be working with DMAs and stakeholders on roles and responsibilities for achieving these objectives.

Objective	Sub-objective	Description
1. Track and Assess Compliance	1.1 Meet Fish Tissue MeHg Criterion	This is the water quality criterion for the level of MeHg in fish tissue used in the listing for protection of human health beneficial use through fish consumption not being met
	1.2 Meet Instream THg Target	This is the water column THg concentration determined in the TMDL analysis that links instream THg to the MeHg fish tissue criterion. This target also ensures that the THg aquatic life criterion is met
	1.3 Use Instream TSS surrogate to	TSS is used in combination with THg to evaluate the reductions in THg associated with sediment entering river

Objective	Sub-objective	Description
	identify delivery of large THg loads	system because TSS is more easily measured and much cheaper than analysis of THg
2. Monitor TMDL Implementation	2.1 Meet Load Allocations	Part of the TMDL that will need to be evaluated using monitoring and other information from DMA Implementation plans and reports. This will also be assessed using the Willamette Basin mass balance model
	2.2 Meet Wasteload Allocations	Part of the TMDL that will need to be evaluated using monitoring information in addition to other types of information from permit regulators and permittees. This will also be assessed using the Willamette Basin mass balance model
	2.3 TMDL Implementation Plans from DMAs	Will be used to estimate reductions associated with management actions described in plans and includes these objectives: Management Actions Implemented by DMAs - DEQ will work with DMAs to evaluate which management strategies to include in the Willamette Basin mass balance model. Meet Timelines - DEQ will monitor progress of DMA implementation to ensure timelines and milestones of the WQMP are met.
	2.4 Reduce Sediment Delivery	DEQ will estimate sediment delivery to river network using Willamette Basin mass balance model and information from management action implementation information reported by DMAs
3. Resolve Uncertainty: Research and Refinement of TMDL Linkage Analysis	3.1 Better Understand Sources	DEQ along with any other interested parties will conduct additional monitoring and analysis to better understand sources, such as atmospheric, groundwater, reservoir processes and other sources of Hg
	3.2 Study how reservoir management actions impact MeHg production	Reservoirs can be sites where the rate of methylation of Hg is enhanced by conditions of low DO and elevated organic carbon and sulfate in bottom waters and sediment. This can enhance both the mobility and bioaccumulation risk of Hg. Rates of MeHg production in reservoirs appear to be sensitive to reservoir management practices. For instance, sulfate (an input to bacterial methylation of Hg) can become depleted in a lake with reducing low DO conditions and a stable water level; however, if a reservoir is drawn down prior to the wet season, the exposed bottom areas can replenish sulfate and increase organic carbon supplies. Additional studies are needed to determine if there are modifications to reservoir operating rules that would tend to limit MeHg production without compromising flood control services.
	3.3 Identify BMPs that reduce MeHg concentrations in reservoirs	MeHg concentrations in reservoirs depend on the balance between MeHg gains and losses in the water column. In addition to controlling conditions that enhance methylation there may be management opportunities to enhance MeHg losses from the water column by encouraging photo-demethylation (which produces elemental Hg that tends to volatilize into the atmosphere) and suppressing net transport

Objective	Sub-objective	Description
		of MeHg from the sediment to the water column by changing the balance between MeHg resuspension and settling or inhibiting diffusion out of the sediment. A literature review of case studies and possible on site experiments in Willamette Basin reservoirs could help determine whether there are techniques that could help reduce MeHg concentrations in reservoirs in a cost-effective manner.
	3.4 Understanding groundwater Hg concentrations within the Willamette Basin	Groundwater Hg concentrations have not been well characterized within the Willamette Basin. Additional groundwater data is needed to help improve load estimates
	3.5 Identify how forestry practices impact the mobilization of atmospherically and soil-bound Hg and methylation	A large percentage of land in the Willamette Basin is used for forestry operations. The TMDL proposes reductions of Hg loads from these lands, so forestry BMPs aimed at reducing MeHg can be improved by understanding these dynamics
	3.6 Identify how agricultural practices impact the mobilization of atmospherically and soil-bound Hg and methylation	A large percentage of land in the Willamette Basin is used for agriculture. The TMDL proposes reductions of Hg loads from these lands, so agricultural BMPs aimed at reducing Hg and MeHg can be improved by understanding these dynamics
	3.7 Understand how urban stormwater BMPs can be optimized to reduce THg	Urban stormwater detention ponds have the potential to reduce THg loads, specifically when the Hg is bound to particles. It is unclear if some of these BMPs can enhance MeHg production
	3.8 Identifying source of MeHg production	Currently, it is unknown where most of the MeHg in the Willamette Basin is produced. Specifically, the relative contribution from the river's sediment versus external loading from the watershed is unknown. Knowing where MeHg is being produced is important to reducing MeHg in the water column and fish tissue. If zones of elevated MeHg production are discovered within Willamette Basin, these areas can be targeted for enhanced treatment
	3.9 Improve and refine the watershed model to ensure robust representation of flow and loads from specific source areas	The Mass Balance model in the Willamette Basin Mercury TMDL is used to attribute THg loads to sources. The Mass Balance model makes use of an existing HSPF watershed model to describe flow and sediment amounts and transport pathways. This model was built for other purposes and has a relatively coarse spatial scale and calibration to flow and sediment observations at the HUC8 scale. Converting the HSPF model to a finer spatial scale and pursuing additional calibration refinements at a local scale could reduce uncertainties in the attribution of THg loads to specific source areas and help to more effectively focus implementation efforts.

Assessment and monitoring design guidance

DEQ will use this approach to work with DMAs on assessment and monitoring design and will follow EPA's guidance on monitoring and evaluating nonpoint source watershed projects: https://www.epa.gov/nps/guidance-monitoring-and-evaluating-nonpoint-source-watershed-projects.

Monitoring designs describe the sampling approach, monitoring site location, measurement frequency and duration of sampling. General guidance is provided in this strategy for DMAs to develop specific designs to implement objectives 2.1-2.4 within site-specific QAPPs.

The following elements should be considered in designing monitoring plans:

- Watershed identification and characterization
- Problem identification
    - Critical water quality impairments or threats including:
        - Key pollutants involved
        - Sources of key pollutants
        - Transportation of pollutants through the watershed
        - Important drivers of pollutant generation and delivery
- Project goals and objectives
- Land treatment(s) to be implemented
- Monitoring plan
    - Water quality
        - Design scale
        - Variables
        - Sample type, collection and analysis
        - Locate stations
        - Frequency and duration
    - Land use/land treatment—process and responsibility
    - Availability of funds, personnel, and facilities
- Data management and analysis
- Administration/management/coordination
- Reporting, communication, stakeholder involvement
- Timetable and list of deliverables
- Budget

Numerous potential water quality variables exist and selection criteria may conflict or overlap, therefore monitoring designs should take a deliberate approach to setting priorities. Formulating a written justification for each candidate variable can assist in prioritizing which variables to monitor for. Systematic evaluation of correlations among candidate variables may suggest that one variable is highly correlated to another (e.g. turbidity and TSS) so that both need not be measured.

In practice, monitoring does not always achieve all of the objectives, and such limitations should be considered:

- Availability of resources

- Ability to evaluate cost effectively in the face of a large number of different situations/scenarios
- Socio-economic factors
- Watershed size, access or other features that pose significant logistical limitations
- Variability of water quality conditions
- Quality of data
- Environmental uncertainty (e.g. desired response to treatment cannot be monitored due to flooding, other physical changes in the resource, random or catastrophic events)
- Lag time between land treatment and water quality response

Scale selection is also a key aspect of a monitoring design. The choice of scale affects monitoring costs, duration and logistics. One of the biggest challenges to watershed-scale monitoring is to determine when a watershed is too large for successful monitoring.

The frequency and duration of sampling is a critical part of a monitoring program and will be contingent upon objectives, type of waterbody involved, variables measured and available budget. To evaluate effectiveness of management actions at a sub-watershed scale, sampling frequency must be relatively high and conducted daily to weekly. A program with objectives to track long-term trends or evaluate watershed-level program effectiveness can sample in longer intervals (e.g., weekly to monthly). Sampling frequency must also take into consideration the type of waterbody being monitored and the variability of water quality in the waterbody.

The difficulty and cost of analysis must be considered in the selection of variables to monitor. While other factors like program objectives and pollutant sources should be more important criteria in the selection process, cost of analysis often drives choices among suitable variables because of budget constraints. Therefore cost-benefit analysis should be implemented with consideration to monitoring programs. For several monitoring objectives, alternative monitoring variables that are lower cost may be available. For example, suspended sediment analysis cost less than measuring total mercury.

Existing Sources of Monitoring

Current sources of monitoring data to be utilized include:

1. DEQ's Willamette Basin ambient network to support framework.
    a. ODEQ Water Monitoring Program (https://www.oregon.gov/deq/wq/pages/wqdata.aspx)
    b. U.S. Geological Survey (https://waterdata.usgs.gov/nwis/qw)
    c. U.S. EPA (https://www.epa.gov/waterdata/water-quality-data-wqx#portal)
2. Following further discussion on roles and responsibilities, identified DMAs may need to collect long-term monitoring at representative sites. DMAs could include ODF, ODA, USACE, BLM and USFS. MS4 communities will also be directed to collect data as part of renewing their permits.
3. Combination of 1 and 2 above—i.e. Use some/all ambient sites, but augment sites with DMA support in large contiguous areas representing NPS sources, such as downstream of USFS property or in USACE reservoirs. It may be more difficult for DMA jurisdictions that are checker boarded or spread out across the basin to locate monitoring sites representative of their land use.

DEQ will develop specific monitoring projects to address monitoring objectives listed above when there are not currently available monitoring programs as needed.

Summary statistics of the mercury data used in the TMDL can be found in the spreadsheet titled “Willamette Basin Mercury TMDL Summary Statistics”. This data will be reviewed and used by DEQ for summarizing mercury data in the Willamette Basin. This information will assist DEQ, DMAs, and other watershed partners for developing study design questions and then the data needed for addressing the objectives in Table 2.

Project tracking and administrative monitoring

Each DMA should establish and operate a program for tracking and monitoring the implementation of projects and practices. DMAs’ specific tracking systems should align and communicate with the overall tracking and accountability program described by the WQMP (see WQMP section 14.1). A description of the project tracking and monitoring system must be sufficiently described in DMA TMDL implementation plans. Characteristics of a tracking and reporting program should:

- Efficiently compile and report management strategies and actions to assess against interim milestones.
- Be easily accessible to the public and agencies for review and audit.
- Be regularly maintained and updated.
- Facilitate submittal of annual progress reports to DEQ.
- Provide sufficient information to document, itemize and enumerate the location, type, installation date, maintenance schedules and performance duration of BMPs or strategies.
- Include sufficient information to document the performance of practices and strategies in reducing Hg loads and evaluating compliance with TMDL allocations.
- Describe changes to design, operation, or maintenance taken by DMAs and responsible persons in response to performance evaluations (i.e., adaptive management and design).
- Include a central filing approach, as applicable, to manage hard copy information (e.g., chain of custody forms, design plans, monitoring field sheets) related to project implementation and evaluation.
- Report compliance with TMDL load allocations and surrogate measures as needed to assess against interim milestones.

Implementation and performance monitoring

DEQ will work with DMAs to design a monitoring system that quantifies the implementation and performance of individual BMPs and strategies. Example implementation measurements could include: percentage of bare ground reduced during wet seasons or increases in streambank stability measured in feet.

Considerations in characterizing the performance of structural, distributed or practice-based BMPs could include but are not limited to:

- Identify appropriate sample sizes needed to provide the desired level of statistical effect size and significance. Existing datasets and literature can provide a pilot dataset that can be used to estimate the number of samples, storms, seasons, etc. that should be sampled to achieve desired statistical rigor.

As requested, DEQ will coordinate with DMAs as part of the site-specific QAPP process to assist with study design.

Data management and analysis

Each DMA is responsible for compiling, managing and reporting data obtained in the performance of monitoring objectives. Data management systems implemented by DMAs should: (1) effectively support project tracking and accountability objectives, (2) facilitate timely reporting, (3) facilitate timely uploads to state (AWQMS) or federal (WQX) databases, and (4) include those meta data necessary to describe and document the quality of stored data. DEQ will provide a template for reporting data to DEQ to facilitate data sharing.

Analysis approaches used to construct experimental designs and evaluate collected data should be described in site-specific QAPPs and structured data analysis plans. DEQ will work with DMAS on appropriate design studies for addressing objectives identified in Table 2. Data analysis plans for each objective should be prepared. For example, how will data be compared to applicable water quality standards to assess status, or, what trend analysis technique(s) will be used to detect breakpoints or monotonic changes in water quality time-series. Statistical techniques and computer models used to analyze data should comport with applicable DEQ or federal guidance. Important assumptions should be documented.

For practical reasons, there is not a uniform or ‘one-size-fits-all’ set of analysis techniques. As requested, DEQ will coordinate with DMAs as part of the site-specific QAPP process to assist with design of data analysis plans.

Timelines and reporting

The Willamette Basin Mercury monitoring strategy includes reporting requirements to support adaptive management, project tracking, and implementation assurance. Reporting requirements are summarized below.

DEQ will work with DMAs and stakeholders to identify roles and responsibilities for achieving the monitoring objectives. Dependent on those discussions DMAs listed in the WQMP may need to submit monitoring data and a project tracking summary to DEQ on an annual basis. Information generated by each DMA will be pooled and used by DEQ to determine whether management actions are having the desired improvements or if changes in management actions are needed.

- **Annual Progress Report**

  Annual Review of DMA Implementation Plans – DEQ will report results of reviews of DMA implementation plans and status and trends in water quality to help track implementation progress and provide status reports. These reviews may serve as decision events with respect to the adaptive management cycle. At a minimum, every five years, DMAs will update TMDL implementation plans based on adaptive management principles learned from the past four years of implementation.

Each DMA should submit an annual progress report that: (1) tracks progress in implementing strategies and BMPs, (2) transfers monitoring data to DEQ, (3) interprets and summarizes available data, and (4) documents any changes made to implementation plans in response to new information or data.

- **Five-Year Effectiveness and Performance Monitoring Report**

  A performance and effectiveness evaluation report for best management practices will be submitted by each DMA on a 5-year cycle. If progress is insufficient, then the appropriate DMA will be contacted with a request for corrective action. Each DMA should submit a report every five years that: (1) documents the type, location, number and effectiveness of water quality improvement strategies, (2) evaluates progress in achieving allocations and applicable surrogates against timelines and milestones established in the TMDL Water Quality Management Plan and (3) documents any proposed changes to the number and/or type of strategies necessary to achieve allocations based on performance evaluations.

- **Status and trend evaluation**

  In conjunction with the statewide integrated report, DEQ will evaluate status and trend data in the Willamette Basin collected by DMAs and other parties. DEQ is currently developing an annual statewide water quality status and trend report that will be available in 2020.

- **System response report**

  As described in section 1.3, DEQ may conduct system response evaluations in select priority areas of the Willamette Basin if applicable mercury criteria are not achieved. If these studies are triggered, DEQ will complete a report documenting these studies and recommendations following EPA's approval of the Willamette Basin Mercury TMDL.

- **Site-specific Quality Assurance Project Plans**

  DEQ will work with DMAs to decide which DMAs will develop QAPPs and when those need to be developed

Useful references

Dressing, S.A., et al. (2016). *Monitoring and Evaluating Nonpoint Source Watershed Projects*. U.S. EPA.

Conroy, M. J., & Peterson, J. T. (2013). *Decision Making in Natural Resource Management: A Structured, Adaptive Approach.* Hoboken: Wiley-Blackwell.

Appendix A

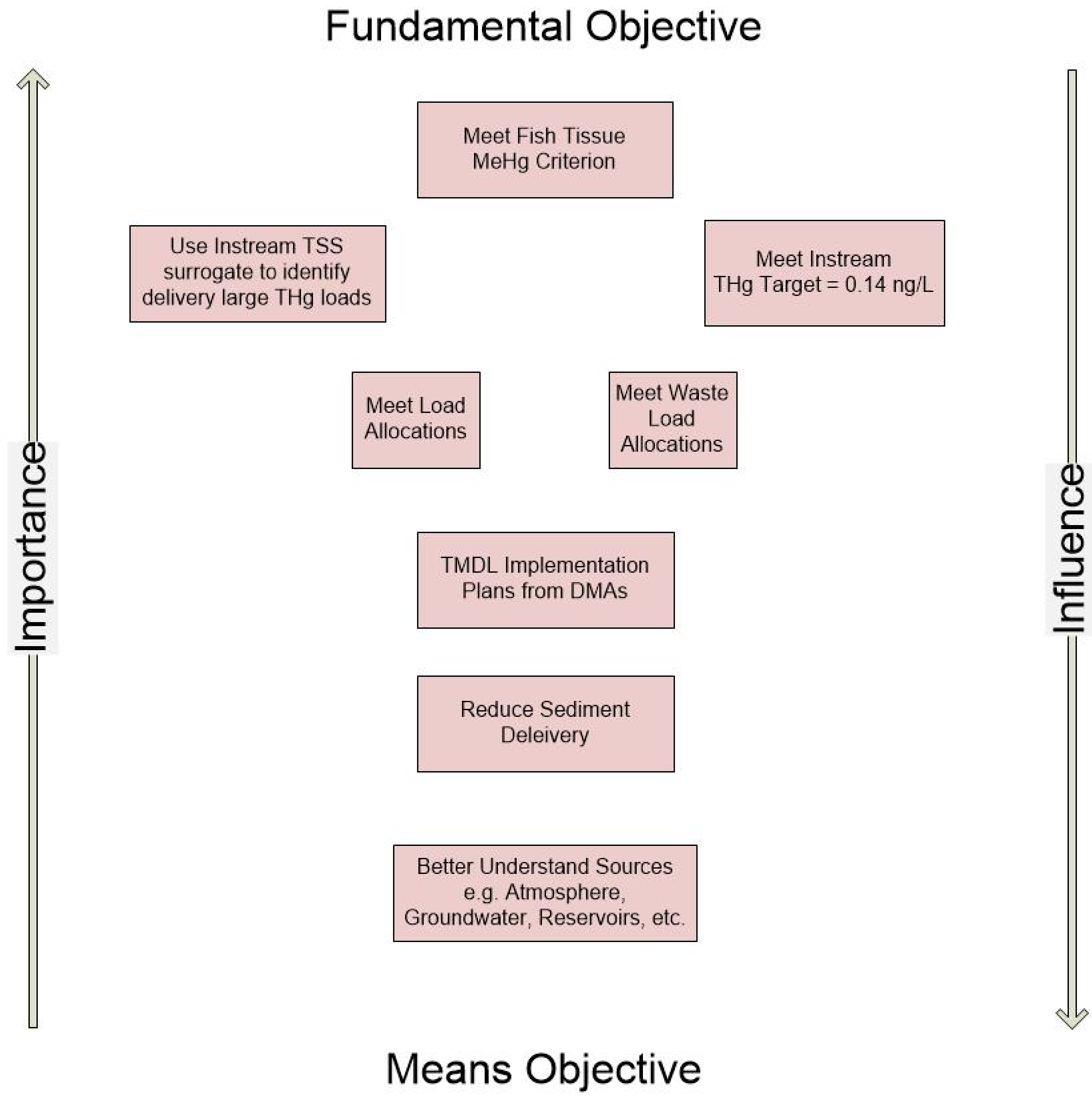

Figure 1. Objectives placed along the fundamental and means objectives axis DRAFT.

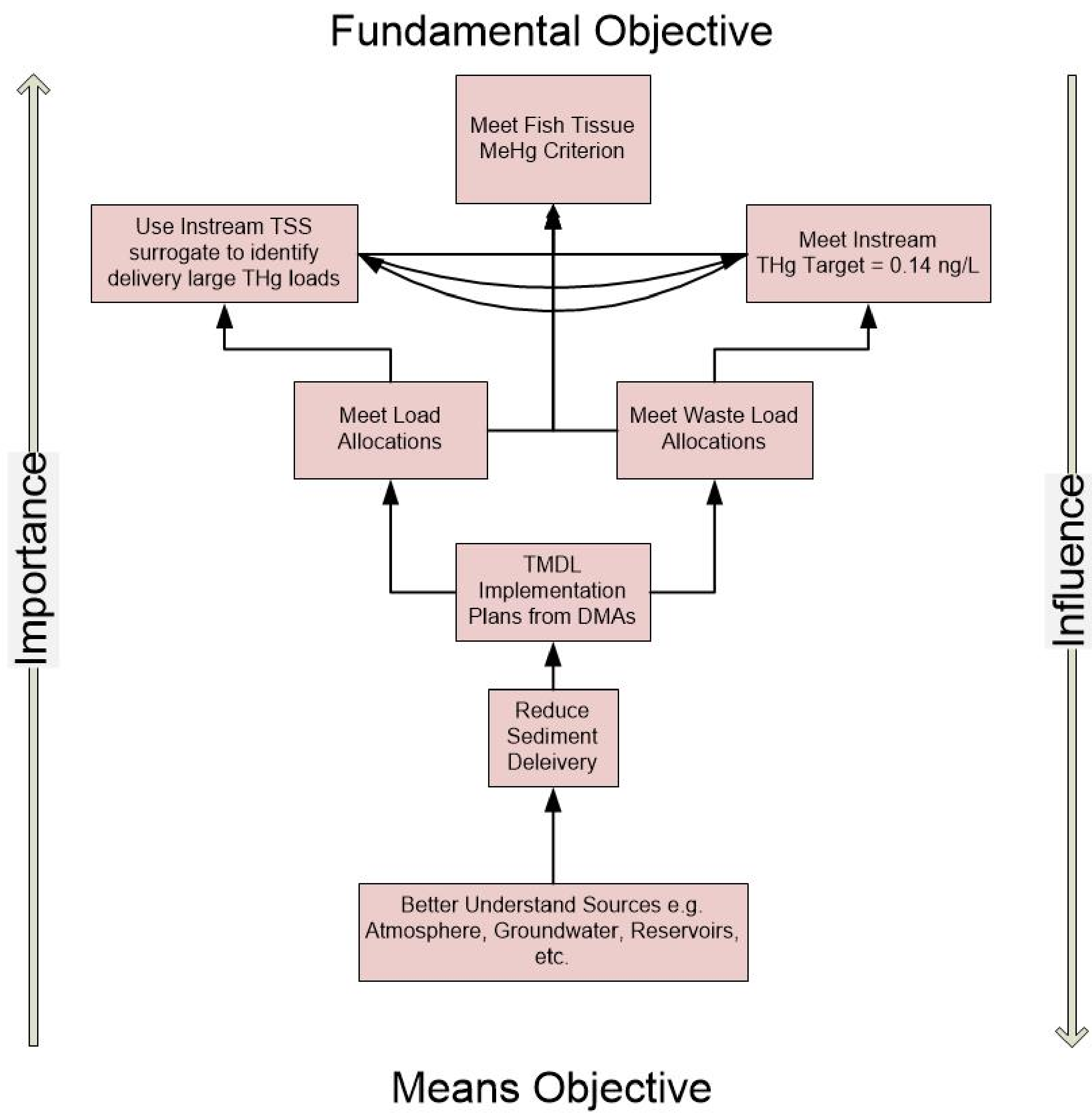

Figure 2. Influence diagram for fundamental and means objectives DRAFT