STATEMENT OF WORK
For Springs Protection Initiative:
Springs Protection Initiative Science (SPIS)-NITROGEN BIOGEOCHEMISTRY WORKGROUP

I. INTRODUCTION/BACKGROUND

The concentration of nitrate in Silver Springs (Marion County, FL) has increased from less than 0.05 mg L^{-1} NO_3-N in the early 1900's to a present day concentration of 1.2 mg L^{-1} (Munch et al 2007). The increase in nitrate discharge from the springs is considered a primary factor that has contributed to an increase in epiphyte biomass and algal mat cover in the spring run (Quinlan et al 2008). Thus, a critical part of Silver Springs' restoration is to reduce the delivery of N from springshed land surface to aquifer.

Springs protection and restoration requires an interagency effort to implement practices for managing N loads, and central to this effort is an understanding of the transport and transformation of N from land surface to aquifer. The rate of N (primarily nitrate) leaching from the soil layer may be slowed by plant uptake and immobilization, or N may be removed completely by the conversion of nitrate into gaseous N through denitrification. The attenuation of N by these processes can be estimated by land-use specific attenuation coefficients in order to more accurately predict N loading to the aquifer at the springshed scale (Katz et al 2009). However, there is still considerable uncertainty in this approach because it does not account for spatial and temporal variability in local surface hydrology, soil processes, and hydrostratigraphic features (e.g., presence of a confining unit). Constructing models that account for these aforementioned landscape features to estimate the attenuation of N in a spatially explicit manner will improve targeting of mitigation efforts in areas that experience high N loading and low natural attenuation.

Denitrification within the Floridan Aquifer System (FAS) may also remove nitrate after it has passed through the unsaturated zone. It was recently estimated that 32% of the N load to the FAS in North and Central Florida is removed by denitrification in the aquifer prior to emergence at springs (Heffernan et al 2012). This loss of N in the aquifer may be underestimated in groundwater models, which generally assume negligible denitrification rates in the FAS. Measurements of excess N_2 (the endproduct of denitrification) and stable isotopes of nitrate ($\delta^{15}N$ and $\delta^{18}O$) from the Silver Springs main vent has not provided clear evidence for denitrification within the FAS (Phelps 2004). However, multiple sources of nitrate and a varying contribution of young and old groundwater may obscure any denitrification signal at the spring vent.

It is estimated that 75% of the flow to the springs originates in the 2-year capture zone (Munch et al 2007), which comprises 4% (52 sq. miles) of the springshed. The removal of N in groundwater outside of the 2 and 10 year capture zones may be an important determinant of the contribution of legacy N loading to nitrate concentration in Silver Springs. Determining the extent of denitrification in older versus younger groundwater, in conjunction with improved estimates of the contribution of older water to spring flow, will be informative with respect to the timescale of recovery of nitrate concentrations in Silver Springs.

II. OBJECTIVES

The overall goal of this project is to determine the capacity for natural attenuation of land surface N loads in the soil, vadose zone, and upper FAS and identify potential sources of other nutrient/geochemical constituents which may influence biota in springs. Three primary objectives are defined pursuant to this goal:

a) Characterize sources of N and potential denitrification loss in soils of major land uses
b) Determine the impact of denitrification within the Floridan Aquifer System on N loading to Silver Springs
c) Identify hot spots and hot moments of N delivery and attenuation within the Silver Springs springshed

The proposed project is synergistic with projects from other groups within the Springs Initiative at SJRWMD and other organizations. The contribution of this project to the Springs Initiative will be to estimate soil N attenuation processes in major land uses and assess rates and pathways of aquifer denitrification in monitoring wells throughout the springshed. The project deliverables will be used to improve the spatial modeling of subsurface N attenuation and transport in the springshed and to inform resource allocation to meet management criteria.

III. SCOPE OF WORK

This project will run parallel to quarterly sampling of water quality data by SJRWMD District staff in a network of monitoring well clusters (see Figure 1 for proposed locations). The wells are located under land uses that are expected to contribute N to the aquifer. Most of the wells are located in the western half of the springshed where there is high recharge and the FAS is thinly confined to unconfined. At each well location, 2 - 3 wells will be installed at depths corresponding to the surficial aquifer, intermediate confining unit (if present), and Upper Floridan Aquifer (Figure 2). The borehole for the Upper Floridan well at each well cluster will be sampled during well installation by District staff for water quality parameters at 10 ft. intervals and soil/aquifer material characteristics.

Task 1-UF. Characterization of N sources and denitrification in soils of various land uses.

Rationale: Sources of nitrogen in groundwater systems are frequently inferred based on the isotopic composition of nitrate (Fogg et al. 1998) where various N sources have distinct isotopic composition ranges in $\delta^{15}N$ and $\delta^{18}O$ (Kendall and McDonnel 1999). Based on changes in groundwater nitrate isotopic composition, it is also possible to infer and calculate denitrification and other N loss processes, but with the caveat that isotopic composition of nitrate sources is known (Xue et al. 2009). For this reason, accurate spatial measurements of nitrate isotopic composition within the watershed are required to adequately separate transformation and mixing processes of nitrogen in groundwater systems.

In addition to N source (e.g., organic N, fertilizer) soil processes (such as nitrification and denitrification) can directly affect the isotopic composition of leached NO_3^-. Therefore, it is required that signatures of surface N from various land uses be accurately related to the isotopic signature of N leaching from various systems in the Silver Spring springshed. Soil processes and conditions are thus a key to understanding the identification of sources and attenuation of nitrogen prior to input into the FAS.

The ability of a soil to support denitrification largely depends on soil conditions such as moisture content affecting oxygen status, availability of carbon fuel denitrifying microbial populations, and levels of nitrate (Smith and Tiedje 1979). Many of these parameters are highly temporal or seasonal in nature depending on rainfall levels and management practices (fertilizer applications, etc.). For this reason, models of N attenuation in the soil zone should be parameterized to capture the diversity of N levels and transformations and the soil conditions affecting denitrification-based N attenuation in the Silver Springs springshed.

Experimental elements: In conjunction with SJRWMD and cooperatively with work by other UF groups (PI: M. Kramer), key N sources from land uses will be identified based on factors of 1) land uses which cover a majority of land surface in the springshed and 2) land uses which have a high intensity of nitrogen loss. Up to 10 key land uses will be selected in areas with close proximity to monitoring wells for subsequent isotope measurements of major N forms ($\delta^{15}N$ of DON and $\delta^{15}N$ and $\delta^{18}O$ of NO_3^-). Additional analyses of isotopes of boron (^{11}B and ^{10}B) will also be included to potentially allow better separation of N sources, in particular those of manure-based nitrogen sources (Widory et al. 2005). These isotopic samples will be obtained from either soil profiles, leachates from lysimeters, or intact soil columns based on the experiments conducted by Kramer. An additional effort will also be made to collect as many known nitrogen sources (e.g., fertilizers, manures, wastewaters) as possible from the springshed land uses to better constrain the population of nitrogen isotopes within the system.

Determination of denitrification rates in soils will be accomplished using soil samples from the 10 key land uses selected above (obtained in conjunction with work by Kramer). Rates of soil denitrification will be determined using the standard denitrification enzyme assay (DEA) protocol of Smith and Tiedje 1979, Liao and Inglett *in prep*). Kinetics of the denitrification process and identification of limitation (NO_3^-, and C) will also be performed to fully parameterize the attenuation within land use categories receiving ranges of inputs and management (e.g., manure vs. fertilizer, intensive vs. passive management)(Myrold et al. 1985). Additional soil moisture experiments using intact soil cores may be used to determine the relationship between rainfall patterns and denitrification activities (Parkin et al. 1984).

Deliverables and outcomes: Documentation of isotopic signatures of N leaching from various landuses will provide baseline data to properly assess N sources and delivery to the FAS. Measured denitrification rates and kinetics in soils and relationships with soil moisture will provide better parameterization for N loss in surface N loading models, and thus, improved estimates of N loading to the Upper FAS.

Task 2-UF. Estimation of aquifer denitrification and its effect on N loading to the Silver Springs group.

Rationale: It has been demonstrated that the different vents of the Silver Springs group represent a variety of potentially different groundwaters from the springshed (Osmond et al. 1974, Phelps 2004). Likewise, there is also high potential for these different groundwaters to reflect different N sources and potential for attenuation of N loading to the Silver River. The sources and attenuation processes are also likely to be seasonal in nature varying with both intensity of groundwater discharge and changes in landuse activities.

Heffernan et al. (2012) demonstrated that analysis of dissolved gases and stable isotopic composition of nitrate can be used to indicate the percentage of nitrogen present in samples of spring water that has been removed by the process of denitrification during transit to the spring vent. Thus, seasonal changes in these indicators of denitrification could serve as a powerful tool to identify covarying springshed or climate-related processes which contribute to the observed nitrogen attenuation within the FAS.

Experimental elements: Based on this potential for seasonal variation in N sources and attenuation in the aquifers feeding the Silver Spring group vents, we will monitor dissolved gas composition (N_2, Ar, O_2 and Ne) in the major vents of the Silver Springs group monthly for 18 months. Dissolved gas ratios of N_2/Ar will be used to estimate excess N_2 produced by denitrification or Anammox processes in the aquifer (Inglett et al. 2013, Heffernan et al. 2012). Neon measurements on a subset of samples will allow better constraints for excess air entrainment in the groundwater of this karst aquifer (Heffernan et al. 2012). Nitrate concentration and nitrate stable isotopic ratios (^{15}N, ^{18}O) will also be measured monthly at the spring vents to further establish seasonal patterns of denitrification. The differences between isotopic shift due to flow or a change in N source may be separated from the potential shift due to denitrification (estimated by excess N_2 patterns).

Deliverables and outcomes: When compared with N load patterns, seasonal patterns of excess N_2 will provide an indication of the proportion of total watershed N that is being denitrified in transit to the spring vents. Variation in nitrate stable isotope values at the spring vent will be compared to similar seasonal patterns of N sources obtained from the studies of Task 1 and 3. Additionally, relationships between patterns of denitrification estimated at the spring vent will then be compared to temporal patterns of spring vent water quality and other variables measured spatially throughout the springshed to better estimate the role of seasonal landscape activities and conditions to affect nitrogen loads reaching the spring vent.

Task 3-UF. Identification of hot spots of denitrification in the Floridan Aquifer System

Rationale: The flowpath of water from soils underlying various landuses may contain several areas where conditions may be suitable for denitrification, including the vadose zone, and regions of the Floridan aquifer system where inputs of reduced carbon, iron or sulfur may occur (Goldscheider et al. 2006). Identifying these hotspots of favorable conditions and actual rates of denitrification is essential to understand the microbial processes involved (including Anammox) and enable spatial prediction of N attenuation under changing land use and climate conditions.

Detection of denitrification in the aquifer waters and materials can occur via several approaches including measurement of dissolved gases (Inglett et al. 2013), measurement of the functional enzymes (i.e., DEA), or by the presence and abundance of organisms involved in the process. Dissolved gas measurements offer a way to quantify the amount of N present in an aquifer water sample that has passed through the denitrification pathway (Heffernan et al. 2012). This technique is based on the comparison of amounts of dissolved N_2 gas (which changes in response to denitrification and nitrogen fixation) relative to other conservative gases (e.g., Ar or Ne) whose solubility is primarily a function of temperature and pressure.

In the case of microbial enzyme and population approaches, both techniques are highly sensitive, and the DEA method will give a useable rate for model parameterization. But because system conditions (i.e., nitrate, oxygen and carbon levels) can be highly variable, the likelihood of missing key areas of N cycling/attenuation in a spatial analysis is increased when assessing only active enzyme expression among functional populations of the involved organisms which can be highly persistent even in non-ideal conditions. Thus, it is recommended to use a multifaceted approach of detecting and quantifying zones of denitrification in complex groundwater systems at a landscape scale.

Experimental elements: To identify the potential of for denitrification in the vadose zone and upper FAS, denitrification enzyme activity will be assessed in profiles of soil, vadose, and saturated zone samples of core materials obtained from the well boreholes from selected sites characterizing the majority of land surface area in the springshed and land uses with high potential for nitrogen loading. Kinetics of denitrification will be assessed in these aquifer materials using separate DEA incubations with various NO_3^- and C (glucose) levels (Myrold et al. 1985) from materials collected from up to 4 depths in 5 boreholes. For evidence of both denitrification capacity and identification of dominant N loss pathways (nitrification, denitrification, Anammox), functional gene sequencing of major N cycling genes (e.g., *amoA*, Archaeal *amoA*, *nirS*, *nirK*, *nosZ* and the Anammox hydrazine oxidoreductase *hzo*.), will be analyzed in core samples collected from at 3 depths from up to 10 boreholes (selected based on geochemical indicators)(Penton et al. 2013).

Spatial detection of denitrification activity in the FAS is also necessary to identify hotspots at the intersection of land use, zones of aquifer and surface water mixing, and geologic formations (Giannotti et al. 2005). Available monitoring wells (approximately 80) will be sampled twice (both wet and dry seasons) for indicators of denitrification, including dissolved gases (N_2, Ar) and stable isotopes of nitrate ($\delta^{15}N$, $\delta^{18}O$). As in Task 2, Ne analyses will be performed in a subset of these samples. Results of age dating of well water samples will facilitate determination of the relationship between groundwater age and extent of denitrification.

Differences in patterns of dissolved gases and isotopes will be used in conjunction with changes in geochemistry (e.g., pH, DIC, Fe, SO_4^{-2}) which serve as indicators for the presence of heterotrophic and lithotrophic denitrification processes (Burgin and Hamilton 2007, Herman et al. 2008). Samples taken from the wells throughout the springshed will also be filtered for collection of microbial particulates which will be analyzed for functional gene sequencing of major N cycling genes (e.g., *amoA*, Archaeal *amoA*, *nirS*, *nirK*, *nosZ* and the Anammox hydrazine oxidoreductase *hzo*.)(Penton et al. 2013). Spatial analysis of microbial genes involved in nitrogen cycling will allow more sensitivity to detect the presence of alternate pathways of N_2 generation, in particular that involved in the Anammox process.

Where possible, every effort will be made during well installation to obtain samples of wall surface materials characterizing the conduits and aquifer cave systems within the FAS. These materials will be preserved and processed for determination of both denitrification activity and kinetics using the DEA protocol, and for determination of microbial composition related to nitrogen cycling. Additional samples of cave walls and potential biofilms from the spring vent (Mammoth spring) could also be assayed if diving access is feasible (http://www.theledger.com). These measurements of surface activity would be determined on an areal basis to potentially allow for inclusion into groundwater nitrogen models with estimated conduit volume and size.

Deliverables and outcomes: Measured rates of denitrification will supplement the SJRWMD database of geochemistry in the surficial and upper FAS. These data will be used for parameterization and validation of groundwater N fate and transport models, as well as for the spatial nitrogen model. The results of denitrifier composition will be related to system level conditions in both the soil, vadose and aquifer zones to not only characterize the types and diversity of N attenuation processes within the FAS, but also derive the best indicators for spatial determination of denitrification.

Task 4-UF. Hot moments of N delivery and attenuation

Rationale: Biogeochemical hot spots have high reaction rates relative to the surrounding matrix, and hot moments occur when rates are temporarily elevated above background (McClain et al 2003). During high recharge events (i.e. large storm events) and areas that receive stormwater (e.g., retention basins, karst depressions) there may be hot moments for denitrification due to the coincident delivery of N and organic matter to the aquifer during rain events. During these events, microbial activity may reduce oxygen levels to favor denitrification. These events may last for only a short duration, but because they coincide with the events of significant nitrogen leaching, the combined effect of elevated nitrogen with excess carbon may dramatically affect the proportion of added nitrogen that is attenuated in the surficial aquifer.

Using a selected number of the nested wells installed for the Springs initiative, we will attempt to quantify rates of denitrification nitrogen loss in locations that receive stormwater runoff will be measured to determine the potential for natural N attenuation in stormwater. Following a long-term analysis of well level fluctuations in response to rainfall events, up to 10 well clusters will be selected for sampling after high rainfall events. After a suitable rainfall event, samples will be taken daily for up to several days for determination of dissolved gases (excess N_2, dissolved O_2), concentrations of various N species, and nitrate stable isotopic ratios (^{15}N, ^{18}O).

Deliverables and outcomes: Results from this task will be incorporated into the spatial nitrogen model. Additionally, the relative contribution of hot moments of N delivery to total surface loading will inform management priorities for better mitigating point sources such as storm water retention basins. Relationships between dissolved oxygen and changes in isotopic ratios as well as dissolved gas composition will be used to derive temporal patterns of denitrification after a given rainfall event. These measurements will also help to derive relationships for future assessments based on more easily or continuously measured parameters such as dissolved oxygen.

Task 5-UF. Reporting

University shall provide a semi-annual report containing a brief summary and update of work completed thus far, and an annual report containing a summary of progress and up-to-date findings for the entire year along with a synthesis in relation to stated goals. All reports will be submitted in an electronic format compatible with District operating systems. When possible, reports should be submitted in journal formats for future publication. District scientists shall share authorship in projects where material support is provided in hypothesis development, experimental design, data collection, analysis, or writing.

Task 1-SJR. Nutrient Inventory

The workgroup will compile information and data necessary to construct springshed nitrogen loads to Silver Springs. We will focus on collecting loading data representing the heterogeneous land use/land cover to facilitate springshed modeling.

The Workgroup will review existing WQ data collection for adequate spatial coverage within each springshed. We will identify additional WQ data required to provide spatial representation across different land uses to help meet modeling needs. We will work with FDEP and SJRWMD staff to fill any recognized data deficiencies.

Deliverables: GIS-based database cataloging springshed N sources, springs water quality database, chapter in the final synthesis report.

Task 2-SJR. Nitrogen attenuation and event loading.

Using a combination of UF experimental data and SJR ambient sampling we will construct model(s) to predict N attenuation through the soil gradient and in the UFA. District and UF staff will collaborate to measure the effects of significant storm events on nutrient loading and attenuation to the UFA.

Deliverables: Quasi mechanistic or stochastic models of N attenuation, time series data from storm events

Task 3-SJR. Spatial nitrogen model.

The workgroup will collaborate with UF and SJR workgroups to construct a spatially explicit nitrogen model. The model will use a variety of data layers (including over-burden thickness, karst features, land use, and soil types) to highlight areas that are susceptible to generating high nitrate loads and have the potential to transport water to the aquifer. We are especially interested in areas that have high levels of connectivity with the springs, which we will investigate using relationships between spatial rainfall estimates and spring discharge to infer springshed areas with high springs connectivity.

Deliverables: GIS input data layers, spatially explicit GIS nitrogen model

Task 4-SJR. Deliver nitrogen load data.

Nutrient load data will be formatted into input files suitable to perform groundwater fate and transport modeling of nitrogen.

Deliverables: Data input files.

Task 5-SJR. Synthesis report.

District staff will work collaboratively with UF staff to produce a comprehensive and synthetic report summarizing findings from this project and exploring how these findings synergistically interact with the models and processes of others workgroups.

Deliverables: Final synthetic report, derivative peer-reviewed journal submissions.

Task 6-SJR. GIS Support

Procurement and management of contract support to manage GIS data and analyses.

IV. TASK IDENTIFICATION & REQUIRED RESOURCES

- Task 1-UF: Borehole solid-phase sample collection. Dependent on successful well construction.
- Task 2-UF: Spring vent water and trace gas sampling. Dependent on sample collection by SJR contract staff.
- Task 3-UF: Denitrification and trace gas sampling in wells.
- Task 4-UF: Event sampling in springshed wells.
- Task 5-UF: Workplan development, routine reporting, and manuscript development.
- Task 1-SJR: Springshed nutrient inventory. Dependent on measured nitrogen species (UF) and ambient well water quality (SJR).
- Task 2a-SJR: Calculate nitrogen attenuation in soil/groundwater. Dependent on denitrification rates (UF) and ambient well water quality (SJR).
- Task 2b-SJR: Measure event scale nitrogen loading. Dependent on isotopic source characterization (UF) and continuous nitrate monitoring (SJR).
- Task 3-SJR: Construct a spatially explicit nitrogen loading/attenuation model.
- Task 4-SJR: Deliver attenuated nitrogen loading data to the groundwater supergroup.
- Task 5-SJR: Final synthesis report and summary of all work.
- Task 6-SJR: Contract GIS support

V. PROJECT TIMEFRAME & DELIVERABLES

	2014-15		2015-16				2016-17				2017-18	
Research Tasks/Accomplishments	**Q3***	**Q4**	**Q1**	**Q2**	**Q3**	**Q4**	**Q1**	**Q2**	**Q3**	**Q4**	**Q1**	**Q2**
Task 1-UF												
Site selection												
DEA in soil materials												
Isotope measurements of springshed N												
Data analysis												

Task 2-UF					
Seasonal gas measurements in spring vents					
Seasonal isotopes in spring vents					
Data analysis					
Task 3-UF					
Nutrient characterization of well materials					
DEA in aquifer/borehole materials					
Denitrification tracers in aquifer/vadose					
Gas composition in wells					
Isotope composition in wells					
Denitrification rates of conduit wall biofilms					
Data analysis					
Task 4-UF					
Site selection					
Gas composition after rainfall events					
Isotopic changes after rainfall events					
Data analysis					
Task 5-UF					
Workplan development					
Annual reports					
Draft Final report					
Final report					
Task 1-SJR: Springshed nutrient inventory					
Task 2a-SJR: Nitrogen attenuation					
Task 2b-SJR: Event scale loading					
Task 3-SJR: Spatial nitrogen model					
Task 4-SJR: Deliver loading data					
Task 5-SJR: Synthesis report					
Task 6-SJR: GIS support					

List of Key Deliverables with Dates

Deliverable	Date	Associated Task	Comments
Workplan development	Jun. 2014	Task 5-UF	Completed UF/SJR workplan
Solid phase data	Sep. 2014	Task 1-UF	Soil DEA, springshed N isotopes
Draft nutrient inventory	Oct. 2014	Task 1-SJR	
Annual Report	Sep. 2014	Task 5-UF	Annual status report
Draft Spatial N model	Sep. 2015	Task 3-SJR	
Annual Report	Sep. 2015	Task 5-UF	Annual status report
Final nutrient inventory	Dec. 2015	Task 1-SJR	

Solid phase analysis/report	Mar. 2016	Task 1-UF	Analysis & synthesis report
Seasonal data	Mar. 2016	Task 2-UF	Gas & isotope sampling in spring vents
Well sample data	Mar. 2016	Task 3-UF	Well gas & isotope data
Seasonal synthesis report	Sept. 2016	Task 2-UF	Analysis & synthesis report
Well analysis/report	Sep. 2016	Task 3-UF	Analysis & synthesis report
Annual Report	Sep. 2016	Task 5-UF	Annual status report
Deliver nutrient load data	Mar. 2017	Task 4-SJR	Nutrient load data for use in groundwater fate & transport modeling
Final Project report	Jun. 2017	Task 5-UF	Final UF project report
Final Synthesis report	Jun. 2017	Task 5-SJR	Final SJR project report

VI. BUDGET/COST SCHEDULE

External costs by task

	2014		2015				2016				2017	
	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2
Task 1-UF	0	0	10493	10493	10493	10493	8018	8018	8018	8018	0	0
Task 2-UF	0	0	4014	4014	4014	4014	4330	4330	4330	4330	0	0
Task 3-UF	21250	21250	24618	24618	24618	24618	7584	7584	7584	7584	0	0
Task 4-UF	0	0	0	0	0	0	2569	2569	2569	2569	0	0
Task 5-UF	0	0	0	0	0	0	0	0	0	0	4750	4750
Task 6-SJR	64507		78667				82600				43365	
Quart. Tot.	85757	21250	117792	39125	39125	39125	105100	22500	22500	22500	48115	4750
FY Tot.		107007				235167				172600		96230
Proj. Tot.												$567639

Task Name	**Start Date**	**End Date**	**Resource Names**	**Fixed Costs**
Task 1-UF: Borehole solid-phase sample collection	10/1/2014	3/31/16	UF/ P. Inglett	74,044
Task 2-UF: Spring vent water and trace gas sampling	1/1/2015	6/30/2017	UF/ P. Inglett	33,376
Task 3-UF: Denitrification and trace gas sampling in wells	6/1/14	6/30/2017	UF/ P. Inglett	171,308
Task 4-UF: Event sampling in springshed wells	10/1/2015	9/30/17	UF/ P. Inglett	10,276

Task 5-UF: Workplan development, routine reporting, and manuscript development	7/1/14	3/31/18	UF/ P. Inglett	9,500
Task 1-SJR: Springshed nutrient inventory	7/1/2014	3/31/17	ES1[0.1], ES2[0.4], ES3[0.2], ES4[0.2]	
Task 2a-SJR: Calculate nitrogen attenuation in soil/groundwater	10/1/2016	6/30/17	ES1[0.2], ES2[0.2]	
Task 2b-SJR: Measure event scale nitrogen loading	10/1/2016	6/30/17	ES1[0.2], ES2[0.3]	
Task 3-SJR: Construct a spatially explicit nitrogen loading/attenuation model	7/1/2014	12/31/2017	ES1[0.2], ES2[0.4], ES3[0.2], ES4[0.3]	
Task 4-SJR: Deliver attenuated nitrogen loading data to the groundwater supergroup	10/1/2017	12/31/2017	ES1[0.2]	
Task 5-SJR: Final synthesis report and summary of all work	10/1/2017	3/31/2018	ES1[0.2], ES2[0.5]	
Task 6-SJR: Contract GIS support	4/1/2014	3/31/2018	ES1[0.1]	269,139

VII. REFERENCES

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VIII. <u>Figures</u>

Figure 1. Proposed well cluster locations within the Silver Springs springshed.

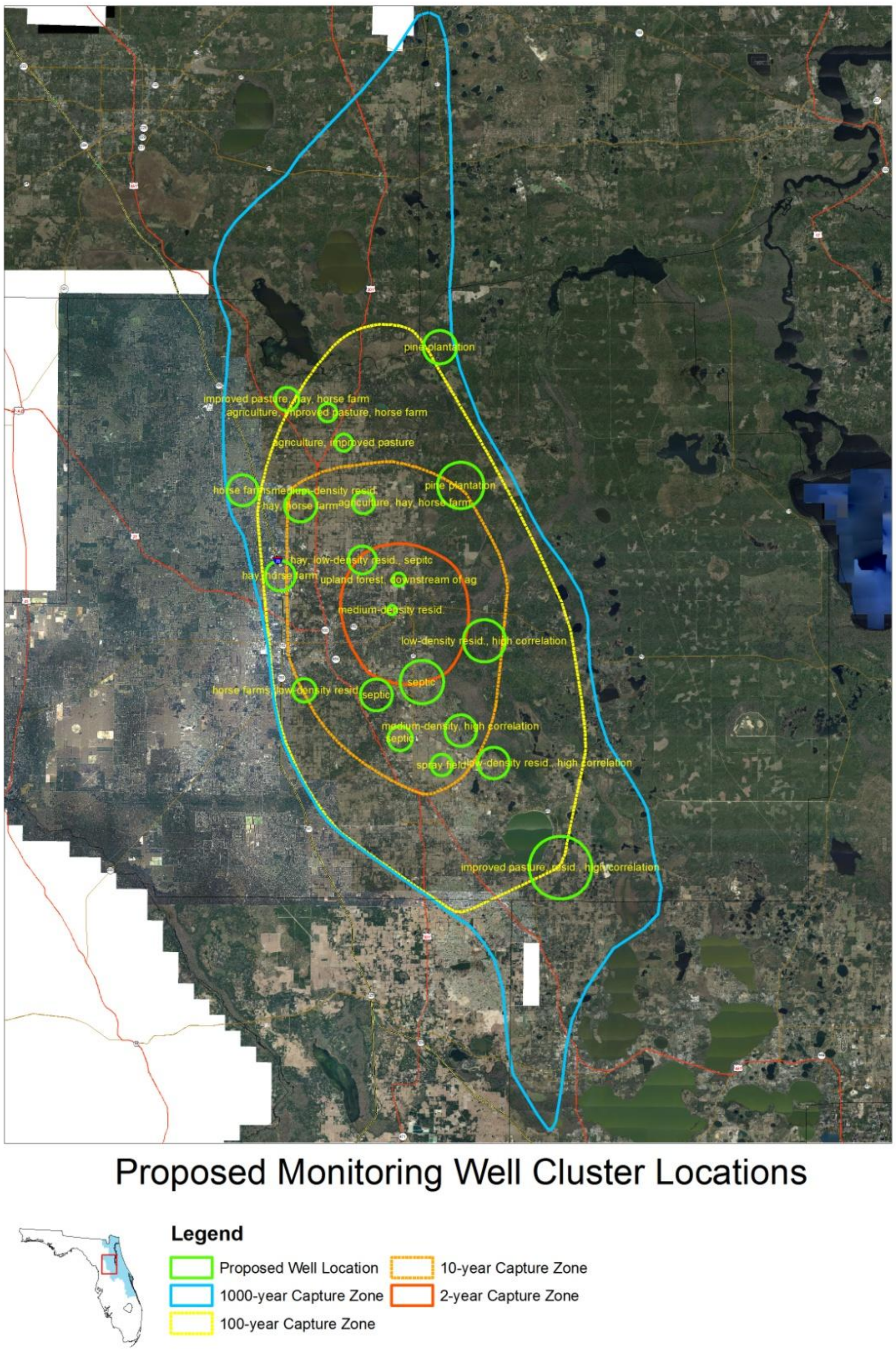

Figure 2. Diagram of well cluster configuration at each monitoring site.