Utah Department of Environmental Quality
Division of Water Quality
TMDL Section

Scofield Reservoir TMDL

Waterbody ID	**Scofield Reservoir, HUC 14060007**
Location	**Carbon County, Central Utah**
Pollutants of Concern	**Total Phosphorus, Dissolved Oxygen**
Impaired Beneficial Uses	**Class 3A: Protected for cold water species of game fish and other cold water aquatic life, including the necessary aquatic organisms in their food chain.**
Loading Assessment **Current Load** **TMDL Target Load** **Load Reduction**	 **6,723 kg/year total phosphorous** **4,842 kg/year total phosphorous** **1,881 kg/year or 28%**
Defined Targets/Endpoints	**1) Shift in phytoplankton dominance from blue-green algae** **2) DO level of no less than 4.0 mg/L in 50% of water column** **3) TSI values between 40-50**
Implementation Strategy	**1) Stream restoration BMP's** **2) Elimination of grazing below**

	high water line of reservoir

Executive Summary

This document is identified as a TMDL for Scofield Reservoir and is officially submitted to the U.S. EPA to act upon and approve as a TMDL for the State of Utah, Department of Environmental Quality (DEQ), Division of Water Quality (DWQ). Scofield Reservoir is a 2,815 acre body of water located in western Carbon County. The watershed is located in Hydrologic Unit Code (HUC) 14060007 and the uses are quite diverse and consist of year-round fishing, agriculture, and coal mining.

Scofield Reservoir is listed as impaired for 3A, cold water fishery. Parameters of concern are total phosphorous concentrations, low winter dissolved oxygen (DO) concentrations and nuisance algal blooms. These parameters have directly and indirectly lead to annual fish kills for several years. The reservoir is a high priority for TMDL completion and will be submitted to U.S. EPA April 1, 2000. Designated beneficial uses are 1C, 2B, 3A, and 4, domestic use, secondary water contact, cold water fish, and agricultural uses, respectively.

Water quality endpoints were chosen which are linked to reduction of total phosphorous from the surrounding watershed. They include: 1) A shift in phytoplankton dominance from blue-green algae to a more diverse phytoplankton community, 2) DO level of no less than 4.0 mg/L in 50% of the water column at the deep end of the reservoir during critical periods (late winter and late summer), 3) TSI values in the range of 40-50. These endpoints are linked either indirectly or directly to achieving Scofield Reservoir's designated beneficial uses.

An acceptable load to Scofield Reservoir was estimated by Denton et al. (1983) as 1881 kg/year. The nutrient load allocation was linked to stream restoration strategies on Mud Creek and Fish Creek drainages which contribute 87% of the total annual phosphorous load to Scofield Reservoir. Denton et al. (1983) estimated that this load reduction would allow achievement of water quality standards and designated beneficial uses of Scofield Reservoir.

Technical analysis for this TMDL consists of regression equations used to calculate Carlson's Trophic State Index (TSI), intensive water quality monitoring conducted in 1997-1998 and the Clean Lakes Phase I and II studies conducted in 1982-1983 and 1990, respectively. A model specific to Scofield Reservoir is being developed to better estimate acceptable nutrient allocations and effects on the TSI. The model may also be used to validate endpoints and recommendation of future pollution control strategies.

The Margin of Safety (MOS) consists of conservative estimates of the endpoints to assure attainment of water quality standards and load allocations associated with pollution control techniques or Best Management Practices (BMP's). Future efforts will be directed to modeling load allocations and monitoring of Scofield Reservoir in a process of evaluation and refinement of TMDL endpoints.

The acceptable total phosphorous load (1,881 kg/year) to Scofield Reservoir will be allocated to stream restoration of Mud Creek and Fish Creek drainages. Some BMP's include: streambank revetments, installation of gabion check dams, re-seeding and planting of willows in devastated riparian areas, fencing and controlled livestock management techniques.

Public participation for this TMDL consists of the Price-San Rafael Steering committee and associated technical advisory committees. These committees were recently organized and officially formed to deal with water quality issues in Scofield Reservoir and the Price and San Rafael River basins. The Steering Committee and TAC's consist of Emery and Carbon County Commissioners, SCD board members, BLM, Forest Service, DWQ, DWR, and State Parks and Recreation representatives. These committees have been designated to develop watershed and implementation plans, including funding mechanisms to address water quality issues in Scofield Reservoir and surrounding watersheds. During the Phase I Study a locally administered Steering Committee was in-place to guide and approve the recommendation of the Phase I Clean Lakes Study.

Waterbody description

Scofield Reservoir is a 2,815 acre body of water located in western Carbon County, which is in central Utah (Figure 1). Uses of Scofield Reservoir and its watershed include coal mining, agriculture, residential, fishing, hunting, snowmobiling, camping, and a variety of other types of summer and winter recreation. Scofield Reservoir is fed by several perennial streams (Figure 1), Fish Creek and Mud Creek account for 34,487 and 8,441 acre feet of water, respectively. These two streams account for 87 % of the inflow to Scofield Reservoir (Denton et al. 1983). The reservoir is one of the prime cold water fisheries in the state, both summer and winter because of its close proximity to Salt Lake City. Therefore, Scofield Reservoir is heavily impacted by anglers and other recreational users.

Scofield Reservoir is listed as impaired for a 3A, cold water fishery and the parameters of concern are total phosphorous concentrations and low dissolved oxygen (DO) concentrations, this condition also leads to algal blooms which may be related to seasonal fish kills. Scofield Reservoir is targeted for TMDL development and is considered a high priority in Utah's 1998 303(d) list. A Phase I Clean Lakes study was completed for Scofield Reservoir in 1982. In this report (Denton et al., 1983), it was determined that Fish Creek and Mud Creek accounted for the majority of the nutrient input to Scofield Reservoir, 52% and 29%, respectively. The Utah DEQ/DWQ is considering this TMDL for one pollutant (total phosphorous) because low DO is scientifically linked to high total phosphorous levels. Any reductions in phosphorous loadings will likely improve the DO content in the reservoir. The Utah Division of Wildlife Resources (DWR) has documented fish kills for the last three years (Louis Berg, per. comm.) which has corresponded to blue-green algae blooms which are a result of excess nutrients such as phosphorous. The intent of this TMDL is to reduce the inflow of nutrients in an effort to restore beneficial uses of this water. The result of this action would also improve the recreational aspects (fishing) of Scofield Reservoir.

This TMDL is based on information reported from a Phase I Clean Lakes Report completed in 1983 and as such is a conservative estimate of nutrient loadings to the reservoir. As the implementation of controls or BMP's occur, as outlined in this TMDL, validation or refinement of TMDL endpoints may occur. In addition, modeling of the reservoir and input of new data may also require modification of endpoints or controls to achieve water quality standards.

Water Quality Standards

Beneficial use designation for the waters of Scofield Reservoir are presented in Table 1.

Table 1. Utah Division of Water Quality beneficial use designation for Scofield Reservoir.

Class	Beneficial Use Designation
1C	protected for domestic purposes with prior treatment as required by Utah Department of Environmental Quality
2B	protected for secondary water contact; class
3A	protected for cold water species of game fish, including the necessary aquatic organisms in their food chain
4	protected for agricultural uses such as irrigation and stock watering

The reservoir is listed in the 1998 303(d) for excess total phosphorous and low DO. Although Scofield Reservoir was assessed as fully supporting (1998 305 report) based on numeric water quality criteria (pH, DO, and temperature) during the productivity season (May-Sept.), narrative water quality standards such as depleted winter DO levels, presence of nuisance algae, and documented fish kills show the reservoir as partially supporting its beneficial uses.

Water quality studies conducted in 1990 (Judd, 1992) show blue-green algae comprised 99% of all taxa present, indicating poor water quality conditions. Eutrophication trends for Scofield Reservoir were assessed using Carlson's (1977) Trophic State Index (TSI) and show an increasing trend through 1991, reaching 66.34 indicating a highly eutropic condition. In 1991 rough fish were removed from Scofield Reservoir and the TSI in subsequent years has shown a downward trend, reaching 41.69 in 1995-96, which indicates a mesotrophic condition. More recent (1998-99) data indicate a slight increase in the TSI. It is hypothesized that the removal of rough fish in 1992 was beneficial in that bottom sediments were disturbed less, resulting in decreased release of nutrients into the water column. Throughout this time (from 1991 on) significant blue-green algae blooms were observed and fish kills were documented. The data used to derive TSI values is limited (not collected at the same period of time) and therefore has a relatively high degree of variability which may not reflect actual eutrophication trends for Scofield Reservoir. Recently formed local stakeholder committees have agreed to commit time and resources for a more coordinated water quality sampling. This will lead to a more detailed investigation of the relationship between blue-green blooms and TSI values.

The Scofield Reservoir Phase I and II Clean Lakes Studies (Denton, et al. 1983 and Judd, 1992), have shown blue-green algae blooms are a result of increased nutrients, which are often limited by aqueous phosphorous levels. Therefore, the pollutant of concern for this TMDL document is total phosphorous, because reductions of phosphorous (as a result of implemented TMDL) will limit the blue-green algae and directly alleviate low winter DO conditions and reduce fish kills.

Water Quality Targets/Endpoints

Improvement of water quality in Scofield Reservoir is linked to a reduction of nutrients from the surrounding watershed. We propose to use three endpoints, they include:

1. A shift in phytoplankton dominance from blue-green algae to a more diverse phytoplankton community.

2. DO level of no less than 4.0 mg/L in 50% of the water column at the deep end of the reservoir during critical periods (late winter and late summer).
3. TSI values in the range of 40-50.

A major factor in restoring Scofield Reservoir's beneficial use (cold water fishery) is reducing the blue-green algae blooms and either directly or indirectly improving the DO levels throughout the year. At this time we feel the best endpoint would be to measure the dominance of blue-green algae when they appear to be the most problematic, which is during the productivity period, May through September. Qualitative samples would be taken throughout this period to determine dominance of blue-green algae. The shift from dominant blue-green algae to increased diatoms and green algae would be an indicator of reduced total phosphorous levels in Scofield Reservoir.

The second endpoint that will be linked to nutrient reduction in Scofield Reservoir is DO concentrations no less than 4.0 mg/L in 50 % of the water column during the critical periods (late summer and late winter). This endpoint is directly linked to the protection and survival of cold water fish species (Louis Berg, per. comm.) and therefore to attainment of one of Scofield Reservoir's designated beneficial uses (Table 1). Utah's Division of Wildlife Resources (DWR) has shown that a DO concentration of less than 5.0 mg/L has lead to mortality of cold water fish in lakes and reservoirs. A DO concentration profile will be measured at one meter intervals at the deep site in Scofield Reservoir to determine this endpoint.

The third endpoint, a TSI in the range of 40-50 is directly linked to nutrient levels in Scofield Reservoir. This endpoint takes into account chlorophyl-a, secchi depth, and total phosphorous concentrations which are a direct measure of the nutrient levels in Scofield Reservoir. These water quality parameters (chlorophyl-a, secchi depth, and total phosphorous concentrations) can be measured when the blue-green algae samples are taken. This sampling coordination will increase the validity of the TSI values on an annual basis.

Water quality samples for chlorophyl-a, total phosphorous, and secchi depth will be taken semi-annually (May and Sept) at STORET sites 593098, 593099, and 593100 (Figure 2). The type of sampling will consist of grab samples. Phytoplankton samples and DO concentrations will be taken only at the deep site (STORET 593100). During implementation of BMP's a more rigorous sampling protocol will be developed to track progress towards water quality goals.

TMDL

Based on data in the Phase I Clean Lakes report (Denton et al., 1983), the total phosphorous acceptable load allocation for Scofield Reservoir is 4,842 kg/year. This is based on all inputs to the reservoir (Figure 1; Table 2). The load reduction is 1881 kg/year which is a 28% reduction of nutrients from non-point sources to Scofield Reservoir. The reduction of total phosphorous was linked to implementation of several stream restoration strategies (Table 3). Denton et al. (1983) projected that designated beneficial use and water quality criteria would be achieved by this plan of action.

In support of this phosphorous reduction plan, several other concepts were developed outside of the scope of this plan that would also control nutrient reduction in Scofield Reservoir. They included the following:
1. Developing and implementing livestock grazing management plans.
2. Planning of recreational development, providing an improved sewer disposal system.

3. Controlling of surface disturbance activities and solid waste disposal.

Although Fish Creek contributed 53% of the phosphorous loading to the reservoir, it was not selected as the primary area for streambank restoration due to lack of local cooperation, extremely steep, and unstable streambanks. However, the following restoration techniques were applied and total phosphorous was linked primarily to suspended solids.

1. Approximately 3,300 feet of fencing was installed to protect area from further deterioration from livestock and vehicular travel.
2. Some eroded area within the above enclosure were filled, sloped, and re-seeded for stabilization.

Based on the Clean Lakes Study I (1983) the implementation of proposed Mud Creek Project would reduce total phosphorous loading to Scofield Reservoir by 500kg/year. The project consisted of installation of gabion check dams, bank stabilization using Juniper revetments, re-vegetation and establishment of riparian habitat, and enclosure of project by fencing.

The Phase II Clean Lakes Study (1990) concluded that insufficient data exists to confirm the effectiveness of these stream restoration activities in reducing phosphorous loads to Scofield Reservoir. The data, although limited, does show a slight reduction in total phosphorous levels after stream restoration had taken place. One possible reason may have been that fencing of a significant portion of Mud Creek was not completed and no livestock grazing management was instituted due to landowner conflicts.

Currently a model that will be used to determine more scientifically acceptable load allocations based on long term water quality data, reservoir morphology and morphometery is being developed. The Clean Lakes Phase II report also concluded that internal phosphorous loading may also be occurring in the winter. The model under development will include attempts to show internal phosphorous loading and its effects on eutrophication of Scofield Reservoir. This model either validate or modify current projections of nutrient loading allocations and thereby implement control actions which will attain designated beneficial uses for Scofield Reservoir. The model coupled with an ongoing monitoring plan will act as the margin of safety required under the TMDL guidelines. As information is acquired the TMDL may be modified according to the information obtained.

Table 2. Stream and reservoir restoration techniques and nutrient load allocations for Scofield Reservoir (Clean Lakes Phase I, Denton et al. 1983 report).

Restoration Technique or Alternative	**Estimated Phosphorous removal (kg/yr)**	**Public Benefits**	**Water quality Benefits**	**Public Acceptance**	**Feasibility**
Stream restoration on private lands (Mud Creek)	500	Good	Great	Good	Feasible
Improved recreation facilities	200	Moderate	Little	Good	Feasible
Law enforcement	50	Good	Little	Good	Feasible
South shore wetland project	481	Good	Moderate	Good	Feasible
Enforcement fish entrails disposal	50	Good	Moderate	Good	Feasible
Fish Creek restoration	500	Good	Excellent	Good	Less Feasible
Fish cleaning station	100	Good	Moderate	Good	Feasible
Total estimated phosphorous reduction	**1881**				

Significant sources

The Utah Division of Water Quality completed a study of Scofield Reservoir and its watershed through an EPA Clean Lakes Phase I study in 1983. The study identified the sources of pollution and determined that phosphorus and nitrogen were both limiting nutrients. However, recommended remedial action for lake restoration was directed towards a reduction of phosphorus within the watershed.

Denton and others (1983) determined external phosphorus contributions to the reservoir as shown in Table 3. Fish Creek contributes 52% (3508 kg/year) and Mud Creek contributes 24% (1613 kg/year) of all external phosphorus loads. The remaining tributaries, shoreline wash, and precipitation contribute 24% of the external phosphorus load. Slightly higher loading values with similar distributions were reported by Waddell and others (1983) for the 1979-80 water year.

The external sources of phosphorus include stream sediments, sewage, and agricultural wastes. In an effort to reduce human waste a centralized leech field system was put in place for the town of Scofield in 1983. However, erosion and agricultural practices continue to be a problem. Sediment release by erosion in the watershed contributes to a large fraction of the phosphorus load into the reservoir. Intensive livestock grazing in the watershed, grazing within the riparian zones (stream banks), in particular in close proximity to the reservoir, road construction, summer home construction, and mining activities have all accelerated the erosion process.

Table 3. Annual Phosphorus contributions from sub-basin areas

Sub-basin	Annual Total Phosphorus Load (kg/year)
Fish Creek (FCI)	3508
Mud Creek (PVC-1)*	158
Mud Creek (PVC-2)*	528
Mud Creek (PVC-3)*	249
Mud Creek (PVC-4)*	323
Mud Creek (PVC-5)*	115
Mud Creek (PVC-6)*	240
Pondtown Creek (PC-1)	488
Woods Canyon Creek (WC-2)	172
Miller Canyon Creek (MC-1)	66
Dry Valley Creek (DVC-1)	89
Eccles Creek (EC-1)	337
Shoreline Wash (SW-1)	308
Precipitation	142
TOTAL	**6723**

* The drainage was subdivided and annual loadings determined for each sub-basin. Total load for Mud Creek minus Eccles Creek was 1613 kg/year.

The Manti LaSal National Forest has completed a water resource inventory for the Price River watershed. Data were compiled on 72,359 acres in and around the National Forest. Sediment yields were estimated and watershed improvement needs were identified. The work on these ongoing improvements need to be accelerated. Of the land surveyed 7257 acres or 10.1 percent of the watershed was classified with high to extreme erosion potential. Water quality in the streams based on suspended sediments was estimated to range from 52 mg/L in the Fairview Lakes to 276 mg/L in Mud Creek. Anything above 100 mg/L is considered high or very poor water quality. Erosion is the major source of pollution into Scofield Reservoir. Sediment and sediment related nutrients are primary reasons for the deteriorating water quality in the reservoir.

In addition to phosphorus loads from external sources the resuspension of phosphorus from lake sediments back into the water column is occurring. Internal loading of phosphorus involves chemical interactions within the reservoir. Since the reservoir was constructed in 1946, sediments have been deposited on the reservoir bottom. These sediments contain phosphorus that is stored in different chemical forms. The phosphorus is bound to other elements (iron and calcium) forming phosphate salts. However, when the lake stratifies water from the hypolimnion (bottom) does not mix with the surface water and dissolved oxygen in the hypolimnetic water column is used to oxidize organic materials. Eventually the hypolimnion becomes anoxic. Under these conditions phosphate salts break down and the phosphorus is released into the water column. At turnover, when the water in the reservoir mixes in the spring and fall, this rich source of phosphorus becomes available for algal production. Dissolved oxygen studies indicate that internal phosphorus loading may be higher than was previously expected (Judd, 1992).

Technical Analysis

The technical analysis for this TMDL consists of regression equations (1-3) used to derive TSI values, intensive water quality monitoring conducted in 1997-1998, and Clean Lakes Phase I and II studies conducted in 1982-1983 and 1990, respectively. Nutrient load allocations for this TMDL were estimated based on the Clean lakes Phase I and II reports (Denton et al., 1983). A water quality model specific to Scofield Reservoir is being developed to better estimate nutrient allocations and effects on the TSI. At this time the model is not complete, but will be used in validation of endpoints and recommendation of phosphorous control strategies if needed for Scofield Reservoir. The model will be completed by May 2000 and will be used to better define load allocations for Fish Creek and Mud Creek.

1. TSI = 60 - 14.41 ln Seechi Depth
2. TSI = 9.81 ln Chl A + 30.6
3. TSI = 14.42 ln Total Phosphorous + 4.15

Margin of Safety and Seasonality

The margin of safety (MOS) for this TMDL is built into the load allocations in the Phase I and II Clean Lakes Report. The pollution control techniques or BMP's were a conservative approach to attainment of designated beneficial uses for Scofield Reservoir. Selection of endpoints has a MOS built into them, for example, the reduction of blue-green algae will be attained by a simple shift in dominance, the DO concentration of 4.0 mg/L in 50% of the water column allows for a sufficient niche for fish during winter as the hypolimnion (O^2 deficient) increases, and the TSI has a wide range (40-50) which equates to mesotrophic conditions.

Using the concept of adaptive management, as BMP's are implemented annual water quality monitoring and analysis of TMDL endpoints will provide information that will allow mid-course management changes to be made that assure water quality goals are met.

The choice of endpoints also takes into account seasonality of the TMDL. Blue-green algae blooms due to increased nutrients predominantly occur in late summer and fall. The DO concentration profile will be measured in summer and fall. The TSI will also be calculated on data taken throughout the productivity season (summer and fall).

Allocation of Load Reductions or Management Strategies

The specific recommendation of the Phase I study included the following stream restoration elements:

1. Implementation of stream restoration and streambank stabilization for Mud Creek and Fish Creek.
2. Construction of a public fish cleaning station.
3. Development of a public education and awareness campaign.
4. Chemical treatment for internal nutrient loading (contingent on future modeling results).

The majority (79%) of total phosphorous load reductions (Table 2) to Scofield Reservoir will be allocated by continuing with stream restoration projects on Mud Creek and Fish Creek. Based on the report by Denton et al., 1983, the implementation of stream restoration will result in a total phosphorous load reduction to Scofield Reservoir of 1881 kg/year and represents a 28% reduction of non-point source pollution. Due to extremely steep banks in the Fish Creek drainage stream restoration efforts will be directed to Mud Creek drainage (see TMDL section). The other load allocations are specific to management of recreation facilities (managed by State Parks and Recreation) at Scofield Reservoir, such as enforcement of fish entrails disposal, fish cleaning stations, improved recreation facilities. The Phase II Clean Lakes report documented that attainment of load reductions has not occurred due to incomplete implementation of restoration practices. Loading estimates included in this TMDL still can be achieved through adequate implementation of BMP’s in the Scofield Reservoir watershed.

The south shore wetland project would reduce total phosphorous to the reservoir significantly, approximately 481 kg/year (Table 2). This project consists of reducing nutrient inputs associated with livestock grazing by fencing off a portion of the south shore of the reservoir. Based on a livestock model developed by Natural Resources Conservation Service (NRCS) in Utah this load allocation (481 kg/year) is thought to be underestimated. The NRCS livestock model indicates a total phosphorous load allocation of 674 kg/year. At this time we do not know the livestock grazing allotment on the south shores of the reservoir, therefore, we are basing the load allocation on 100 head of livestock grazing on the south shore for 180 days per year. This equates to a 10% (193 kg/year) difference for the total load allocation. This difference will be part of the TMDL’s MOS as well.

One element of the Scofield Reservoir water quality model is an internal nutrient loading factor. If this model suggests internal loading of nutrients is a significant factor, other nutrient load reduction plans will need to be developed, such as P-inactivation by chemical means. This will only be done when all other nutrient reduction efforts have been completed and subsequent data shows significant internal nutrient loading. The TMDL will be modified if this is the case.

Implementation of these projects has recently been taken up by organized local stakeholder committees to develop a watershed management plan. One priority of the Price River Technical workgroup will be to mediate landowner conflicts in the Scofield Reservoir watershed and secure 319 NPS funds and other funding to implement these nutrient load allocation projects.

Public Participation

Public participation for this TMDL consists of the Price-San Rafael Steering committee and associated technical advisory committees. These committees were recently organized and officially formed to deal with water quality issues in Scofield Reservoir and the Price and San Rafael River basins. The Steering Committee and TAC's consist of Emery and Carbon County Commissioners, SCD board members, BLM, Forest Service, DWQ, DWR, and State Parks and Recreation representatives. These committees have been designated to develop watershed and implementation plans, including funding mechanisms to address water quality issues in Scofield Reservoir and other impaired waters in surrounding watersheds. During the Phase I Study a locally administered Steering Committee was in-place to guide and approve the recommendation of the Phase I Clean Lakes Study.

The notice of this TMDL was published one time for a 30 day comment period in the Salt Lake Tribune and Deseret News. The TMDL was also available in its entirety on the State of Utah DEQ-DWQ web page (http://www.eq.state.ut.us) for thirty days. No public comments were received.

References

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