Scale Considerations in the Development of a Nine-element Management Plan
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Introduction

The most fundamental decision in the development of a watershed management plan is determining the geographic extent or scale of the project. The scale of a plan constitutes the unit of analysis, and this decision impacts stakeholder participation, data capture and analysis, inventories, policy recommendations, remedial actions, monitoring, cost and ultimately the success or failure of the plan to affect water quality. Watershed size must be appropriate to address the land and water concern, yet many agencies that promote watershed-based approaches provide no specifics on linking the problems to the appropriate watershed scale (Davenport, 2003). The issue is further complicated in that the appropriate scale to address the biophysical concerns of an area maybe incompatible with the scale needed to be responsive to the local social systems (Ziemer, 1999; Curtis et al, 2002).

Summary of Recommendations

The following recommendations are based on a review of guidance from the United States Environmental Protection Agency (U.S. EPA), guidance from groups developing watershed management plans, a review of the literature, and experience with planning efforts in Michigan. Supporting information is presented in subsequent sections of this paper:

1. Nine-element watershed management plans funded or approved by the Nonpoint Source (NPS) Program should typically be developed at the ten-digit Hydrologic Unit Code (HUC) scale or smaller.
2. Exceptions for developing a nine-element plan that exceeds the ten-digit HUC scale should be based on the six variables listed in the Metrics section on page 6-8, with emphasis placed on the extent of the impairment or water quality concern, the potential source areas of a pollutant, and the ability to conduct an on-the-ground inventory within the identified impaired subwatersheds.
3. All nine-element plans implementing vegetative or structural Best Management Practices (BMPs) must conduct field inventories, as field inventories form the basis of detailed plans. This stipulation does not apply to conservation easements. An analysis and prioritization including water quality components of potential conservation easements is required.
4. Nine-element plans need to conduct field inventories within all impaired subwatersheds.
5. Regardless of scale, all nine-element plans need to contain the same level of detail, allowing for variation in the geographic extent containing detailed information.

Issue

Historically, Michigan's NPS Program has funded and approved watershed management plans ranging in size from 370 to 3,016,311 acres. In 2003, the U.S. EPA released guidance requiring all watershed management plans to incorporate nine-elements, which are quantitative, require an increased level of detail, and are primarily developed to address areas with impaired waters. Tetra Tech was contracted by the NPS Program to develop a strategy for incorporating the elements into plans developed at varying scales. The resulting strategy was plans developed with a small geographic extent needed to contain more detail and plans developed with a large geographic extent require less detail. The subjective nature of this strategy has fostered concerns that the NPS Program is inconsistent in its efforts to meet the nine-elements. Further,

the lack of more clearly-defined criteria has led staff to question the appropriate level of information required to approve a nine-element plan. Tetra Tech's strategy has produced plans that are model based and devoid of inventories, with work plans predominantly consisting of generalities for the installation of vegetative or structural BMPs. These plans are generally lacking in detail making them uncompetitive for implementation funding. The 2012 NPS Program Plan identifies the objective of watershed management planning as defining

> ". . . all water quality problems and threats within the watershed and to propose specific actions to address those problems (including priorities, responsible parties, costs, and schedules) in order to restore degraded waters or protect high quality waters."

The purpose of this paper is to bring our planning efforts into closer alignment with the goal stated above. This paper will provide a brief review of the 2013 Federal Register guidance identifying factors having the greatest impact on scale, a review of the literature identifying metrics other groups have found to influence scale, and a recommendation section.

Guidance Factors Influencing Scale

Several aspects of the U.S. EPA's 2013 *Nonpoint Source Program and Grants Guidelines for State and Territories* affect the scale of management plans. These aspects are briefly examined to provide context.

The Federal Register guidance places a strong emphasis on the development and implementation of watershed management plans in watersheds that contain impaired waters. The geographic extents of impaired waterbodies, and the areas contributing runoff, need to be taken into account when determining the scale of a management plan. The guidance allows a limited amount of funds to be used to develop watershed management plans to protect unimpaired/high quality waters. Planning efforts that are predominantly preservation-oriented are similarly limited in scale by the extent of the resource they are proposing to protect, and by the extent of the pollutant sources degrading the resource.

The Federal Register guidance provides specifics on the content of watershed management plans developed or implemented with Section 319 incremental funds, requiring most plans to meet the nine-elements. The elements are quantitative in nature. The elements that have the greatest impact on scale are:

- Element A - An estimate of the extent of pollutant sources and their associated loads.
- Element B - An estimate of the quantity of BMPs needed to address the identified sources and the expected load reductions.
- Element C - Identification of areas within the watershed that are critical to address.
- Elements H and I - Establishing environmental criteria and a monitoring strategy to evaluate progress toward restoring impaired uses.

Michigan's NPS Program is stressing to groups developing watershed management plans the importance of field inventories of the riparian areas and windshield surveys of the upland areas as the basis for quantifying the extent of sources, estimating pollutant loads and reductions, and selecting appropriate BMPs. The Program is placing a higher priority on implementation projects that are based on field inventories. Field inventories are labor intensive and thus place

a significant constraint on the scale of plan development, or at least require the prioritization of subwatersheds if the entire planning area can not be inventoried.

The Federal Register guidance promotes a locally-driven process consisting of diverse and well-integrated partnerships. A decentralized, bottom-up approach is key to getting stakeholder buy-in and commitment, and successful planning and implementation. Planning efforts that are representative of the diversity of interests, and are inclusive of local decision making entities, have the greatest potential to develop meaningful watershed management plans. More importantly, this diversity will increase the probability of having significant and effective implementation of the plan.

Finally, Michigan's NPS Program Plan includes goals related to the restoration of subwatersheds and specific waterbodies, removal of particular causes of impairments, and goals related to the protection of high quality waters. The NPS Program's ability to meet these goals depends on the level of information developed during the planning process. Restoring impaired uses requires planning efforts to conduct detailed field inventories that identify specific sites contributing pollutants impairing those uses, and a geographically focused monitoring strategy to detect environmental improvements.

Literature Review

A review of publications addressing the spatial scale of watershed management planning was conducted to expand the pool of water resource professionals whose experiences and views are considered.

The Center for Watershed Protection (CWP), a leading water resource management organization, has suggested 1,280 to 9,600 acres as the appropriate management unit of watersheds in urban areas (CWP, 1998), with the following rationale:

1. It is easier to incorporate fewer stakeholders into the management process.
2. Regulatory authority maybe more clearly established with fewer political jurisdictions.
3. The influence of impervious cover on hydrology, water quality, and biodiversity is strongest.
4. Fewer sources of pollutants may be present, making management decisions easier.
5. It is small enough to perform monitoring, mapping and assessments in a short timeframe.

Although the CWP suggests a scale of 1,280 to 9,600 acres as the primary planning management unit (subwatershed), they also recognize that planning needs to take place at the 64,000 acres scale (watershed). The smaller planning area includes measures to provide effective management of the area, but they need to be developed within the context of the larger level watershed. Overall planning is to take place at the larger scale, yet specific goals, objectives, and much of the analysis takes place at the more detailed level.

In a subsequent publication, the CWP identifies scale to be the critical factor in the preparation of effective watershed management plans in urban areas (Schueler and Holland, 2000). The publication identifies planning at too-large of a scale as a reason for failure. The article defines "too large" as 50 square-miles (32,000 acres). The article identified the following inadequacies associated with large-scale planning:

1. Recommendations within the plan were too general.
2. The number of stakeholders increased, yet the actual responsibility for implementing the plan decreased.
3. The plan became fuzzy because too many subwatersheds had to be considered, and differences in stream quality and development patterns could not be isolated.

Advantages identified for developing small-scale watershed management plans are similar to those previously mentioned:

1. Fewer political jurisdictions leading to clear regulatory authority.
2. More meaningful resolution for the public.
3. Reduced cost for monitoring and analysis.

Illinois Environmental Protection Agency's (IEPA, 2007) Guidance for Developing Watershed Action Plans in Illinois discusses appropriate planning scale. An important point identified in this guidance is the impracticality of large-scale plans. Specifically, does the group have the resources and the ability to plan, and more importantly implement over the proposed geographic extent of the project? Plans with larger geographic extents include more people, jurisdictions, and agencies, making the process and coordination of efforts more cumbersome. Similar to CWP, IEPA asserts that large-scale plans potentially sacrifice the sense of being local. The guidance contends the U.S. EPA identified planning projects conducted at a smaller scale, 63 square-miles (40,000 acres), to more likely be successful. The IEPA guidance identifies 32,000 acres or less as the generally appropriate scale for watershed management plan development. The guidance does not entirely exclude large-scale plan development, indicating it is "realistic in rural or undeveloped watersheds which have homogeneous land use, or few pollutants of concern." An important caveat placed on this point is that although the planning can be successful at a large scale; the development of an implementation plan will need to occur at a smaller scale.

The U.S. EPA (2008) Handbook for Developing Watershed Plans to Restore and Protect Our Waters addresses scale in several places. Section 1.1.3 states:

> "Where existing plans and strategies have been developed at a basin-wide or other large geographic scale, they usually need to be refined at the smaller watershed scale to provide the information needed to develop a watershed plan. The assessment, monitoring, and other data collection requirements for larger basin studies typically are not as detailed as those for watershed plans or assessments generated for site-level work plans."

Section 2.2.3 also discusses how watershed management plans should be defined geographically:

> "A watershed plan should address a geographic area large enough to ensure that implementing the plan will address all the major sources and causes of impairments and threats to the waterbody under review. Although there is no rigorous definition or delineation of this concept, the general intent is to avoid a focus on single waterbody segments or other narrowly defined areas that do not provide an opportunity for addressing watershed stressors in a rational, efficient, and economical manner. At the same time, the scale should not be so large that it hampers the ability to conduct detailed analyses or minimizes the probability of

involvement by key stakeholders and successful implementation. *If you select a scale that is too broad, you might be able only to conduct cursory assessments and will not be able to accurately link the impacts back to the sources and causes.* (italics added)

Plans that bundle subwatersheds with similar sets of problems or address a common stressor (e.g., sediment, nutrients) across multiple related watersheds can be particularly useful in terms of planning and implementation efficiency and the strategic use of administrative resources."

Section 2.6 offers the following on scale in relation to the nine-elements:

"The level of detail . . . needed to address the nine key elements of watershed management plans will vary in proportion to the homogeneity or similarity of land use types and variety and complexity of pollution sources. Urban and suburban watersheds will therefore generally be planned and implemented at a smaller scale than watersheds with large areas of a similar rural character. Similarly, existing watershed plans and strategies for larger river basins often focus on flood control, navigation, recreation, and water supply but contain only summary information on existing pollutant loads. They often generally identify only source areas and types of management practices. In such cases, smaller subbasin and watershed plans and work plans developed for nonpoint source management grants, point sources, and other stormwater management can be the vehicles for providing the necessary management details. *A major purpose of this manual is to help watershed managers find planning tools and data for managing watersheds at an appropriate scale so that problems and solutions can be targeted effectively."* (italics added)

Section 4.4 defines the desired geographic extent of watershed plans, the handbook states:

". . . most watershed planning efforts to implement water pollution control practices occur at the ten- or twelve-digit HUC level, although smaller drainage areas within subwatersheds might be used if they represent important water resources and have a significant variety of stressors and sources."

A 2009 United States Geological Survey (USGS) publication outlines interagency guidelines and requirements for the development of ten-digit (watershed) and twelve-digit (subwatershed) level HUCs. The publication indicates that although the eight-digit HUCs (subbasin) are widely used:

". . . the geographic area of units is too large to adequately serve many water-resource investigations or resource-analysis and management needs. For example, the focus of many water-resource issues is pollutant loading and land-surface processes and the cumulative effects of pollution over space and time. Management of these issues requires working with areas smaller than those defined by the 8-digit hydrologic units."

The implication is that the origin for the ten-digit (watershed) and twelve-digit (subwatershed) HUCs is due to the need of a number of agencies and programs for a smaller sized geographic unit to conduct their analysis.

Cheng and Daniels (2005) conducted a qualitative comparative case study in Western Oregon, focusing on the social implications of scale, and its impact on group identity and the potential affect on collaboration among stakeholders in the watershed management planning process. They found that in small-scale planning (114,000-acre/ten-digit HUC versus 853,000-acre/eight-digit HUC); stakeholders were more likely to place watershed issues within the context of watershed health and community well-being. In addition, the stakeholders were also more likely to know and interact with each other as members of a shared community. The threats to the watershed and hence community health allowed an "in-group" to develop, which lead to mutually agreed-upon decisions and actions. An in-group is defined as an esteemed group to which individuals perceive membership, and attributes loyalty and a sense of belonging. In large-scale planning efforts, watershed issues were framed as regional conservation efforts with no direct relationship established between watershed health and community well-being. The interaction between stakeholders was based more on organizational affiliation, than members of a shared community. This relation led to an "in-group/out-group" attitude, with individuals tending to personalize and guard their organizations opinions and principles due to competing values and positions.

The 1993 Forest Ecosystem Management Assessment Team Report discusses scale within the context of ecosystem management (United State Fish and Wildlife Service, 1993). The report contends that ecosystem planning needs to be conducted at four scales to establish context:

1. Site specific - <1 square-mile (640 acres).
2. Watershed - 20 to 200 square-miles (12,800 to 128,000 acres).
3. River basin - >1,000 square-miles (640,000 acres).
4. Regional multi-river basin or state.

While a multi-scale approach is fundamental to ecosystem planning, a central concept is that the watershed represents a socially acceptable and an ecologically and physically relevant scale. It is at the watershed scale that the most comprehensive analysis takes place, as it is small enough to provide a meaningful level of precision, and big enough to exhibit many interactions important to environmental issues.

Lane and MacDonald (2005) found scale to be an issue when identifying problems associated with community-based environmental planning in Australia and Oregon. The article contends that the traditional theory and practice of community-based environmental planning has provided a localized response to ecological problems. Increasingly ecological theory advocates responses at a wider scale, with emphasis on the systemic dimensions of ecological function rather than the locally perceived expression of an ecological problem.

Metrics

Based on a review of the guidance and literature, and experience with plan development in Michigan, the following six metrics have the greatest influence on the scale of a nine-element plan. These factors are not discrete, and need to be considered in combination when assessing the geographic extent of nine-element watershed management plans.

> ***Extent of the impairment or threat*** - The geographic extent of water quality impairment, and potential source areas to the waterbody are perhaps the most important metrics to consider when determining the scale of a management plan. This metric is also applicable to unimpaired/high quality waterbodies, and should not only include the geographic extent of the pollutant source, but the extent of the water resource in need of protection. The Water Quality and Pollution

Control in Michigan 303(d), 305(b), and 314 Integrated Report and monitoring data need to be reviewed as part of this determination.

Scope - The number of concerns and the breath of goals that a management plan addresses. Scale and scope within the context of the nine-elements have an inverse relation. As the number of pollutants impairing or degrading designated uses increase, or as the number of sources of a pollutant increases, the level of effort needed to identify specific sites for remediation also increases. Exception to this would be when pollutants and sources are related, and by addressing one source you will address multiple pollutants for example, sediment, *E.coli*, and nutrients from livestock access sites. Management plans that address areas impaired by a variety of pollutants, or a pollutant with multiple sources, should encompass a smaller geographic extent or focus on one or two prioritized pollutants or sources.

Stakeholder - Watershed management plans need to be locally driven, and as the extent of the planning area increases, the sense that the plan is local can be lost. Plans incorporating a large geographic area may increase the number of people, jurisdictions, and issues making consensus on priorities and actions more difficult to achieve. As the population density or jurisdictional complexity of an area increases the geographic extent of the plan should decrease. A few exceptions to consider are:

1. Rural areas with low population density, which need an increased size to attract enough people to participate.
2. Areas in which the land use planning is coordinated by the county.
3. Larger geographic areas where active stakeholder groups are representative of the diversity of interests, actively engaged in the development and pursuit of watershed management goals, and able to demonstrate significant progress through historic actions within the proposed area.

Land Use - The relationship between land use and NPS pollutants make it an important characteristic to consider when determining the scale of a management plan. There are two aspects of land use to consider within the context of scale, its variability and its type. The more diverse the land use within an area is the more varied the pollutants, sources, and causes are likely to be. Heterogeneous land use also increases the number of stakeholder groups, concerns to address, and goals to be incorporated into the planning process. As the variety of anthropogenic land uses within an area increases, the geographic extent covered by a nine-element watershed management plan should decrease.

The type of land use comprising an area also influences the scale of management plan development. In the context of this paper we will consider three broad classes of land use: rural-areas predominantly consisting of natural lands and in which the road network comprises a significant portion of the built environment, agricultural areas used for the production of food or managed for the cultivation and harvesting of some commodity, and urban areas composed predominantly of the built environment. As the amount of anthropogenic land within an area increases the geographic extent of the watershed management plan should decrease.

Plan Orientation - Management plans developed for the NPS Program are primarily designed to protect high quality waters and restore impaired waters. Although all watershed management plans need to encompass both of these aspects, they are in varying proportions depending on the specific conditions within a given watershed. Protection oriented plans can be developed at a larger scale because they tend to lack or have few impaired waters, have homogeneous land uses, consist primarily of natural land uses and have lower population densities. Management plans that are dominantly restoration in orientation should cover a smaller geographic area with size decreasing as the population density, jurisdictional complexity, number of impairments, number of sources, or amount of managed land increases.

Inventory - The NPS Program is stressing the need for planners to conduct field inventories of the riparian areas and windshield surveys of the upland areas of a watershed as part of the planning process. Plans that utilize field inventories and windshield surveys have a better quantification and presentation of the extent of sources contributing pollutants impairing designated uses and provide better information for implementation proposals. In addition, field inventories and windshield surveys are the basis of developing specific and detailed implementation objectives to address pollutant sources in impaired areas of a watershed. Field inventories need to be targeted and informed by a comprehensive data collection and analysis. The area a group can inventory within a two year planning cycle needs to be factored into the scale at which a nine-element watershed management plan is developed. Based on estimates from the CWP and Michigan's NPS Program a team of two can cover approximately two miles of stream in a day. The CWP estimates 2.5 square-miles of upland in urban areas can be evaluated per day using their Unified Subwatershed and Site Reconnaissance method.

In areas devoid of waters on the nonattainment list, or any pollutants substantiated to be impacting water quality, field inventories may be an inappropriate method for selecting priority areas for protection. In these instances comprehensive data collection, analysis, and modeling would supplant field inventories and wind shield surveys as forming the basis of a detailed plan. However, planners in such areas, proposing the implementation of structural or vegetative BMP, would need to conduct field inventories and wind shield surveys as appropriate, to make the plan competitive for 319 implementation funds.

Conclusion

The U.S. EPA and the Tetra Tech handbook acknowledge that the detail required to develop a nine-element plan necessitates a reduced geography. The ten-digit and twelve-digit HUCs are discussed as the size most used for plans implementing pollution control practices. Groups addressing water quality impairments limit the size of watershed management plans, promoting a geographic extent roughly equivalent to a twelve-digit HUC or smaller. Although these limits are generally placed on areas consisting of anthropogenic landforms, there is still a need to balance between providing a broader context with the ability to plan, inventory, and implement within the proposed area. To meet our restoration goals and develop management plans that are adequately prepared for implementation of vegetative and structural BMPs, the NPS Program must limit the extent of nine-element watershed management plans.

Recommendations

The NPS Program will promote the following USGS HUC nomenclature when referring to drainage areas of varying sizes:

Numerical name	Common name	Average size (square miles)
Two-digit	region	273,647 (175,134,080 acres)
Four-digit	subregion	16,800 (10,752,000 acres)
Six-digit	basin	10,596 (6,781,440 acres)
Eight-digit	subbasin	700 (448,000 acres)
Ten-digit	watershed	227 (145,280 acres)
Twelve-digit	subwatershed	40 (25,600 acres)

Nine-element watershed management plans funded or approved by the NPS Program should typically be at the ten-digit HUC scale or smaller, unless the development of a plan that encompasses a larger geographic extent can be justified by the criteria identified in this paper. Michigan's ten-digit HUCs range in size from approximately 40,000 to 260,000 acres. This scale allows a broader context to be considered yet is still a manageable size for a significant portion of the area to be inventoried. Nine-element management plans funded above the median size of a ten-digit HUC (137,000 acres) should have few, geographically discrete, water quality impairments or be in areas devoid of waters on the nonattainment list.

Twelve-digit HUCs (subwatersheds) need to be prioritized for inventory and implementation. Field inventories of the riparian areas and wind shield surveys of the upland portions of all subwatersheds with impaired waterbodies would be required. Field inventories and wind shield surveys would be used to:

- Identify sources of pollutants.
- Prioritize sites for remediation.
- Provide pollutant load and reduction estimates.
- Recommend BMPs, identify locations of implementation projects, and provide cost estimates.

Regardless of scale, all nine-element plans need to contain the same level of detail, allowing for variation in the geographic extent containing detailed information.

The criteria for exceptions to the proposed scale are the previously identified metrics, with emphasis placed on the geographic extent of the water quality concern or impairment, potential source areas of the pollutant, and ability to inventory the proposed planning area. Groups proposing to develop nine-element management plans at a scale larger than the ten-digit HUC need to articulate why the proposed scale is appropriate and necessary to address an impairment or pollutant threatening water quality. The NPS Program district staff responsible for the planning area and the NPS Program watershed management planning coordinator will make a recommendation to the NPS Unit Chief or District Supervisor on the appropriateness of plans exceeding the ten-digit HUC scale. If the development of a large-scale plan is warranted, inventories of the riparian areas and wind shield surveys of the upland areas within all impaired subwatersheds (twelve-digit HUCs) would be required. The inventories must be used to identify and prioritize sites for remediation. The NPS Program funded implementation of structural and vegetative BMPs will favor areas where field inventories and wind shield surveys are conducted.

Plans developed in areas lacking impairments may choose not to conduct a field inventory, but would be expected to develop a comprehensive desktop analysis, which would form the basis of a detailed plan. The desktop analysis would need to prioritize subwatersheds and identify areas posing the greatest threat to water quality. The plan would be expected to indentify the most important next steps needed to address the pollutants identified as threatening water quality. Without field inventories and wind shield surveys the management plan would not be competitive for the implementation of 319 funded structural or vegetative BMPs.

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