Appendix I. Adaptive Management Implementation Plan

Note: The Utah Division of Water Quality has included the Draft of the ‘City of Logan Adaptive Management Plan for Middle Bear River and Cutler Reservoir TMDLs’ as an appendix to this document to demonstrate that through cooperative efforts there is a reasonable assurance that the TMDL endpoints will be achieved. However, permit compliance schedules will be established during the permitting process and may not concur with the timelines provided in the Adaptive Management Plan.

City of Logan

Adaptive Management Plan for Middle Bear River and Cutler Reservoir TMDLs

August 2009

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1 Introduction

The Utah Department of Environmental Quality (DEQ) has prepared a total maximum daily load (TMDL) for dissolved oxygen and total phosphorus in the Middle Bear River and Cutler Reservoir (DEQ, 2009). The Division of Water Quality and City of Logan have developed an adaptive management plan for the TMDL. The Division of Water Quality objectives are to complete the TMDL and initiate progress in reducing phosphorus loadings. The goals of the City of Logan are to develop a phased wastewater program that is affordable and meets the City of Logan's needs for providing long-term wastewater service. The TMDL adaptive management plan is designed to reflect the City of Logan's planned implementation activities based on near-term and long-term wastewater program needs.

Implementation of the required phosphorus reductions to Cutler Reservoir will be technically challenging and require substantial monetary investment. An adaptive management plan will provide a pathway forward for the City of Logan to address the TMDL and formulate a wastewater treatment and effluent management plan. Phased phosphorus reduction, or adaptive management, will allow the City of Logan time to modify wastewater management facilities and further assess and understand water quality and fishery conditions in Cutler Reservoir.

While the City of Logan undertakes this adaptive management plan with actions it can either directly undertake or indirectly support or assist with initiation, it is hoped that adaptive management is adopted for the watershed and includes a range of phosphorus load reduction activities undertaken by all stakeholders. The City of Logan recommends continued water quality monitoring and studies to determine the effects of the TMDL, understand the contributing factors, and improve the quantification of loadings to Cutler Reservoir and the associated tributaries. Additionally, the effects of the approved tributary TMDLs for Spring Creek, Little Bear River, Newton Creek, and Bear River upstream of the Utah/Idaho Stateline should also be considered in the long-term goals of water quality improvement. As part of the adaptive management, point source and nonpoint source delineation should be refined and efforts made to determine what additional water quality limits are needed after the studies are completed and new information is collected about Cutler Reservoir water quality. While the City of Logan implements this adaptive management plan, nonpoint sources will also have to implement water quality best management practices (BMPs) to improve water quality of the reservoir.

2 Approach

The City of Logan plans to make substantial commitments to the implementation of the TMDL as summarized in the following:

- The City of Logan plans to work together with the DEQ to implement the TMDL requirements for the City.
- The City of Logan plans to implement all TMDL requirements by the end of ten years.
- The City of Logan will participate in the development of the further studies needed to collect the additional information required to develop an attainable and maintainable TMDL.
- The City of Logan plans to participate in the monitoring and data collection process, data validation, data analysis, data interpretation, and completion of further studies.
- The City of Logan understands that data collection will include a period of time before and after the first phase of the TMDL implementation and may take several years.
- The City of Logan plans to fund additional studies and work based on the results of the studies.

The City of Logan intends to implement, support, and consider a variety of phosphorus reduction activities during the next ten years based on the effectiveness of implemented phosphorus reductions, costs, and overall strategy to apply an adaptive management approach and achieve progress.

3 Phosphorus Management Strategy and Implementation

DEQ has prepared the *Middle Bear River and Cutler Reservoir TMDLs* (DEQ, 2009) which it plans to submit to the Environmental Protection Agency (EPA) for approval. The City of Logan completed a review of the TMDL and requested that DEQ include an adaptive management plan as an implementation strategy to provide a path forward for meeting the City of Logan's wasteload allocation (WLA) while protecting water quality.

TMDLs categorize pollutant sources into point sources and nonpoint sources. Point source implementation involves permitted facilities reaching certain pollutant load reductions, WLAs, through actions managed by the National Pollutant Discharge Elimination System (NPDES). The City of Logan seeks to use this adaptive management plan to work towards meeting the TMDL and potential future water quality based effluent limits in the next NPDES permit.

Table 1 summarizes the Southern Reservoir total phosphorus loadings by area with the TMDL allocation and percent reduction in loading required by the TMDL. Swift Slough includes the City of Logan wastewater discharge. Table 2 summarizes the Northern Reservoir total phosphorus loadings, allocated load and percent reductions in loading required by the TMDL. Table 3 presents the City of Logan phosphorus wasteload allocation from the TMDL. The wasteload allocation includes both winter and summer phosphorous allocations. The TMDL includes a summary of data gaps that are shown in Table 4.

Table 1. Southern Reservoir Annual Phosphorus Loads and Reduction Required

Southern Reservoir				
Area	Loading Type	TP Loading (kg TP/year)	TMDL Allocated Load (kg TP/year)	Reduction
Little Bear River	Point Source	1,050		
	Non-Point Source	6,980		
	Total	8,030	3,285	59%
Spring Creek	Point Source	23,818		
	Non-Point Source	3,313		
	Total	27,131	5,998	78%
Logan River	Point Source	0	0	
	Non-Point Source	5,642	2,256	
	Total	5,642	2,256	60%
Swift Slough	Point Source (including City of Logan Regional Wastewater Treatment Plant)	32,832	15,499	53%
	Non-Point Source	4,061	1,930	52%
	Total	36,893	17,429	53%
Direct Drainage to Southern Reservoir	Point Source	37	16	57%
	Non-Point Source	23,764	9,712	59%
	Total	23,801	9,728	59%
Internal and Unknown Loading	Summer	14,781	5,649	62%
	Winter	11,466	4,435	61%
	Total	26,247	10,084	62%
Totals	Total Point	57,737		
	Total Non-Point	43,760		
	Total	127,744	48,114	62%

Table 2. Northern Reservoir Annual Phosphorus Loads and Reduction Required

Northern Reservoir				
Area	Loading Type	TP Loading (kg TP/year)	TMDL Allocated Load (kg TP/year)	Reduction
Clay Slough	Point Source	0	0	0%
	Non-Point Source	8,864	5,281	40%
	Total	8,864	5,281	40%
Middle Bear River	Point Source	0		
	Non-Point Source	48,203		
	Total	48,203		
Bear River	From Idaho	35,665	35,665	0%
	Cub River	7,207	3,285	54%
	Total	42,872	38,950	9%
Newton Creek	Point Source	0	0	0%
	Non-Point Source	4,603	81	98%
	Total	4,603	81	98%
Direct Drainage to Northern Reservoir	Point Source	0	0	0%
	Non-Point Source	8,867	4,645	48%
	Total	8,867	4,645	48%
Internal and Unknown Loading	Summer	18,513		
	Winter	8,595		
	Total	27,108		
Totals	Total Point	35,665		
	Total Non-Point	77,744		
	From the Southern Reservoir	127,744		
	Total	241,153		

Table 3. City of Logan TMDL Phosphorus Wasteload Allocation

Facility	Current Load (kg/season)	TMDL Allocated Load (kg/season)	Load Reduction (kg/season)	Percent Reduction
Logan WWTP	11,236 (summer) 21,597 (winter)	4,294 (summer) 11,205 (winter)	6,942 (summer) 10,392 (winter)	62 (summer) 48 (winter)

Table 4. Data Gaps Identified in the Cutler Reservoir Watershed TMDL

Data Gap	Description	Proposed Mechanism to Address/Accommodate Gap
Lack of measured flow data	Flow data are lacking for tributaries and reservoir canal outflow.	A combination of surface flow information identified by the UDWR in the Bear River Basin Water Plan (January 2004), measured flow data from tributary and reservoir systems (DEQ and PacifiCorp Energy), and estimates of groundwater infiltration (Utah GS and USGS) have been assessed collectively and applied to calculation of annual inflow volumes and a generalized water budget for the reservoir. Outflow will be estimated through gauged dam release and irrigation records for the canal.
Lack of water quality monitoring in reservoir canal outflow	Few water quality data are available for the reservoir canal outflow, with the exception of a limited suite of samples collected during the summers of 2004–2005.	The current suite of data, along with model output for the location immediately upstream of the dam (if modeling software is approved by DEQ), will be used to determine the canal outflow component of reservoir loading. Canal volumes available from the irrigation records will be used to populate the model boundary conditions for the summer irrigation season. Conservative assumptions will be applied in the calculation of loading to minimize error. An appropriate margin of safety (MOS) will be applied.
Lack of diurnal DO data	Grab-samples do not represent the critical period for DO excursions	Additional, continuous (diurnal) data for several locations in Cutler Reservoir and the inflowing tributaries better characterize DO conditions in the reservoir and support of the designated warm water game fishery.
Lack of diurnal temperature data	Grab-samples cannot be assumed to represent the critical period for temperature excursions	Additional, continuous (diurnal) data were collected for several locations in Cutler Reservoir and the inflowing tributaries to better characterize temperature conditions in the reservoir and support of the designated warm water game fishery.
Lack of comprehensive fisheries data	Essentially no current or recent fisheries data exist for Cutler Reservoir or Middle Bear River. Legacy data are very sparse.	Biologists at the USU Fish Ecology Lab were contracted to provide a fisheries study for Cutler Reservoir in 2005–2006. The report summarizes species diversity, recruitment, and fishery health at several locations in the reservoir (Budy et al. 2007).
Lack of information on the perceived support status of recreation uses on Cutler Reservoir	As recreational uses are dependant on public perception of water quality and aesthetics, an assessment of public opinion was requested by the TAC for the TMDL.	A public survey of perceived existing conditions and the influence of water quality conditions on existing use levels was conducted at four stations around the reservoir and on 09/03/05 and 10/01/05. Additionally, more comprehensive recreational survey data (2002) available from PacifiCorp Energy were identified and incorporated into the TMDL process.
Lack of information on wetland functional status	Properly functioning wetlands are critical to the support of the waterfowl, shorebirds, and associated food chains (3D) DBU. Data for in-depth evaluation of wetland	Using a modified hydrogeomorphic model, SWCA will perform a functional assessment on wetlands within the project area. Functions to be evaluated include hydrology, water treatment, and wildlife habitat. Examples of variables included in this assessment include land use, vegetation, and hydrologic modification.

	functional condition were not available at the initiation of the TMDL effort and were identified as a critical data gap by the TAC for the TMDL.	
Lack of information on impacts of eutrophic conditions on avian uses of reservoir	Cutler Reservoir is recognized as an IBA by the National Audubon Society. Migratory and resident bird populations depend on Cutler Reservoir for nesting habitat and feeding. Data on changes in nesting habitat and avian food chains related to eutrophication in Cutler Reservoir were identified as a critical data gap by the TAC for the TMDL.	The dietary requirements of birds observed around Cutler Reservoir were summarized using species specific information available in the Birds of North America monographs. Components of the food chain known to be impacted by eutrophication were compared to the list of food items required by birds at Cutler Reservoir. A limited benthic macroinvertebrate dataset was obtained from Wayne Wurtsbaugh at USU to supplement the literature review of avian food chains.

The City of Logan will investigate and implement a variety of projects to reach the wasteload reduction target. Completion of these projects may begin as a result of increased awareness of water quality problems as an outcome of the TMDL development and its associated outreach and education. Operational changes to reduce phosphorus loadings, such as modified wastewater effluent management plans, may be implemented early in the adaptive management program with modest capital investments. Treatment studies and pilot testing may provide the foundation for implementation of new technologies that require longer periods of time for construction and greater capital investment.

The City of Logan has categorized the efforts necessary to reduce phosphorus loads into three areas:

- Supporting phosphorus reduction activities
- Phosphorus load reduction activities
- Wastewater treatment and effluent management

Supporting activities are those that do not directly result in a reduction in phosphorus loads but are required to be able to monitor flows and phosphorus loadings, perform analytical assessments of conditions, track the implementation of actions and the results, and adapt actions to most efficiently reduce phosphorus. Phosphorus load reduction activities include management efforts to reduce the phosphorus loads that enter the City of Logan sewer system and add to the load that needs to be treated at the City of Logan Regional Wastewater Treatment Plan (RWWTP). Activities to reduce phosphorus include actions as the wastewater treatment facility and management of effluent through wetlands treatment, agricultural recycling, and reuse.

The proposed activities under the three categories are summarized in the schedule presented in Figure 1 over a ten year period. Each activity has a targeted time frame beginning with initiation of the analysis. Multi-year efforts extend through the entire schedule. Early analytical activities link to subsequent steps for pilot testing, preliminary design, detailed design, and facility construction. Implementation of some activities will be predicated by available funding. Phosphorus reduction efforts that are distinctly effective can be accelerated for earlier implementation. Activities will be eliminated from the program and replaced with more cost effective activities if they are found to be of limited effectiveness or inordinately expensive.

The proposed activities are described in the following sections of this adaptive management plan. A summary of each activity, a preliminary cost estimate, schedule, and identification of the lead agency is presented for each planned effort. The budget information presented is a preliminary estimate of the range of potential costs to accomplish an activity. The funding requirements are not the exclusive responsibility of the City of Logan and the City plans to collaborate with other agencies and to seek outside funding support, including federal and state grants and loans. Actual costs of activities may vary and if possible, be reduced, by more efficient efforts and by combinations with other existing and future programs. The identified lead agencies will work together to identify roles and responsibilities to participate in the activity during the early period of the schedule, prepare work plans to document the specifics of the activity, refine estimates of phosphorus load reductions and cost estimates, and pursue sources of funding. For the schedule, ongoing activities may have more activity initially and then be followed by review or sustaining efforts in the years that follow.

Figure 1. Adaptive Management Plan Implementation Schedule

Activity	Title	Responsible Entity	Schedule Year (shading indicates relative intensity of activity)											Progress Tracking[a]
			2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	
	Supporting Phosphorus Reduction Activities													
SPR-1	Flow and Load Monitoring	City of Logan, DEQ, NRCS, USU												Annually
SPR-2	Water Quality Monitoring	City of Logan, DEQ, NRCS, USU												Annually
SPR-3	Phosphorus Source Identification	City of Logan												Annually
SPR-4	Analytical Tools	City of Logan, DEQ												Annually
SPR-5	Data Assessment, Implementation and TMDL Adjustments	City of Logan, DEQ												Annually
SPR-6	Implement and Maintain Project Tracking Database	City of Logan												Annually
SPR-7	Develop Cutler Reservoir Phosphorus Exchange	DEQ												Biannually
	Phosphorus Load Reduction Activities													
PLR-1	Public Education and Outreach Programs	DEQ, USU, County, Cities												Biannually
PLR-2	Limitations on Phosphate Dishwashing and Detergent Products	Cache County, City of Logan												Biannually
PLR-3	Residential Fertilizer Management	DEQ, USU, County, Cities												Biannually
PLR-4	Effluent Land Application Fertilizer Management	Logan, NRCS, Conservation Dist.												Biannually
PLR-5	Effluent Land Application Deficit Irrigation	NRCS, Conservation Dist.												Biannually
PLR-6	Municipal Stormwater Management	City of Logan												Annually
PLR-7	Stormwater Management Public Education	City of Logan												Annually
PLR-8	Construction Site Stormwater Runoff Technical Assistance Program	DEQ, City of Logan												Biannually
PLR-9	Stormwater Monitoring	City of Logan												Biannually
PLR-10	Septic System Management and Phosphorus Loading	City of Logan, Cache County, USU												Biannually
PLR-11	Industrial Pretreatment	City of Logan, Industries												Biannually
PLR-12	Service Agreements and Loads from Nearby Communities	City of Logan, Communities												Biannually
	Wastewater Treatment and Effluent Management Activities													
WWT-1	Treatment Technology Evaluation and Pilot Studies	City of Logan, DEQ												Annually
WWT-2	Review Lagoon Operations	City of Logan												Annually
WWT-3	Review Wetlands Efficiency and Monitoring	Rocky Mountain Power, Bridgerland Audubon Society, Logan, DEQ												Annually
WWT-4	Land Application to Local Agricultural Fields	Logan, DEQ, NRCS, USU												Annually
WWT-5	Review Irrigation of Dry Land Farming	City of Logan												Biannually
WWT-6	Reclaimed Water Reuse Opportunities	City of Logan												Biannually
WWT-7	Prepare Wastewater Master Plan	City of Logan												Annually
WWT-8	Pre-Design and Detailed Design of Treatment Improvements	City of Logan												Annually
WWT-9	Construct Wastewater Treatment Improvements	City of Logan												Annually

[a] Biannually is every 2 years

3.1 Supporting Phosphorus Reduction Activities

There are supporting activities to be undertaken as part of the adaptive management plan in addition to those activities designed to provide a direct phosphorus reduction. These supporting activities, while not having a specific phosphorus reduction value, are tangible TMDL activities. These activities include monitoring and data collection, data assessment, analytical tools, and adaptive management. Understanding and quantifying phosphorus reductions as activities are implemented will be critical to measuring progress and success.

The phased approached includes these activities, many of which are to be initiated early in the adaptive management program. The adaptive management strategy also relies on many of these activities. The adaptive management approach will be supported by, but not limited to, data collection and analysis that assists with determining the most effective ways to comply with water quality standards.

3.1.1 Wastewater Flow and Load Monitoring

Information about wastewater flows and loadings is important to assessing the water quality conditions. Influent wastewater management activities may need measurements of flows to isolate areas and quantify phosphorus loads from specific areas and/or sources. Effluent management activities will need measurements of flow at currently unmeasured diversion points and will be important to quantifying and tracking phosphorus loads to Cutler Reservoir. Measurements at Outfalls 001, 001B, and 002 will be continued to ensure continuity of data (Figure 2). Measurements may need to be continuous or timed with water quality sampling events. Wastewater flow measurements will be coordinated with water quality monitoring efforts in the Cutler Reservoir watershed.

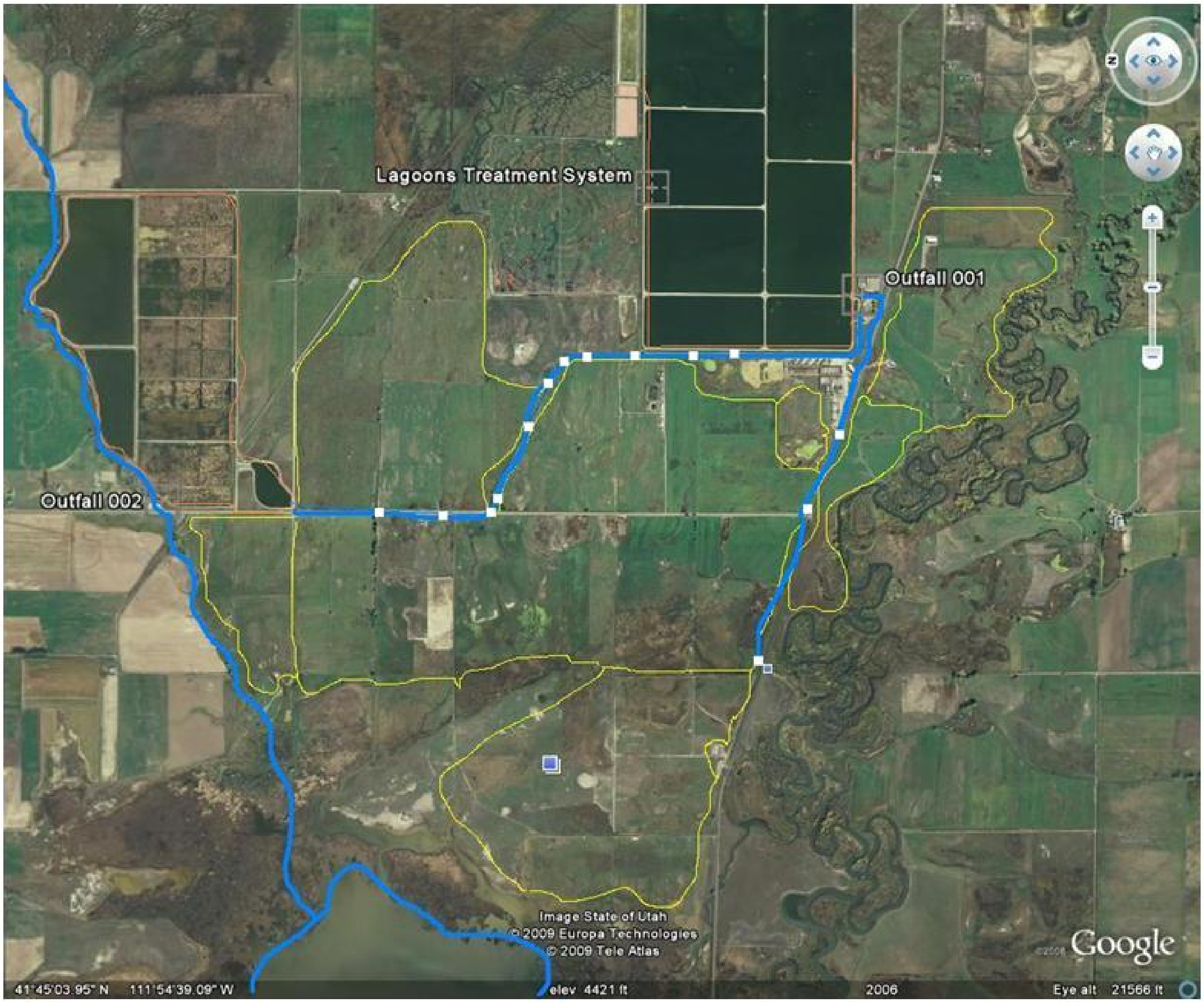

Figure 2. Existing Effluent Outfalls

3.1.1.1 Flow and Total Phosphorus Data Summary

Observed wastewater flow and total phosphorus (TP) data are shown in Figure 3 and Figure 4. Flow data available include inflow to the lagoons (HW Influent), discharge of the lagoons (Outfall 001), discharge from the wetlands to Swift Slough (Outfall 002) and a diversion to the south then northwest that is rarely used (Outfall 001B). In addition, a calculated diversion to the west and then north to treatment wetlands (Outfall 001A) is included in Figure 4. Similarly, the total phosphorus data illustrated in Figure 4 include the HW Influent, Outfall 001 and Outfall 002. The data are limited in both frequency and timeframe and do not include information regarding diversions for land application or seepage.

3.1.1.2 Data Gaps

Flow and total phosphorus data have been analyzed and Figure 3 and Figure 4 show that more data are needed to accurately model and understand the system. The discussion that follows describes the lack of measured flow and total phosphorus data and options for filling these data gaps.

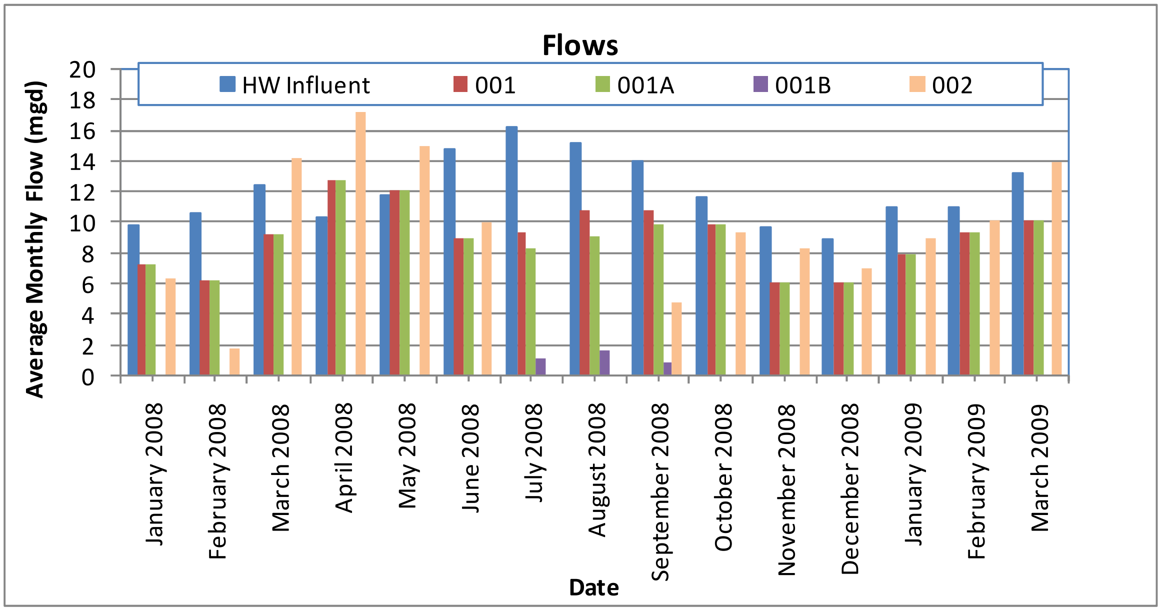

Figure 3. Average Monthly Influent Wastewater and Effluent Flows (mgd)

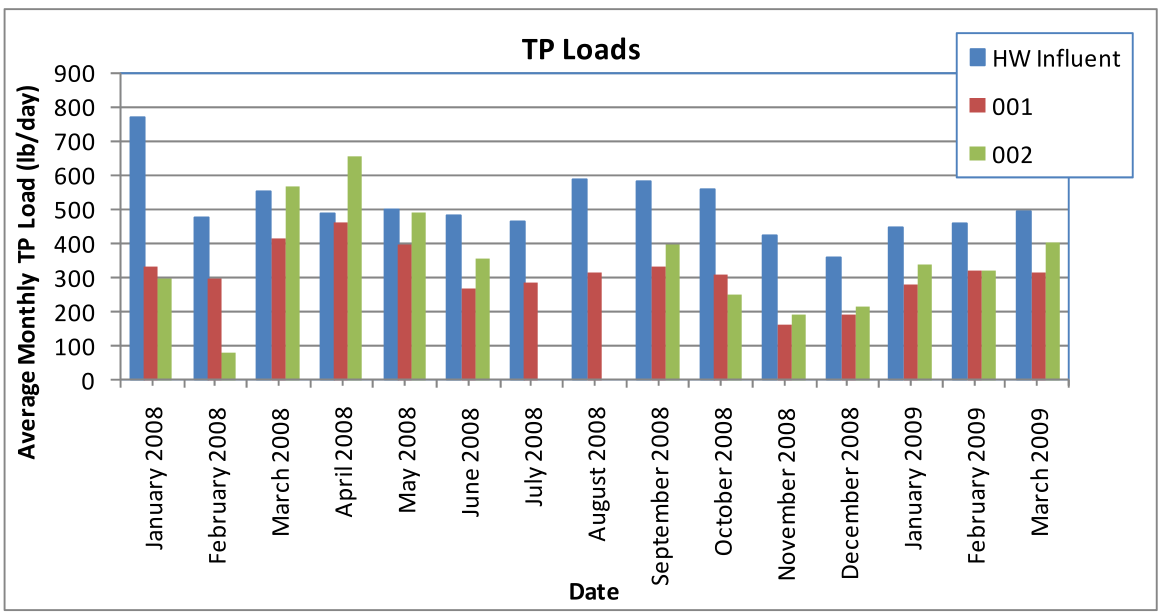

Figure 4. Average Monthly Influent and Effluent Phosphorus Load (lb/day)

There are 11 or more diversion points along the north canal between Outfall 001A and 002, and there are three or more diversion points along the south canal below Outfall 001B (Figure 2). These diversion points have gates to control the diversion. Records of the diverted flows would be useful for quantifying the loads diverted to land application and estimating seepage losses along the canal.

Measuring water in the effluent surface irrigation systems is critical for peak efficiency management. Without knowing the amount of water being applied, it is difficult to make decisions on when to stop irrigating or when to irrigate next. Irrigation managers should know the flow rate of the irrigation water, the total time of the irrigation event and the acreage irrigated to attain peak efficiency. From this, the total amount of water applied can be determined, which will help determine whether the irrigation was adequate and when the next irrigation should occur. Irrigation management decisions should be made based on the amount of water applied and how this relates to the consumptive use demands of the plants and the soil water holding capacity.

Measurement of the diverted water should also occur to track the volume of water use, as most of the flow has water rights claims. Water rights complicate the ability to change water use patterns unless excess water is being diverted. Flow measurement will provide a record of actual usage.

At a minimum, effluent flow monitoring should occur in two places: flow to the canal and flow from the canals. During the irrigation season a significant portion of the RWWTP effluent discharge is diverted to agricultural recycling. The remainder of the effluent is discharged to the treatment wetlands and then Swift Slough.

There are a number of methods available for measuring water flow in irrigation canals and ditches. The following is a summary of various techniques:

The Float Method: This method is useful to get a rough estimate of flow. Float an object (tennis balls, apples, oranges, etc.) over a known distance with a known cross sectional area to obtain a rough estimate of flow.

Tracer Method: This method is very similar to the float method but with one exception, a colored dye or salt is used instead of a float.

Velocity Head Rod: The velocity head rod is used to measure the velocity of water in a ditch and is relatively inexpensive and fairly accurate. The rod is in actuality a ruler used to measure the depth of the water. The water height is first measured with the sharp edge of the ruler parallel with the flow and the again with the ruler turned 90 degrees. The difference in the height of water is the head differential. With this information an estimate of the velocity can be made.

Weirs: There are several different types of weirs that can be constructed and used to accurately determine the flow rate in a ditch or stream by measuring the height of the water over the weir.

Other Methods: There are several other methods available and many devices that can be purchased "off the shelf." One is a current meter, which is a propeller meter that is lowered into the stream of water and records velocity. There are flumes, submerged orifices and acoustic ultrasonic meters that use ultrasonic pulses to measure the velocity of the flow stream. All of these methods have limits to their use and associated costs.

Proposed wastewater flow monitoring activities to support the TMDL implementation include:

Activity: Continue flow measurement at outfalls
Cost Estimate: $5,000 to $10,000
Schedule: 2009 through 2019
Lead Agencies: City of Logan and Utah State University

Activity: Flow measurement of effluent flows to agricultural land
Cost Estimate: $5,000 to $10,000
Schedule: 2009 through 2019
Lead Agencies: DEQ and NRCS

3.1.2 Water Quality Monitoring

Water quality will be tracked through ambient monitoring and targeted phosphorus source identification. Identification of potential sources and monitoring of water quality will be instrumental to the success of the adaptive management plan. Monitoring is needed during all phases of the TMDL to identify the location of water quality impacts, contributing sources, and to verify that corrective actions have been and remain effective. Two types of water quality monitoring are needed to implement the water quality implementation: source detection monitoring and effectiveness monitoring.

Source detection monitoring is used to pinpoint location and relative severity of suspected phosphorus sources. It will allow the City of Logan to focus implementation resources where they are needed most. Source detection monitoring is used when phosphorus sources are not obvious and additional data is needed to track down the unknown or suspected causes. When high phosphorus levels are observed, additional sampling can help to track the source down to a discrete geographic area.

3.1.2.1 Improved Phosphorus Monitoring

Future monitoring and data collection will be necessary to assess changes in water quality conditions. New water quality data gathered in the course of the adaptive management plan will provide the necessary information for prioritizing and selecting the activities to implement, and determine whether changes to the TMDL are warranted. The City of Logan will monitor the performance of these activities and will review progress at least annually, as well as prior to critical changes to ongoing and new activities. Monitoring locations should be added where activities are implemented to be able to evaluate the success and reduction in total phosphorus from that activity. The identification of new locations for monitoring will also be based on field observations, previous data, and effectiveness monitoring.

As data are collected, the data will be maintained in a database for long-term recovery and analytical use. The City of Logan's Environmental Department will maintain the data. Depending on funding source requirements, the City of Logan may provide the data for DEQ's environmental database. The new data should be assessed annually, at a minimum, for specific implementation activities, to evaluate progress, and make adaptive management decisions.

Proposed water quality monitoring activities to support the TMDL implementation include:

Activity: Identify locations for water quality monitoring and establish sampling locations, determine sampling frequency, perform sampling and track and record results
Cost Estimate: $100,000 to $125,000
Schedule: 2009 through 2019
Lead Agencies: City of Logan

Activity: Continued and enhanced TDML water quality monitoring
Cost Estimate: Unknown
Schedule: 2009 through 2019
Lead Agencies: DEQ

3.1.3 Identification of Phosphorus Sources

The City of Logan will actively seek to further identify and define sources of phosphorus listed in this adaptive management plan and seek out additional unknown and unexpected phosphorus sources that may be contributing to the City of Logan's total phosphorus load and other Cutler Reservoir surface water loadings. City agencies will coordinate efforts that may lead to further identification of sources to capture the full range of potential sources. Members of the City of Logan staff have an extensive knowledge of water resources and flow patterns throughout the city. However, they may not have considered the potential phosphorus load associated with these flows or how these flows may eventually flow into and impact Cutler Reservoir. Coordination and communication between staff will likely result in some new insights on phosphorus sources.

The City of Logan will also research trends and phosphorus source identification programs of other communities facing similar TMDLs and requirements to reduce phosphorus. The City of Logan can leverage the findings of other communities to make sound decisions about reduction activities. Using the lessons learned from previous efforts to reduce phosphorus will be very helpful in continuing to define the City of Logan's strategy.

Proposed phosphorus source identification activities to support the TMDL implementation include:

Activity: Coordination, research, and identification of phosphorus sources
Cost Estimate: $5,000 to $10,000
Schedule: 2009 through 2019
Lead Agencies: City of Logan

3.1.4 Analytical Tools

The City of Logan and DEQ may use a variety of analytical tools to support the activities within this plan and to assess the performance of these activities. Additionally, the tools used to develop the TMDL were an important component of the process of assessing the data and determining the load reductions. Since the tools used are an important component of the subsequent conclusions, an evaluation of the usefulness of available tools as part of the adaptive management phase is warranted.

Some analytical tools include water quality models. Further refinement of the BATHTUB model that was used in the TMDL, or investigation of other more powerful water quality models is an option. A more thorough understanding of the dynamics of Cutler Reservoir, including internal nutrient cycling and response to proposed changes in the watershed, could aid management activities. Creating a water quality analytical tool to assess reservoir response to BMPs could aid in assessing the effectiveness of the adaptive management plan.

Another analytical tool that may merit further consideration for assessing effluent land application recycling is CROPSIM. CROPSIM can aid in irrigation analysis by predicting crop water usage and nutrient uptake.

Proposed activities to consider analytical tools for supporting TMDL implementation include:

Activity: Identify and use of analytical to support adaptive management activities. Consider performing an evaluation of available water quality analytical tools and applicability
Cost Estimate: $5,000 to $10,000
Schedule: 2010
Lead Agencies: City of Logan and DEQ

3.1.5 Data Assessment, Implementation and TMDL Adjustments

During the course of implementation, true adaptive management requires adjustments to the implementation plan and potentially the TMDL, as new information is gathered and the understanding of system responses and cause and effect relationships improve. Instituting a framework that allows these adjustments as recommendations become apparent is important to effectively selecting the most appropriate and cost effective implementation activities to reduce or eliminate water quality numeric criteria exceedances. Developing a framework with a viable schedule for collecting and assessing the necessary information to evaluate water quality improvements, along with a method to revise forward looking plans relative to the end goal are critical to having a complete adaptive management plan. Adaptive management is the process by which strategies can be changed if it is determined that the implementation approach currently in place is not meeting water quality goals set forth in the TMDL.

Natural systems are complex and dynamic. Watershed response to human management activities is often unknown and may be described by probabilities or possibilities. Adaptive management involves testing, monitoring, evaluating applied strategies, and incorporating new knowledge into management approaches that are based on scientific findings. In the case of a TMDL, adaptive management is used to assess whether the actions identified as necessary to solve the identified pollution problems are the correct ones and whether they are working. As actions are implemented, the system will respond, and it will also change. Adaptive management allows for actions to be fine-tuned to make them more effective, and to try new strategies if there is evidence that a new approach could achieve compliance more efficiently or effectively.

If implementation activities are not producing expected or required results, the City of Logan may choose to conduct additional studies to identify the significant sources of total phosphorus. If the causes can be determined, implementation of additional or alternative activities will be taken. However, if some unforeseen event affects the landscape, the timelines to meet the load allocations in the TMDL may need modification.

Selection of implementation activities is partially dependent on knowledge of the effectiveness of the activity taken. The appropriate QA/QC will be followed as a part of the monitoring plans to demonstrate that the data collected meet water quality standards for use in TMDL review, validation, and implementation adaptive management.

The City of Logan will generate an annual report of activities, track progress, and report data results. The report will provide something like a scorecard or report card to monitor the adaptive management plan. The City of Logan will meet with DEQ to review the results annually.

Proposed activities related to data assessment, review, and updates to the plan include:

Activity: Develop the framework for integrating and updating the implementation plan and TMDL with the results from future data collection and assessment
Cost Estimate: $15,000 to $25,000
Schedule: 2009 through 2019
Lead Agencies: City of Logan, DEQ

3.1.6 Implement and Maintain Project Tracking Database

Incorporating all water quality improvement efforts in the watershed, especially those by the City of Logan, into a comprehensive project tracking database linked with GIS would provide a useful and appropriate tool for TMDL implementation management. Water quality improvement activities and BMPs will likely have a spatial component to link with a GIS database that can also incorporate information on lead agency, funding source, estimated cost, removal efficiency, year implemented or constructed, etc.

Proposed activities for the development of a phosphorus exchange include:

Activity: Develop a project tracking database tool
Cost Estimate: $10,000 to $50,000
Schedule: Initiate in 2010 and sustain.
Lead Agency: City of Logan

3.1.7 Develop Cutler Reservoir Phosphorus Exchange

Develop a phosphorus exchange program that allows total phosphorus loadings to Cutler Reservoir to be reduced by off-sets or trades between point sources and nonpoint sources. The objective of the exchange is to provide a flexible way to achieve Cutler Reservoir water quality goals in the most cost effective manner. Dischargers may choose to achieve compliance with their WLA by implementing treatment technology, by exchanging a phosphorus load reduction with another point source discharger (water quality offset), by exchanging a phosphorus load reduction from a nonpoint source (water quality offset), or all of these methods. The initial WLA will be based on the TMDL and will be tracked and adjusted as appropriate based on the on-going monitoring effort in the adaptive management plan. Equivalency between loadings will be based on the framework developed as part of the phosphorus exchange.

Proposed activities for the development of a phosphorus exchange include:

Activity: Formulate a phosphorus exchange program to facilitate load reductions in a flexible and cost effective manner
Cost Estimate: $50,000 to $100,000
Schedule: 2011 through 2019. Initiate in conjunction with updated water quality analysis for Cutler Reservoir and sustain the program if benefits are provided to stakeholders
Lead Agency: DEQ

3.2 Phosphorus Load Reduction Activities

Sources of phosphorus loading to Cutler Reservoir identified in the TMDL include sources that directly or indirectly affect the quality of the influent flow to the wastewater lagoon system or other flow from the city that ultimately reach Cutler Reservoir. The influent management portion of this plan deals with reducing phosphorus loading to the wastewater treatment lagoon influent, stormwater from developed areas, and loading from agricultural lands that receive the effluent from the lagoon system.

Reducing nonpoint sources will be implemented adaptively. Monitoring and quantification of nonpoint source loadings will be conducted to provide a baseline. Concurrently, proposed actions should focus on those that are most likely to have the most significant load reductions first. As the results of the proposed monitoring and quantification of sources become available, the information will be used to target the next highest priority source control activities. Once actions have been implemented, their effectiveness will be monitored, and will provide feedback for the next round of actions. The adaptive management strategy proposed here also allows for voluntary actions to be implemented while ordinance changes are adopted.

3.2.1 Public Education and Outreach Programs

Potential phosphorous reductions are likely to be realized through voluntary actions and BMPs on the part of many citizens living in the watershed. For success to occur on voluntary actions, a robust public education and outreach program that addresses sources of phosphorus in the watershed is essential. The initial effort will be to identify and quantify potential phosphorous reductions and then tailor the public education and outreach program to focus on the most effective areas to provide load reductions. Examples of potential practices that may require education and outreach are:

- Solicitation of support for the adoption of a limit on phosphorus in dishwashing and laundry detergents.
- Fertilizer management in residential yards and gardens, hobby farms, city parks, and business owned landscapes.
- Appropriate management of pet waste (i.e., "scoop the poop").
- Reduction of phosphorus from car washing practices (i.e., wash over the lawn, use a car wash that captures and recycles wash water, use low phosphorus detergents for fundraising car washes).
- Technical assistance through farm plans and BMPs for hobby farms.

Many of these outreach campaigns can also affect stormwater quality and may be incorporated into meeting the requirements of the Phase II Utah Pollutant Discharge Elimination System (UPDES) Stormwater General Permit for Discharge from Small Municipal Separate Storm Sewer Systems (MS4s). The City of Logan could partner with the other MS4 communities in the watershed, i.e., Smithfield and Hyrum. Further, many educational materials have been developed by states and other communities. For reference, the Washington State Department of Ecology has developed extensive outreach materials for stormwater protection. These are available for downloading from the following website: http://www.ecy.wa.gov/washington_waters//

Proposed public education and outreach programs as part of the TMDL implementation include:

Activity: Develop and implement education and outreach efforts that could include elements such as: adoption of phosphorus limitations for detergents, fertilizer application rates; low phosphorus detergents, scooping pet waste; effective maintenance of septic systems
Cost Estimate: $5,000 to $10,000
Schedule: 2009 through 2019
Lead Agencies: State of Utah with participation by the City of Logan and other MS4s in Cache Valley

3.2.2 Limitations on Phosphorus Dishwashing and Detergent Products

Source control programs target phosphorus reduction in wastewater, so there is less phosphorus that must be removed through biological and physical treatment processes. One example of phosphorus reduction through source control is from the area around Spokane, Washington. Spokane County has banned the sale of dishwashing detergents containing phosphorous. After eight months, the influent at Liberty Lake, one of the local wastewater facilities was reduced by an average of 12 percent (Kimberly, 2009). Recent studies indicate that each dishwasher generates wastewater phosphorus of 10.2 grams/week (Hanrahan and Winslow, 2004).

A ban or limitation on the phosphates in dishwashing detergent, as well as laundry detergent products, would reduce phosphate loading to the City of Logan wastewater lagoon system to an even greater extent than in the Spokane Valley in Washington. The total load of phosphorus removed from the influent to the wastewater lagoon system should be estimated to quantify the potential reduction to the Cutler Reservoir. Further phosphorus reductions could be realized if the limitation or ban were applied county-wide.

Proposed activities related to phosphorus in dishwashing and detergent products include:

Activity: Estimate the potential phosphorus loading reductions from a ban or limitation on phosphorus in detergents. Develop an ordinance banning or limiting the phosphate concentrations in dishwashing detergents and laundry detergents. This would be more effective if conducted county-wide
Cost Estimate: $10,000 to $35,000
Schedule: 2011 through 2012; Estimate of potential load reduction
Lead Agencies: Cache County with participation by the City of Logan

3.2.3 Fertilizer Management

The 30 percent population increase in the watershed between 1990 and 2000 cited in the TMDL (DEQ, 2009) and the continuing growth within city limits will increase the potential for sediment and associated nutrient loads to enter surface water. Stormwater runoff from fertilized lawns and gardens can add to the nutrient loading of the reservoir.

3.2.3.1 Residential Fertilizer Management

Lawn fertilizer restrictions are often considered in watersheds sensitive to nutrient enrichment. Residential fertilizers are frequently over applied. In addition, established lawns generally do not require phosphorus in fertilizer. Some states, cities, and watersheds have even taken steps to ban phosphorous in lawn fertilizer. Overland flow from stormwater runoff can either infiltrate to the groundwater or can flow to the nearest surface water body. This runoff can be laden with high concentrations of nutrients (both phosphorus and nitrogen) accumulated by flowing over fertilized lawns and fields.

To manage this activity adaptively, the program could be phased beginning with a quantification of the potential phosphorus reduction, an education campaign and voluntary program that includes incentives for use reduction, followed by ordinance development and implementation of a program addressing lawn applications of fertilizers for established lawns.

Proposed activities related to management of phosphorus from residential fertilizer include:

Activity: Develop an education and voluntary BMP incentive program to eliminate use of phosphorus fertilizers on established lawns. Assess the program. Develop and implement ordinances addressing applications of fertilizers for established lawns. Such a ban would require public outreach and community-based marketing
Cost Estimate: $2,500 to $5,000
Schedule: 2011 through 2012
Lead Agencies: DEQ, USU, Cache County with participation by the City of Logan

3.2.3.2 Effluent Land Application Agricultural Fertilizer Management

Impacts from agriculture within the watershed are outside of the purview of the City of Logan; however the City of Logan's wastewater effluent is being used to irrigate agricultural lands and is part of the phosphorus loading. While the City of Logan has little control due to water rights issues, land application of wastewater is needs phosphorus management. The City of Logan will participate with agencies that can tackle these flow and phosphorus management issues. Where agricultural lands are receiving treated effluent to irrigate fields, the return flow (either direct or through shallow subsurface flow) can leach a substantial load of phosphorus if the loading from the wastewater plus applied fertilizers totals more than crop needs.

An element of a fertilizer management program could include fertilizer reductions by those farmers receiving lagoon effluent for irrigation water. This program element would also require an adaptive management approach with the following steps:

- Quantify the phosphorus loading the farmers receive in the lagoon effluent, the phosphorus concentrations in the soils, applied fertilizers, and identify the crop needs.

- Work with the local NRCS and Conservation District offices to identify appropriate phosphorus concentrations for crops.
- Educate the farmers about the most applicable BMPs to reduce phosphorus applications to meet (and not exceed) the crop needs on the farmlands.
- Solicit volunteers to implement the BMPs using an incentives program.
- Require BMP implementation for all irrigators receiving lagoon effluent.

Control and management of fertilization may also consider fertigation. According to the Utah Fertilizer Guide, fertigation is the addition of liquid fertilizer into irrigation water; the fertilizer is then distributed on the field with the water. Fertigation is not generally recommended as a method of satisfying all of the fertilization needs, but it is used as a supplemental method in special circumstances.

Fertigation is an option for treating soil fertility deficiencies caused from inadvertent under-fertilization at the beginning of the season. It can also be used beneficially on fall-planted small grains where leaching of fertilizer during the winter makes it uneconomical to apply all the needed fertilizer to the crop in the fall. Fertigation is more common on sandy soils because it is difficult to avoid deep percolation and leaching losses on these types of soils.

The land manager desiring to apply fertilizer via the irrigation system should keep in mind that commercial sprinkle systems do not distribute water uniformly. In general, water application is heaviest near the nozzle, decreasing in a non-linear pattern to zero at the perimeter of the sprinkle circle. This feature is considered in the design of an overhead irrigation system. A certain amount of overlap between adjacent sprinklers is designed into the system to smooth out variations in the amount of water applied per unit area.

Fertigation via furrow-applied water is not recommended as a routine practice because of the risk of fertilizer loss in run-off water and because the application uniformity is very low. Loss of fertilizer in runoff water represents not only a direct economic loss to the farmer, but constitutes also an undesirable risk of environmental pollution. Water (and contained fertilizer) loss in furrow run-off water could be controlled by collecting water at the bottom of the field and recycling it back to the headlands by pumping. Whether or not recycling of water in this manner would be economically feasible would depend on the value of water (e.g. dollars per acre-foot) and the cost of installing the collection and redistribution system.

In summary, fertigation is a useful method of supplemental fertilization if it does not degrade the environment and the irrigation system is well managed to keep the applied fertilizer in the root zone to facilitate crop utilization.

USDA -Soil Conservation Service Economic Research Service-Forest Service in Cooperation with the States of Idaho, Utah, Wyoming, Irrigation Conveyance Systems, Working Paper for the Bear River Basin Type IV Study, Idaho-Utah-Wyoming, April 1976

Proposed effluent land application fertilizer management activities include:

Activity: Quantify the phosphorus loading to the corps and identify crop needs. Identify appropriate phosphorus concentrations for corps. Educate farmers about the most applicable BMPs to reduce phosphorus applications to meet the needs. Develop and implement voluntary BMP implementation program with incentives. Require BMP implementation for all farmers receiving lagoon effluent.
Cost Estimate: Quantify phosphorus loadings and crop needs - $10,000 - $20,000
Educate farmers about the most applicable BMPs - $15,000 - $20,000
Develop and implement voluntary BMP implementation - $15,000 - $20,000
Require BMP implementation for all farmers receiving lagoon effluent - $15,000 - $25,000
Schedule: Quantify phosphorus loadings and crop needs – 2012
Educate farmers about the most applicable BMPs - 2012
Develop and implement voluntary BMP implementation – 2013 and on-going
Require BMP implementation for all farmers receiving lagoon effluent - 2015
Lead Agencies: NRCS and Conservation District offices with participation by the City of Logan

3.2.3.3 Effluent Land Application Deficit Irrigation

The City of Logan and local NRCS office and or the Conservation District office could collaborate to assess the cost-effectiveness of deficit irrigation. This practice reduces the fertilizer applied to a crop to less than crop requires for maximum productivity. The break even point is determined when the reduced cost of fertilizer equals the reduce crop production income. NRCS may be able to leverage a grant for a pilot project with one or more of the farms receiving irrigation water from the lagoons.

Proposed effluent land application deficit irrigation activities include:

Activity: Assess cost-effectiveness of deficit irrigation. Identify potential funding for farms that want to pilot the concept. Implement pilot project and assess effectiveness
Cost Estimate: $15,000 to $25,000
Schedule: Assess cost-effectiveness of deficit irrigation – 2012. Identify potential funding and implement pilot project and assess effectiveness – 2014
Lead Agencies: NRCS and Conservation District offices with participation by the City of Logan

3.2.4 Municipal Stormwater Management

The TMDL notes that one of the significant sources of phosphorus loading in the Cutler Reservoir watershed is stormwater runoff from developed areas. According to JUB Engineers (2003), stormwater conveyance within the basin is very complex and there is currently no regional planning to address stormwater. However, it is reasonable to assume that stormwater and its associated nutrient load will ultimately reach the Cutler Reservoir. The TMDL estimates current loading from stormwater to be 0.41 kg TP/ha during the summer season and 0.60 kg TP/ha during the winter season (DEQ, 2009).

The City of Logan (as well as Smithfield, and Hyrum) has an MS4 system that discharges directly to surface waters and ultimately flows to Cutler Reservoir. Together, these three municipalities represent the majority of areas with urban land uses. Mixed within the urban areas are other land uses such as suburban and small agricultural lands that may include irrigated acreages and animal production activities (DEQ, 2009). The TMDL also notes that the City of Logan is the largest city in the watershed with an estimated population of 43,675 and has the largest amount of high density development with a total average density of 4.04 residents per acre (DEQ, 2009).

Phosphorus loads may be reduced through controlling stormwater runoff. The national average total phosphorus concentrations transported in stormwater in arid regions was reported as 320 µg/L (Ecology 2004). The adoption, design, and implementation of phosphorus reducing stormwater BMPs will help limit the phosphorus loading from stormwater runoff. For example, the Stormwater Management Manual for Eastern Washington (SMMEW) provides a menu of treatment train options for stormwater for new development and re-development that is located within a phosphorus-limited watershed. Such a menu of treatment train options could be implemented by the City of Logan.

Treatment technologies can reduce total phosphors loading by as much as 50% (Ecology 2004). The use of an engineered soil or other media could be used in stormwater BMPs for phospohrus treatment. Updated BMPs to control stormwater phosphorus loadings would need to be adopted as local development standards by the City of Logan to be effective. Broader adoption by other jurisdictions such as Hyrum, Smithfield, and Cache County could enhance the phosphorus load reductions.

The BMPs adopted for new development may also need to be applied subsequently in retrofit situations to realize further phosphorous reductions. The City and County should also give consideration to phosphorus reductions that can be achieved through low impact development (LID) features.

Proposed municipal stormwater management activities to support the TMDL implementation include:

Activity: Update the City of Logan ordinances to require stormwater BMPs such as those in the Stormwater Management Manual for Eastern Washington (Ecology 2004). Consider including LID for new and re-development. Consider use of stormwater retrofits for phosphorus removal in existing areas, as needed within the adaptive management strategy.
Cost Estimate: $10,000 to $25,000
Schedule: 2012 through 2014
Lead Agencies: City of Logan in collaboration with development community

3.2.4.1 Stormwater Management Public Education

A major component of a stormwater management program to reduce pollutant loadings is education and outreach. The goal is to alter the behaviors of many people whose actions (or inactions) contribute to pollutant loading. A public education and outreach program should be tailored to focus on the most effective behavioral changes that optimize phosphorus load reductions. Examples of practices that can realize load reductions with an education and outreach effort are listed in the Public Education and Outreach Section.

As part of the public education and outreach programs, specific stormwater targeted activities include:

Activity: Develop and implement education and outreach efforts
Cost Estimate: $2,500 to $5,000
Schedule: 2010 through 2019
Lead Agencies: City of Logan, possibly in conjunction with other MS4s in Cache Valley

3.2.4.2 Construction Site Stormwater Management

In addition to the options described above, load reductions may be realized if construction activities are better controlled. Sediment laden run-off from construction activities from clearing and grubbing through final site stabilization can carry phosphorus that is sorbed to the soil particles. The UPDES Stormwater General Permit for Construction Activities administered by DEQ requires all sites that disturb one acre or greater and discharge to a surface water to apply BMPs [as described in a site-specific Stormwater Pollution Prevention Plan (SWPPP)] that will eliminate or significantly minimize pollutants from leaving the site. The BMPs, when properly and consistently implemented can reduce sediment loads and associated phosphorus by orders of magnitude.

The City of Logan, as part of its UPDES General Permit for Discharges from Small MS4s, is required to develop, implement, and enforce a program to reduce pollutants in any storm water runoff to the small MS4 from construction activities that disturb one acre or more of land. To implement this requirement, the City of Logan is likely already reviewing construction site plans and SWPPPs, and inspecting construction sites for appropriate implementation of the SWPPPs. To facilitate compliance, the City of Logan could develop and implement a technical assistance program in conjunction with DEQ to assist developers and their contractors in complying with the Stormwater General Permit for Construction Activities and reducing loading.

Proposed construction site stormwater management activities to support the TMDL implementation include:

Activity: Develop and implement a technical assistance program for the construction industry
Cost Estimate: $10,000 to $25,000

Schedule: 2011 through 2019
Lead Agencies: State of Utah with participate by the City of Logan and collaboration with developers

3.2.4.3 Stormwater Monitoring

A limited amount of stormwater water data are available from the City of Logan and other municipalities in the watershed. However, the City of Logan is currently collecting water quality data related to stormwater runoff. The City of Logan will continue its monitoring program to quantify the effectiveness of the ordinance changes and BMP implementation.

Proposed stormwater monitoring to support the TMDL implementation include:

Activity: Continue stormwater monitoring program to determine trends and BMP effectiveness.
Cost Estimate: $10,000 to $25,000
Schedule: 2009 through 2019
Lead Agencies: City of Logan

3.2.5 Septic System Management and Phosphorus Loading

Areas that are not serviced by sanitary sewer systems rely on onsite or septic systems for wastewater treatment. The analysis for the TMDL indicates that loads from septic systems are a potentially significant nonpoint source of nutrients to Cutler Reservoir. In areas where residential development on septic systems is present, improper operation or failure of multiple individual systems can constitute a significant threat to water quality. It is important to ensure that all septic systems are properly sited, designed, operated, and maintained to reduce the risk of environmental harm in critical areas.

There are no known septic system service areas in the City of Logan. Therefore, it is anticipated that the analysis of septic system loadings will conducted in conjunction with Cache County.

Septic system failure is when one or more components of the septic system do not work properly and untreated waste or wastewater leaves the system. The wastewater may pond in the leach field, ultimately running off into nearby streams or percolating into the groundwater. Untreated septic system waste is a potential source of phosphorus. Failure can occur for several reasons. The most common reason is improper maintenance. Other reasons for failure include improper installation, and location. Although the percentage of systems that are not functioning properly is unknown, it is likely that not all the systems are providing maximum treatment.

According to the 1986 Utah Groundwater protection strategy: Septic tank and soil absorption systems (STSASs) are composed of the following three components: (1) a building sewer, (2) a septic tank, and (3) a soil absorption system. Sewage flows through the building sewer into the septic tank where its velocity is reduced and many of the suspended solids settle to the tank bottom or float to the wastewater surface. The principal sewage treatment opportunity occurs when aerobic bacteria in the soil act on the sewage. For this reason, soil absorption systems should be used only in well-drained soils of suitable texture, where an appropriate separation between the bottom of the soil absorption system excavation and the maximum seasonal ground water elevation can be maintained. A properly installed and maintained STSAS should provide a high level of treatment before the effluent reaches ground water. Ideally, a soil should be able to convert a pollutant into an unpolluted state at a rate equal to or greater than the rate at which it is added to the soil.

In considering ground water contamination from STSASs, attention must be directed to the transport and fate of pollutants from the soil absorption system through underlying soils and into the ground water. Physical, chemical, and biological removal mechanisms may occur in both the soil and ground water systems. As septic tank effluent moves through the soil pores, remaining suspended solids are removed by filtration. The point at which removal occurs varies with the size of particles, soil texture, and rate of water movement. Absorption, ion exchange, and chemical precipitation are the most important chemical processes governing effluent renovation. The biological transformations that occur in the soil are organic matter decomposition and nutrient assimilation by plants.

Some suggested septic system management activities are summarized in the following:

- Ensure public education about septic systems by distributing State of Utah authored education material, some of which can be found at: (http://www.drinkingwater.utah.gov/documents/spec_services/pollution_prevention_septic_tanks.pdf)

- A septic system impact analysis could be performed to determine the impacts from septic systems on groundwater that discharges to the surface water. This study could assess the impact of septic systems in the watershed, evaluate alternative treatment technologies and determine criteria for implementing various alternatives in high impact or high risk zones, such as areas that drain to the southern portion of the reservoir. The project could be divided into two phases;

    - The first phase would be to inventory existing septic systems on a household, parcel, or neighborhood basis and mapping those systems, along with other relevant information (such as system age), on a Geographic Information System (GIS) map. Utah requires registration of on-site wastewater treatment systems under Utah Administrative Code R317-4. The outcome of the first phase would be to identify zones of high risk for impacts to groundwater which would then transport phosphate to the reservoir. A subset of this study should be to assess soil capacity to handle on-site systems by using the GIS data on soils in the area. A second subset of this study would be studying the depth to groundwater in the area. One of the tools that could be used to assess loadings is to use the 2010 census data to recalculate population densities and growth trends within the watershed. Then, using the study completed by the UGS (Lowe et al. 2003) who determined appropriate septic system density on a per-acre basis, compare the actual septic system density with the optimum septic system density. Along with the septic system study, the new GIS data from the census could be used for a more detailed urban/suburban groundwater phosphate loading analysis.

- The second phase is intended to develop options to mitigate impacts from conventional septic systems which could include identifying appropriate alternative technologies and methods by which those technologies could be applied, such as proving sewer service to unsewered areas, and/or providing financial incentives for septic system upgrades or replacement.

Proposed septic system management and phosphorus loading activities to support the TMDL implementation include:

Activity: Assess septic system impacts on groundwater that discharge to surface water.
Cost Estimate: $50,000 to $90,000
Schedule: 2010 through 2012
Lead Agencies: City of Logan, Cache County, USU, and DEQ

3.2.6 Industrial Discharges to the City of Logan Regional Wastewater Treatment Plant

The City of Logan accepts and provides treatment of wastewater from a variety of industrial customers. A majority of these customers are related to the agricultural and food processing industry. These processes can generate high phosphorus loads.

The current average summertime phosphorus loads from industrial customers are estimated to be about 50 percent of the total load from the wastewater facility. Reduction of phosphorus at the industry before discharge to the City of Logan RWWTP may be achieved through biological or chemical methods, which are the most common means for removing phosphorus from process wastewater.

For a variety of reasons, biological methods are generally not practiced at industrial wastewater treatment facilities. A more commonly practiced method at industrial facilities is chemical precipitation of phosphorus, which can be accomplished in an activated sludge system or tertiary clarifier using chemicals such as alum or ferric chloride. The chemical precipitate could then be disposed of separately from the wastewater stream. Given the various industries and available pretreatment options, the amount of potential phosphorus reduction is unknown, although it is estimated that approximately 20-percent of the influent wastewater loading to Logan may be reduced through industrial pretreatment.

The City of Logan has begun reviewing the pretreatment ordinances and agreements with industrial customers. While the City of Logan can perform this part of the activity, ultimate changes to industrial wastewater pretreatment will be up to the individual industrial customers.

Proposed activities for industrial pretreatment include:

Activity: Industrial pretreatment of phosphorus
Cost Estimate: $80,000 to $100,000
(Construction costs for industrial pretreatment facilities is undefined)
Schedule: Modify ordinances, update agreements, and discuss with industries in 2009 to 2012
Lead Agencies: City of Logan (initially) and industrial customers

3.2.7 Service Agreements and Loads from nearby Communities

The TMDL addresses the phosphorus discharge from the following neighboring communities:

- Nibley
- Providence
- River Heights
- North Logan
- Smithfield
- Hyde Park

Interlocal agreements for provision of sewer service by the City of Logan may be used to place emphasis on control of phosphorus loadings to the sewer system. User charges (sewer rates) that include an allocation to phosphorus as a cost parameter provide an economic incentive to control wastewater strength for residential, commercial, and industrial customers.

3.2.7.1 Loads from Nearby Communities

Detailed data from 2005 were analyzed to better understand the total phosphorus loads from the nearby communities. With the exception of a datum from the town of Providence during February 2005, each town averages a monthly contribution of less than or equal to 10 percent of the overall load to Cutler Reservoir as shown in Figure 5. It appears from the data set that Providence and North Logan are typically the largest contributors amongst the neighboring communities.

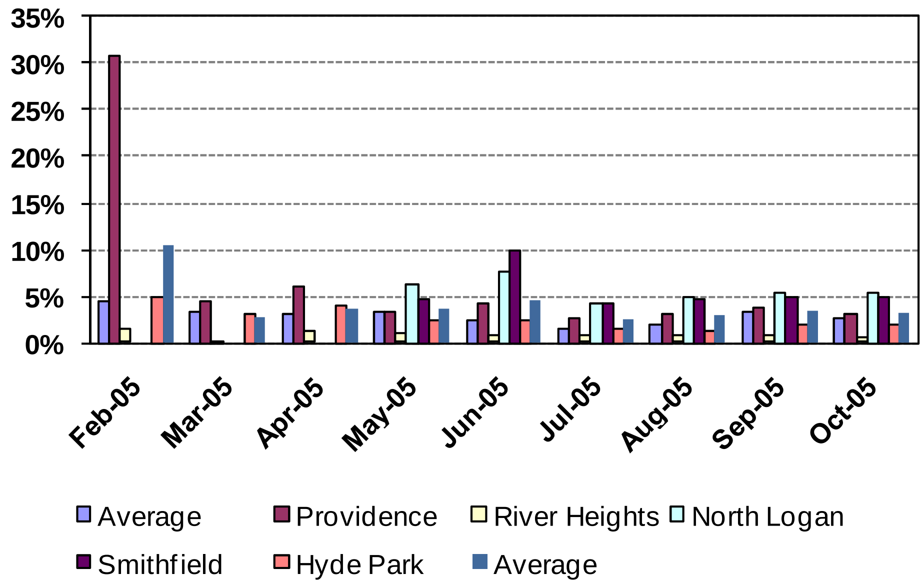

Figure 5. **Total Proportion of Phosphorus Loads from Nearby Communities**

The average monthly combined contribution from all the neighboring communities is approximately 25 percent of the total phosphorus load to Cutler Reservoir. The average monthly concentrations from each community are shown in Figure 6. The phosphorus concentration for Providence during the month of February 2005 (<8 mg/L as P) suggests that the corresponding load in Figure 5 is not an outlier. In fact, it appears to relate to elevated flows from Providence in February, 2005. The overall average phosphorus concentration for all the nearby communities is 6.1 mg/L as phosphorus, which is falls within the range of 'medium-strength' wastewater (5 to 7 mg/L) according to MOP30 (WEF, 2006)

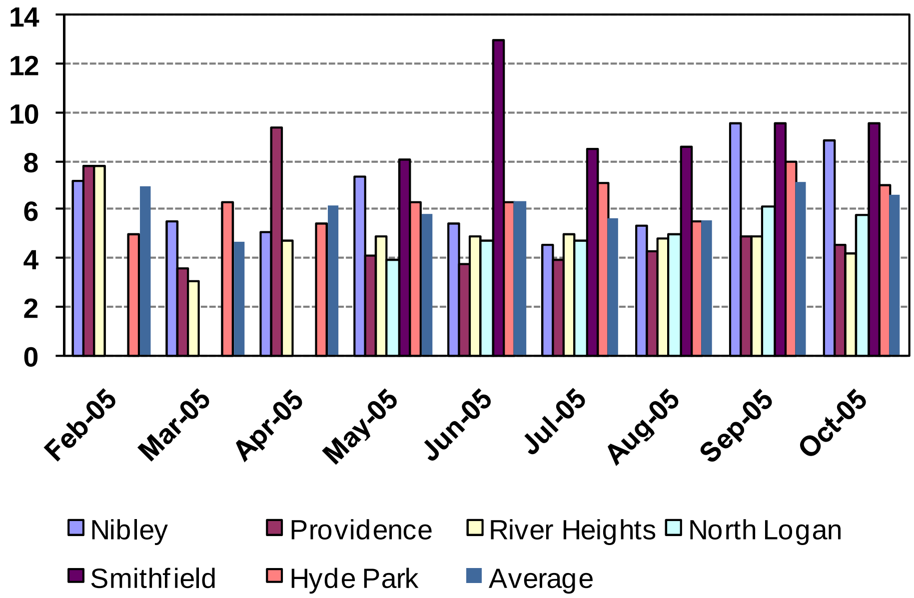

Figure 6. **Average Monthly Phosphorus Concentration from Nearby Communities**

Proposed activities related to wastewater from nearby communities include:

Activity: Phosphorus load reduction from nearby communities through cost of service analysis, phosphorus user charges and updated inter-local agreements
Cost Estimate: $5,000 to $10,000
Schedule: 2009 through 2019
Lead Agencies: City of Logan and nearby communities

3.3 Wastewater Treatment and Effluent Management

Reducing effluent phosphorus from the City of Logan will be implemented adaptively. Influent wastewater source monitoring and quantification will be conducted to provide baseline knowledge. The existing wastewater data reveals overall trends in historical phosphorus loadings, but a more detailed analysis to fully characterize loading will be required to provide the necessary baseline information for further analysis.

The load sources from the City of Logan include the wastewater treatment lagoons, effluent, and wetlands effluent. Each element will be assessed and analyzed separately in subsequent sections of the adaptive management plan. As the results of the proposed monitoring and quantification of phosphorus sources become available, information will be used to target the highest priority source control activities. Once actions have been implemented, their effectiveness will be monitored to provide feedback for the next round of actions to enhance the effectiveness of the program with time. This adaptive management strategy allows for voluntary actions to be implemented while ordinance changes are adopted on an appropriate schedule.

In terms of modifications to the wastewater treatment lagoons by either operational changes, or the addition of new equipment, a detailed evaluation of treatment technologies will be carried out. The results of the analysis will identify the most promising treatment technologies to pursue further. For example, if a filter technology appears most viable from the analysis, further development of that option will likely include pilot testing study to monitor filter performance under site specific conditions with City of Logan wastewater.

A culmination of the subsequent sections of the adaptive management plant will enable the City of Logan to cost effectively address the future phosphorus wasteload reduction requirements for Cutler Reservoir.

3.3.1 Lagoon Operational and Mechanical Review

The ability to meet the future permit, in particular the target total phosphorus, will likely necessitate alteration or signification mechanical additions to the existing aerated lagoon/wetlands treatment system. Figure 7 presents a characterization of the lagoon headworks phosphorus concentrations and illustrates that a majority of the influent wastewater phosphorus (i.e., on average 94 percent) is comprised of ortho-phosphate.

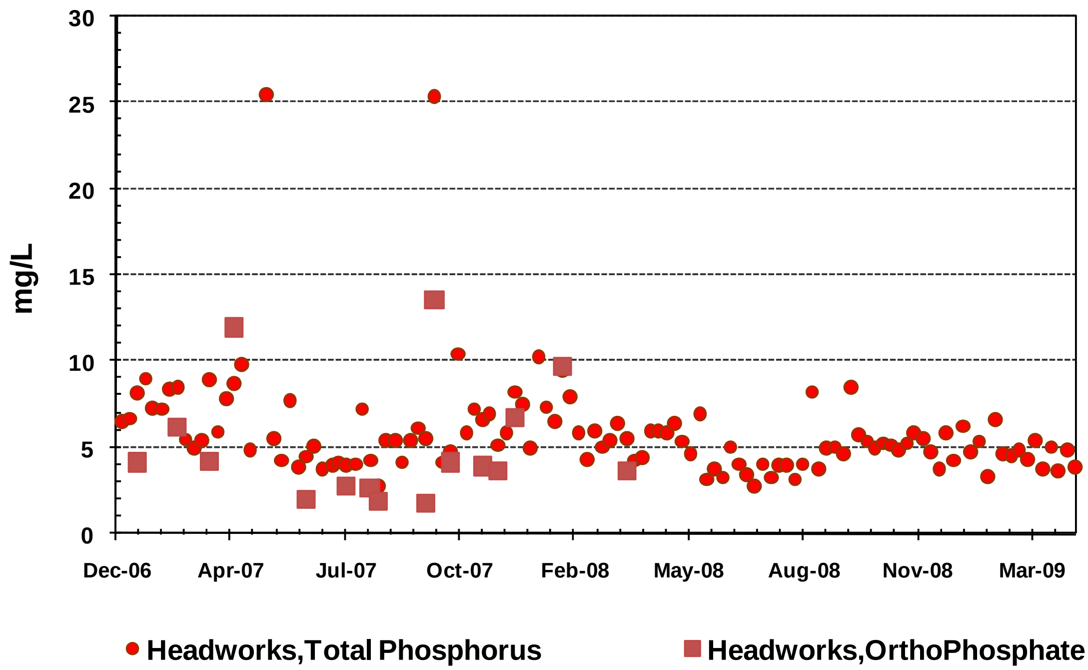

Figure 7. Lagoon Headworks Phosphorus Characterization

Although only a few phosphorus data points throughout the lagoons are available from 'snap shot' sampling events, all three sampling events from the summer 2008 are plotted in Figure 8. The snap shot monitoring reveals that no significant phosphorus removal occurs within the aerated lagoons.

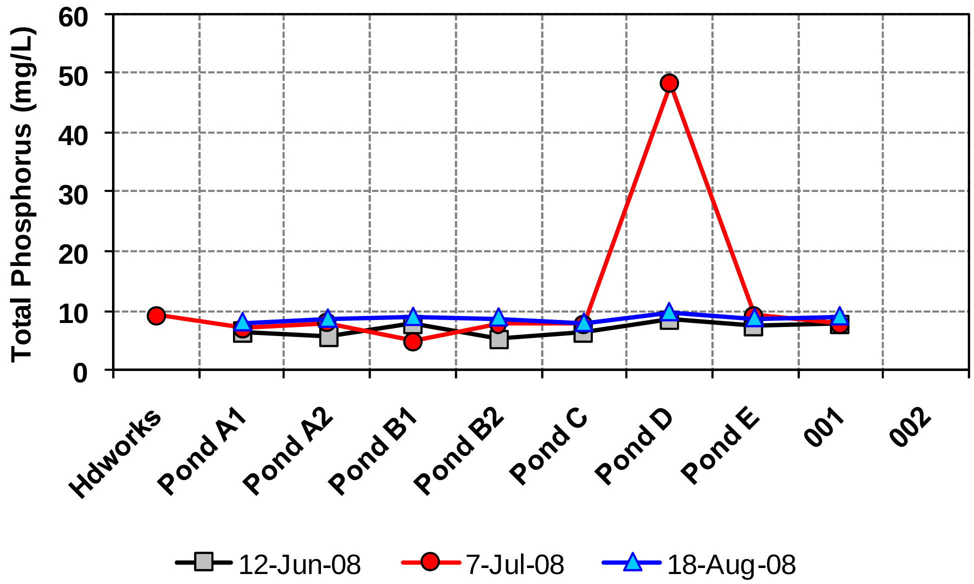

Figure 8. Total Phosphorus Monitoring from 2008

To validate the total phosphorus snap shot results, the total suspended solids (TSS) monitoring results are plotted in Figure 9. The TSS trends in Figure 8 mimic those of total phosphorus in Figure 9, where a spike is revealed in Pond D for both plots. It appears that suspended solids (algae) carry substantial amount of phosphorus and impact effluent performance.

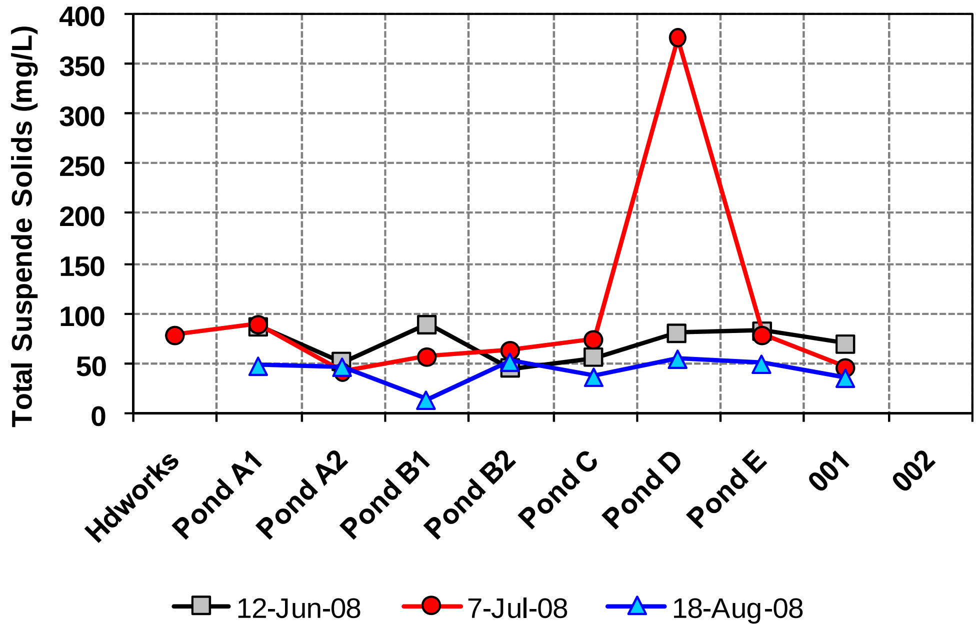

Figure 9. Total Suspended Solids (TSS) Monitoring from 2008

3.3.1.1 Treatment Options to Meet the TMDL

Analysis of historical wastewater phosphorus and TSS data indicate that limited removal within the aerated lagoons poses a challenge in meeting the TMDL requirements with the existing treatment system. The City of Logan may consider a variety of strategies to reduce effluent wastewater phosphorus, including the following:

- Filtration with continuous backwash moving bed sand filters with chemical addition (Blue Water ® Filters with ferric, Parkson Dual Sand with alum).
- Micro-filtration (MF) using membranes downstream of the lagoons to filter algae and other solids.
- Dissolved air flotation (DAF) downstream of the lagoons to float algae, followed by filtration.
- Membrane bioreactor (MBR) operating as a constant flow plant in parallel with the existing lagoons.
- Conversion of the existing lagoon to an advanced integrated wastewater pond system.
- Implementation of an algae wastewater technology (e.g., Algae Wheel) coupled with biofuel production.

The subsequent sections supply an overview of each aforementioned technology.

3.3.1.2 Filtration

Two different filtration approaches are considered to enable the treatment of aerated lagoons effluent by way of filtration. The first is continuous backwash moving bed sand filters with chemical addition. A Blue Water® Filtration pilot unit was tested in August, 2008 at the City of Logan lagoons. The two week pilot yielded results presented in Figure 10. Despite promising results with total phosphorus averaging less than 0.5 mg/L as phosphorus, the pilot was only carried out for two weeks and would require a more long-term pilot testing period to validate the process. Additionally, the amount of ferric chloride used to precipitate inorganic phosphates, particles, colloidal material, and algae was not provided along with the influent and effluent phosphorus levels to fully evaluate performance. It is imperative to view the ferric dosing to ensure that environmentally relevant doses were used to achieve the reported effluent levels.

A major operational concern with the use of filters for this application relates to the potential for blinding the filters with algae.

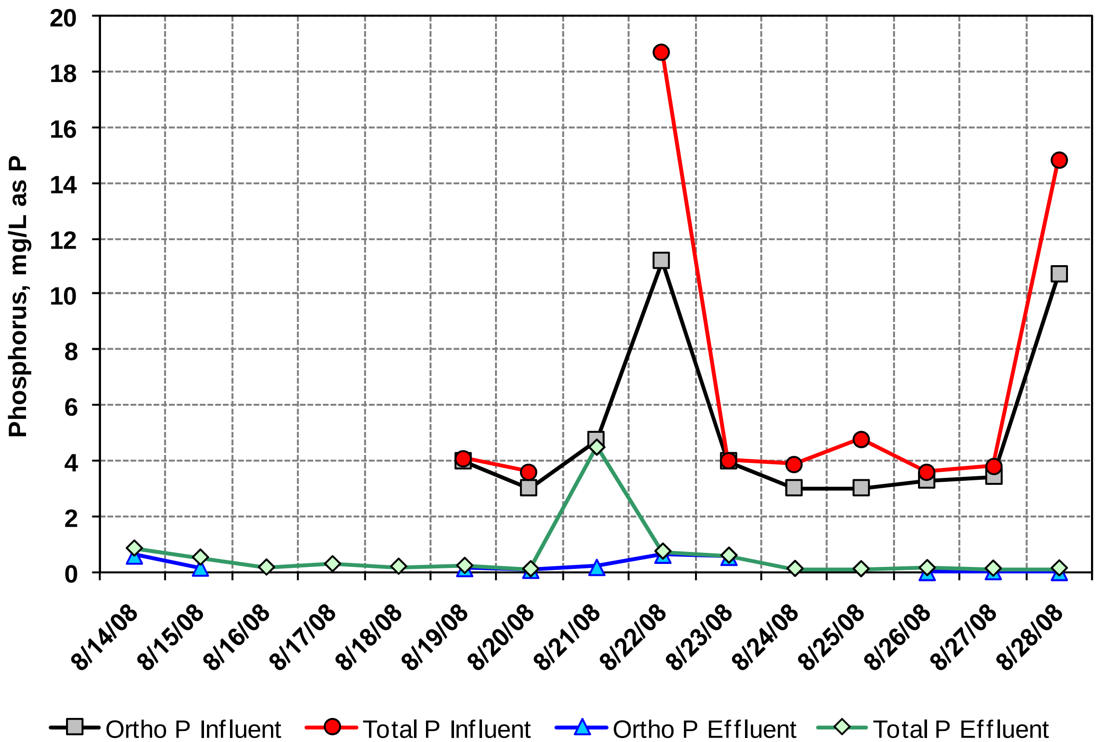

Figure 10. BlueWater Filter Pilot during August 2008

The other filtration technology, microfiltration (MF), employs a membrane to separate solids using a defined pore size. The data in Figure 11is based on a 0.05 micron membrane over a six month long pilot study that was used to exclude solids primarily comprised of algae leaving an aerated lagoon in Washington State. As with the continuous backwash moving bed sand filters, there is concern over the potential for filter blinding with algae. The MF filter data does not incorporate membrane fouling, cleaning, and/or replacement, but it does provide a platform to show the long-term efficacy of algae based solids removal by microfiltration.

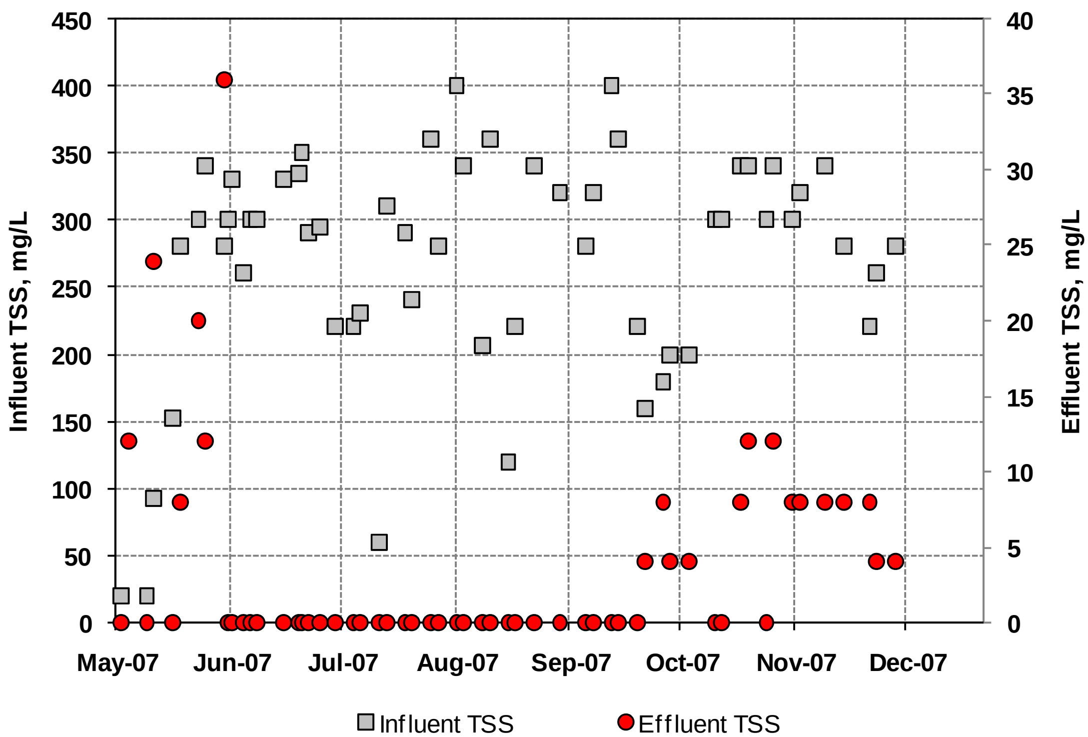

Figure 11. Example of Microfiltration Pilot Results on Aerated Lagoon Effluent in Washington State

3.3.1.3 Dissolved Air Flotation Combined with Filtration

The potential concern over algae blinding of media and membrane filters with treated aerated lagoon effluent may be overcome by adding dissolved air flotation (DAF) to the treatment process train. It is well documented that algae is more apt to float rather than settle. As a result, DAF technology that floats algae upstream of filtration would enhance filtration capacity.

Although DAF would greatly enhance downstream filtration efficacy, it would require supplemental solids treatment of the separated algae. Anaerobic digestion would provide a means to destroy algae, which would release micro-nutrients into solution. The subsequent micro-nutrients could be sequestered by side-stream treatment technologies and might provide a valuable soil amendment. The process would also results in methane gas which could be used for power generation.

3.3.1.4 Membrane Bioreactor

Rather than attempting to treat aerated lagoon effluent, the use of a mechanical wastewater treatment plant operating in parallel with the aerated lagoons and blended with aeration lagoon effluent offers a means to meet the target phosphorus levels in a phased implementation program. The strength in this approach relates to the ability to supply a designated hydraulic flow on the selected technology and produce a high quality effluent with very low phosphorus. There are a multitude of biological systems that remove phosphorus, but a membrane bioreactor (MBR) provides a reliable technology to meet effluent levels of less than 0.5 mg/L as phosphorus, as well as produce reclaimed effluent suitable for reuse in urban irrigation, industrial process water, cooling water, and groundwater recharge. Furthermore, as future discharge permits become more stringent over time, the MBR facility could be expanded to ensure the proper blending ratio to meet the future limits by adding additional advanced treatment capacity.

3.3.1.5 Convert the Existing Lagoon to an Advanced Integrated Wastewater Pond System

Another potential option is to convert the existing lagoon system to an integrated wastewater pond system. Dr. William Oswald and other researchers at the University of California at Berkley pioneered the development of an advanced algal pond system called the Advanced Integrated Wastewater Pond System (AIWPS). The AIWPS comprises four separate ponds in series: an enhanced facultative pond, a high-rate algal pond, algae settling pond, and a maturation pond. The AIWPS has been shown to provide improved biological treatment and solids digestion in the anaerobic layers and require less land area than conventional facultative pond systems (Oswald, 1990).

The implementation of an AIWPS to the pre-existing aerated lagoon would require the following changes:

- Increase the depth in the first basin to maintain an anaerobic zone that spurs facultative activity with simultaneous BOD removal and solids digestion (20+ day hydraulic detention time).
- Decrease the depth in the middle basins to a few feet that flow in a elliptical raceway fashion (3 to 10 day hydraulic detention time). This component of the strategy exploits solar energy and the ability of algae to produce oxygen. The generated oxygen promotes BOD removal and nitrification.

An algae settling pond with a 1 to 2 day hydraulic detention time in cells 4 and 5 can remove 50 to 80 percent of the algae in the effluent from a paddle wheel-mixed high rate algal pond (HRAP). Paddle-wheel mixing in the HRAP appears to improve the settling characteristics of the micro-algae grown in the HRAP (Greene, 1996).

The maturation pond in the AIWPS typically functions as a storage reservoir for irrigation or other form of wastewater reuse. The significant die-off of bacteria that occurs in the maturation pond over a 10 day or more hydraulic retention time provides disinfection without the use of chemicals (Oswald, 1990).

Evaluation of AIWPS for Cutler Reservoir would require a detailed evaluation of hydraulic detention time, as well as the required movement of earth fill within the existing aerated lagoon.

3.3.1.6 Algae based Wastewater Treatment Combined with Biofuel Production

There are several algae based wastewater treatment technologies, such as Algal Turf Scrubbers (ATS). The ATS is an attached algae system comprising a sloped horizontal area with an impermeable liner topped by a mesh media that serves as a point of attachment for algae, with concrete influent distribution and effluent collection channels. Influent is distributed evenly across the width of the ATS basin, typically in a pulsed feed fashion; flows at a depth of one to two inches across the mesh media; and is collected in the effluent channel. Nitrogen and phosphorus are removed from the flow by the growing algae mat. Algae is harvested on a periodic basis by suspending the flow of water to the ATS, allowing the mat to dry for a day or more, and mechanically harvesting via scraping or vacuuming the algae.

The algae used to treat the wastewater can be subsequently used to produce biofuels. Key findings on biofuel production are summarized as follows:

Algae-based fuels are not yet cost-competitive with fossil fuels or other biofuels such as plant-based ethanol or biodiesel. Cost-effective algae cultivation and harvesting is the major obstacle that needs to be overcome to narrow the significant cost disadvantage of algae fuels.

Coupling algal-based wastewater treatment and biofuel production is a topic of special interest. However, wastewater-derived algae typically have much lower lipids content than algae cultivated specifically for biofuel production, making wastewater-derived algae less attractive as a raw material for fuel production. Harvesting also remains an obstacle, as the use of chemical flocculants used for state-of-the-art algae removal in wastewater applications has a negative impact on the lipids extraction and subsequent processing employed for biofuel production.

3.3.1.7 Next Steps in Wastewater Analysis

The City of Logan is working to define which treatment technologies are of interest to pursue further in a detailed analysis. Once selected, a detailed feasibility study that includes an assessment of capital, and operation and maintenance costs, will be carried out.

Implementation of the required phosphorus reductions to Cutler Reservoir will require that the City of Logan prepare a detailed phosphorus management plan. Phosphorus reduction may be accomplished by reduction in influent wastewater loadings, advanced wastewater treatment, effluent management which diverts loadings away from Cutler Reservoir, and/or water quality offsets accomplished by reduction in other areas of the watershed.

A City of Logan phosphorus management plan will summarize the planned activities into a concept plan or strategy for City management of phosphorus loadings to Cutler Reservoir. Projects will be identified along with project phasing and a proposed schedule. Costs will be estimated for individual project efforts and cost effectiveness will be analyzed in terms of dollars per pound of phosphorus removed.

The City of Logan's wastewater master plan will need to be updated to match the approach developed in the adaptive management plan for the TMDL and the City of Logan's phosphorus management plan. Although the phosphorus management plan will include detailed information about the City of Logan's wastewater treatment facilities, the focus will be primarily on phosphorus management. The wastewater master plan will build upon the City of Logan's 2006 facility plan where possible and will add the details necessary to implement a complete wastewater program.

The selected wastewater improvements developed in the wastewater master plan will be implemented as conventional public works projects with the principal steps as follows:

- Preliminary design
- Detailed design
- Construction
- Start-up and operations

Proposed treatment technology evaluation and pilot studies to support the TMDL implementation include:

Activity: Treatment technology evaluation and wastewater treatment improvements to meet the future phosphorus TMDL
Cost Estimate: $200,000 to $700,000
Schedule: 2009 through 2012
Lead Agencies: City of Logan with State of Utah funding

3.3.2 Wetlands Efficiency Monitoring

A wide range of physical, chemical and biological processes contribute to removal of nutrients and other constituents from water in wetlands. These processes include sedimentation, plant uptake, chemical adsorption and precipitation in wetland soils, and volatilization (DeBusk, 1999). The City's existing wetlands operation may be enhanced to improve phosphorus removal and the configuration of the system provides an opportunity for winter storage of treated effluent. Further, the Cutler Reservoir watershed provides the potential opportunities for the development or restoration of other wetlands.

3.3.2.1 Wetland Treatment Alternatives

There are two basic types of constructed wetlands, subsurface flow (SSF) and surface flow (SF). In subsurface flow wetlands, water is treated by passing flow vertically or horizontally through permeable soil-like media that is populated by wetland plants. An impervious liner beneath the media prevents seepage to the groundwater.

In contrast surface flow wetland water flows primarily above the soil media. A surface wetland also has a low permeability barrier material beneath the soil to prevent seepage. Surface wetlands are generally constructed in long, narrow channels to simulate plug flow conditions. Both SSF and SF wetlands have an inlet device, wetland basin, wetland plants and an outlet device.

SSF flow wetlands are believed to provide better waste treatment because they have an increased presence of attached growth microbes compared to SF wetlands. However, SSF wetlands are more expensive to construct and to maintain compared to surface flow type wetlands because more media is required and clogged media must be replaced. Due to the greater management requirements of a SSF wetland, SF wetlands are more common for treatment of municipal wastewater.

3.3.2.2 Hydrology

Water depth in a SF wetland generally ranges from 0.5 to 2 feet. However, operating depth should be adjusted to optimize plant growth while maintaining treatment objectives. If open water areas are desired, a depth of 3 feet or more in these zones will prevent growth of emergent vegetation. Wetland outlet structures must allow control of water depth from zero to the maximum design depth.

Bed depth in a subsurface flow wetland should range between 1 and 3 feet, but should generally be about 2 feet. Bed depth should allow for maximum root growth for the wetland plants. However, anticipated flows must pass through the bed without overland flow or flooding and without stranding the plants above the water (no excessive head space). Maximum and minimum flows should be considered in design.

Flow must be distributed evenly across the wetland in order to optimize treatment and promote complete coverage of wetland plants. Even flow distribution must be assured throughout the life of the wetland, which may require the ability to adjust for irregularities made during construction. If a distribution header is used, it should be equipped with individual flow controls along the header (or an influent swale or deep zone immediately following the header) and removable end plates for cleaning.

In order to assure even flow distribution, to prevent channelization in the surface flow wetland and to enhance nitrification, it may be desirable to include deep water zones perpendicular to the flow. These deep zones help redistribute the flow evenly across the wetlands at intermediate points and promote re-aeration and nitrification (conversion of ammonia to nitrate). Deep zones should be included in wetlands and may include diffusers or mechanical aerators to further enhance nitrification. The deep zones also provide for wildlife habitat. As mentioned above, the deep zones must be deep enough (at least 3 feet) to prevent the growth of emergent vegetation and should cover no more than 30% of the wetland area. It should be noted that algae may propagate in the deep zones. Therefore, it may not be appropriate to incorporate a deep zone at the terminal end of the wetland if Total Suspended Solids (TSS) is a parameter of concern in the effluent. Constructability of the deep zones may warrant slopes flatter than 3H:1V.

3.3.2.3 Monitoring

Monitoring is important to assure the continued health of the wetland, to determine its treatment efficiency, and to provide a base of information for future design parameter modifications. Sampling frequency should be sufficient to reflect changes in flow, loading, temperature, wetland growth or other conditions that might affect the performance of the wetland. Sufficient sampling must be provided so that the performance of the wetland can be determined. Therefore, influent and effluent samples and flow measurements should be taken for the wetland. Table 5 lists the minimum parameters, locations and frequency of an adequate sampling and monitoring program.

Table 5. Recommended Parameters for Monitoring of Wetlands

Parameters	Locations	Frequency
BOD, TSS, NH4, NO2+NO3, TKN, TP, P, Temperature, DO	Inflow & Outflow*	Monthly
Flow	Inflow or Outflow	Monthly or Weekly**
Water Level	In Wetland	Monthly
Plant Cover	In Wetland	Quarterly
Ice Cover	In Wetland	Monthly

*Effluent sampling should be conducted for each treatment train.
**If flow is continuous and relatively constant, monthly flow measurement could be adequate. Flow for each treatment train must be measured.
BOD = Biological Oxygen Demand; TSS = Total Suspended Solids; NH4 = Ammonia-N; NO2+NO3= nitrite and nitrate; TKN= Total Kjeldahl Nitrogen; TP = Total Phosphorus; DO = Dissolved Oxygen

The City of Logan will continue to monitor the efficiency of the existing wetlands. Based on the results of the data evaluations, the monitoring program may be updated as necessary. Additionally based on the review, operational or other options may be considered for cost effectiveness and coordination with other selected activities.

The potential development or restoration of other wetlands in the watershed for phosphorus reduction will be led by Rocky Mountain Power and Bridgerland Audubon Society.

Proposed wetlands efficiency review activities to support the TMDL implementation include:

Activity: Review wetlands efficiency and update monitoring as necessary
Cost Estimate: $50,000 to $100,000
Schedule: 2009 through 2019
Lead Agencies: Rocky Mountain Power and Bridgerland Audubon Society with City of Logan and DEQ

3.3.3 Land Application to Local Agricultural Fields

Land application is a proven method of wastewater recycling. The existing system is shown in Figure 12. Improved irrigation efficiency can alleviate water quality problems. Reduced conveyance seepage losses will result in less salt accumulation during subsurface transport. Reduced tailwater runoff (return flows) from irrigated fields will result in less soil erosion and less adsorbed phosphate fertilizer and insecticides being transported to downstream water bodies such as Cutler Reservoir. Land application can be effective when the water is applied at agronomic rates. This prevents saturation of the soils and potential infiltration to the groundwater. Phosphorus can also be tracked from the load applied to the amount taken up by the plants.

The most common crops in the area include irrigated pasture, hay, alfalfa, and corn, all of which are used locally to feed livestock. Farmers near the wastewater lagoons to divert wastewater flows for land application to nearby fields. The Logan Cow Pasture Water Company has a water right to use about 12 mgd of the City of Logan effluent for irrigation during the summer and an additional 3 mgd of the City of Logan effluent is used for wetland and wildlife habitat. However, neither the flows nor phosphorus loadings have been measured and tracked to provide the basis for phosphorus contributions or removal from surface water.

In terms of BMPs, there should not be any tailwater flow or overland flow from the fields into the surrounding surface waters. However, the application rate of water for flood irrigation is not monitored and the potential exists for soil saturation and movement into the groundwater. Improving this situation means monitoring the flow and tracking the phosphorus loads to understand the potential reduction in loading.

Modifying the irrigation from flood irrigation to sprinkler irrigation may provide an easier means to monitor the applied flow rates and minimize saturation of the soils with water as an enhanced phosphorous management approach. Conversion to sprinkler irrigation would allow for the more efficient management of water. The Wyoming State Water Plan estimates 33% irrigation efficiency with canal diversion irrigation in the Bear River watershed. This means as much as 67% of the water diverted for irrigation is returned to the surface or groundwater. Many on-farm application technologies exist which have the potential to improve irrigation application efficiency. For example, pressurized irrigation can be employed, such as sprinkle irrigation (designed for 80 percent irrigation application efficiency) or trickle (drip) irrigation (designed for 95 percent application efficiency) (http://waterplan.state.wy.us/plan/bear/techmemos/diversions/francislee.html).

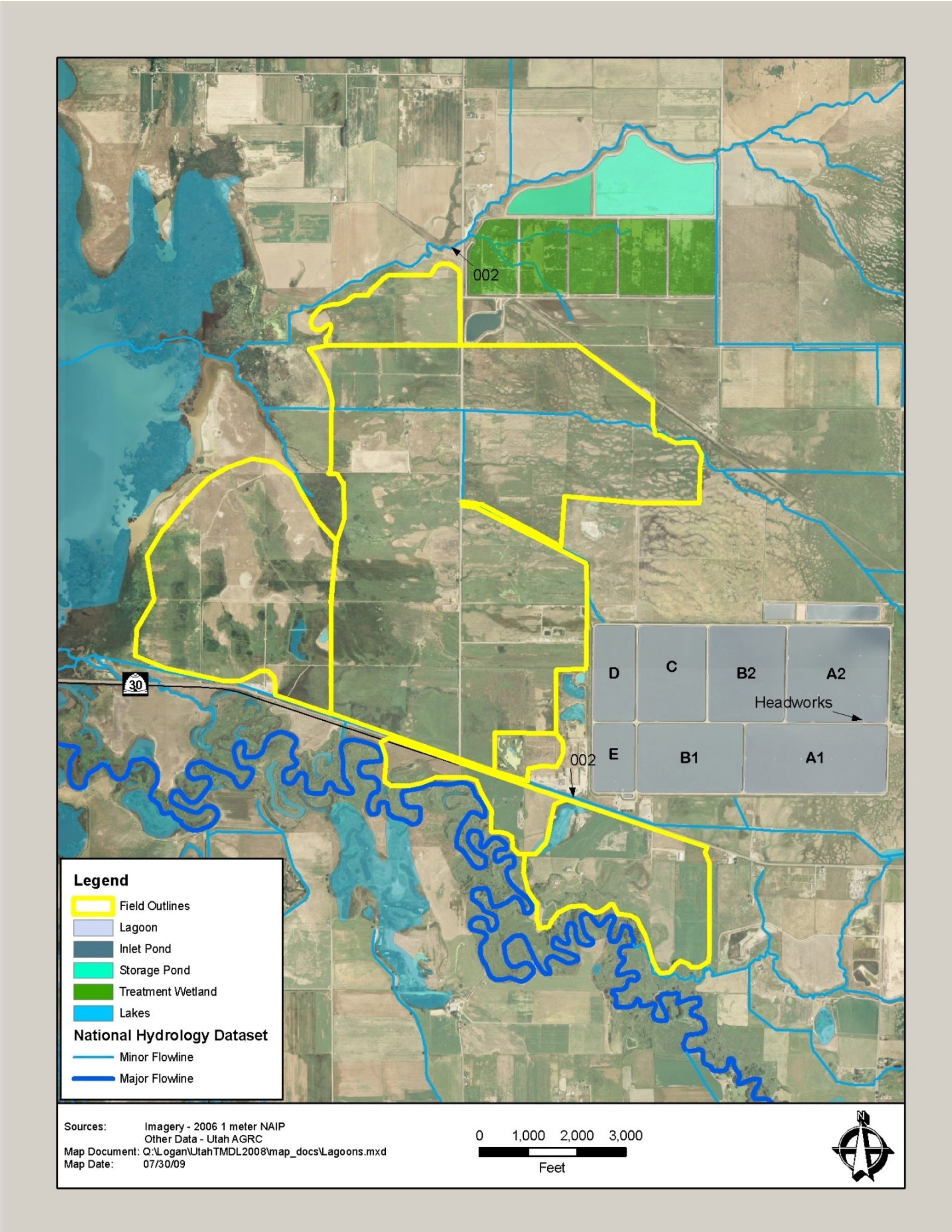

Figure 12. Existing Effluent Distribution System, Wetlands, and Agricultural Reuse Areas

Proposed activities related to the land application to local agricultural fields include:

Activity: Update and improve monitoring and control of land application of wastewater
Cost Estimate: $50,000 to $100,000
Schedule: 2010 through 2011
Lead Agencies: City of Logan, State of Utah, NRCS, USU

3.3.4 Irrigation of Dry Land Farming

Irrigating additional land with wastewater would further reduce the phosphorus loading to the wetlands and Swift Slough. There appear to be opportunities south of the Logan River where conveyance systems are in place and agricultural production is greater than in the vicinity of the lagoons. Negotiations with the farmers would be necessary to determine the potential quantity of flows that could be diverted. There are multiple additional challenges including water rights, summer versus winter, and storage. Water right issues would need to be reviewed due to the movement of water throughout the valley. Land application opportunities tend to only assist with the reduction of the summer loads and provide little or no reduction opportunities in the winter. Additional storage would likely be necessary to balance the wastewater flow with the irrigation demand flow. Soil conditions, types of crops to be grown, and land areas would need to be investigated to calculate the flows that could be accepted and then estimate the potential phosphorus loading.

A potential pilot study could be performed using a field that has center pivot or gravity drip irrigation with water pumped from ground water by switching the source of water to the wastewater treatment effluent. A similar amount of water will likely be used, but the goal of the study would be to asses the cost reduction from applying less fertilizer to the cost of using treatment plant effluent.

Proposed irrigation of dry land farms with additional land application activities to support the TMDL implementation include:

Activity: Consider additional land application opportunities
Cost Estimate: $10,000 to $15,000
Schedule: 2015 to 2017
Lead Agencies: City of Logan

3.3.5 Reuse Opportunities

Opportunities to divert wastewater to industrial users, golf courses, parks, and other reuse options will be investigated. Diverting flows to reclaimed water reuse options will reduce the amount of treated effluent and phosphorus discharged to Swift Slough. Challenges associated with advanced treatment for reclaimed water reuse include the expense of additional treatment to meet reuse water quality standards (effluent filtration) and the distribution system infrastructure to move the water to the location(s) of reuse customers (purple pipe system). Fortunately, there is an overlap between the advanced treatment requirements for low phosphorus effluent and the requirements for reclaimed water. Treatment technologies for low phosphorus effluent with chemical addition and effluent filtration (media filtration, membranes) meet the requirements for the least restrictive reuse of reclaimed water for irrigation in areas with public access such as parks, medians, golf courses, etc. An additional challenge for reclaimed water reuse in Logan is that there are generally sufficient existing supplies of inexpensive water of sufficient quantity and quality to meet existing demands without the expense of a reclaimed water distribution system to pump reclaimed water back up the valley. Therefore, reuse opportunities may be part of the longer-term strategy but will require upfront studies to understand the potential for use of significant quantities that would benefit phosphorus management.

Treatment technologies for low effluent phosphorus include chemical precipitants and advanced filtration. The treatment processes for phosphorus will need to meet the regulatory requirements for Class A reclaimed water production. Class A reclaimed water can be used with few restrictions as a substitute for non-potable water uses such as urban irrigation, cooling water, etc.

Proposed reuse activities to support the TMDL implementation include:

Activity: Consider reuse opportunities
Cost Estimate: $10,000 to $15,000
Schedule: 2015 to 2017
Lead Agencies: City of Logan

4 Schedule and Estimate Costs

The schedule for the Logan adaptive management plan is shown in Figure 1 with the targeted timing and duration of activities. Preliminary cost estimates for the activities will be refined as the activities are scoped and initiated.

4.1 Funding Opportunities

Financial and technical assistance is needed to ensure success of this adaptive management plan. There are many potential sources for funding that will be actively pursued by the City of Logan to implement water quality improvements. These sources include, but are not limited to the following:

- State Revolving Fund. SRF funds administered by DEQ are used to fund wastewater treatment and water quality improvement projects.
- CWA 319 projects refer to section 319 of the Clean Water Act. These are Environmental Protection Agency funds that are allocated to states. The DEQ has primacy to administer the

Clean Water Act §319 Non-Point Source Management Program. Funds focus on projects to improve water quality and are usually related nonpoint sources.

- Natural Resources Conservation Service (NRCS): NRCS funding is used to implement agricultural and conservation activities and can be targeted on water quality improvements.
- Conservation Reserve Program (CRP): CRP is a land retirement program for blocks of land or strips of land that protect the soil and water resources, such as buffers and grassed waterways http://www.nrcs.usda.gov/programs/crp/.

5 Measuring Progress

Monitoring and evaluation will occur throughout the TMDL implementation period and will be conducted in accordance with an adopted Quality Assurance Project Plan (QAPP). Monitoring will address both water quality within Cutler Reservoir and the effectiveness of management actions and BMPs.

TMDL effectiveness monitoring indicates whether or not phosphorus levels are decreasing in response to management efforts. This is accomplished in two ways: 1) by directly measuring the reduction of phosphorus from individual sources and 2) by indirectly measuring the success by monitoring water quality in Cutler Reservoir. The City of Logan will measure the effectiveness of activities within this adaptive management plan while DEQ and stakeholders will conduct effectiveness monitoring to determine whether the TMDL is working.

5.1 Water Quality Effectiveness Monitoring Plan

A water quality effectiveness monitoring plan will be established with the TMDL implementation plan. This plan will incorporate the wastewater water quality and flow monitoring activities described in detail above for the City of Logan.

Water quality management activities and structural BMP monitoring should be chosen based upon what makes the most sense for the area given practical considerations. BMPs may be monitored directly by measuring inflow concentrations and comparing that to outflow concentrations. This is time consuming and resource intensive. An indirect measurement may be used by monitoring entire tributaries, such as Swift Slough, but that would measure potentially the results of many management activities. An even more indirect measurement will be provided by the continued monitoring of Cutler Reservoir.

5.2 Performance Measures and Targets

Performance measures, as used in this document, indicate the City's success at implementing actions known to improve watershed and Cutler Reservoir health. Performance measures do not measure the impact of specific projects on the environment; rather, they measure whether the City has accomplished specified actions. For example, the enhancement wetland areas is known to improve nutrient removal effectiveness but a performance measure, as used here, may be how many acres of wetlands enhancement were accomplished, not the change in the effluent stream concentrations.

Performance measures allow the City to report on water quality progress annually. The long-term success of actions implemented to directly improve water quality conditions will be measured with environmental measures. Environmental measures, as used in this document, are the quantities evaluated through monitoring to reveal changes to environmental conditions.

Potential performance measures may be based on three basic types of criteria:

- Valid
    - *Relevant:* to goals of the plan, or to your assessment questions
    - *Appropriate scale:* representative of entire region (or tributary watersheds) over an appropriate time scale
    - *Sensitive/Responsive:* natural variability can be reasonably explained; quickly reflects changes in the watershed
- Understandable
    - *Meaningful*: interpretable and meaningful to local resource managers, residents, and political representatives
    - *Trend:* demonstrates or will demonstrate a trend (increase, decrease, or stable) from a reference condition
    - *Measurable:* it is easy to measure and calculate periodically and therefore replicable
    - *Goal:* periodic assessment can be compared against an established quantifiable goal (reference condition)
- Available
    - *Supported:* supporting data is long-term monitoring, immediately usable, and likely to continue
    - *Data quality:* supporting data quality is acceptable
    - *Cost-effective:* dataholder or other entity partially or fully provides data aggregation, analyzing, and modeling of datasets

Examples of some performance measures are linear feet of riparian buffer, number of wastewater treatment system improvements, number of public education outreach meetings that occurred, or number of septic tank users that have been provided sewer service.

5.3 Progress Tracking Database

The project tracking database tool described above as activity SPR-6 will be designed to provide a management tool for the watershed. Watershed managers face a broad group of challenges in orchestrating restoration projects with numerous stakeholders, overlapping regulatory authorities, multiple pollutants, and varied funding sources. Sustaining the effort over a multi-year period adds to these challenges. Prioritization of the most effective best management practices and phosphorus reduction projects is essential for a successful, long-term effort. Decision support systems which aid managers in tracking the implementation of water quality projects and BMPs provides a foundation for long-term watershed management. These systems provide the watershed manager with tools to track progress and prioritize efforts on those actions that are found to be most effective in restoring water quality. Systematic tracking of water quality improvement efforts provides a means for overall program management.

6 Adaptive Management

As part of this TMDL, DEQ and the City of Logan agree to use an adaptive management approach that will assure that the efforts to meet the WLA for the City are undertaken in the most efficient and effective manner. The adaptive management approach includes, but is not limited to, data collection, analyses, and pilot programs to: validate the proposed wasteload allocation specified in this TMDL, compare measured changes in water quality to actual changes in water quality, make recommendations to change the proposed wasteload allocations (if supported by the additional data collection and analyses) and determine the most effective ways to comply with water quality standards based on pilot program results.

DEQ and the City of Logan believe that the proposed adaptive management approach will be scientifically defensible and provide the greatest level of protection of the resources. As indicated, the City of Logan anticipates implementing early actions to start the adaptive management approach as shown in the schedule. The City of Logan expects that this will provide empirical data that will allow for prudent decisions in the subsequent phases of the adaptive management plan. The City of Logan will work to monitor progress towards these goals, evaluate successes, obstacles, and changing needs, and make adjustments to the cleanup strategy as needed. If necessary, DEQ and the City of Logan will change the scheduled activities in later phases based on the data collected in this early phase.

7 Reasonable Assurance

For the *Middle Bear River and Cutler Reservoir TMDLs* (DEQ, 2009), both point and nonpoint sources contribute to the phosphorus load. TMDLs (and related action plans) must show “reasonable assurance” that contributions from these sources will be reduced to the allocated amounts.

The goal of this TMDL is to set targets and provide a strategy to meet the state’s water quality standards for dissolved oxygen in Cutler Reservoir. The TMDL establishes reductions of a particular pollutant are allocated among the pollutant sources (both point and nonpoint) in the water body. Education, outreach, technical and financial assistance, permit administration, and enforcement will all be used to ensure that the goals of this TMDL are met.

The City of Logan will undertake activities in this adaptive management plan to reduce the phosphorus contribution identified as the WLA for the City of Logan. DEQ and the City of Logan agree that these adaptive management activities are intended to support this TMDL and add to the assurance that dissolved oxygen in Cutler Reservoir will meet conditions under current Utah water quality standards. DEQ and the City will also support, continue, and maintain implemented activities that are demonstrated to reduced and/or limit the phosphorus loading to Cutler Reservoir.

The following rationale provides reasonable assurance that the activities proposed by the City of Logan will lead to meeting the WLA for the City identified in the TMDL goals.

- The City of Logan has conducted education activities in schools, within the community and at other events and will continue public education and outreach programs.
- Technical assistance is available from various organizations in the watershed and national experts. The City of Logan has utilized this technical assistance and will continue to look for opportunities where this assistance can be helpful in meeting these adaptive management plan goals.
- Local, regional, State, and Federal agencies have various programs to provide financial assistance to promote TMDL related activities. The City of Logan will look for these opportunities to fund adaptive management activities.
- DEQ, the City of Logan and others monitor flow and water quality in the watershed. These groups commit to maintaining this monitoring, reviewing the data, and modifying the monitoring program as necessary.
- The City of Logan is committed to a phased adaptive management approach that is protective of water quality and the financial resources of the community, with appropriate investments in activities that will lead to the long term water quality improvement of Cutler Reservoir.

DEQ is authorized to impose strict requirements or issue enforcement actions to achieve compliance with state water quality standards. However, it is the goal of all participants in the TMDL process to achieve clean water through cooperation and implementation of this adaptive management plan.

8 Summary of Public Involvement

The City of Logan will follow existing policies for public announcements and involvement in adaptive management activities. For activities with funding from sources other than the City of Logan and/or that other agencies lead, the policies and requirements for those agencies will be followed regarding public announcements and involvement.

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