Executive Summary

To:	City of Ames Water Pollution Control		
From:	David Dechant/HDR John Christiansen/HDR Brian Bakke/HDR Adam Smith/HDR	Project:	Water Pollution Control Facility Nutrient Reduction Feasibility Study
CC:	City/HDR Project Team Members		
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The existing Ames Water Pollution Control Facility (WPCF) went into initial operation in 1989. It has and continues to meet National Pollutant Discharge Elimination Permit (NPDES) requirements.

However, as the Ames WPCF approaches 30 years in age, it faces two major challenges.

- More stringent regulatory requirements to remove the nutrients nitrogen and phosphorus outlined in Iowa's 2013 Nutrient Reduction Strategy
- The age, condition, and remaining useful life of the four existing trickling filters that are the heart of the treatment process

Figure 1: Existing Ames WPCF

This Executive Summary of the Ames WPCF Nutrient Reduction Feasibility Study provides:

- An overview of work completed by HDR in collaboration with the City of Ames (City) Water Pollution Control staff in 2018.
- A cost-effective plan to address both challenges facing the Ames WPCF while providing additional capacity for the future.

Figure 2 shows the targeted objective of the Ames WPCF Nutrient Reduction Feasibility Study, that is, finding the appropriate balance costs and benefits. Figure 3 shows the sequence of work completed.

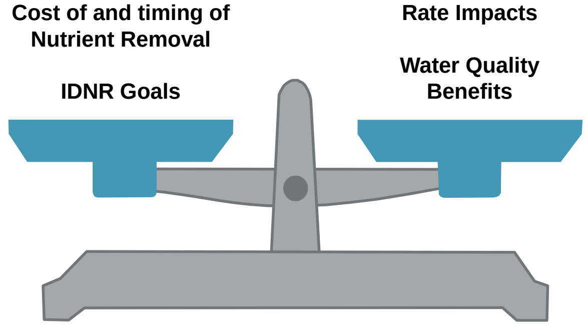

Figure 2: Nutrient Reduction Feasibility Study Objective

A series of Technical Memoranda (TMs) document the work, providing additional detail and supporting information. After initial introduction and summary sections, each subsequent section of this Executive Summary corresponds to one of those TMs, as follows.

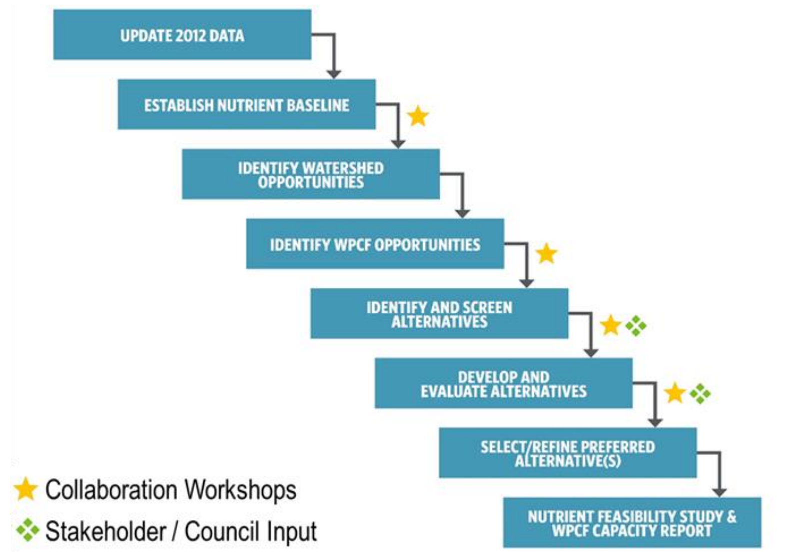

Figure 3: Nutrient Reduction Feasibility Study Delivery Process

- Introduction
- Summary
- Task 300 – Background Information
- Task 400 – Skunk River Nutrient Baseline
- Task 500 – Off-site Nutrient Reduction
- Task 600 – WPCF Nutrient Reduction Baseline
- Task 700 – Alternatives Identification and Screening
- Task 800 – Alternatives Development and Evaluation
- Task 900 – Stakeholder Involvement
- Task 1000 – Preferred Alternative Refinement

Introduction

The primary driver for the Ames WPCF Nutrient Reduction Feasibility Study is the 2013 Iowa Nutrient Reduction Strategy. This strategy targets 45 percent reductions in nitrogen and phosphorus leaving Iowa. The 2013 Iowa Nutrient Reduction Strategy is part of a broader regional plan to address the growing hypoxic zones in the Gulf of Mexico attributed to nutrient discharges from the Mississippi River Basin (see Figure 4). However, the 2013 Iowa Nutrient Reduction Strategy also addresses$100. nutrient related water quality issues in local watersheds.

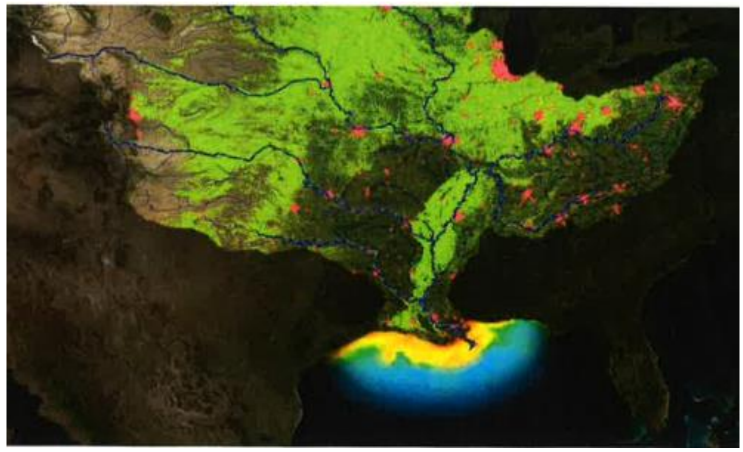

Figure 4: Mississippi River Basin and Gulf Hypoxic Zone

As shown in Figure 5, the 2013 Iowa Nutrient Reduction Strategy targets 16 percent of the phosphorus and 4 percent of the nitrogen reductions through implementation of biological nutrient removal for point source wastewater treatment plant discharges. The strategy targets voluntary reductions from nonpoint watershed sources for the remaining 29 percent phosphorus and 41 percent nitrogen reductions.

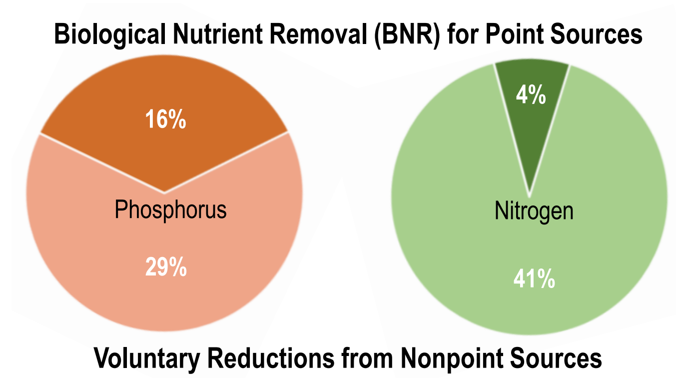

Figure 5: Iowa Nutrient Reduction Strategy Targets

A secondary driver for the Ames WPCF Nutrient Reduction Feasibility Study is the age, condition, and remaining useful life of the four existing trickling filters that are the heart of the treatment process (see Figure 6). The trickling filters have performed exceedingly well for their original design purpose, but both the exterior structure and the interior media are approaching the end of their useful lives. Additionally, the existing trickling filters would cost an estimated $8.8 million to replace and would provide limited value with respect to the biological nutrient removal required by the 2013 Iowa Nutrient Reduction Strategy.

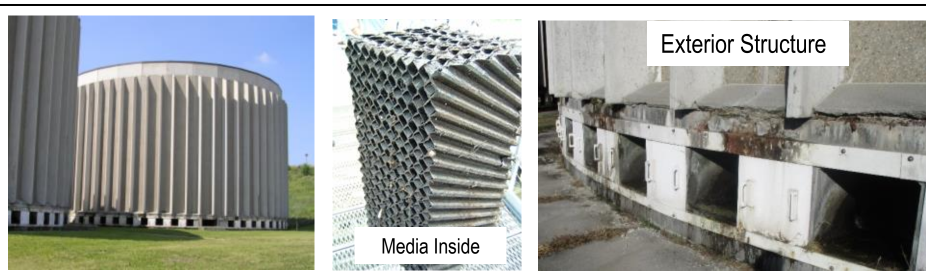

Figure 6: Existing Trickling Filters

Summary

The Ames WPCF Nutrient Reduction Feasibility Study recommends an integrated strategy that comprises off-site watershed nutrient reductions and on-site Ames WPCF nutrient reductions. The integrated strategy balances the cost and timing of nutrient reduction to achieve Iowa Department of Natural Resources (IDNR) goals with customer rate impacts and associated water quality benefits.

The first component of the integrated strategy would transition the Ames WPCF from an existing trickling filter solids contact process to a future biological nutrient reduction process, incorporating one of three alternative technologies, simultaneous nitrification denitrification, carbonaceous activated sludge, or granular activated sludge. In doing so, the Ames WPCF would provide capacity for projected flows and loadings and would progressively achieve compliance with the 2013 Iowa Nutrient Reduction Strategy. The transition would occur in three phases over the next 20 years to take advantage of the remaining useful life of existing facilities, most notably the trickling filters. The specific biological nutrient removal technology would be determined at the beginning of the first phase.

The required capital investment, in 2018 dollars, is estimated to be as follows.

- Phase 1: $8.5 million over the first 5 years
- Phase 2: $11 million over the next 5 years
- Phase 3: $11 million over the last 10 years

Nutrient reduction at the Ames WPCF would progressively increase from current reductions of approximately 42 percent nitrogen and 25 percent phosphorus to the targeted 2013 Iowa Nutrient Reduction Strategy reductions of 66 percent nitrogen and 75 percent phosphorus on an annual average basis. The anticipated progression is outlined in the following.

- Minimal additional removal following Phase 1
- Seasonal biological nutrient removal following Phase 2
- Full biological nutrient removal following Phase 3

The configuration of the existing Ames WPCF and the goal of fully using the remaining useful life of the existing trickling filters precludes more aggressive nutrient reductions earlier than what is planned with the integrated strategy.

The Ames WPCF would concurrently and progressively increase from current maximum month flows and loadings to projected future influent maximum month capacities as follows:

- 12.6 million to 15.7 million gallons per day flow
- 12,100 to 16,600 pounds per day 5-day biochemical oxygen demand (BOD_5)
- 16,300 to 22,400 pounds per day total suspended solids (TSS)
- 1,680 to 2,300 pounds per day ammonia

- 2,340 to 3,210 pounds per day total nitrogen
- 299 to 410 pounds per day total phosphorus

The second component of the integrated strategy would continue the City's practice to incorporate stormwater best management practices (BMPs) in public works projects and would target additional off-site watershed nutrient reduction projects to demonstrate commitment and progress toward the 2013 Iowa Nutrient Reduction Strategy. Likewise, the City would continue to collaborate with Iowa State University as they explore additional agricultural BMPs such as perennial cover crops.

The Ames WCPF Nutrient Reduction Feasibility Study identifies example sites and projects to convey the associated concepts and established criteria to prioritize off-site nutrient reduction projects. The City's associated capital investment is budgeted at $200,000 per year. It is anticipated that the City would leverage that amount to obtain additional funding from available state and federal funding sources. Nutrient reductions would be registered with the Iowa Nutrient Reduction Exchange as potential offsets to more stringent future requirements at the Ames WPCF.

Task 300 – Background Information

The *Task 300 Background Information TM* provides relevant background information for the Ames WPCF Nutrient Reduction Feasibility Study, including:

- Ames WPCF influent flows and loadings, and hydraulic and organic capacity data updated from the *2012 Long Range Facility Plan* to reflect changes and trends over the past 6 years.
- Recent updated trickling filter condition assessment and media survey results.
- Influent nitrogen and phosphorus loadings and speciation reflective of more extensive recent data.

As part of the background information, Table 1 presents current and projected influent wastewater flows and loads based on monthly monitoring report data from January 1, 2015, through December 31, 2017. Future flows and loads in 5-year increments were projected through the design year of 2040 based on future population growth estimates developed as part of the *Ames Water Treatment Plant Capacity Assessment TM Number 2-A* (June 2009), but those projections were updated to reflect estimated 2016 Census population rather than the population estimates used in the 2009 TM.

The past 17 years have exhibited a trend toward precipitation extremes. The years 2007 through 2010 were significantly wetter than the previous 5 years (2002 through 2006). The years 2011, 2012, 2016, and 2017 were also drier periods. Influent flows to the Ames WPCF show a similar trend toward precipitation extremes.

The monthly influent flow and precipitation data for a 17-year period (2001 through 2017) were reviewed to determine trends in influent flows and to compare those trends to the capacity of the upstream Skunk River trunk sewer. The current and future maximum daily flow reflected in

Table 1 is representative of the most extreme wet weather period during those 17 years; the largest maximum day flow was recorded on May 31, 2008. The current and future maximum month flows reflected in Table 1 are representative of the second most extreme wet weather period during those 17 years; the second largest maximum month flow was recorded in August 2015. From prior experience working with IDNR and from discussions during Workshop 3, the extreme maximum flow event recorded in May and June 2008 was discarded for the purposes of projecting future maximum month flows and loads. Therefore, the second largest maximum month flow, 12.6 million gallons per day recorded in August 2015, was selected to generate future flow and loading projections.

The hydraulic capacity of the Ames WPCF was identified through hydraulic modeling performed in 2012; there have been no appreciable changes at the Ames WPCF since that modeling was performed. The 2012 hydraulic modeling identified the maximum hydraulic capacity to be 26.4 million gallons per day with four raw wastewater pumps operating in conjunction with all downstream unit processes in service. However, normal Ames WPCF operation diverts peak flows approaching 20.4 million gallons per day to flow equalization basins with a volume of 4.4 million gallons during elevated Skunk River elevations and/or localized precipitation events.

The flows and loadings presented in Table 1 were used to update the process-by-process analysis and modeling of the Ames WPCF performed in 2012. Table 2 presents the organic capacities for current maximum month flows and loadings with current and potentially more stringent ammonia permit limitations. Table 2 also provides a comparison to the original design basis for the Ames WPCF and organic capacities for previous maximum month flows and loadings with current and potentially more stringent ammonia permit limitations.

Trickling filters went into operation at the Ames WPCF in late 1989. The trickling filter complex consists of four individual trickling filters: two are first-stage filters and the other two are second-stage filters. Each trickling filter has a diameter of 80 feet and is filled with modular plastic media manufactured by BF Goodrich to a depth of 26 feet. Trickling filter condition assessments were previously completed in 2006, 2012, and 2017, and phone surveys of other facilities using BF Goodrich media were performed in 2006 and 2018. Based on the prior condition assessments and media phone surveys, it seems reasonable to expect an additional 5 to 10 years of useful life from the existing trickling filters.

Task 400 – Skunk River Nutrient Baseline

The *Task 400 Skunk River Nutrient Baseline TM* established the current nutrient baseline for the Skunk River watershed by characterizing the sources and quantities of nitrogen and phosphorus loadings, both upstream and downstream of the Ames WPCF. The nutrient baseline provides the basis for considering nutrient reduction options to achieve the objectives of the 2013 Iowa Nutrient Reduction Strategy. The nutrient baseline also provides the basis for exploring potential opportunities for watershed nutrient reductions as offsets against Ames WPCF reductions or as alternatives or supplements to Ames WPCF reductions.

Table 1: Current and Projected Influent Wastewater Flows and Loads

	2015-2017 Data		2020			2025			2030			2035			2040		
		Concentration, mg/L	Residential/ Commercial Growth	Reserve	Total	Residential/ Commercial Growth	Reserve	Total	Residential/ Commercial Growth	Reserve	Total	Residential/ Commercial Growth	Reserve	Total	Residential/ Commercial Growth	Reserve	Total
Flow, MGD																	
Average Annual	6.19	N/A	6.25	0.50	6.75	6.43	0.50	6.93	6.62	1.00	7.62	6.81	1.00	7.81	6.99	1.50	8.49
Maximum Month	12.6*	N/A	12.7	0.50	13.2	13.1	0.50	13.6	13.5	1.00	14.5	13.9	1.00	14.9	14.2	1.50	15.7
Maximum Day	37.2**	N/A	37.5	0.50	38.0	38.7	0.50	39.2	39.8	1.00	40.8	40.9	1.00	41.9	42.0	1.50	43.5
BOD_5, lb/day																	
Average Annual	9,360	181	9,450	800	10,250	9,720	800	10,520	10,000	1,500	11,500	10,300	1,500	11,800	10,600	2,300	12,900
Maximum Month	12,100	115	12,200	1,000	13,200	12,600	1,000	13,600	13,000	1,900	14,900	13,300	1,900	15,200	13,600	3,000	16,600
Maximum Day	18,100	58	18,200	1,500	19,700	18,800	1,500	20,300	19,400	2,900	22,300	19,900	2,900	22,800	20,400	4,400	24,800
TSS, lb/day																	
Average Annual	11,000	213	11,100	900	12,000	11,400	900	12,300	11,800	1,800	13,600	12,100	1,800	13,900	12,400	2,700	15,100
Maximum Month	16,300	155	16,400	1,300	17,700	16,900	1,300	18,200	17,500	2,700	20,200	18,000	2,700	20,700	18,400	4,000	22,400
Maximum Day	31,300	101	31,600	1,700	33,300	32,600	1,700	34,300	33,500	3,500	37,000	34,400	3,500	37,900	35,300	5,200	40,500
Ammonia, lb-N/day																	
Average Annual	1,300	25.2	1,310	110	1,420	1,350	110	1,460	1,390	210	1,600	1,430	210	1,640	1,470	320	1,790
Maximum Month	1,680	16.0	1,690	140	1,830	1,750	140	1,890	1,800	270	2,070	1,850	270	2,120	1,890	410	2,300
Maximum Day	2,360	7.6	2,380	200	2,580	2,460	200	2,660	2,520	380	2,900	2,590	380	2,970	2,660	580	3,240
TKN, lb-N/day																	
Average Annual	2,050	39.7	2,070	170	2,240	2,130	170	2,300	2,190	330	2,520	2,260	330	2,590	2,310	500	2,810
Maximum Month	2,340	22.3	2,360	190	2,550	2,430	190	2,620	2,510	380	2,890	2,580	380	2,960	2,640	570	3,210
Maximum Day	2,720	8.8	2,740	230	2,970	2,830	230	3,060	2,910	440	3,350	2,990	440	3,430	3,070	660	3,730
TP, lb-P/day																	
Average Annual	263	5.09	266	21	287	273	21	294	281	42	323	289	42	331	297	64	361
Maximum Month	299	2.85	301	24	325	311	24	335	320	48	368	330	48	378	337	73	410
Maximum Day	324	1.04	327	26	353	337	26	363	347	52	399	356	52	408	366	79	445

*Based on second largest maximum month flow recorded in August 2015.

**Based on largest maximum day flow recorded on May 31, 2008.

Table 2: Ames WPCF Organic Capacity

	Original Design Basis	Previous Max Month Loading	Current Max Month Loading	Capacity with Current Permit and Previous Flows and Loads		Capacity with Current Permit and New Flows and Loads		Capacity with Potential Ammonia Permit and Previous Flows and Loads		Capacity with Potential Ammonia Permit and New Flows and Loads		Previous Conc. for Capacity	New Conc. for Capacity
				Value	%	Value	%	Value	%	Value	%	mg/L	mg/L
Flow, MGD	12.1	10.1	12.6	14.1	117%	11.9	98%	10.1	83%	9.0	74%	-	-
BOD_5, lb/day	16,150	10,700	12,100	14,900	92%	16,200	100%	10,700	66%	9,500	59%	127	115
TSS, lb/day	16,190	16,600	16,300	23,200	143%	22,300	138%	16,600	103%	14,800	91%	197	155
TKN, lb-N/day	4,950	2,500	2,340	3,500	71%	3,200	65%	2,500	46%	2,300	46%	29.7	22.3
NH3-N, lb-N/day	2,750	1,530	1,680	2,100	76%	2,200	80%	1,500	55%	1,400	51%	18.2	16.0

Table 3 provides estimated total watershed loadings for the South Skunk River Watershed. Nonpoint source loadings were based on the United States Geological Survey (USGS) SPAtially Referenced Regressions On Watershed Attributes (SPARROW) model. Point source loadings were estimated from typical pollutant concentrations and average dry weather flows. Figure 7 and Figure 8 present the distributions of the SPARROW nonpoint source loadings.

Table 3: Nutrient Loadings in the South Skunk River Watershed

Location		Total Phosphorus, lb/year	Total Nitrogen, lb/year
Total Skunk River Watershed	Nonpoint	769,000	19,115,000
	Point	136,000	775,000
	Total	905,000	19,890,000
Skunk River Watershed Upstream of the Ames WPCF	Nonpoint	276,000	8,950,000
	Point*	80,000	491,000
	Total	356,000	9,441,000

*Inclusive of the Ames WPCF

On an average annual basis, agricultural contributions of nutrients represent the largest fraction of the total phosphorus (TP) and total nitrogen (TN) loading in the watershed. Depending on the location within the South Skunk River Watershed, SPARROW results suggest that farm fertilizer and manure collectively represent approximately 72 percent to 76 percent of TP loadings and 66 percent to 68 percent of TN loadings. SPARROW results suggest that urban stormwater loadings represent approximately 14 percent to 16 percent of TP loadings and 4 percent to 5 percent of TN loadings within the watershed.

In contrast, Table 4 presents the estimated annual nutrient loadings from the Ames WPCF. Approximately 71,540 pounds per year of TP (approximately 8 percent of the total watershed load and approximately 20 percent of the upstream watershed load) and 433,255 pounds per year of TN (approximately 2 percent of the total watershed load and 5 percent of the upstream watershed load).

Table 4: Ames WPCF Nutrient Loadings in the South Skunk River Watershed

	Total Phosphorus	Total Nitrogen
Average Effluent Concentration (2015-2017), mg/L	3.80	23.0
Average Load*, lb/day	196	1,187
Average Load*, lb/year	71,540	433,255

The South Skunk River Watershed includes 23 municipal and semi-public wastewater treatment facilities. Total point source loadings within the South Skunk River Watershed are estimated at 136,000 pounds per year of TP and 775,000 pounds per year of TN. Based on available information, the Ames WPCF represents the largest point source discharge within the watershed at approximately 53 percent of the total TP load and 56 percent of the total TN load.

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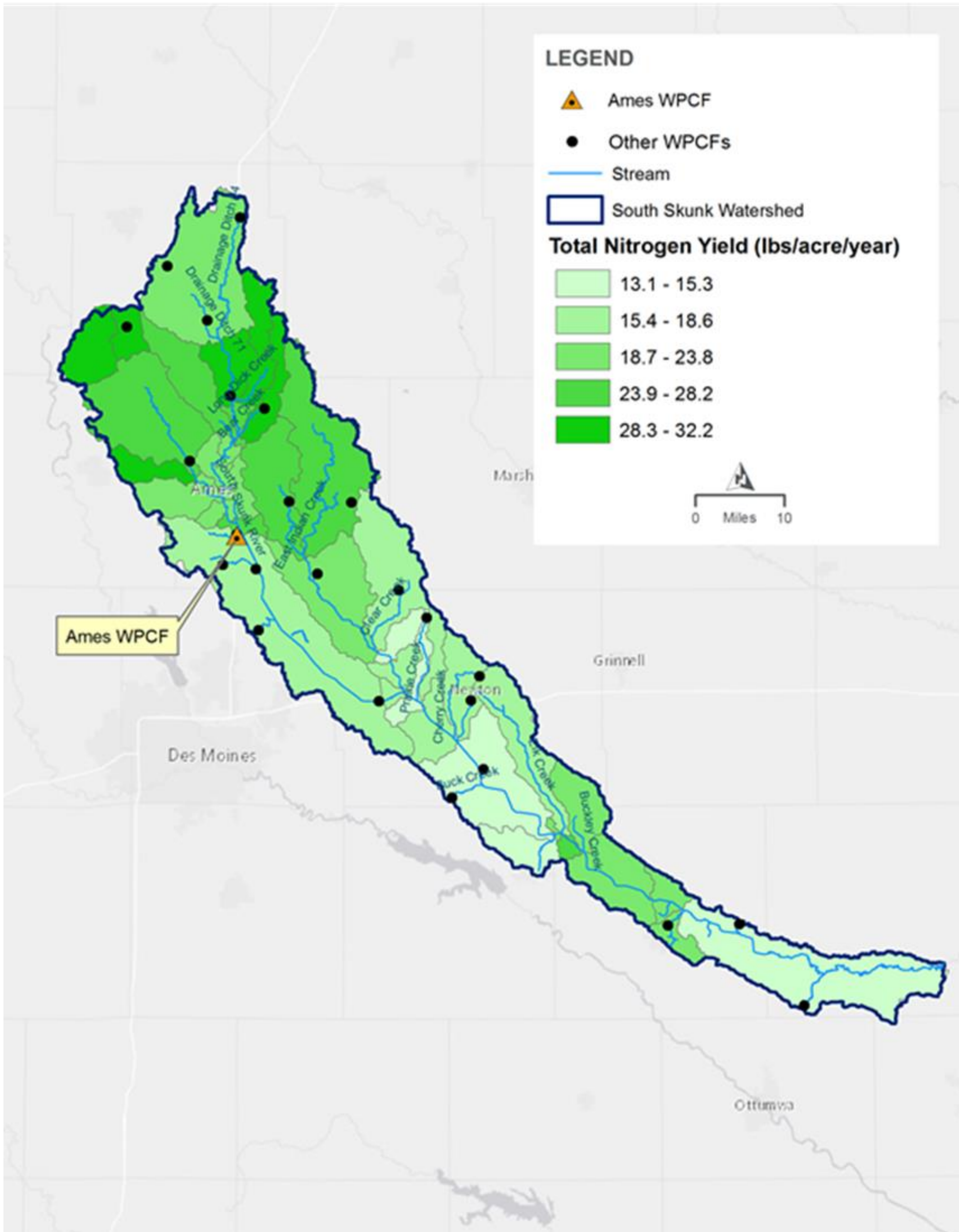

Figure 3: SPARROW Model Total Nitrogen Nonpoint Source by Area

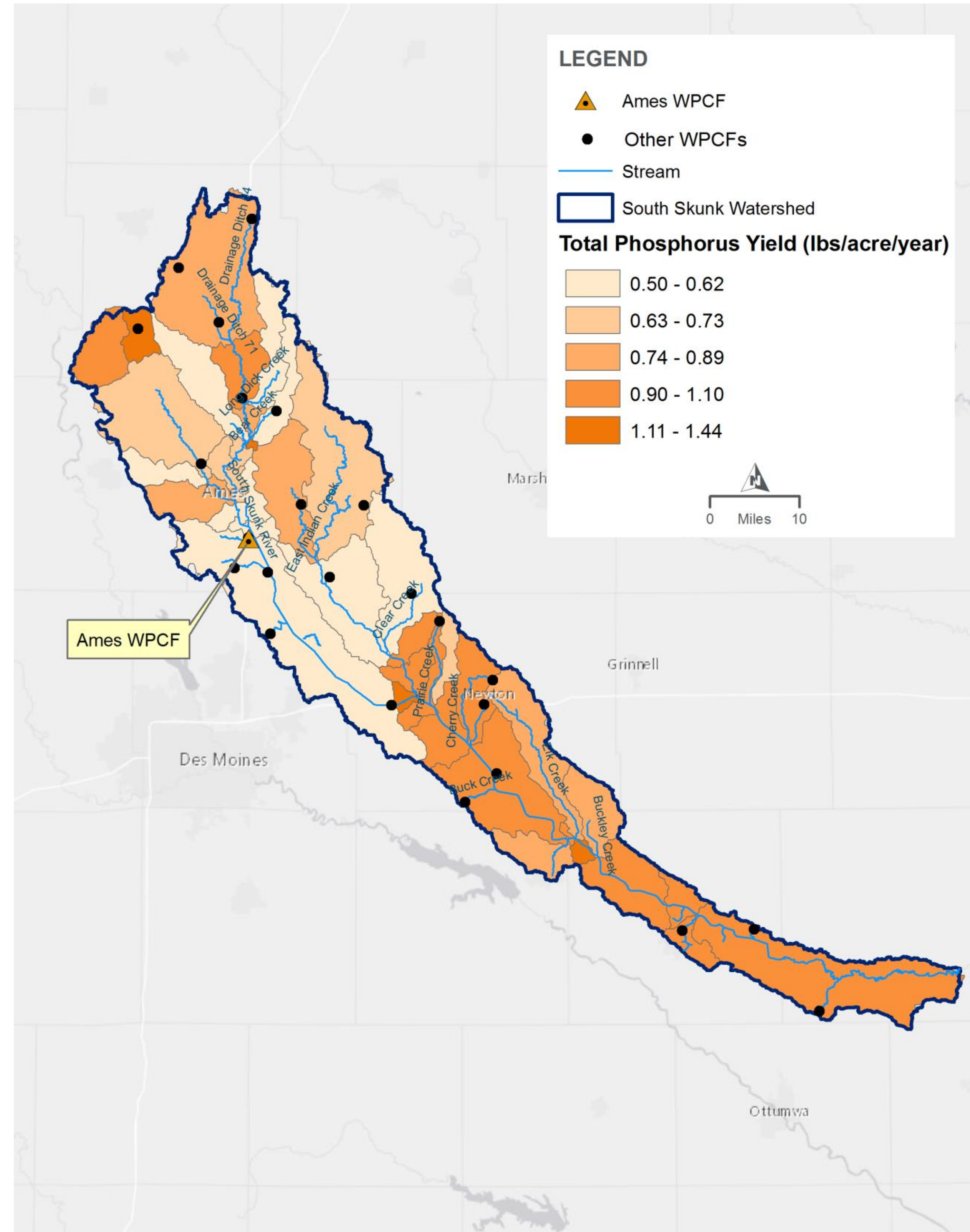

Figure 2: SPARROW Model Total Phosphorus Nonpoint Source by Area

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The 2013 Iowa Nutrient Reduction Strategy targets 66 percent of TN and 75 percent of TP equivalent annual reductions in raw wastewater point source discharges. Based on current loadings, Ames WPCF targeted reductions are as follows.

- Approximately 72,000 pounds per year of TP, of which the Ames WPCF is currently removing approximately 24,500 pounds per year of TP.
- Approximately 493,800 pounds per year of TN, of which the Ames WPCF is currently removing approximately 315,000 pounds per year of TN.

Relative to upstream nonpoint source loads, the Ames WPCF targeted reductions suggest that opportunities exist for addressing nutrient reduction targets through implementation of BMPs upstream of the Ames WPCF, particularly for TN reductions.

Task 500 – Off-site Nutrient Reduction

The *Task 500 Off-site Nutrient Reduction TM* explores nutrient reduction opportunities in the upstream Skunk River Watershed to provide a foundation for identifying integrated watershed and Ames WPCF nutrient reduction strategies. Watershed opportunities implemented through BMPs would potentially be synergistic with flood mitigation, wetland mitigation banking, water quality, and other ancillary benefits. The *Task 500 Off-site Nutrient Reduction TM* also includes assessment of IDNR's receptiveness to and the implications of watershed nutrient offsets, and identification of potential funding sources.

Nutrient offset is a form of water quality trading whereby pollutant control requirements for point sources can be met through off-site watershed reductions. Several agricultural BMPs can achieve off-site watershed reductions.

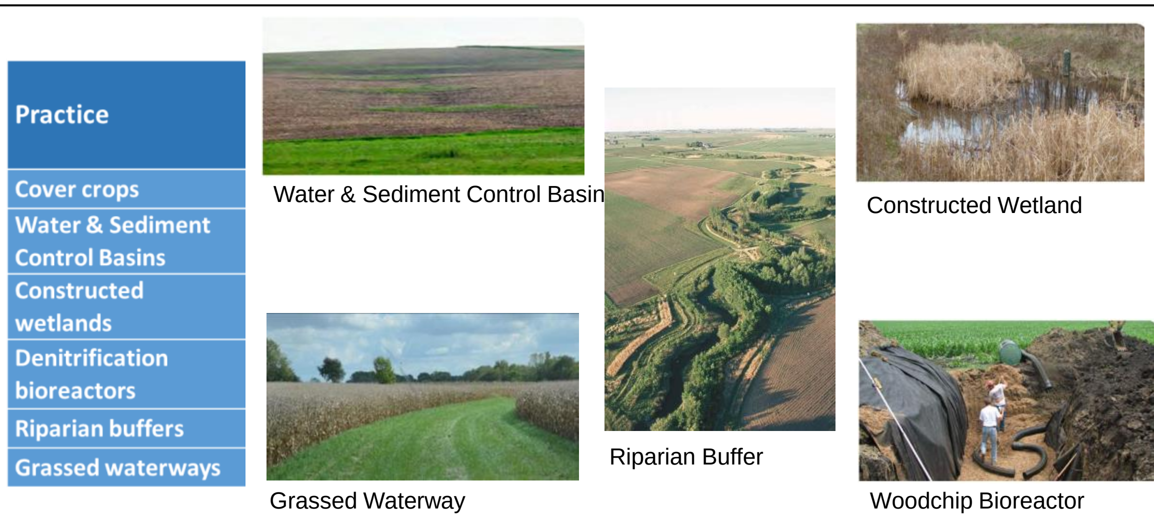


Figure 9: Agricultural Best Management Practices

Table 5 presents the varying performance and cost of agricultural BMPs. Most of these practices are well established and are shown to not only be effective at reducing nutrient loadings, but are shown to have other ancillary benefits in some cases including reduced soil erosion and improved habitat. Performance, as measured by nutrient reduction rates and costs, are highly variable and site specific for individual BMPs. Table 5 reflects assumed performance and cost numbers estimated from literature, 2013 Iowa Nutrient Reduction Strategy, and the Natural Resources Conservation Service (NRCS) Environmental Quality Incentives Program (EQIP) practice costs. Actual agricultural BMP performance and costs could vary significantly.

Table 5: Performance and Cost of Agricultural Best Management Practices

Practice	% Reduction		Cost of TN Reduction, $/lb	Cost of TP Reduction, $/lb
	TN	TP		
Cover crops	31%	29%	$6.00	$210
Water and sediment control basins	0%	80%	--	$29
Constructed wetlands	52%	58%	$1.20	$35
Denitrification bioreactors	43%	0%	$1.50	--
Riparian buffers	7%	18%	$5.50	$70
Grassed waterways	7%	18%	$33	$410

Table 6: Potential Applicability of Agricultural Best Management Practices

Practice	Treatment Area, ac	Potential Credits (lbs/yr)	
		TN	TP
Cover crops	304,133	2,262,768	65,280
Water & Sediment Control Basins	7,768	0	4,896
Constructed wetlands	**176,507**	**2,202,792**	**75,752**
Denitrification bioreactors	57,870	597,176	0
Riparian buffers	**235,100**	**394,944**	**31,280**
Grassed waterways	65,663	110,296	8,704

The analysis suggests that constructed wetlands appear to be the best value for nitrogen and phosphorus, denitrifying bioreactors appear to offer value with respect to nitrogen, and water and sediment control basins (WASCOBs) appear to offer value with respect to phosphorus.

The nutrient reduction targets for the Ames WPCF are 47,450 pounds per year for phosphorus and 179,200 pounds per year for nitrogen. In comparison, Table 6 identifies the availability of potential nutrient reduction credits for individual BMPs to offset Ames WPCF requirements. The estimated reduction credits reflect the results of an Agricultural Conservation Planning Framework (ACPF) analysis. ACPF is a toolset for identifying and optimizing the placement of BMPs on the landscape.

Based on ACPF findings, there are sufficient nitrogen credits upstream of the Ames WPCF to address its reduction targets for most individual BMPs. From a credit supply and cost perspective, the BMP of using constructed wetlands appears to be the most promising of all the BMPs. While there appears to be sufficient nitrogen credits upstream, the analysis suggests that offsetting 100 percent of Ames WPCF phosphorus removal targets with upstream reduction credits would be impractical given that doing so would require nearly 100 percent implementation of potential upstream BMP sites.

Iowa State University is researching an additional practice that could make cover crops significantly more attractive. That concept, perennial groundcover in the presence of row crops (see Figure 10), appears to offer multiple benefits in terms of both continued crop productivity, improved water quality, and reduced cost. However, cost information and nutrient removal rates for this practice were not readily available for analysis.

The City has a history of implementing urban stormwater BMPs, notably the following:

- City Hall Parking Lot Reconstruction
- Stormwater Erosion Control Project – South Skunk River from Carr Park to Homewood Golf Course
- Bioretention Cells on 24th Street with Street Rehabilitation Project
- Riffle Pools and Streambank Stabilization with Squaw Creek Water Main Stabilization at Lincoln Way
- Phosphorus Free Fertilizer on Parks
- Water Quality Treatment of Stormwater Runoff through City's Current Post-Construction Ordinance

Figure 10: Perennial Cover Crop

These urban stormwater BMPs can achieve off-site watershed nutrient reduction and can provide other ancillary benefits. As standalone projects, these urban stormwater BMPs are significantly more expensive ranging from several hundred to several thousand dollars per pound for both nitrogen and phosphorus.

Ancillary benefits of agricultural BMPs and urban stormwater BMPs include potential flood mitigation, other water quality improvements such as reduced sedimentation, wetland mitigation, additional wildlife habitat, water source protection, and recreational opportunities. Potential synergies provide additional incentive for the City to pursue off-site watershed nutrient reductions.

Use of off-site watershed nutrient reductions as potential offsets to Ames WPCF required reductions is in the formative stage in Iowa. As currently envisioned, offsets are more a means to avoid more stringent Ames WPCF requirements in the future than to reduce the initial Ames WPCF requirements. In any case, there are a number of regulatory issues to be addressed before offsets may be directly applied toward meeting permit requirements. These include, but are not limited to, defining baseline conditions for generating nutrient credits, determining the watershed trading area and trading ratios, and addressing issues of liability, monitoring, and enforcement.

Several state and federal sources of funding could potentially be used to help finance off-site watershed BMPs for nutrient reduction.

- The Water Resource Restoration “Sponsored Projects” program provides $1 for watershed water quality improvement projects for every $10 borrowed for wastewater improvements through the Clean Water State Revolving Fund Loan Program. As such, use of the Clean Water State Revolving Fund Loan Program for the City’s wastewater capital needs creates funding for off-site watershed BMPs to achieve off-site nutrient reductions.
- The Iowa Department of Agriculture and Land Stewardship (IDALS) Water Quality Infrastructure Fund allocates an estimated $282 million over the next 12 years to fund both edge-of-field and in-field BMPs on a cost-share basis. The fund establishes a water quality financial assistance fund, 15 percent of which will support the water quality urban infrastructure program.
- The Iowa Conservation Reserve Enhancement Program (CREP) provides financial incentives to private landowners to develop and restore wetlands that intercept tile drainage from agricultural watersheds.
- The Iowa Environmental Quality Incentives Program (EQIP) provides technical and financial assistance to plan and install conservation practices on cropland, pastureland, and non-industrial private forest.

Task 600 – WPCF Nutrient Reduction TM

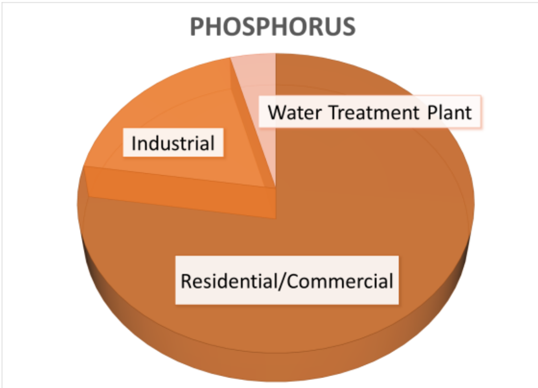
The 2013 Iowa Nutrient Reduction Strategy targets point source wastewater treatment plant reductions consistent with biological nutrient removal to achieve effluent limitations of 10 milligrams per liter (mg/L) total nitrogen and 1 mg/L total phosphorus on an average annual basis for typical domestic wastewater influent nutrient concentrations of 30 mg/L nitrogen and 4 mg/L phosphorus. The requirement is 66 percent total nitrogen reduction and 75 percent total phosphorus reduction for point source dischargers with higher nutrient loadings such as the Ames WPCF.

As previously reported in Table 1, annual average influent nitrogen and phosphorus concentrations are slightly above typical domestic strength wastewater at 39.7 mg/L and 5.09 mg/L, respectively. Current annual average effluent nitrogen and phosphorus concentrations are 23.0 mg/L and 3.80 mg/L, respectively. This represents 42 percent nitrogen and 25 percent phosphorus reduction, short of the 66 percent and 75 percent targets.

The *Task 600 WPCF Nutrient Reduction TM* explores and characterizes opportunities for nutrient reduction at the Ames WPCF. The TM considers nutrient reductions through wastewater source reductions and at the Ames WPCF, either through optimization or implementation of alternative technologies for nutrient reductions at Ames WPCF. The TM assesses the implications of potential future regulatory requirements, peak wet weather flows, and existing solids handling capabilities.

Wastewater Source Reductions

Figure 11 shows that industry and university sources contribute just under 20 percent of the phosphorus and just over 20 percent of the nitrogen influent loadings at the Ames WPCF. The City's water treatment plant contributes an estimated 4 percent of the phosphorus loading at the Ames WPCF. Residential and commercial sources account for the majority of influent loadings, nearly 80 percent for both phosphorus and nitrogen.



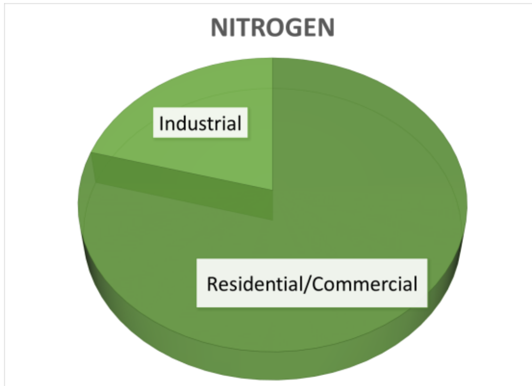


Figure 11: Ames WPCF Nutrient Sources

Additional data should be obtained and discussions should occur with the most significant industry and university sources, but it appears unlikely that such reductions could be a particularly significant part of the City's nutrient reduction strategy. There is no single large contributor of either phosphorus or nitrogen. Similarly, water treatment plant phosphorus discharges are not likely a significant part of the City's nutrient reduction strategy; they are a relatively insignificant contributor to Ames WPCF influent phosphorus loadings and are critical to the production of a stable noncorrosive potable water supply to the City.

Figure 12 identifies various sources of phosphorus in residential and commercial wastewater based on research by Sean Comber et al. in 2012. As reflected in the data, urine, food additives, and faeces (sp) account for nearly 70 percent of the phosphorus, with dishwashing and laundry detergents accounting for approximately 23 percent.

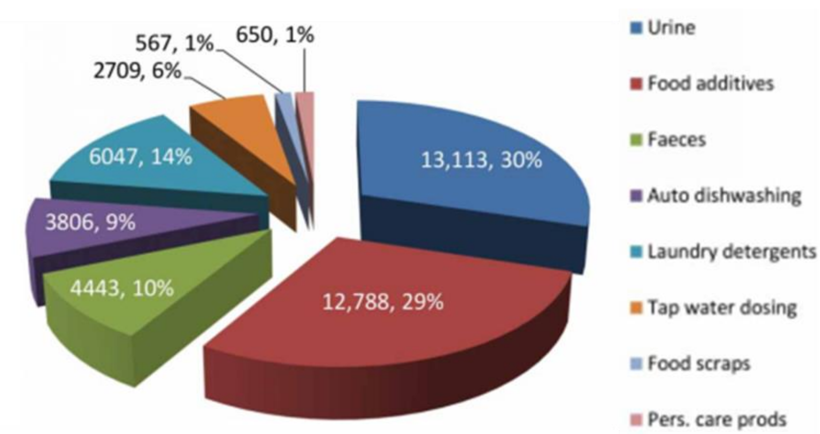


Figure 12: Residential and Commercial Phosphorus Sources

Data from Sean Comber et al. 2012

Phosphorus contributions from detergents reflect a downward trend that began with restrictions on phosphate in laundry detergent in the early 1970s, continued with a nationwide voluntary ban in 1994, and multiple states following up with bans on phosphate use in automatic dishwasher detergent in 2010. Additional investigations specific to the City of Ames could be conducted, but is appears unlikely that residential and commercial wastewater source reductions could be a particularly significant part of the City's nutrient reduction strategy.

Ames WPCF Reductions

There are three potential strategies for nutrient reductions at the Ames WPCF: solids recycle management, existing facility optimization, and alternative technology implementation.

Solids Recycle Stream Management. Digester supernatant and sludge lagoon decant are intermittently returned to the Ames WPCF and recycle nutrients previously removed from the liquid treatment process. The solids recycle streams appear to contribute to effluent phosphorus concentrations higher than expected based on a calibrated mass balance and review of the raw blended and land applied solids volumes and concentrations. Estimates indicate effluent concentrations that solids recycle streams may be adding as much as 0.66 mg/L of the effluent phosphorus and as much as 2.2 mg/L of the effluent nitrogen concentrations. As such, eliminating the effects of recycle streams could be a part of the City's strategy, but would not be sufficient to achieve 2013 Iowa Nutrient Reduction Strategy targeted reductions.

Table 7 identifies several options to reduce solids recycle nutrient loadings. The first two options are not desirable in that they require the addition of mechanical thickening or dewatering equipment at the Ames WPCF that has and continues to manage solids without such equipment. The third and fourth options are related to each other and are straightforward to implement. The associated cost of implementing the third and fourth options is estimated at $20,00- to 30,000. The City is working with Gross Wen Technologies to pilot test algae based nutrient recovery on the solids recycle stream. Gross Wen Technologies estimates the associated capital costs and operations and maintenance costs to implement this technology full scale at $1.2 million and $10,000 per year exclusive of an annual market value for algae estimated at $8,000 per year.

Table 7: Solids Recycle Management

Number	Options to reduce solids Recycle Nutrient Loadings
1	Reduce volume through digested sludge dewatering
2	Reduce volume through primary and waste activated sludge thickening
3	Eliminate digester supernatant by thickening in sludge lagoon
4	Modify sludge lagoon outlet to manage lagoon recycle flow
5	Treat recycle streams to remove nutrients

Ames WPCF Optimization. Six options were identified to target reduced effluent phosphorus concentrations through Ames WPCF optimization. The six options target phosphorus reductions given that the opportunities for watershed phosphorus reduction are limited. All six options include various combinations of the flow routing, repurposing of facilities, separate solids thickening, and modified operations noted in Table 8. The overall intent was to create an anaerobic zone with sufficient organic loading for phosphorus uptake.

Five of the six optimization options achieved the required phosphorus reduction at reasonable costs ranging from $6 to $17 per pound of phosphorus removal. However, none of the options provided any additional nitrogen reduction, construction costs ranged from $4.9 million to $10.6 million, the optimization concepts would require pilot testing prior to implementation, and all reflected continued dependency on trickling filter technology that needed to be replaced to achieve biological nutrient removal. Components of the optimization options should be incorporated into the alternative technology options identified in Table 9, to the extent that they are compatible.

Table 8: Ames WPCF Optimization

Number	Ames WPCF Optimization
1	Create anaerobic zone for phosphorus uptake using a) part or all of existing RAS reaeration tanks, b) one primary clarifier, and/or c) one secondary clarifier
2	Increase carbon loading on anaerobic zone by a) diverting a portion of primary effluent around the trickling filters and b) installing dedicated sludge thickening and diverting thickening liquid stream

Alternative Technology. Five biological nutrient removal technologies have been identified as potentially applicable for implementation at the Ames WPCF. All five alternatives shown in Table 9 represent a conversion from the current trickling filter solids contact technology and are capable of achieving the targeted 2013 Iowa Nutrient Reduction Strategy requirements.

Table 9: Alternative Technology

Number	Alternative Technology
1	2012 Baseline Alternative – Simultaneous Nitrification and Denitrification
2	Alternative 1 – Convention Activated Sludge BNR with RAS Fermentation
3	Alternative 2 – Integrated Fixed Film Activated Sludge BNR with RAS Fermentation
4	Alternative 3 – Granular Activated Sludge
5	Alternative 4 – Membrane Aerated Bioreactor

Simultaneous nitrification and denitrification is the baseline given that it was the alternative with the lowest present worth cost at the time of the *2012 Long Range Facility Plan*. That Plan was developed prior to in anticipation of the 2013 Iowa Nutrient Reduction Strategy. The Plan contemplated three potential levels of nutrient reduction: levels achieved through biological nutrient removal; lower levels achieved through enhanced nutrient reduction; and the lowest levels achievable within the limits of technology.

The four alternatives (as seen in Table 9) reflect advancements in nutrient reduction technology since 2012 and specifically target biological nutrient removal as eventually targeted by the 2013 Iowa Nutrient Reduction Strategy. Given site limitations, alternatives with a smaller footprint are preferable from a constructability perspective. The degree to which each alternative can be implemented in phases is considered given the need for phase implementation to manage rate impacts on customers. Likewise, the ability to accommodate peak wet weather flows and consistency with current solids handling facilities are important to consider when selecting technology.

Several other emerging technologies were identified as potentially applicable in the future, but were not selected for inclusion in the current planning effort. Those technologies include:

- Use of lime solids from the City's water treatment plant for chemical phosphorus removal at the Ames WPCF.
- Algae treatment for effluent or solids recycle nutrient reduction.
- Microvi MNETM process for targeted removal of soluble contaminants including nitrification and denitrification.
- Mainstream or sidestream annammox for nitrogen removal.
- InDence hydro cyclones for increasing the density of activated sludge flocs for enhanced activated sludge performance.

Finally, in addition to commonly used funding mechanisms such as the Clean Water State Revolving Fund (SRF) program, new funding has been approved by the State of Iowa for use by cities to meet the goals of the 2013 Iowa Nutrient Reduction Strategy. The Wastewater and Drinking Water Treatment Financial Assistance Fund (SF 512) provides two programs for additional funding for point sources; a new revolving loan program with $51.3 million in funding through 2029 and a grant program with individual grants up to $500,000.The Iowa Finance Authority is developing the detailed grant application requirements and the City should be watching for those details to be distributed.

Task 700 – Alternatives Identification and Screening TM

The *Task 700 Alternatives Identification and Screening TM* identifies and screens on-site Ames WPCF, off-site watershed, and integrated combinations of nutrient reduction alternatives for further development and evaluation. Key findings, resulting strategies, and preliminary concepts are presented in the following. The intent is to establish a roadmap for future nutrient reduction to cost effectively achieve the objectives of the 2013 Iowa Nutrient Reduction Strategy.

Off-site Watershed Nutrient Reductions

Key findings with respect to off-site watershed nutrient reductions are as follows, with the first being most significant.

1. It is not practical to offset the need for Ames WPCF nutrient reductions entirely with watershed nutrient reductions.
2. Land requirements for offsetting watershed nutrient reductions are surprisingly large.
3. There is no guarantee that watershed nutrient reductions are acceptable offsets to Ames WPCF reductions short term, but an exchange program is under development to enable watershed nutrient reductions to offset future, more stringent Ames WPCF nutrient reductions longer term.
4. The City has effectively implemented and should continue to implement urban BMPs to achieve nutrient reductions as ancillary benefits.
5. Implementation of off-site watershed BMPs for nutrient reduction can be configured to achieve ancillary benefits including flood mitigation, erosion control, habitat restoration, source water protection, and/or recreation opportunities.
6. Off-site watershed reductions may still be useful to demonstrate leadership, make progress, and offset future Ames WPCF requirements.

Table 10 identifies the resulting off-site watershed nutrient reduction strategies.

Table 10: Potential Off-site Nutrient Reduction Strategies

Number	Potential Off-site Nutrient Reduction Strategy
1	Demonstrate commitment and progress to the 2013 Iowa Nutrient Reduction Strategy through continued implementation of urban best management practices with added emphasis on the associated watershed nutrient reductions
2	Identify and prioritize projects that demonstrate good stewardship of City property, provide multiple benefits on sites located within the City of Ames, and then provide multiple benefits on sites outside of the City of Ames.
3	Establish a goal and commit the required annual funding for implementing watershed-based practices that provide nutrient reduction and other ancillary benefits such as flood mitigation, erosion control, source water protection, habitat restoration, and recreational opportunities.
4	Register and bank credits with the Nutrient Reduction Exchange to offset potential future requirements such as water quality-based nutrient limits.
5	Support Iowa State University efforts to develop innovative and alternative watershed based nutrient reduction.

The potential sites and projects identified in Figure 13 through Figure 15 are examples to convey concepts and potential for ancillary benefits for off-site watershed nutrient reduction. The examples include sites and projects on property owned by the City, within the City of Ames, and outside the City of Ames. The City has identified the prioritization criteria as shown in Table 11 for off-site watershed nutrient reduction. Table 12 identifies ancillary benefits for the example sites and projects.

Table 11: Off-site Nutrient Reduction Prioritization Criteria

Category	Criteria
Location	• City-owned land • Within City limits • Land in Upstream Watersheds
Ancillary Benefits	• Flood mitigation • Drinking Source Water Protection • Increased Wildlife Habitat • Improved Water Quality • Increased Recreational Opportunities • Increased hunting opportunities • Other benefits
Nutrient Reduction Cost/Benefit	• Lower $/pound Removed than Ames WPCF • Lowest $/pound Removed • Highest Pounds Removed
Life Cycle	• Number of Years Provided • Lowest Annual Maintenance Costs • Lowest Life Cycle Cost

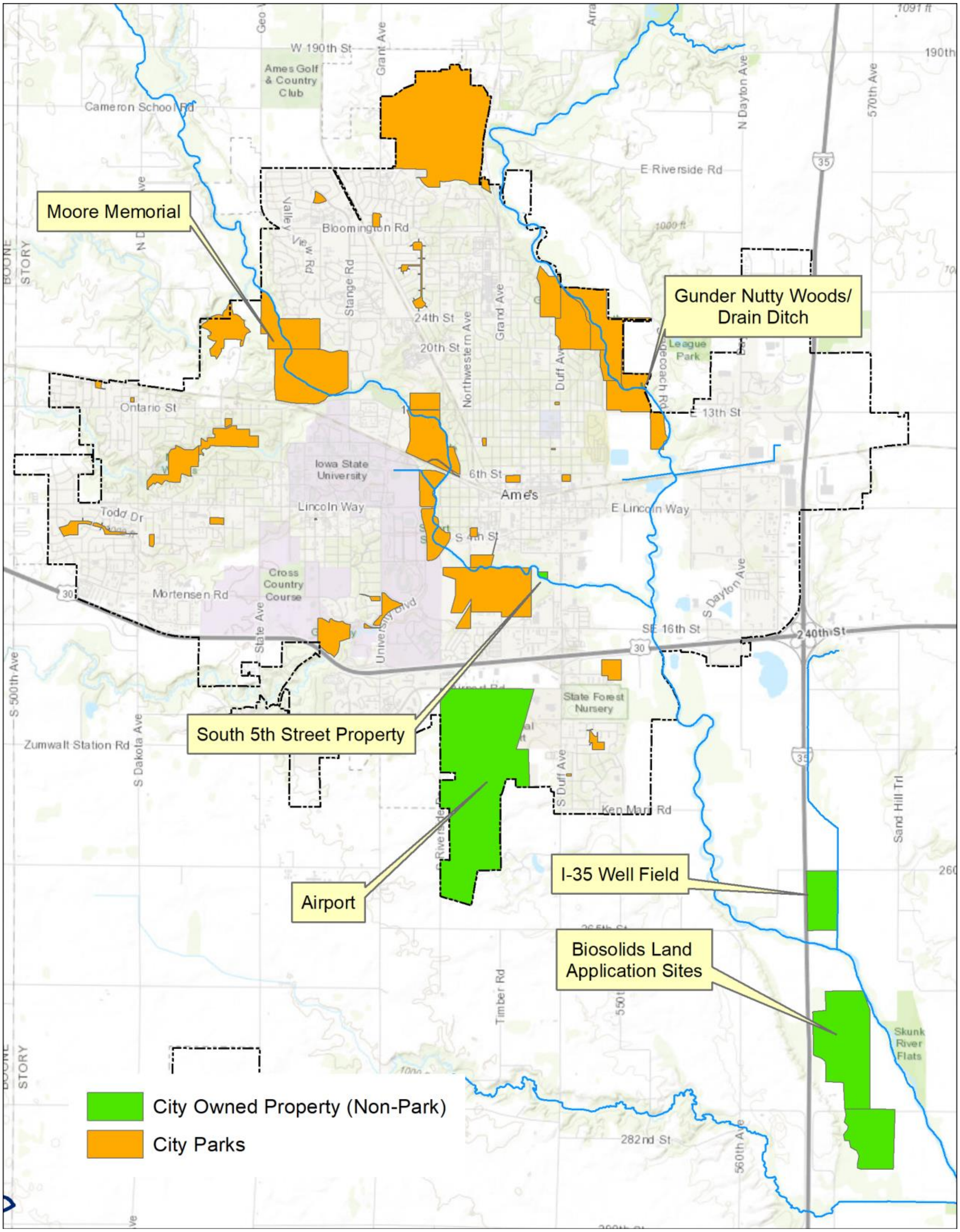


Figure 13: Off-site Nutrient Reduction Example Sites and Projects - City Property

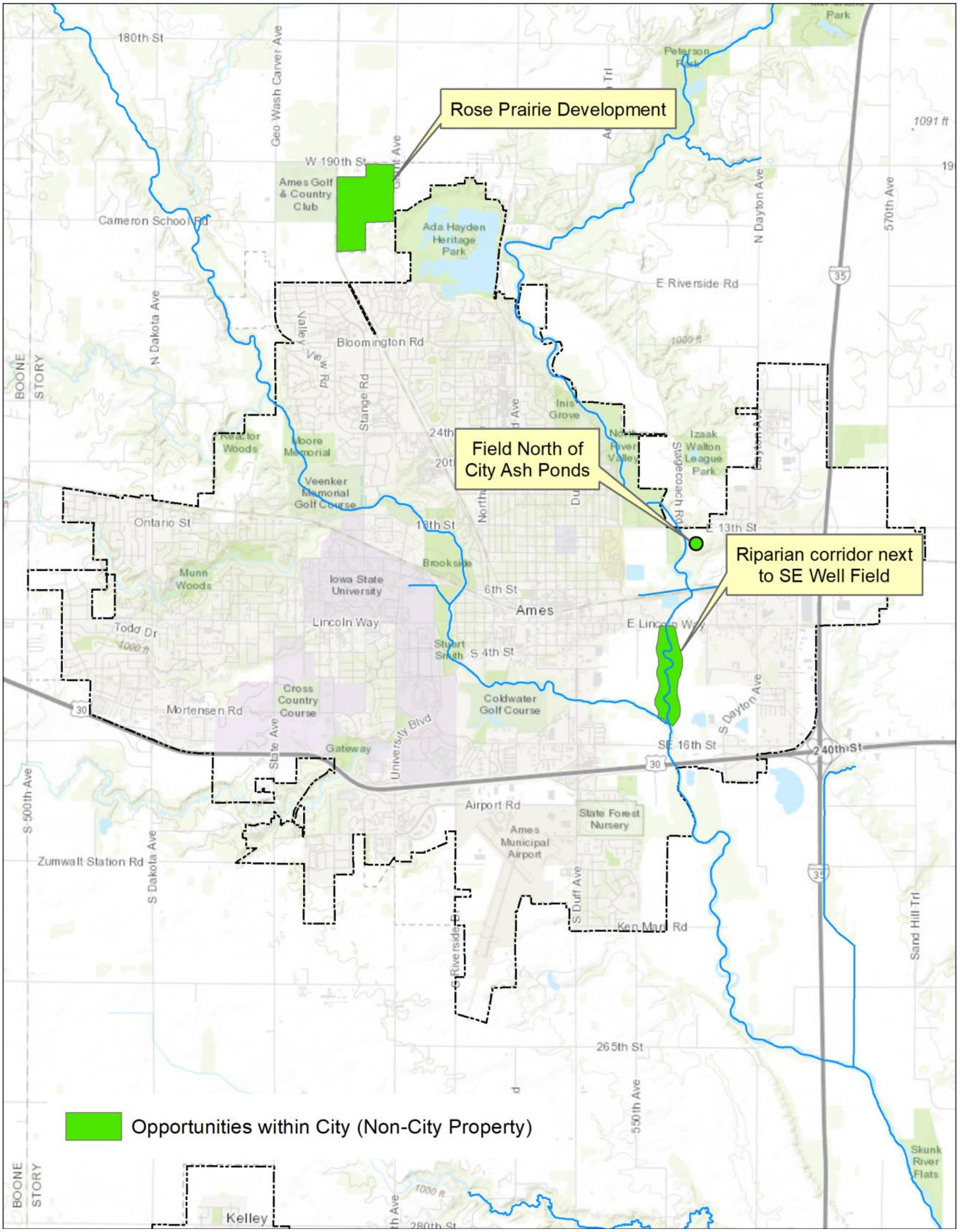


Figure 14: Off-site Nutrient Reduction Example Sites and Projects – Within City

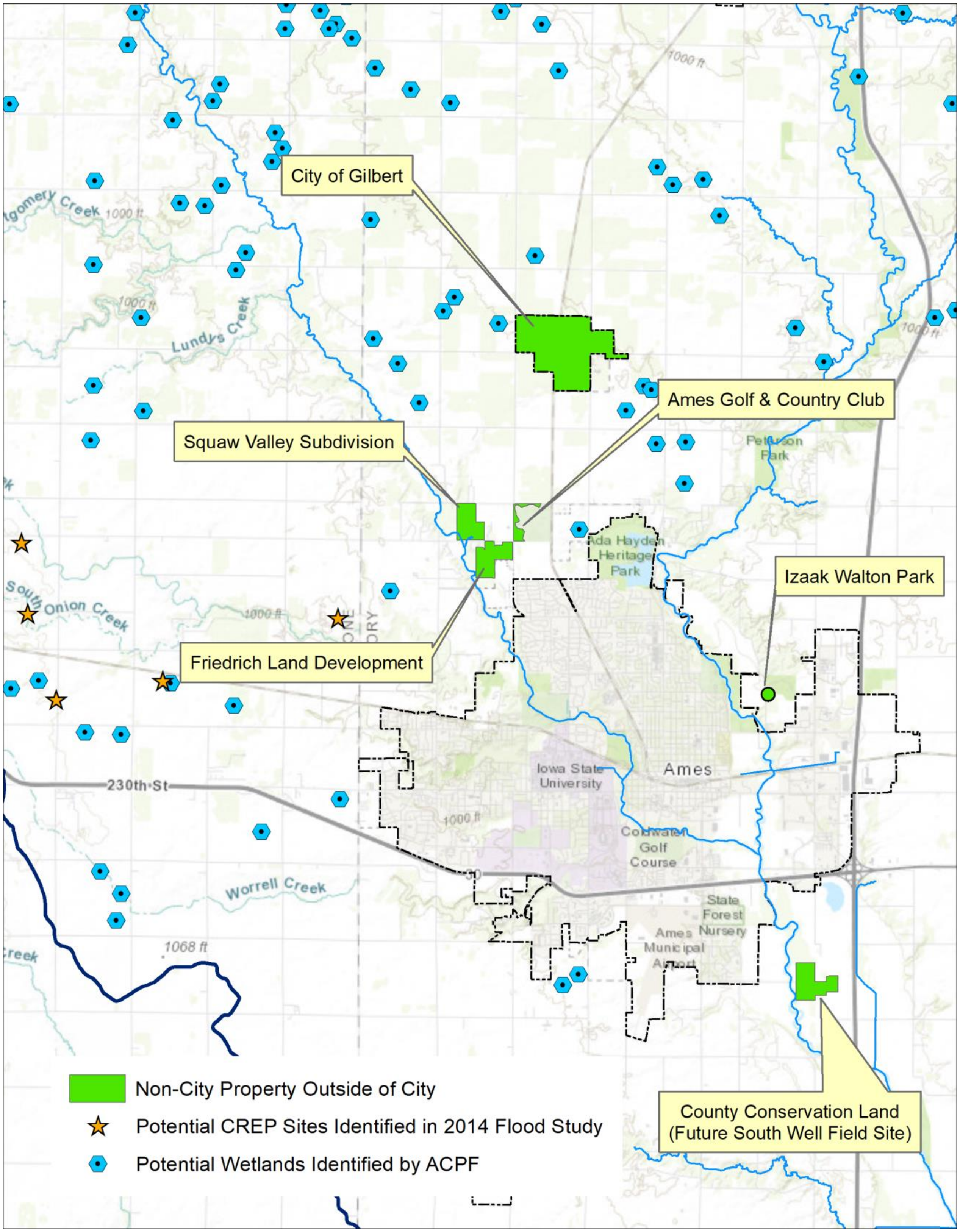


Figure 15: Off-site Nutrient Reduction Example Sites and Projects – Outside City

Table 12: Off-site Nutrient Reduction Example Sites and Projects

Location	Site	Potential BMPs/Project	Water Quality/Nutrient Reduction	Flood Mitigation	Erosion Control	Habitat Restoration	Water Source Protection	Recreational Opportunity
City Property	Biosolids Land Application Sites	Bioreactor, Constructed wetlands	X	X	X	X		
	Airport	Bioreactor	X					
	I-35 Well Field	CRP/Potential ISU Research	X		X	X	X	
	City Parks	Range of BMPs	X	X	X	X		X
	South 5th Street Property	Storm sewer interceptor/constructed wetland	X	X	X	X		
	Gunder Nutty Woods/Drain Ditch	Hydro modifications	X		X	X		
Within City of Ames	Field North of City Ash Ponds	Regional stormwater detention	X	X	X	X		X
	Riparian Corridor next to SE Well Field	Bike trail, wetlands, and riparian restoration	X		X	X	X	X
	Rose Prairie Development	Detention pond	X	X	X	X		X
Outside City of Ames	Ames Golf & Country Club	Reduced phosphorus application and applicable MS4 BMPs	X	X	X	X		X
	Friedrich Land Development	Friedrich Land Development	X	X	X	X		X

Location	Site	Potential BMPs/Project	Water Quality/Nutrient Reduction	Flood Mitigation	Erosion Control	Habitat Restoration	Water Source Protection	Recreational Opportunity
	Squaw Valley Subdivision	Sewer hook up	X					
	County Conservation Land (Future South Well Field)	CRP/IHAP	X		X	X	X	X
	City of Gilbert	Interceptor/hook up with City sewer	X					
	Izaak Walton Park	Lake rehabilitation	X					
	CREP Wetland Sites	Constructed wetlands	X	X	X	X		X

On-site Ames WPCF Nutrient Reductions

Key findings with respect to on-site Ames WPCF nutrient reductions are as follows, with the first three being most significant.

1. Facilities incorporating alternative treatment technology would be required at Ames WPCF to achieve 2013 Iowa Nutrient Reduction Strategy required reductions.
2. The existing trickling filters are not part of the long-term solution at Ames WPCF due to process limitations and condition.
3. The existing trickling filters should be used as long as condition allows, minimizing customer rate impacts.
4. Influent wastewater source reductions alone cannot achieve the required reductions.
5. Ames WPCF optimization alone cannot achieve the required reductions.

Table 13 identifies the resulting on-site Ames WPCF nutrient reductions strategy.

Table 13: On-site Ames WPCF Nutrient Reduction Strategies

Number	On-site Ames WPCF Nutrient Reduction Strategy
1	Convert from trickling filters to an alternative technology that provides additional capacity as well as nutrient removal capability that achieves the goals of the 2013 Iowa Nutrient Reduction Strategy
2	Minimize costs and associated customer rate impacts through phased implementation that continues to use existing trickling filter capacity as long as condition allows
3	Implement the alternative technology in phases that allows performance and capacity to be demonstrated and design criteria to be refined
4	Incorporate existing trickling filter and solids contact optimization options to the extent they are affordable and consistent with the alternative technology selected
5	Consider bench and pilot testing of lime sludge addition as alternative solution for phosphorus removal and/or chemical feed for phosphorus removal as interim solution

Figure 16 provides preliminary site layouts for each of the alternative technologies. Comparative costs are presented in Table 14, and nonmonetary criteria comparisons are presented in Table 15.

As indicated in Table 14, the Baseline simultaneous nitrification denitrification (SNDN), carbonaceous activated sludge (CAS) BNR, and granular activated sludge (GRAS) alternatives are the lowest total present worth cost alternatives in that order, but have comparable capital, operations and maintenance, and present worth costs. Based on estimating accuracy, all three should be considered equal. Notably, there was a clear break in costs with integrated fixed film activated sludge (IFAS) BNR and membrane aerated bioreactor (MABR) being significantly higher than the other three alternatives.

As indicated, nitrogen reduction costs an estimated $2.50 to $2.75 per pound removed and phosphorus reduction costs an estimated $18.0 to $19.25 per pound removed.

As indicated in Table 15, CAS BNR, 3 GRAS, and the Baseline SNDN alternative scored most favorably with respect to both nonmonetary performance and acceptance criteria. Again, with a clear break in favorability with IFAS BNR and MABR being less favorable.

Based on both comparative costs and nonmonetary criteria considerations, Baseline SNDN, CAS BNR, and GRAS were recommended for further development and evaluation. Furthermore, IFAS media and MABR membranes can be subsequently retrofitted into any of the other three alternatives at a future date if the City were to experience a significant increase in organic loading, causing the footprint to become a significant consideration at that time.

Table 14: Comparative Costs

Parameter	Unit	SNDN	CAS-BNR	IFAS BNR	GrAS	MABR
Capital Cost	mil $	20.9***	20.0	26.6	22.2	30.4
Annual Operation Cost	mil $/yr	0.95	1.12	1.33	1.03	1.32
Present Worth Operation Cost	mil $	14.2	16.6	19.8	15.3	19.6
Total Present Worth*	mil $	35.1	36.7	46.4	37.6	50.0
Cost per Nitrogen Removed	$/lb	2.55	2.67	3.38	2.74	3.64
Cost per Phosphorus Removed	$/lb	17.96	18.78	23.74	19.24	25.58
Rank (1 to 5 Best to Worst)		1	2	4	3	5

*Present worth costs reflect a 3 percent interest rate over 20 years

**Capital Costs include construction, contingency, engineering, and administration

***Updated from 2012 using the approach and tools as other alternatives

Table 15: Nonmonetary Criteria Comparison*

	Performance Criteria	SNDN	CAS-BNR	IFAS BNR	GrAS	MABR
1	Reliability	4	5	3	4	2
2	Amenable to wet weather flow	4	4	4	3	3
3	Solids handling	4	4	4	4	4
4	Effectiveness-Consistently meet permit	4	5	3	4	3
5	Adaptability to more stringent nutrient standards	3	3	2	3	2
6	Constructability	2	3	4	5	4
	TOTAL	21	24	20	23	18
Rank (1 to 5 Best to Worst)		**3**	**1**	**4**	**2**	**5**

	Acceptance Criteria	SNDN	CAS-BNR	IFAS BNR	GrAS	MABR
1	Consistency with current operations	3	3	2	1	1
2	Safety	5	5	5	5	5
3	Positive public opinion	4	4	4	5	5
4	Operational requirements	4	4	3	4	3
5	Maintenance requirements	4	4	3	4	3
6	Operations during construction	3	3	5	5	3
	Reliability	21	24	20	23	18
	TOTAL	21	24	20	23	18
Rank (1 to 5 Best to Worst)		**3**	**1**	**4**	**2**	**5**

*Each alternative is rated for each criteria on a scale of 1 (worst) to 5 (best)

Task 800 – Alternatives Development and Evaluation

The *Task 800 Alternatives Development and Evaluation TM* further develops and evaluates three on-site Ames WPCF nutrient reduction alternatives. The TM builds on the *Task 700 Alternatives Identification and Screening TM* and on discussions at Workshop 3 to provide recommendations with respect to Ames WPCF nutrient reduction technology, phasing, and costs. Alternatives were evaluated based on process performance, solids considerations, wet weather issues, capital costs, and operations and maintenance costs.

Phasing

The following phasing goals provide the basis for further evaluation and development of the three alternatives:

- Meet existing permit limits, specifically ammonia limits, as the first priority throughout construction of each phase.
- Provide current and forecast future capacity while allowing the existing trickling filters to operate to failure over the next 5 to 10 years.
- Achieve Ames WPCF 2013 Iowa Nutrient Reduction Strategy targets progressively with full compliance by 2040.
- Minimize capital investment in Phase 1, deferring large capital investment due to rate and operations considerations.
- Minimize wasted new infrastructure through a phased implementation of the selected technology.
- Minimize complexity, impacts on operations, and solids handling.

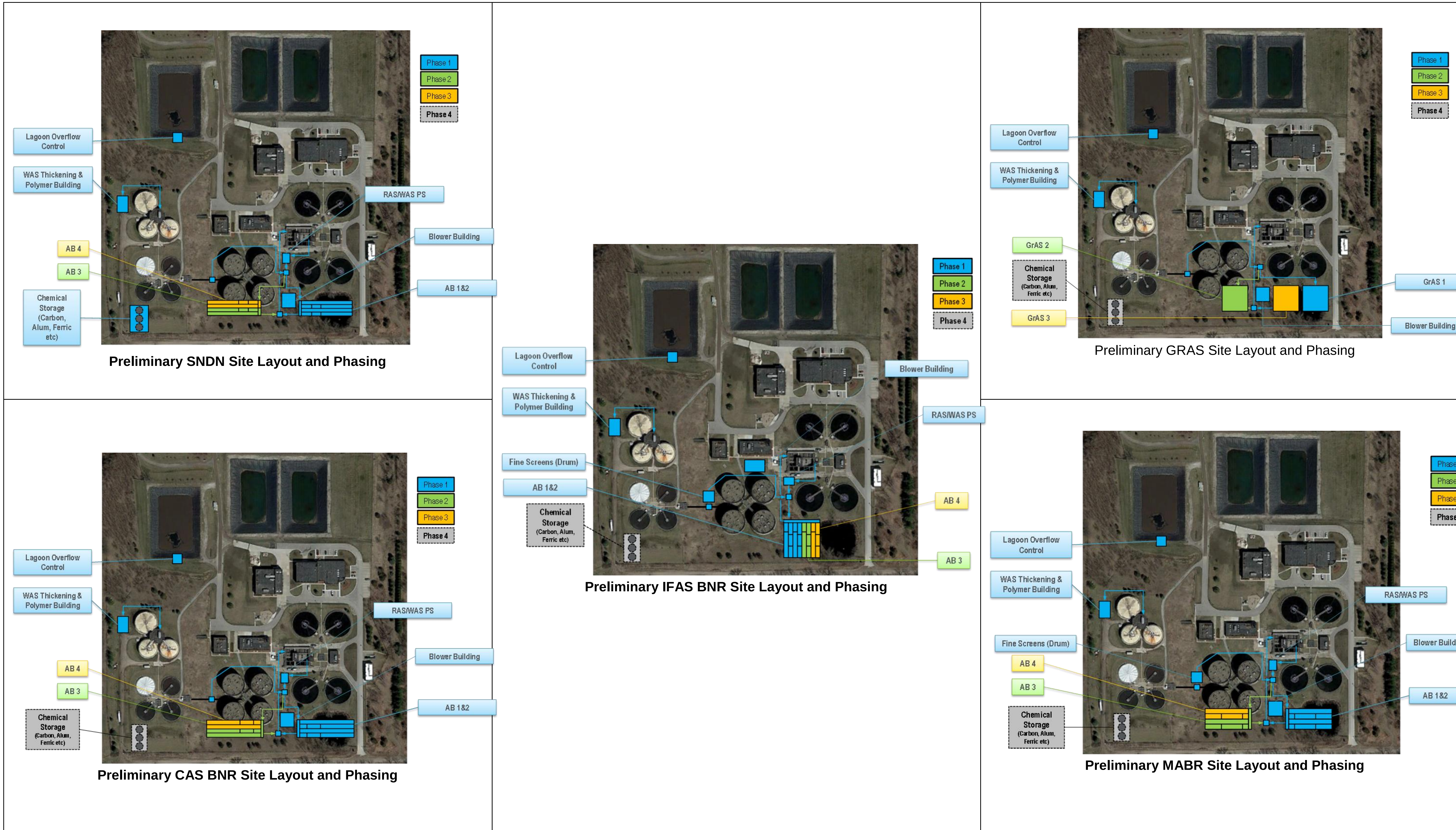


Figure 16: Ames WPCF Alternative Site Layouts

Each alternative was developed based on the projected flow and loads presented in Table 1 for three phases:

- Phase 1: First 5 Years (2030 Flows and Loads)
  - Increase investment in urban watershed BMPs
  - Implement First Phase of alternative technology at Ames WPCF
- Phase 2: Second 5 Years (2035 Flows and Loads)
  - Continued investment in urban watershed BMPs
  - Implement Second Phase of alternative technology at Ames WPCF
- Phase 3: Last 10 Years (2040 Flows and Loads)
  - Implement Third Phase of alternative technology at Ames WPCF

Because of the configuration of the existing Ames WPCF, there are a number of complexities with respect to transitioning from the existing trickling filter solids contact process to an alternative technology for biological nutrient removal.

- Figure 17 shows that raw influent wastewater is mixed with first stage trickling filter effluent and then pumped to the primary clarifiers. Mixing produces a low BOD, high dissolved oxygen primary effluent that makes biological nutrient removal difficult. As long as the first stage trickling filters are in service, biological nutrient removal performance in the mainstream treatment process would be compromised because of low organic loading.

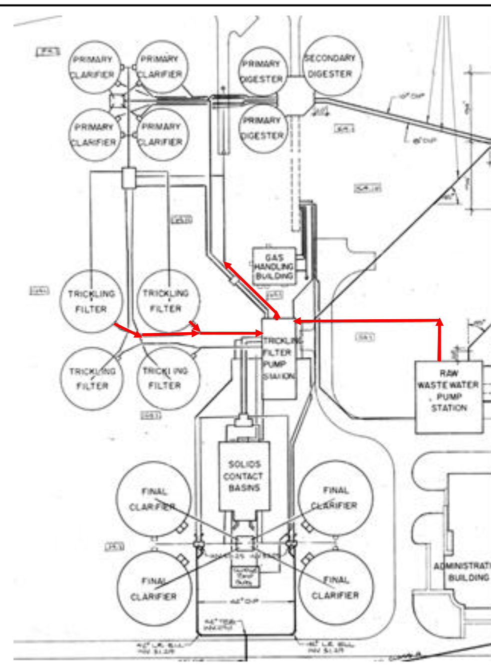


Figure 17: Trickling Filter Pump Station

- For two of the three alternatives, Baseline Simultaneous Nitrification Denitrification and Carbonaceous Activated Sludge BNR, the existing intermediate and final clarifiers need to remain in service, producing a common sludge for the existing trickling filter and parallel alternative technology trains. As long as the existing trickling filters are in service, the common sludge produced by the existing clarifiers precludes operation of alternative technology trains for biological nutrient removal.
- The third alternative, Granular Activated Sludge would not require continued operation of the intermediate and final clarifiers. This alternative could be configured to achieve biological nutrient removal simultaneously while still using the existing trickling filters.

- As long as the existing return activated sludge screw pumps are in service, the hydraulic profile for the existing Ames WPCF precludes operation of the alternative technology at the desired water surface elevation. To capitalize on the remaining useful life of the existing pumps, the first phase of alternative technology would need to operate at a lower water surface elevation and reduced liquid depth as shown in Figure 18. Operating this way would adversely affect biological nutrient removal capability.

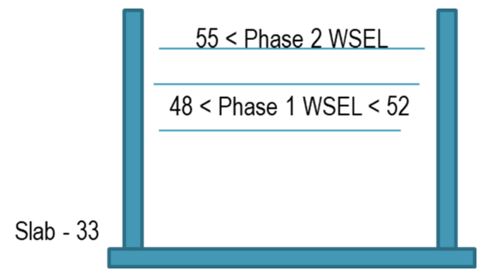


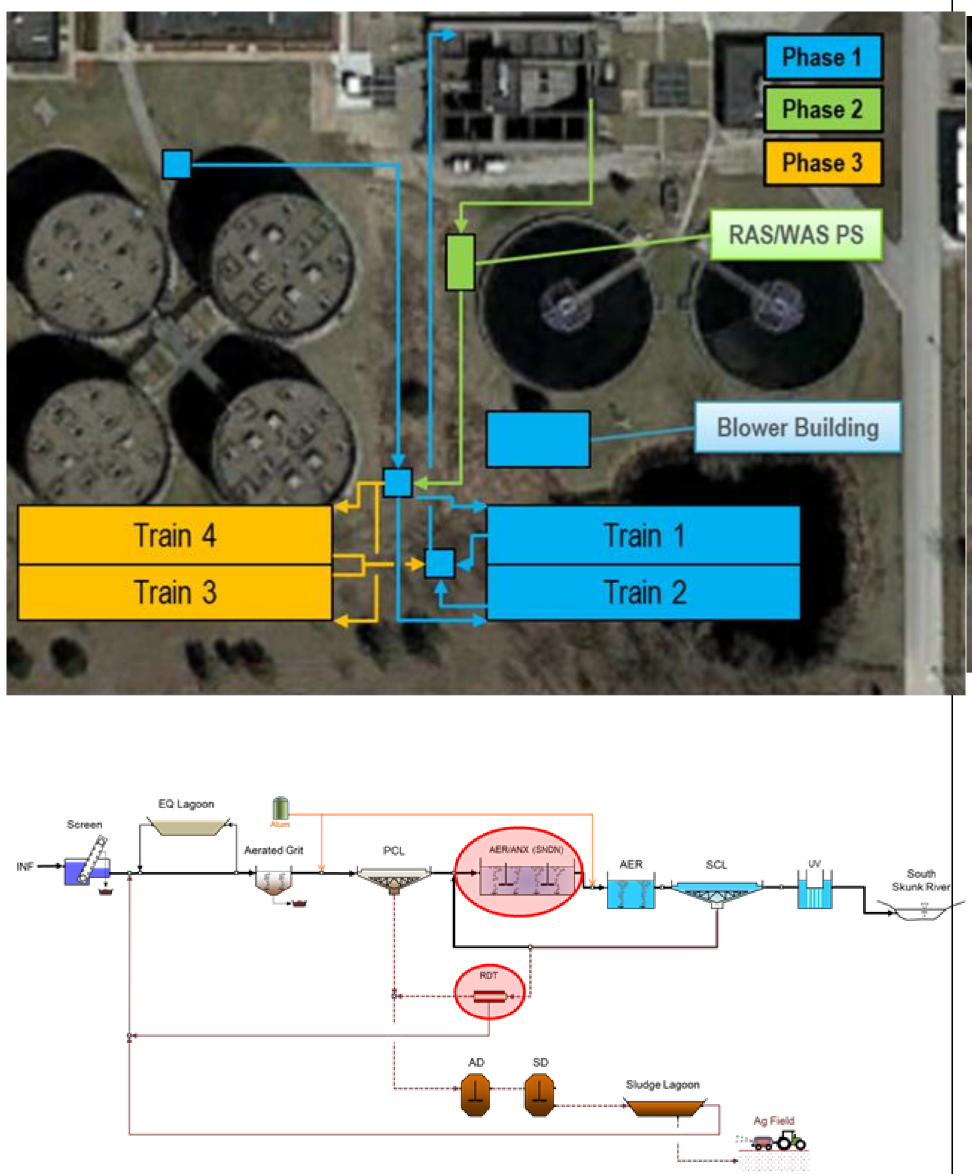
Figure 18: Alternative Technology Phased Water Surface Elevations

- Separate thickening of waste activated sludge would be required as the Ames WPCF transitions from trickling filter humus to waste activated sludge and to produce a recycle stream that serves as a carbon source for biological nutrient removal. Without the additional organic loading, biological nutrient removal would be compromised.

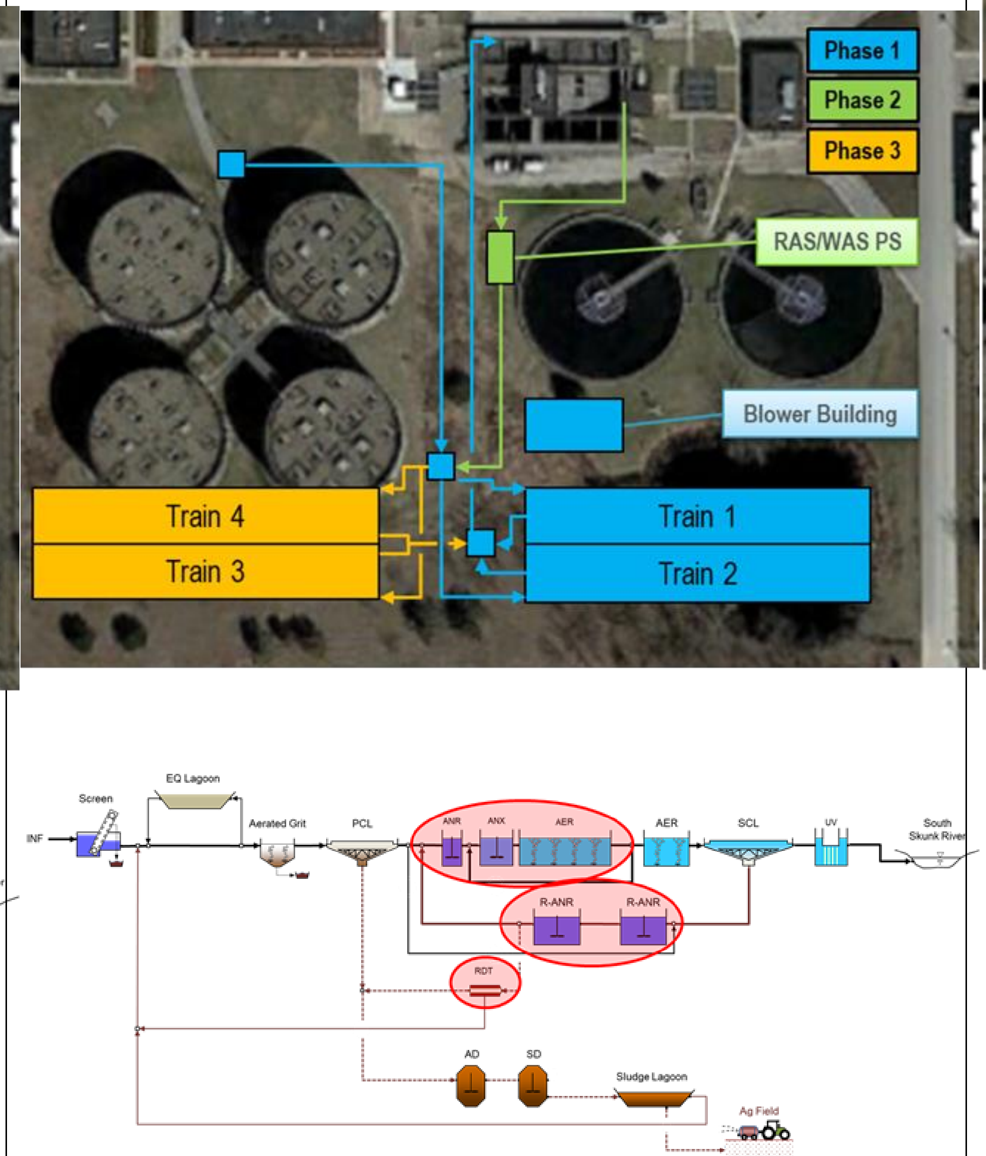
Refined site layout and process flow schematics for the three alternatives are presented in Figure 19; potential phasing is also shown in the figure.

Table 16 identifies the preliminary planning level estimated capital costs, operations and maintenance costs, and present worth costs for each alternative. All costs are expressed in 2018 dollars. Because cost depends on whether biological nutrient removal capabilities are incorporated into Phase 1 or incorporated into Phase 2 (which is similar the two other alternatives), two costs are presented for Alternative 3 Granular Activated Sludge.

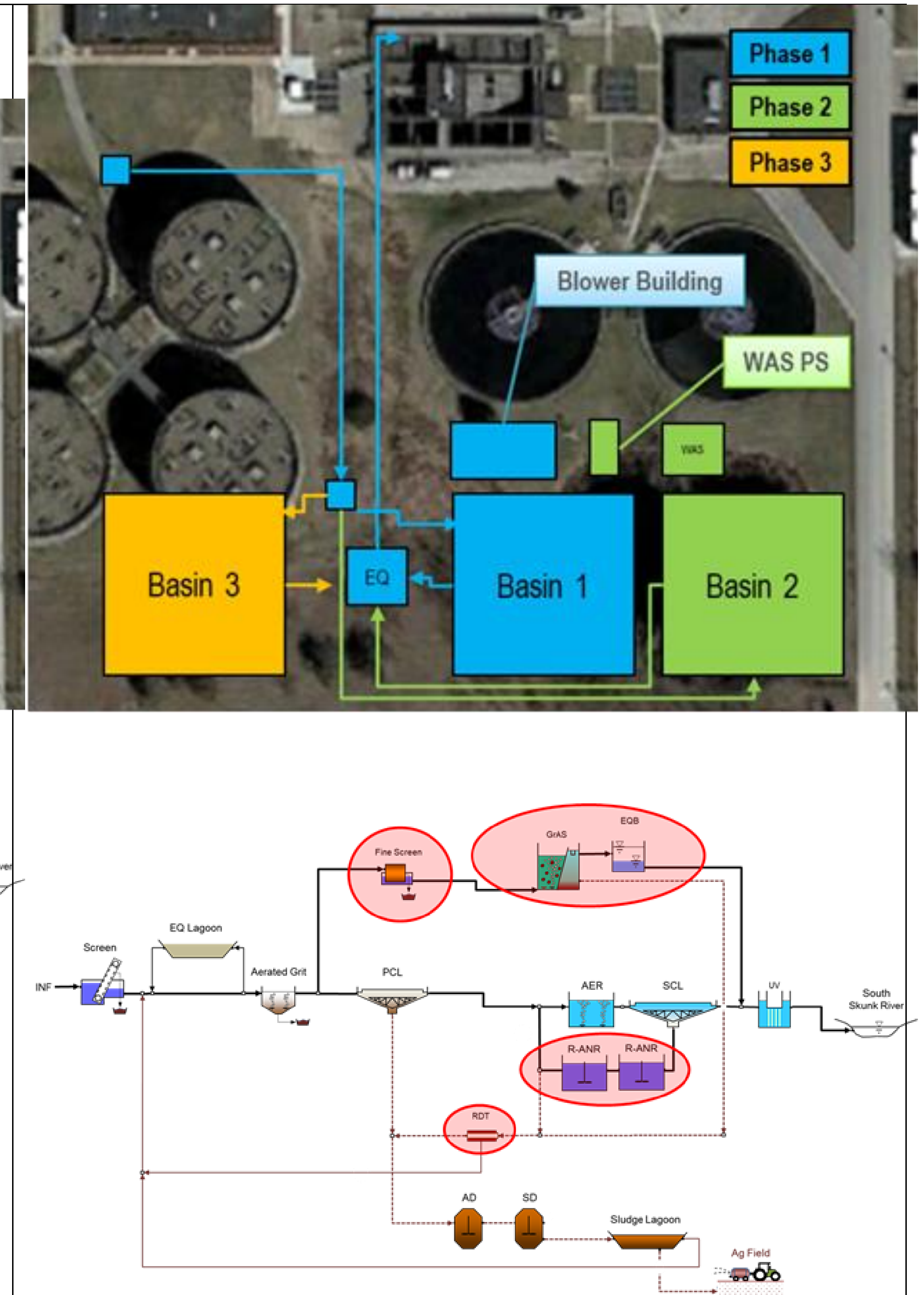
Capital costs include contingency, engineering, and administrative costs. Operations and maintenance costs include chemical, electrical, material, labor, and solids handling costs. Labor costs were based on the hours required for operations and maintenance of the proposed capital improvements for each alternative and do not include operation of existing facilities. Labor costs were based on a rate of $35 per hour. Solids handling and disposal costs include new waste activated sludge thickeners for activated sludge based options and continued disposal using land application. The total present worth summarizing capital costs and operations and maintenance costs for a 20-year period assuming an interest rate of 3 percent were developed for each alternative.



Baseline Alternative SNDN Full Build-Out Layout and Process Schematic



Alternative 1 CAS BNR Full Build-Out Layout and Process Schematic



Alternative 3 GrAS Full Build-Out Layout and Process Flow

Figure 19: Ames WPCF Nutrient Reduction Alternatives

Table 16 Planning Level Estimated Costs ($2018)

	SNDN	CAS BNR	GrAS without BNR in Phase 1	GrAS with BNR in Phase 1
Preliminary Planning Level Capital Costs				
Phase 1 (mil $)	8.2	8.5	7.3	19.0
Phase 2 (mil $)	11.2	10.0	18.6	7.0
Phase 3 (mil $)	8.6	7.8	6.2	6.1
Total	**28.0**	**26.3**	**32.1**	**32.1**
Total Rating	2	1	3	3
Preliminary Planning Level Operations and Maintenance Costs				
Phase 1 (mil $)	0.28	0.31	0.30	0.34
Phase 2 (mil $)	0.70	0.45	0.42	0.41
Phase 3 (mil $)	0.70	0.45	0.42	0.41
Total	**1.68**	**1.21**	**1.14**	**1.16**
Total Rating	4	3	1	2
Preliminary Planning Level Present Worth Costs				
Phase 1 (mil $)	12.3	13.1	11.7	24.0
Phase 2 (mil $)	21.7	16.7	24.9	13.1
Phase 3 (mil $)	19.1	14.5	12.5	12.2
Total	**53.1**	**44.3**	**49.1**	**49.3**
Total Rating	4	1	2	3

Alternative 1 has the lowest capital cost and total present value cost, but all three alternatives are similar in life-cycle costs and nonmonetary value.

- Baseline Alternative – Simultaneous Nitrification Denitrification (SNDN)
- Alternative 1 – Carbonaceous Activated Sludge (CAS) BNR
- Alternative 3 – Granular Activated Sludge (GrAS)

Final selection of a specific technology should be deferred until design of Phase 1 begins. Deferred selection allows City and Ames WPCF staff to become familiar with each technology by providing time to make site visits to other operating facilities. As an emerging technology, this allows the GrAS technology to continue to be developed, potentially yielding additional benefits and cost reductions that are unknown and unrealized at this time.

Task 900 – Stakeholder Involvement

The *Task 900 Stakeholder Involvement TM* documents stakeholder input from an online survey and two open houses held on November 8 and information shared with City Council at the November 20 Council Work Session.

Stakeholder Input

Two open houses were held on November 8, 2018, to share preliminary findings and potential strategies, and to solicit input regarding off-site watershed and on-site Ames WPCF nutrient reductions. A summary of input from the open houses and an online survey follows.

- 20 stakeholders provided input, but not all responded to every survey question
- 90 percent of respondents were Ames rate payers
- 70 percent of respondents consider themselves to have moderate or considerable knowledge on nutrients
- 75 percent of respondents consider nutrients to be an exceptional issue statewide
- 75 percent of respondents identify nonpoint sources as the primary source of nutrients
- 100 percent of respondents believe that the Utility should invest rate payer dollars to address nutrients
- 95 percent of respondents support Utility investment in upstream watershed projects outside of city limits (35 percent without condition, 50 percent if ancillary benefits are included, and 10 percent if less expensive than at Ames WPCF)
- 95 percent of respondents support Utility investment in Ames WPCF upgrade to address nutrients (of those who support Utility investment 58 percent immediately, 32 percent with expansion or other upgrade, and 10 percent with other major environmental issue)
- 95 percent of respondents support a rate increase to address nutrients (6 percent of respondents support a 50 percent increase, 44.5 percent of respondents support a 25 percent increase, and 44.5 percent support a 10 percent increase)

Council Work Session

A Council Work Session held on November 20, 2018, was used to provide an overview of work completed to date and the recommended path forward. A staff report prepared by the City and the presentation prepared by HDR were provided in advance.

Offered the opportunity to do so, Council did not redirect 2013 Iowa Nutrient Reduction Feasibility Study efforts or the path forward as presented. Council was supportive of phased implementation of alternative technology to achieve the required nutrient reductions over the next 20 years at a total cost of $39,630,000. Likewise, Council was supportive of implementation of BMPs targeted at urban nonpoint nutrient reductions and other ancillary benefits at an annual cost of $100,000. At least one council member promoted an education component to encourage practices that reduce nutrient discharges to the Ames WPCF and from urban nonpoint sources. Subsequent discussion prompted an increase in the annual budget to $200,000.

Task 1000 – Preferred Alternative Refinement

The *Task 1000 Preferred Alternative Refinement TM* presents the recommend strategy and implementation plan for nutrient reduction for the City of Ames. Investment in both off-site watershed nutrient reductions and on-site Ames WPCF nutrient reductions are included in the TM.

Integrated Strategy

Table 17 presents the integrated strategy for nutrient reduction.

Table 17: Integrated Nutrient Reduction Strategy

Integrated Nutrient Reduction Strategy
Convert from trickling filters to alternative technology that provides additional capacity for growth and nutrient removal that achieves the goals of the 2013 Iowa Nutrient Reduction Strategy
Minimize Ames WPCF costs and associated customer rate impacts through phased implementation of alternative technology that continues to use existing trickling filter capacity as long as condition allows
Incorporate existing Ames WPCF optimization to the extent affordable and consistent with alternative Ames WPCF technology.
Demonstrate commitment through continued implementation of urban best management practices with added emphasis on associated watershed nutrient reductions
Identify, prioritize, and fund watershed nutrient reduction projects consistent with location, ancillary benefits, cost and benefit, and life-cycle cost criteria.
Register and bank watershed credits with the Nutrient Reduction Exchange to offset potentially more stringent future requirements
Support Iowa State University efforts to develop innovative and alternative watershed based nutrient reduction.

Implementation Plan

Implementation of the integrated nutrient reduction strategy entails parallel tracks to proceed with both off-site watershed nutrient reduction projects and on-site Ames WPCF improvements to achieve nutrient reduction. Both tracks are described in the following.

Watershed Nutrient Reduction. Watershed nutrient reduction includes both a continuation of historic practices to incorporate stormwater BMPs in City projects and an added commitment to additional watershed projects specifically targeted at nutrient reduction but with other ancillary benefits. Example sites and projects were previously presented in Figure 13 through Figure 15 and summarized in Table 12.

Example sites are grouped by location on City Property, within the City of Ames, and upstream of the City of Ames. Example projects include several different practices, including: bioreactors, constructed wetlands, CRP, research, hydraulic modifications, stormwater detention, and riparian buffer. Ancillary benefits in addition to nutrient reduction are identified for each example project, including flood mitigation, erosion control, habitat restoration, water quality, and recreation.

Table 11 presented location, ancillary benefit, nutrient reduction cost and benefit, and life-cycle cost criteria to prioritize and identify specific sites for off-site watershed nutrient reduction. The City's future *Capital Improvements Plan* includes $200,000 per year committed for implementation to be used in conjunction with available grant funding for these types of projects.

Ames WPCF Nutrient Reduction. Figure 20 identifies the phased implementation plan for Ames WPCF improvements to provide 2013 Iowa Nutrient Reduction Strategy targeted reductions as well as capacity for forecast growth. The implementation plan generically refers to alternative technology rather than identify a specific technology for implementation because the three final alternatives identified below are similar in life-cycle costs and nonmonetary value.

- Simultaneous Nitrification Denitrification
- Carbonaceous Activated Sludge
- Granular Activated Sludge

Given the similarities among the three alternatives, final selection of the specific technology can be deferred until 2022, when Phase 1 design and construction begins. Deferring final technology selection allows Granular Activated Sludge to continue to advance and provides the City an opportunity to incorporate site visits to operating facilities.

Figure 20 indicates that nutrient reduction would be achieved progressively. Limited, if any, reduction would be achieved in Phase 1, seasonal reduction would be achieved in Phase 2, and full biological nutrient reduction would be achieved in Phase 3. Two factors drive progressive reduction: 1) the need to take advantage of the remaining useful life to maximize prior investment in the existing trickling filters and 2) the existing Ames WPCF configuration, which intermingles wastewater on the front end and solids on the downstream end of existing Ames WPCF liquid treatment facilities preventing separate parallel operation of the existing trickling filters and new alternative technology.

Figure 21 identifies the estimated capital cost, including both engineering and construction, for each phase in 2018 dollars. It is noteworthy that the estimate does not include any additional capital investment in the existing trickling filters to prolong their remaining useful life. Inflated to the actual construction periods, the estimated cumulative capital cost for all three phases is $39.63 million.

Figure 20: Ames Nutrient Reduction Implementation Plan

Figure 21: Ames WPCF Nutrient Reduction Implementation Costs ($2018)