Boulder 75th Street Wastewater Treatment Facility Nutrient Compliance Study Report

Prepared for
City of Boulder
Boulder, CO

Executive Summary

On June 11, 2012 the State of Colorado implemented new environmental regulations that significantly increased the amount of nutrient removal required for wastewater treatment facilities that discharge to Colorado water bodies. The City of Boulder's 75th Street Wastewater Treatment Facility (WWTF) currently discharges to Boulder Creek and consists of secondary treatment that removes ammonia through nitrification, and nitrate through partial denitrification. Phosphorus removal is not part of the current process configuration. In March of 2012, the City hired Brown and Caldwell to assess the impacts of the new regulations on the WWTF.

The purpose of this Nutrient Compliance Study was to review the treatment process capabilities of the City of Boulder's 75th Street WWTF, and determine how best to meet future nutrient effluent limitations, specifically focusing on the following three regulatory actions:

- City of Boulder 75th St. WWTF CDPS Permit No. CO-0024147 (May 2011)
- Colorado Department of Public Health and Environment (CDPHE) Regulation #85 – Nutrient Management Control Regulation
- CDPHE Regulation #31 – The Basic Standards and Methodologies for Surface Water Regulations

The nutrient related permit limits (existing and expected future) are presented below in Figure 1.

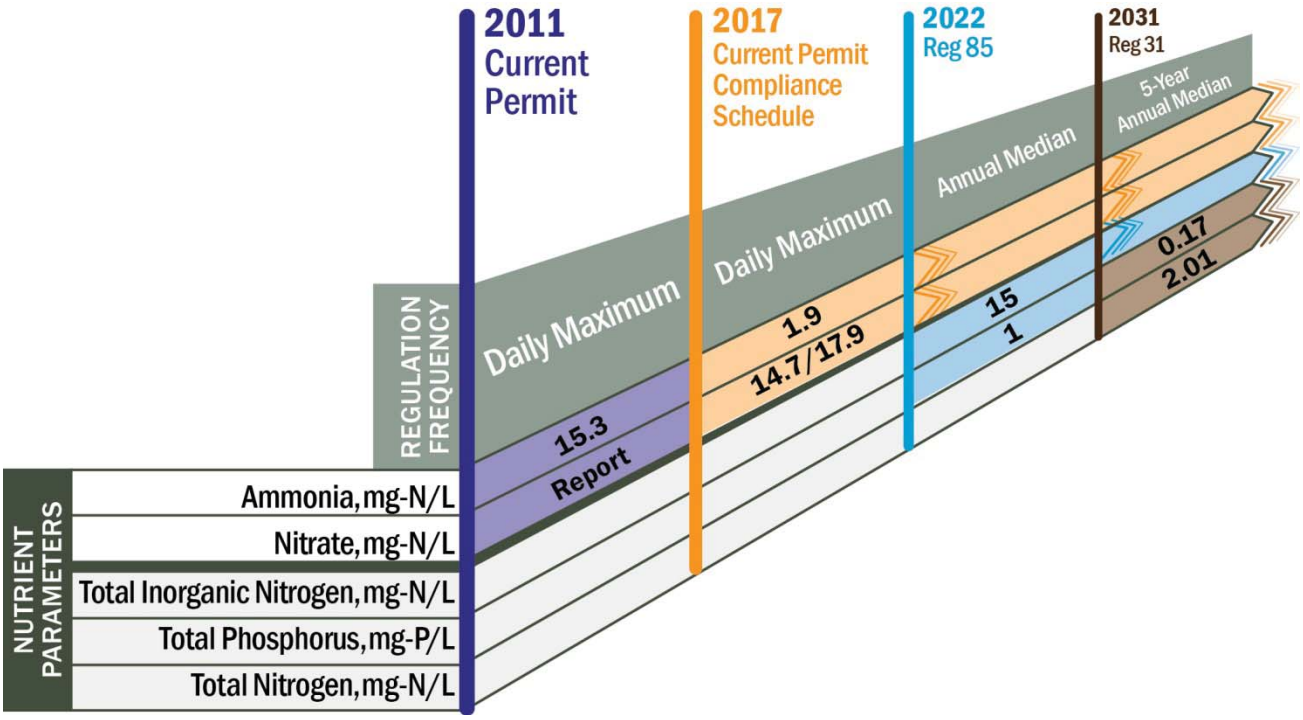

Figure 1. City of Boulder Nutrient Permit Limits.

The overall goals of this Study were to:

1. Assist the City of Boulder with determining what treatment upgrades are best suited to comply with the upcoming regulations
2. Identify when to implement these phased treatment upgrades

3. Provide the City with planning level cost estimates.

This executive summary serves as a brief recap of the Study and highlights the overall recommended treatment technologies, estimated costs, proposed layouts and project schedule. Additional details and information on the alternatives evaluation and selection can be found in the accompanying appendices.

Evaluation and Report Organization

The first phase of this Study was to evaluate the existing treatment processes and determine opportunities for optimization. The subsequent phases of the study evaluated treatment options to meet the current, Regulation 85, and Regulation 31 permit limits shown in Table 1. A summary memo compiled the recommendations and costs from the evaluation and presented a project schedule and budget for implementation.

Five technical memorandums (TMs) were developed for this Study and three workshops were held with City staff to discuss and select the recommended treatment technologies. Details on the evaluation and selection of treatment alternatives can be found in the individual TMs.

The following is a list of the TMs that are provided in the appendices:

- TM 1 – Evaluation of Existing Facility
- TM 2 – Current Permit Limit Compliance
- TM 3 – Regulation 85 Compliance
- TM 4 – Regulation 31 Compliance
- TM 5 – Recommendations and Costs

Recommendations

The following sections summarize the recommendations from each of the TMs including process descriptions and basis for selection. A number of alternatives were evaluated for each phase of treatment, based on the following criteria:

- Best use of the existing facilities
- Compatibility with previous and future phases
- Minimal use of external carbon sources
- Reduced compliance risk

TM1 – Existing Facility Evaluation

The first phase of this study was to evaluate opportunities to optimize the current processes at the 75th Street WWTF in order to most effectively set the plant up to meet future permit limits. As part of this evaluation, Brown and Caldwell compiled and evaluated plant data to conduct a plant-wide mass balance and calibrate the BioWin model. In addition, a supplemental dissolved oxygen (DO) sampling campaign was conducted by plant staff to understand the impacts on denitrification.

The major opportunities for improvements include optimizing nitrification and denitrification performance, and centrate management, specifically:

- Reducing the DO in the anoxic zones to improve denitrification.
- Extending the dewatering schedule from three to five days per week to better equalize the centrate and improve nitrification and denitrification performance.

TM2 – Current Permit Limit Compliance

When the compliance schedule in the current permit goes into effect, the most critical issues for the WWTF will be meeting the future requirements for daily maximum effluent ammonia concentrations and daily maximum effluent nitrate concentrations. A number of viable treatment technologies were considered to meet effluent permit limits including options to address peak ammonia and nitrate excursions, and to address the carbon deficit.

Treatment Recommendation:

4-Stage Bardenpho process with methanol (MeOH) facilities (as-needed basis)

Process Description:

The 4-Stage Bardenpho process has four stages of biological treatment: anoxic, aerobic, anoxic, final aeration. This process can be implemented within the existing aeration basins with some minor internal structural and control modifications. Construction of a second anoxic zone will be required for each basin. This change will require modifying the location of the IMLR pumps, addition of a chimney baffle (for carbon addition) for each basin, new mixers, and relocation of some of the ceramic diffusers.

This alternative assumed carbon addition to the second anoxic zone of each aeration basin. Carbon can be added to either or both anoxic zones, but this can be evaluated during design to determine the optimum proportion.

Benefits:

- Better utilization of free influent carbon than current configuration
- In addition to meeting the maximum daily limits, also meets TIN limits under Regulation 85
- Utilizes existing aeration basins with slight modifications to the configuration
- Similar to current process operation
- Low cost

An immediate result of the analysis is ongoing investigations by City staff to evaluate potential local waste products that could be used to reduce or eliminate the need for methanol or other chemical products as a carbon source.

TM3 – Regulation 85 Compliance

With the annual median TIN limit addressed with the recommended 4-Stage Bardenpho process in TM2, TM3 focused on treatment options aimed at meeting the Regulation 85 TP limit. Evaluated treatment technologies included chemical phosphorus removal, biological phosphorus removal, and phosphorus recovery alternatives.

Treatment Recommendation:

CoMag® for chemical phosphorus treatment and Ostara Pearl® system for phosphorus recovery.

Process Description:

The CoMag® process is an iron ore (magnetite) ballasted coagulation and flocculation process. The flocs are rapidly settled in the clarification system due the magnetite addition. The CoMag® process consists of mixing tanks (with chemical addition), clarifier, and a magnetic drum for recovery of the magnetite. The chemical sludge from the process can be further treated in the DAFTs or returned to the Headworks. The CoMag® facility would be located downstream of the secondary clarifiers, prior to disinfection.

The Ostara Pearl® system transforms the ammonia and phosphorous in the centrate stream into a beneficial commercial-grade fertilizer product. This system can be installed in the existing Dewatering Building.

Benefits:

- CoMag®
  - Can be utilized in future phase to address Regulation 31 limits
  - Provides added benefit of effluent TSS removal
  - Compact system
  - Does not inhibit the biological process
- Ostara Pearl®
  - Reduces struvite precipitation potential of the centrate stream
  - Reduces amount of phosphorus load to the secondary process – resulting in a reduction of chemicals needed for chemical phosphorus removal in the CoMag® process
  - Provides a revenue source from the sale of the recovered product

TM 4 – Regulation 31 Compliance

To meet the Regulation 31 limits, the 4-Stage Bardenpho process would be utilized to achieve the lowest secondary effluent concentrations of both nitrogen and phosphorus without chemical addition. The reasons are as follows: 1) to meet the limits expected for Regulation 31, additional nitrogen and phosphorus removal will be required after secondary treatment; 2) utilization of carbon and coagulant for nitrogen and phosphorus removal, respectively, will be more efficient if carried out in dedicated post-denitrification and post-precipitation facilities.

Treatment Recommendation:

Moving Bed Biofilm Reactor (MBBR) with increased chemical dosages for the CoMag® process.

Process Description:

Post-denitrification MBBR will be implemented in new reactors located downstream of the secondary clarifiers. Methanol addition is required for this process. Media is used in the denitrification reactors to grow the denitrifying bacteria and helps reduce the overall reactor volume. Following the MBBR is a post-aeration basin to increase the DO and consume any residual methanol. This process is then followed by the CoMag® process to remove phosphorus, DON and suspended solids created during the MBBR process. The exact same design and size of the CoMag® process to meet the Regulation 85 limits can be utilized for Regulation 31. Additional alum and sodium hydroxide are needed to meet the lower effluent TP limit.

Benefits:

- MBBR
  - No filter or media blinding issues
  - Smaller footprint compared to denitrification filters
  - Results from US installations show effluent nitrate-nitrogen values less than 1 mg/L
- CoMag®
  - System already in place for Regulation 85
  - Reduces both total phosphorus and DON

Estimated Costs and Proposed Layouts

An important part of the Study was to help the City project future budgets required for the recommended treatment technologies. A summary of the estimated costs for each of the recommended alternatives is provided below in Table 1.

Table 1. Estimated Costs for Recommended Alternatives

Capital Cost		Annual O&M Costs			Total Annual Operating Cost	20-Year O&M Present Worth[3]	Salvage Cost [4]	Total Cost (Capital + O&M PW – Salvage)
Recommended Alternative	Total	Chemical	Power [1]	Other [2]				
4-Stage Bardenpho with Methanol Facility	**$1,376,000**	$44,000	$22,600	$8,300	$74,900	$1,110,000	$534,600	$1,951,000
CoMag® with Ostara Pearl®	**$14,723,000**	$663,000	$7,800	$92,700	$763,500	$11,360,000	$3,270,000	$22,813,000
MBBR	**$8,861,000**	$599,000	$104,900	$58,500	$762,400	$11,340,000	$1,810,000	$18,391,000

1. Includes power costs which assume $0.07/kWh.

2. Other O&M costs were taken as 1% of capital for routine maintenance and parts replacement for mechanical and electrical equipment

3. Assumes inflation = 4% and interest =7%.

4. Salvage value was assumed to be 0% for mechanical- and electrical-related equipment after 20 years, and 60% for non-mechanical equipment after 20 years.

The recommended treatment technologies to meet the current and future permit limits are shown on Figure 2 and the basis for the recommendations is provided in TM5. The proposed locations on the facility site are sized based on preliminary design information noted in the respective TMs. The processes and facilities are color-coded based on when the project is scheduled to be implemented: red for current permit limits, green for Regulation 85, and yellow for Regulation 31.

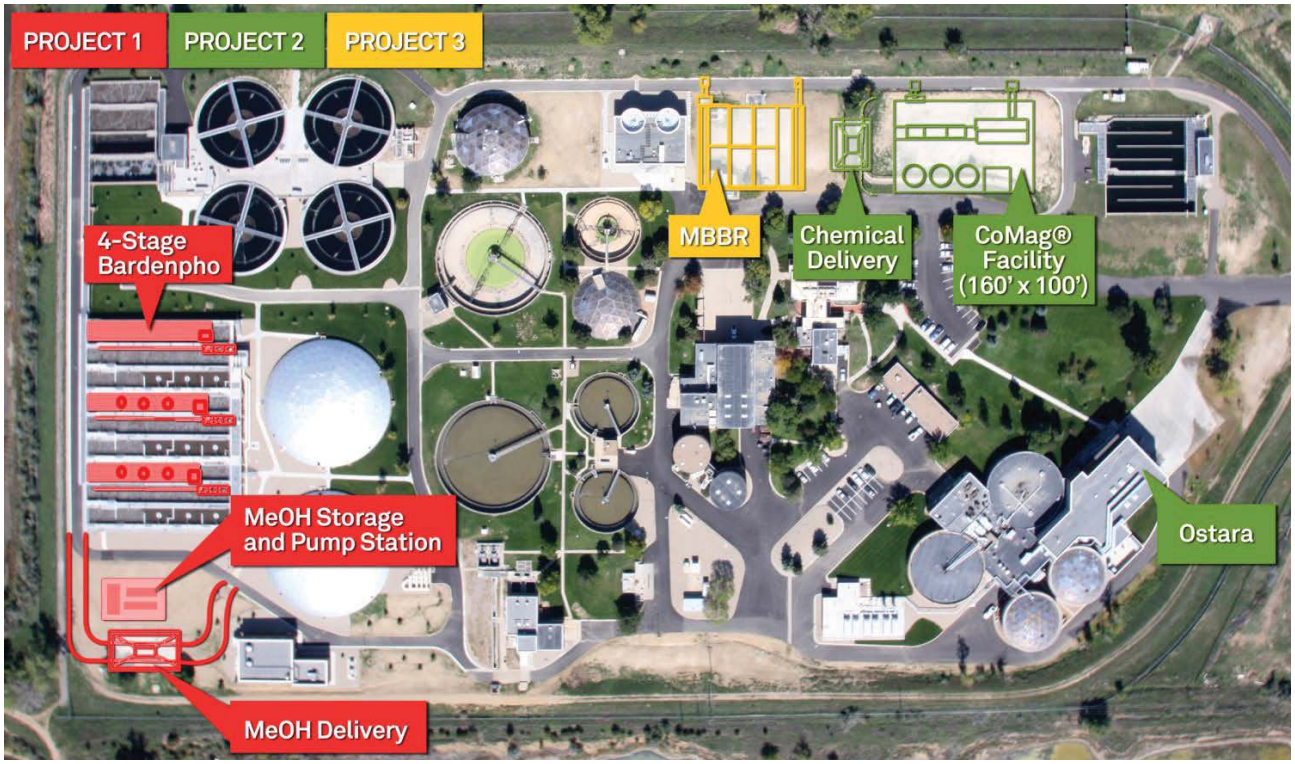

Figure 2. Proposed Layout for Future Processes.

Project Approach and Schedule

The results of the evaluation identify three distinct projects or phases. These projects are identified below in Table 2.

Table 2. Recommended Projects

Project	Regulation Compliance[1]	Target/Goal	Description
1	Current Permit Limits Regulation 85 TIN Limits	Daily NH_3-N < 1.9 mg/L Daily NO_3-N < 14.7 mg/L TIN-N < 15 mg/L	4-Stage Bardenpho with methanol facilities
2	Regulation 85 TP Limits	TP-P < 1.0 mg/L	CoMag® with Ostara Pearl®
3	Regulation 31 Limits	TN-N < 2.01mg/L TP-P < 0.17 mg/L	MBBR with increased chemical dosage for CoMag®

Based on the estimated project capital costs, a schedule of design and construction activities along with the associated costs were determined. The timing and costs of these project activities are presented below in Table 3.

Table 3. Compliance Schedule and Project Costs

Treatment Technology	Time Period	Activities [2]	Total Cost [1]
Project 1: 4-Stage Bardenpho with Methanol **Capital Cost:** $1,376,000 **Total Project Cost:** $1,898,880	2013	Optimization	$ 0
	2014	Pre-Design and Final Design For Current Limits	$ 206,400
	2015	Construction	$ 1,651,200
	2016	Startup/Testing For Current Limits	$ 41,280
	2017	Regulation 85 Related Pilot Testing	$ 0
Project 2: CoMag® with Ostara Pearl® **Capital Cost:** $14,723,000 **Total Project Cost:** $20,317,740	2018	Pre-Design For Regulation 85	$ 736,150
	2019	Final Design For Regulation 85	$ 1,472,800
	2020	Construction	$ 8,833,800
	2021	Construction	$ 8,833,800
	2022	Startup/Testing For Regulation 85	$ 441,690
Project 3: MBBR and CoMag® w/ Increased Chemical Dosage **Capital Cost:** $8,861,000 **Total Project Cost:** $12,228,180	2026	Regulation 31 Related Pilot Testing	$ 0
	2027	Pre-Design For Regulation 31	$ 443,050
	2028	Final Design For Regulation 31	$ 886,100
	2029	Construction	$ 5,316,600
	2030	Construction	$ 5,316,600
	2031	Startup/Testing For Regulation 31	$ 265,830

1. Pre-Design = 5% of capital cost. Final Design = 10% of capital cost. Construction cost includes capital cost + 5% for administrative and legal fees + 15% for construction management. Startup/Testing = 3% of capital cost.

2. For Projects 2 and 3, construction costs occurred were based on 24 months and the total capital cost was spread over two years.

As a result of this Study, the City of Boulder and the Brown and Caldwell team have selected the best treatment alternatives to meet the current and future permits limits. These treatment alternatives optimize and utilize the existing facility, each treatment technology builds upon and compliments the future technologies, and there are no stranded investments. The team has also established a phased schedule to implement these three projects, and the related cost estimates will help to establish the City's upcoming Capital Improvements Plan to maintain compliance for the next 20 years.