Complying with Surface Water TMDL Regulations Through Pollution Prevention Projects

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Abstract

Spurred by a series of lawsuits, EPA has committed to generating and enforcing surface water regulations called Total Maximum Daily Loads (TMDLs). These TMDLs apply to both traditional point-source contamination and pollution from non-point sources, including soil erosion. Many military instillations, especially in the Western U.S., are likely contributors to sediments to surface waters, and will be required to comply with TMDLs. This paper assesses the potential of various types of EPA-approved TMDLs for their potential to focus on pollution prevention projects.

Montana's Deep Creek TMDL is an early example of making pollution prevention the means of compliance. Instead of requiring stakeholders to meet numeric pollution standards, each pollution contributor is required to implement a certain number of pollution control projects of specified size. Instead of spending enforcement dollars on expensive and time-consuming models to quantify the problem or filtering options, those funds can be targeted toward pollution prevention methods like putting in new vegetation or building berms at the "hot spots." Compliance can also be achieved by changing land-use patterns; for instance, by changing the pathways jeeps usually use. This strategy is scientifically defensible, because soil erosion modeling results are often untested and based on poor data, while pollution prevention methods have demonstrated benefits.

This method of writing the regulations not only allows enforcement dollars to go to pollution prevention, it allows stakeholders to focus on reducing pollutants in the long term and short term. Even when the regulation not as explicitly pro-prevention as the Deep Creek TMDL, stakeholders can strongly encourage implementing a compliance plan putting most of the compliance dollars toward pollution prevention.

I. Introduction

Throughout the 1990s, a brace of lawsuits were filed and won across the country, demanding that states (or in the absence of their leadership, the EPA) draw up Total Maximum Daily Loads (TMDLs) for all waterbodies within their states that did not meet water quality criteria. Figuring out what a TMDL is, how to prepare one, and how to implement it consumed years in states and on the federal level, and final answers on those questions are still pending. This year is the first time that we have some results from different approaches. While we still have lessons to learn, it appears pollution-prevention oriented TMDLs with a maximum of stakeholder participation and choice are a quick way to get successful solutions in place. Military instillations that contribute to surface water pollution are in a position to influence the development of these regulations in a manner that will focus on pollution prevention, maximize choice among implementation options, streamline the process, and produce cleaner water.

II. What is a TMDL?

A TMDL is described as "the amount of a given pollutant that can be allowed to enter a waterbody without causing the water quality standards to be exceeded."[1] The Clean Water Act is even more specific, stating that the TMDL should be set to implement water quality standards given seasonal variations. Moreover, the Act mandates that a TMDL have a built-in margin of safety, set according to the degree of scientific uncertainty, and that the TMDLs be adjusted for the potential for pollution growth.[2] These requirements are summed up by EPA in the following equation illustrating how these elements come together to set a TMDL: Allowable Pollutant Load = Wasteload Allocation + Load Allocation + Margin of Safety + Future Growth.[3]

The Department of Defense (DoD) has committed to cooperating with states and the federal government in developing and implementing TMDLs, and to enacting changes in resource management to help comply with these regulations.[4] This mandate to participate is likely influenced by court decisions indicating that federal lands and activities on those lands are not exempt from TMDLs.[5] TMDL regulations do not apply solely to toxic chemical inputs; they also apply to pollutants like excess sediment and temperature. Military activities that contribute to soil erosion (examples include runoff from a dirt or gravel road near a waterbody, or removing vegetation from riverbanks) have the potential to be regulated through a TMDL.

TMDLs for point-source pollution

Imagine you have a river with two sources of anthropogenic pollution: two identical plants that draw river water for cooling purposes and pipe the water back to the river afterward. Both plants have a permit to discharge this water, based on their use of the best available technology to treat the water before it re-enters the river. The plants are complying with those permits. However, the river has a cold-water fishery, and the temperature in the river has gotten too warm to support the designated use of "cold water biota" mandated by the state's narrative water quality standards. In this hypothetical situation, the river would be placed on the state (303d) list of impaired waterbodies, making a TMDL necessary. In this case, in order to develop an ideal TMDL, the state would want to quantify the following (this list is not intended to be exhaustive):

- The highest possible temperature at which no damage would be done;
- The natural (i.e. pre-human effect) temperature of the river;
- The amount of water and temperature of the water that could be discharged without causing the river to exceed the highest possible non-damaging temperature;
- The amount of water and the average temperature of the water currently discharged by each plant.

Suppose the state quantifies these four items using a model for temperature of the river; suppose further that the model itself is perfect and so are the data inputs (i.e. there is no uncertainty). The model predicts that above 14°C, damage will be done to the river; the natural temperature of the receiving water is 10°C; a discharge of 1000 gallons a day at 18°C is the maximum discharge concentration that can be assured not to have the water rise above 14°C. Since the two plants use water equally, 500 gallons a day at 18°C would be allocated to each. The two permits would be changed to reflect this, and the plants would be forced to change their cooling mechanisms or possibly rely on pollution "credits" trading to implement the TMDL.

Even in this much-simplified example, it is easy to see how difficult it is to write a scientifically reliable TMDL, and how much harder it would be to implement. Writing EPA's equation using values instead of variables proves difficult. Enforcement of a TMDL also raises questions. Even when the state can implement the TMDL by changing the permit of all contributing facilities, the state and the plants will still have to figure out a way to achieve those lower levels. Determining the natural vs. anthropogenic loadings of pollutants, and relating the level of pollutants to quantified environmental effects is sometimes beyond "any pretense of precise mathematics," as legal expert and TMDL proponent Oliver Houck has observed—he calls this difficulty the "Achilles' heel" of the process.[6] It is difficult to determine the natural temperature of the river, and the degree of change produced by particular inputs. Most TMDLs will have to turn to modeling to answer those questions. In the real world, the data to be fed into the model will carry uncertainty, and the model results will increase that uncertainty (often to an unknown degree, since few models have been validated).[7] However, it is much easier to quantify the amount of water and the average temperature of the water currently discharged by each plant; this is easily measurable.

TMDLS for non-point source pollution

That one easily measurable element becomes incredibly more complex when the scenario changes from a point to a non-point source of pollution. Non-point pollutants like sediment and temperature account for the majority of the TMDLs in the Western states, and are not infrequent in other parts of the country.[8] For instance, imagine that again, we have a river exceeding temperature standards, and again, there are only two anthropogenic activities on the river influencing river temperature: a ranch and a military base. The ranch raises river temperature by having cattle drink directly from the river, which has removed overhanging vegetation and caused the banks to erode, allowing more sunlight to heat the water. The military base also has increased the amount of sun the river water gets by clearing vegetation to allow boats to be pulled up onto shore more easily, and by conducting exercises that change the normal overhang shape of a river bank.

In the point-source example, it is reasonably simple to determine the inputs of temperature from discharge water in a pipe. However, in the scenario we have now makes the previously simple part of the exercise at least as difficult as the quantification of every other TMDL element. Are the two sources contributing equally to the temperature increase? The EPA has commented on the difficulty of tracing the source of nonpoint pollution since 1984,[9] and modeling techniques are not always up to the challenge; relying on expert opinion is equally if not more valid.[10] Add that to the other difficulties of quantification that are also present for point sources (deciding on a natural river temperature, determining how much temperature increase is allowed, etc.), and the unquantified (and sometimes unquantifiable) uncertainty associated with the TMDL expands dramatically.

Once the TMDL is determined, how to implement it is a matter of great debate. The debate begins with the question of whether Congress intended to regulate nonpoint sources (like temperature and sediment inputs as a result of erosion) via TMDLs at all. So far the courts, EPA and legal experts have said TMDLs can and should be made for non-point sources.[11] The next area of debate is how the TMDLs are supposed to be enforced: everyone agrees that the Clean Water Act provides a "carrot;" the question is whether or not there is a "stick." The carrot is a funding provision for non-point source pollution abatement activities, located in §319. The usual "stick" for polluters, NPDES permits, are not required for non-point sources.[12] While some people have suggested withholding §401 permits as another stick,[13] not all nonpoint source pollution contributors require federal permits for their activities. Probably for this reason, the EPA finds that firm commitments to voluntary action are reasonable assurances that the TMDL will be put into place.

III. Satisfying the Quantification Requirement

TMDL guidance stresses that assimilative capacity and pollution allocations must be quantified. This requirement is one of the most difficult to meet, and for non-point TMDLs in particular, the pollution allocation stage is a significant hurdle. Even in those cases where quantification of a pollutant loading problem can be established from a long-term data record,[14] allocation of that load presents an entirely new problem.

Unless the likely contributors to the problem have not changed their land use practices and all began contributing at a different time, even long-term monitoring of a waterbody alone can't convincingly determine the load from each source. Similarly, even if all stakeholders can agree on a single reference waterbody (a waterbody with similar characteristics to the use-impaired waterbody but in a more pristine states) to establish the natural background level of sediment or temperature, that alone doesn't answer whose eroding banks are causing 20 percent of the problem, whose 40 percent, etc.[15]

The Need for Modeling

For these reasons, allotting the pollution loading is one of the major stumbling blocks for non-point TMDLs, and has delayed the release and implementation of many TMDLs. The allocation process has also proved to be expensive, both in time and money. [16] One of the only (if not *the* only) ways to quantify the long-term effects of varying management techniques or changes in land use is to use a technical model.[17] With strong EPA encouragement, many states have turned to models like the Water Erosion Prediction Project (WEPP),[18] and the EPA makes available a conglomeration of models for creation and transport of different pollutants called BASINS (Better Assessment Science Integrating Point and Non-point Sources).[19]

While models may be the only way to quantify pollutants and allocate those pollutants among contributors, the models are rarely able to do it easily or well, and often increase uncertainty in unknown ways. An experienced soil erosion modeler notes that models can have difficulty predicting, "even to within an order of magnitude, a rate of erosion."[20] When the uncertainties associated with models are considered, it is not hard to see why.

Even before the model is run, difficulties often present themselves while assembling the necessary data inputs. Most TMDLs developers are turning to modeling because there is not enough data to make a clear decision. For this reason, good quality data, and data of the right form, may very well be unavailable.[21] While many models come with sample sets of data for different soil types, etc., the uncertainty of using those data as opposed to site data is unknown. For instance, in one test of the model ANSWERS (A real Nonpoint Source Watershed Environment Response Simulation), a single set of rainfall data was entered into the model in two different ways while all other inputs were held constant. When the ten-year predictions obtained from hourly data were compared to results from minute-by-minute data sets, one estimate of erosion was literally double the other (600 metric tons vs. 300 metric tons).[22]

With differences this dramatic, the professional judgment of the expert running the model is all the more important. The professional should know what data is available, the degree to which the data is trustworthy, the best data input for a model, the more unique characteristics of the watershed being modeled that should be incorporated into the model, and the inputs to which the model is especially sensitive. The process of adapting a model to the particular area being modeled is called calibration, and is nothing less than "essential for all models used."[23] The best calibration is likely also done with a feel for what a realistic outcome range would be, so begs the question of when a model is better than an expert's best professional judgment without the model results; there are times when it is likely no better.[24] Because of the importance of calibration, even experienced modelers working with the same model and the same data sets have been shown to come out with notably different answers.[25]

The relative results of models are generally more trustworthy than absolute results, so a better use of models may be to identify "hot spots," or the areas that are likely contributing the most sediment or causing the largest temperature changes.[26] These are areas that will likely produce the biggest returns to pollution-prevention projects. Some TMDL developers have used very simple models that do not need large data sets or require much calibration (but have larger uncertainties) to pinpoint areas on which to focus their dollars and energies.[27]

While these models are capable of producing a “best guess,” and are scientifically defensible in that the decision made (except in regards to the margin of error/uncertainty) is not arbitrary or capricious,[28] modeling is no panacea. It is unsurprising, then, that stakeholders prove resistant to adopting the outcome of these models as the basis for implementation of a controversial TMDL, and have delayed the publication of these TMDLs by debating the model results. Oliver Houck, an expert in TMDLs cited by judges, predicts that these allocations are likely to be challenged in court, especially as those allocations are “entirely political.”[29]

The Deep Creek Approach

In most cases, getting a TMDL-driven solution on the ground means finding a way through the quantification minefield described above. In its first-ever non-point source TMDL, the State of Montana tried an alternate route: choosing to quantify the solution, not the problem. Deep Creek, MT, with a drainage area of 87.7 square miles, had declining cold-water fish habitat, which the state found was tied to excessive sedimentation from erosion and resulting temperature increases.[30] The Forest Service managed much of the riverbank; private irrigators were responsible for the rest.[31] The state set targets for the number of fish that should spawn per year in Deep Creek, and made the TMDL endpoints a reduction in sediment contributions and water temperatures under 73ºF the majority of the time as the first step toward reaching those targets.

Then, instead of trying to determine the background levels of sedimentation and whose erosion was most responsible, the TMDL was based in part on a 50 percent reduction of the miles of eroding banks (no sediment load change was quantified) within a 10-year period.[32] The State of Montana gave further assurances that after the 10-year period, if the standards remained unmet, more demanding targets would be set.[33] After a single year of voluntary implementation, despite minimal funding, the number of fry in the river doubled and sediment loads dropped. No more than three years after the approval of the TMDL and despite stakeholder complaints of under-funding of streambank stabilization efforts,[34] 14,000 feet of bank had been stabilized, mostly through pollution prevention projects.[35]

The stakeholder group that developed the Deep Creek TMDL cited several reasons for its success, but stressed stakeholder commitment and the fact that the TMDL was not written in a way to make it too large to quickly implement and quickly see results. These factors also point to the related benefits including lower cost and time investment and increased flexibility for participants. Given the limited nature of funding available for implementing the TMDL, the time and money saved by not attempting to run a model (which necessitates time to assemble and input data, calibrate the model, run the model, interpret the results, and when possible, validate the results) can be directed instead toward implementation. Stakeholder commitment to the TMDL is also likely higher because stakeholders have latitude in choosing how they will meet the goals; for instance, to stop erosion, a stakeholder can choose between planting juniper or ceasing activities on the banks that are causing erosion. Thus, the Deep Creek approach maximizes flexibility, cost-savings, and effectiveness.

IV. Advocating for a Deep Creek Approach

When developing the Deep Creek TMDLs, a stakeholders' group composed of regulators and the likely contributors to the problem met to discuss, draft the TMDL, and create an implementation plan. Participation in the development process makes implementation more likely, and because more innovate and workable solutions can emerge from stakeholder groups, EPA encourages states to involve stakeholders in establishing TMDLs.[36] The DoD likewise encourages military installations that are affected by a TDML to participate in these groups.[37]

As part of a group establishing a TMDL strategy for the watershed, military land managers can encourage states not to spend precious time and money on modeling efforts. Or, stakeholders can encourage the state to run simpler and less expensive models only for relative results, particularly the areas in the watershed where projects are likely to have the biggest impact. (To illustrate, relative results may indicate a better area to pull boats up on the bank or build a barb). By emphasizing the demonstrated benefits of pollution prevention projects like building weirs or replanting banks (over the minimal benefits of attempting precise modeling), stakeholders can recommend that those dollars be focused behind projects they support and believe in instead of results that will be debated for months if not years while erosion continues unabated.

Even when the time and money have been spent on quantifying the problem, pollution prevention approaches can be made the focus of the implementation plan if stakeholders become involved at that point. For instance, Chalk Creek, Utah had very similar problems to Deep Creek, but spent time and dollars quantifying the TMDL. The Chalk Creek TMDL allocated the sediment reduction targets by land use: 130,000 tons/year reduction was expected from rangeland, and 8,200 tons/year from cropland. However, the Chalk Creek implementation plan departed from the quantification attempts; it is made up almost entirely of pollution-prevention projects in the form of Best Management Practices (BMPs).[38] While the definitions of these BMPs does decrease the amount of choice each stakeholder has in choosing a project under the Deep Creek method, the pollution-prevention focus does benefit stakeholders by usually requiring minimal costs after the initial investment. (For instance, creating a soil-catch beside a road where runoff is entering a stream, need only be done once and can be maintained with little effort).

By using the Deep Creek approach to TMDL writing, military instillations benefit from an opportunity to select pollution prevention projects with low maintenance costs. In the most flexible approaches, the military land managers may also be able to offset activities that otherwise might need alteration with pollution prevention projects that mitigate the harm done. For instance, moving a road that is directing sediment-laden runoff into a stream might be required as a Best Management Practice, but a more flexible TMDL would allow the installation to build a berm or create some other sediment trap that would prevent the sediment from reaching the affected waterbody. If "hot spots" are identified (areas that are particularly denuded or on steep slopes, for instance), installations could be allowed to aid projects on other landowner's property as a way of fulfilling their TMDL compliance burden. Finally, because the Deep Creek method has potential to show results quickly and is iterative in nature, the installations will not be required to build especially large projects due to the uncertainty of the determination methods; they will be required to keep working until the problem is abated. Thus, several small, less-costly alternatives, spread out over a few years, may be a possibility under a flexible iterative approach, where a one-shot approach might require much larger projects to overcome the margin of error.

V. Conclusion

Because military instillations conduct a number of activities that produce nonpoint source pollutants of surface water (for instance, erosion from streambanks where vegetation has been altered or removed by instream exercises), they have the potential to be regulated by TMDLs. In order to avoid inflexible requirements that may call for an alteration of these activities (and in order to comply with DoD guidance), military land managers can influence the approach and content of these regulations by participation in the development process.

One of the most effective TMDL methods to date, enacted in the Deep Creek, MT TMDL, is also one of the most desirable methods from a stakeholder point of view. Because the Deep Creek method avoids expensive and extensive modeling efforts that rarely yield precise results, and instead focuses on funding and encouraging commitments by stakeholders to voluntary pollution-prevention or activity alteration projects of their choice, costs are decreased and the speed of on-the-ground improvement is increased. In other words, by focusing quantification efforts on the solution instead of the problem, TMDL requirements can be met with a minimum of paperwork and preparation and a maximum of prevention.

While comparatively few TMDLs have been in place long enough to conduct a thorough comparison of effectiveness, after only a year of implementation the restoration of Deep Creek was measurably closer. Therefore, advocating a TMDL design and/or implementation plan drawn on Deep Creek lines is also advocating a high-impact TMDL in the short as well as long term. Military land managers who steer toward a Deep Creek plan can be confident that in choosing a desirable plan for the installation, they are also choosing a desirable plan for the watershed. In speed of development, speed of results, flexibility, opportunity for pollution prevention, and reduced cost, the Deep Creek method of TMDL development and implementation offers many advantages to military land managers and other stakeholders.

ENDNOTES

[1] Margie Williams, ed. "What Farmers Need to Know About Clean Water and TMDLs." Brochure published by the American Soybean Association and National Corn Growers Association. Undated.
[2] Federal Water Pollution Control Act Amendments of 1972 [U.S. Clean Water Act]. (18 Oct. 1972). 33 U.S.C. §1313, ELR Stat. FWPCA §303.
[3] Environmental Protection Agency, Office of Water. 1991. "Chapter 3: Establishing and Implementing TMDLs." *Guidance for Water Quality-Based Decisions: The TMDL Process* www.epa.gov/owow/tmdl/propguid.
[4] *Unified Federal Policy for Ensuring a Watershed Approach to Federal Land and Resource Management*. (17 Oct. 2000). http://cleanwater.gov/ufp/objectives.html. Signed by DoD on 28 Sept. 2000, by Patricia L. Toppings, Alternate OSC Federal Register Liaison Officer.
[5] Debra L. Donahue. (1996). "The Untapped Power of Clean Water Act Section 401." *Ecology Law Quarterly* 101: 201-301.
[6] Oliver A. Houck. (Dec. 1999). *The Clean Water Act TMDL Program: Law, Policy, and Implementation*. Environmental Law Institute: Washington D.C. p. 58.
[7] David Favis-Mortlock, John Boardman and Valerie J. MacMillan. (In press.) "The Limits of Modeling: or why we should proceed with care." *Landscape Erosion and Evolution Modeling*. Kluwer Publishers.
[8] Utah Non-Point Source Task Force (undated). "Total Maximum Daily Loads in the West: Understanding the TMDL Process." Brochure. Available upon request from Jack Wilbur, agmain.jwilbur@state.ut.us.
[9] Oliver A. Houck, ibid. p. 30.
[10] Committee to Assess the Scientific Basis of the Total Maximum Daily Load Approach to Water Pollution Reduction (15 June 2001). *Assessing the TMDL Approach to Water Quality Management.* Prepublication draft available online at http://books.nap.edu/books/0309075793/html/R1.html.
[11] Oliver A. Houck, ibid. p. 62; *Pronsolino v. Marcus* 91 F.Supp.2d 1337 (2000); Margie Williams, ibid.
[12] Federal Water Pollution Control Act Amendments of 1972 [U.S. Clean Water Act]. (18 Oct. 1972). 33 U.S.C. §1313, ELR Stat. FWPCA §402; 40 CFR 130.7 (1995), available online at http://www.access.gpo.gov/nara/cfr/cfrhtml_00/Title_40/40cfr130_00.html.
[13] Sarah Klahn (1997). "Total Maximum Daily Load Litigation: An Opportunity to Augment Instream Flows?" *Rivers*, 6:2, p.8.
[14] For an example of a TMDL with surrogate for long-term monitoring data (a bathymetric analysis), see Pennsylvania Department of Environmental Protection (4 March, 1999). *Total Maximum Daily Loads of Sediments and Nutrients for Lake Luxembourg*. Found online at http://www.epa/gov/reg3wapd/tmdl/tmdl.html.
[15] For an example of a TMDL using a reference stream, see California Regional Water Quality Control Board, North Coast Region (1998). *Garcia River Watershed Water Quality Attainment Strategy for Sediment, including the Total Maximum Daily Load, Implementation Plan, and Monitoring Plan.* Santa Rosa, CA: California Environmental Protection Agency.
[16] Sarah Klahn, ibid.
[17] John Boardman (1998). "Modelling Soil Erosion in Real Landscapes: A Western European Perspective." In Boardman and Favis-Mortlock, eds. *Modelling Soil Erosion by Water.* Berlin: Springer-Verlag in conjunction with NATO Scientific Affairs Division; U.S. Environmental Protection Agency (1994). *Water Quality Standards Handbook: Second Edition.* Appendix O. Office of Water. EPA-823-B-94-005a.
[18] For an example of a TMDL using the WEPP model, see Idaho Division of Environmental Quality (1998). *Paradise Creek TMDL; Water Body Assessment and Total Maximum Daily Load*. Lewiston: Idaho. For information on and evaluation of the WEPP model, see Klik, A. ed. (1998). *Experiences with Soil Erosion Models.* Austria: Institut für Hydraulik und landesklturelle Wasserwirtschaft.
[19] Available from http://www.epa.gov/ost/basins/.
[20] John Boardman, ibid. p. 18.
[21] John Boardman, ibid; David-Favis Mortlock (1998). "The GCTE Validation of Field-Scale Soil Erosion Models." In Klik, A. ed. *Experiences with Soil Erosion Models.* Austria: Institut für Hydraulik und landesklturelle Wasserwirtschaft.; John Quinton and Roy P.C. Morgan (1998). "EUROSEM: An Evaation with Single Event Data from the C5 Watershed, Oklahoma, USA." In Boardman and Favis-Mortlock, eds. *Modelling Soil Erosion by Water.* Berlin: Springer-Verlag in conjunction with NATO Scientific Affairs Division.
[22] R.P. Rudra, W.T. Dickinson, and G.J. Wall (1998). "Problems Regarding the Use of Soil Erosion Models." In Boardman and Favis-Mortlock, eds. *Modelling Soil Erosion by Water.* Berlin: Springer-Verlag in conjunction with NATO Scientific Affairs Division.

[23] David Favis-Mortlock (1998). "Evaluation of Field-Scale Erosion Models on the UK South Downs." In Boardman and Favis-Mortlock, eds. *Modelling Soil Erosion by Water.* Berlin: Springer-Verlag in conjunction with NATO Scientific Affairs Division.

[24] Committee to Assess the Scientific Basis of the Total Maximum Daily Load Approach to Water Pollution Reduction. Ibid. p. 50.

[25] Peter Botterweg (1995). "The user's influence on model calibration results: an example of the model SOIL, independently calibrated by two users." *Ecological Modelling* 81, pp. 71-81.

[26] Victor Jetten, Ad de Roo, and David Favis-Mortlock (1999). "Evaluation of field-scale and catchment-scale soil erosion models." Draft; L. D. Shoemaker, M. Lahou, S. Thoms, R. Xue, J. Wright and M. Martin (May 1997). *Compendium of Tools for Watershed Assessment and TMDL Development*. Washington, D.C.: United States Environmental Protection Agency, Watershed Branch.

[27] For an example of a TMDL using the RUSLE model to pinpoint hot spots, see Idaho Division of Environmental Quality (1998). *Paradise Creek TMDL; Water Body Assessment and Total Maximum Daily Load*. Lewiston: Idaho.

[28] Committee to Assess the Scientific Basis of the Total Maximum Daily Load Approach to Water Pollution Reduction. Ibid. p.54.

[29] Oliver A. Houck. Ibid. p.59.

[30] Utah Non-Point Source Task Force ibid.

[31] Douglas S. Kenney, Sean T. McAllister, William H. Caile, and Jason S. Peckham (2000). *The New Watershed Source Book*. "Chapter 10: Selected Watershed Initiatives in the South Platte-Missouri Region." p. 301. Natural Resource Law Center: Boulder, CO. Available online at http://www.colorado.edu/Law/NRLC/Watershed_Chapters/Chapter_10.pdf.

[32] Endicott, C.L., and T.E. McMahon (1996). *Development of a TMDL to reduce nonpoint source sediment pollution in Deep Creek, Montana*. Report to Montana Department of Environmental Quality.

[33] Environmental Protection Agency, Office of Water, ibid. "Appendix: Case Studies: Deep Creek, Montana."

[34] Douglas S. Kenney et al. Ibid. p. 302.

[35] Utah Non-Point Source Task Force ibid.

[36] Environmental Protection Agency, Office of Water (1991). "Chapter 3: Establishing and Implementing TMDLs." *Guidance for Water Quality-Based Decisions: The TMDL Process*

[37] *Unified Federal Policy for Ensuring a Watershed Approach to Federal Land and Resource Management*. Ibid.

[38] Utah Non-Point Source Task Force ibid.