Florida Department of Environmental Protection

Division of Environmental Assessment and Restoration

Estimated Nitrogen Loading to the Upper Floridan Aquifer:

Nitrogen Source Inventory and Loading Tool Assessment for the Springs of Kings Bay

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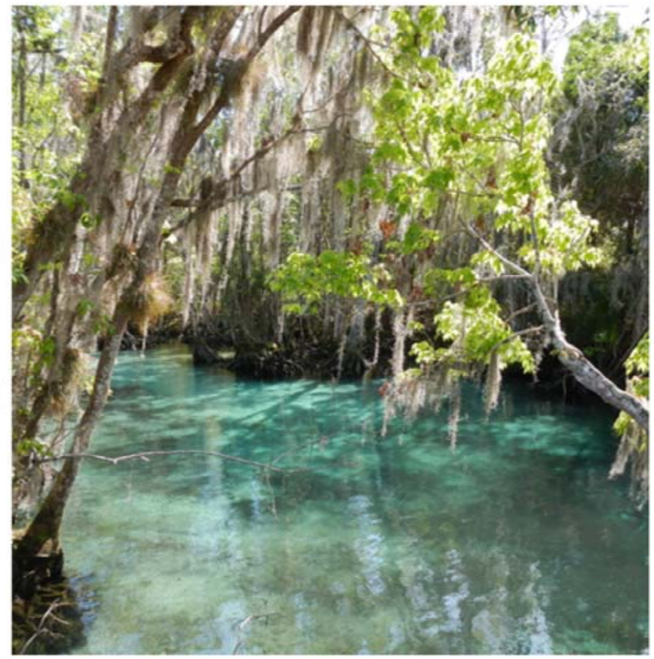
Nitrogen Source Inventory and Loading Tool

- Estimate N loading to ground water with BMAP areas
- Identify sources for which reductions in N loading could achieve restoration of impaired waters
- Customize for individual spring basins
- Inventories have been completed for Wakulla, Silver, Rainbow, Kings Bay, Jackson Blue Springs, Weeki Wachee BMAP areas



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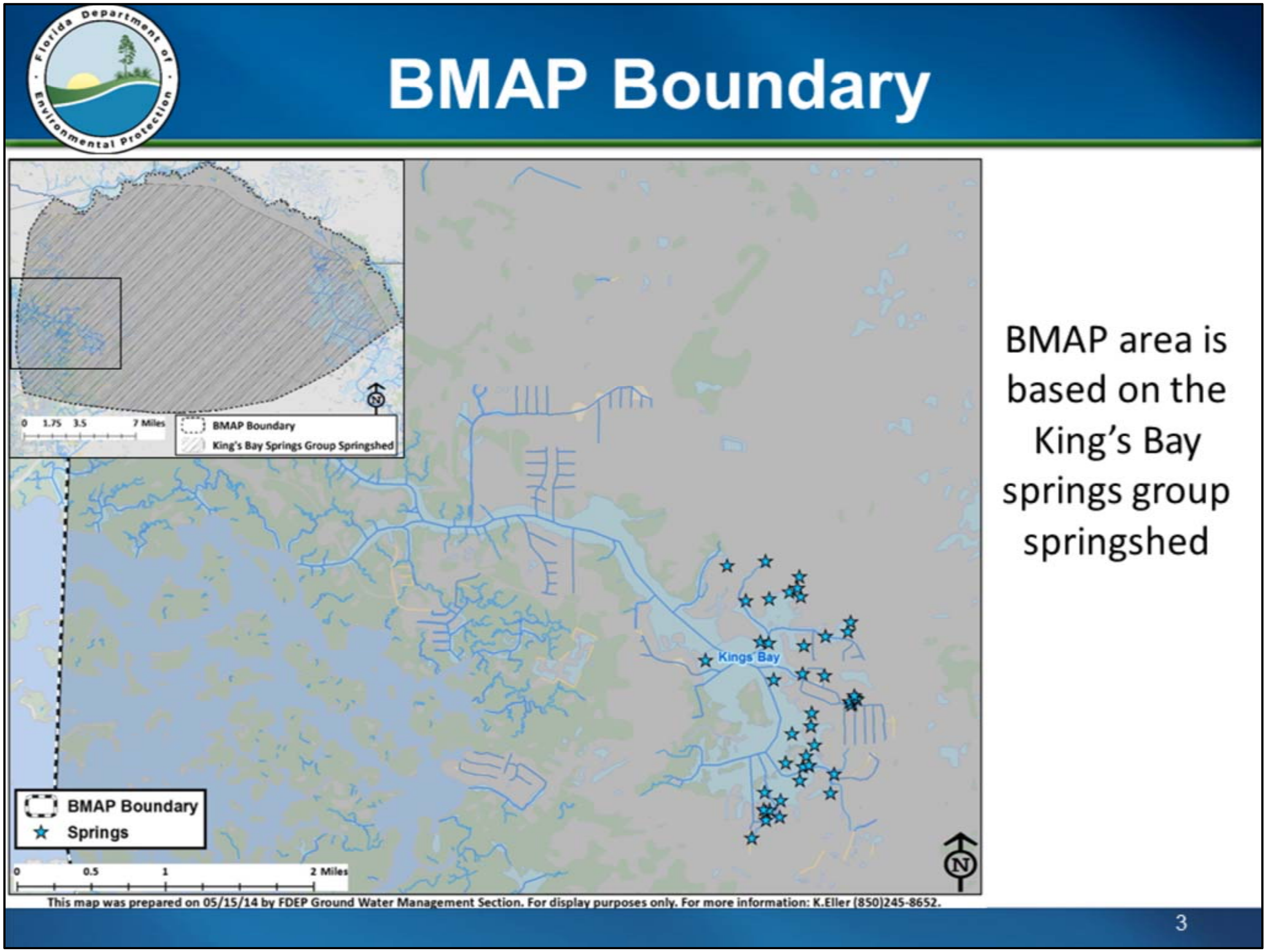
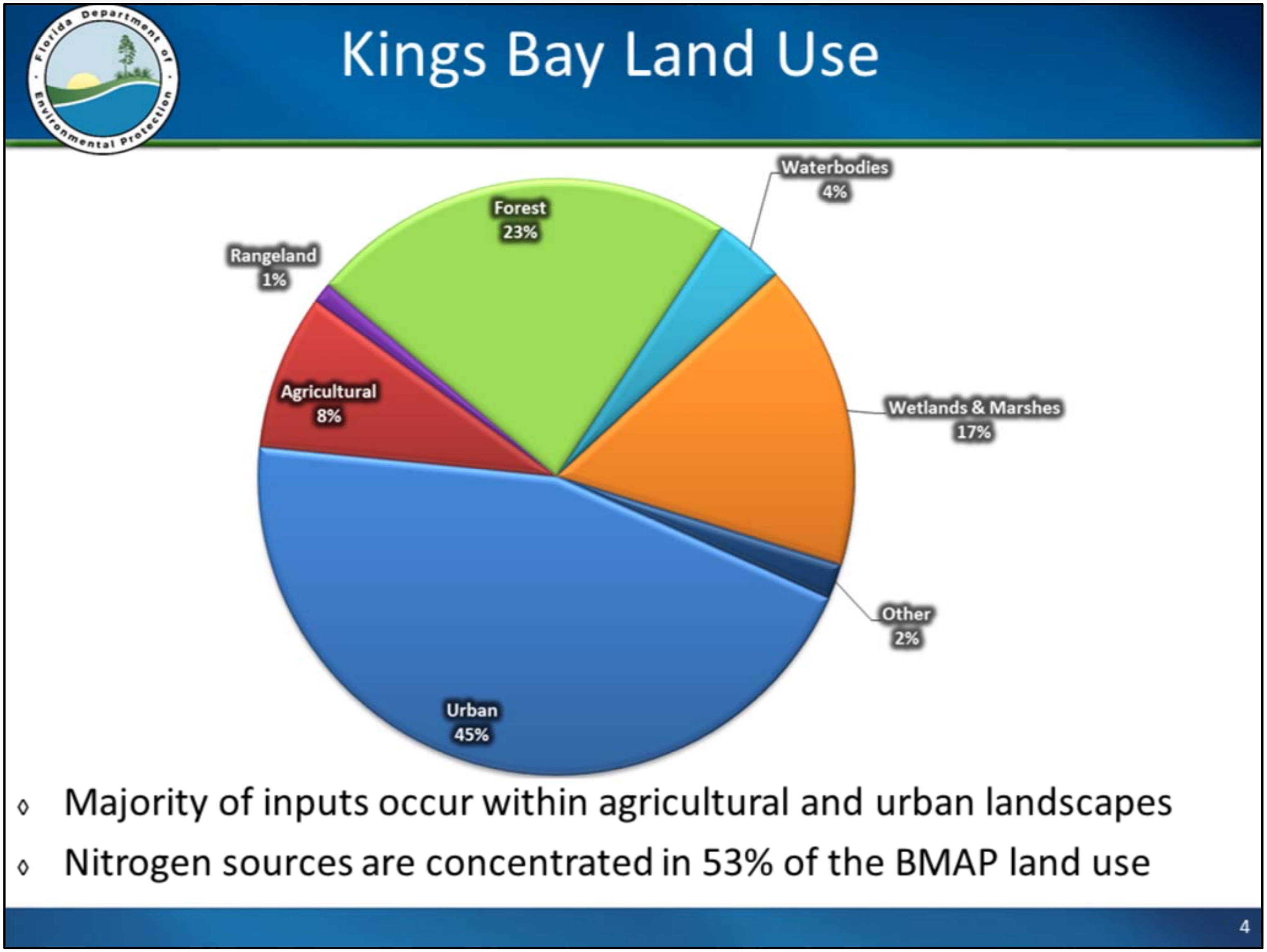
The Nitrogen Source Inventory and Loading Tool (NSILT) was developed to identify and quantify the major sources contributing nitrogen to ground water in the Kings Bay BMAP area. The NSILT is a GIS- and spreadsheet-based tool that provides spatial estimates of the relative contribution of nitrogen from various sources, and takes into consideration the transport pathways and processes affecting the various forms of nitrogen as they move from the land surface through soil and geologic strata into the Floridan aquifer. This analysis is part of the new Florida Springs and Aquifer Protection Act.



The area that is included in the Basin Management Action Plan for Kings Bay/Crystal River is largely based on the springshed. Numerous spring along Kings Bay contribute spring water to the coastal bay system. All of these springs discharge from the same aquifer and have similar nutrient reduction needs.



This chart illustrates the various land uses within the Kings Bay contributing area. The majority of nitrogen sources will enter the environment within an urban or agricultural landscape or within 53% of the BMAP boundary.

Estimating Nitrogen Loads to Ground Water

Steps:

1. **Estimate the inputs of nitrogen to the land surface from the source inventory information (best available).**
2. **Apply attenuation factors based on the various environmental processes that could transform the various forms of nitrogen in the subsurface (such as denitrification, nitrification of ammonia, uptake by plants, mineralization of organic nitrogen).**
3. **Apply areal weighting factors that are based on the rate of recharge to ground water to estimate nitrogen loads to ground water.**
4. **Fine-tune estimates after getting feedback from stakeholders.**

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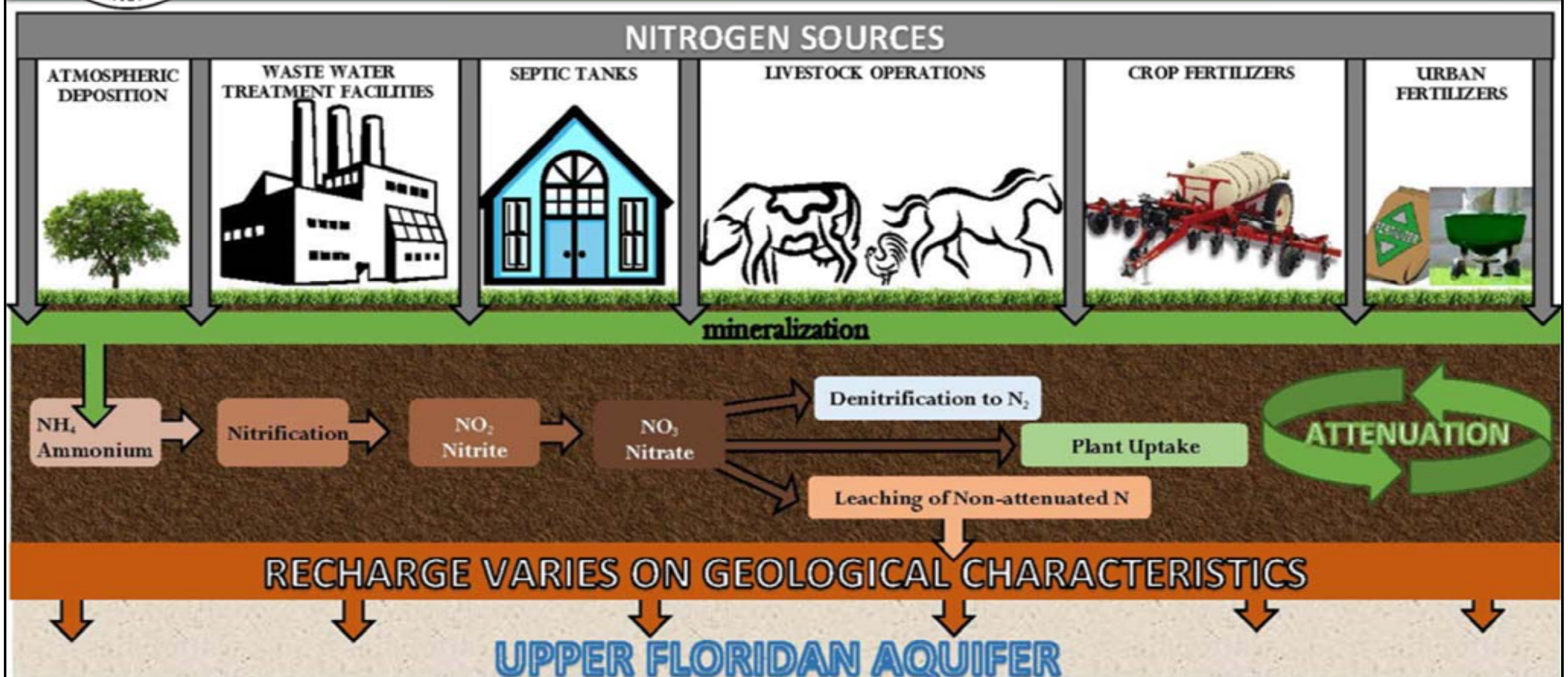
Our multiple step approach begins with estimating the nitrogen input to the land surface from various sources within the Kings Bay BMAP boundary. Next, we estimate the environment's ability to uptake and utilize this nitrogen which is called attenuation. Then, we evaluate the degree of recharge throughout the BMAP boundary. This will naturally vary with the geological conditions and influences the quantity of water reaching the aquifer. We apply a weighted recharge factor to account for this recharge variation. The final step to this process is reaching out to stakeholder groups and seeking their expertise to help us understand the different nitrogen sources and management practices.

Nitrogen Cycle and Nitrogen Attenuation



Processes that control the transformation of N in soils and the subsurface.

The wide ranges reflect variable soil conditions, fertilizer material, livestock, crop types, etc.,
ALL AFFECT LEACHING OF N TO GROUND WATER

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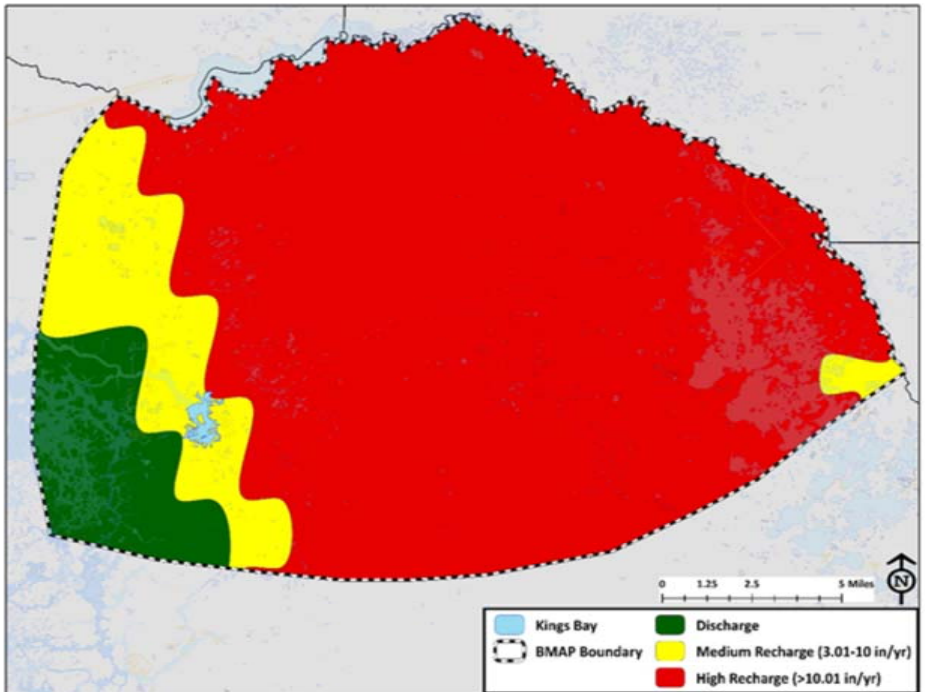
This is a cartoon describing our process. The nitrogen source categories are listed in the top; each with its own input into the environment. The processes listed in the brown bar describe the attenuation or how the environment is able to process and take up nitrogen. For our estimates, we are interested in the bar labeled “Leaching of Non-attenuated N”. This is the nitrogen which is not utilized by the environment and has the potential to reach ground water.

Ground Water Recharge Areas



This map was prepared on 06/17/16 by FDEP Ground Water Management Section. For display purposes only. For more information: K.Eller (850)245-8652.

- Quantify the degree of subsurface flow within the BMAP boundary
  - High Recharge: >10.01 in/yr
  - Medium Recharge: 3-10 in/yr
- Rates are weighted to estimate loading potential for each source category

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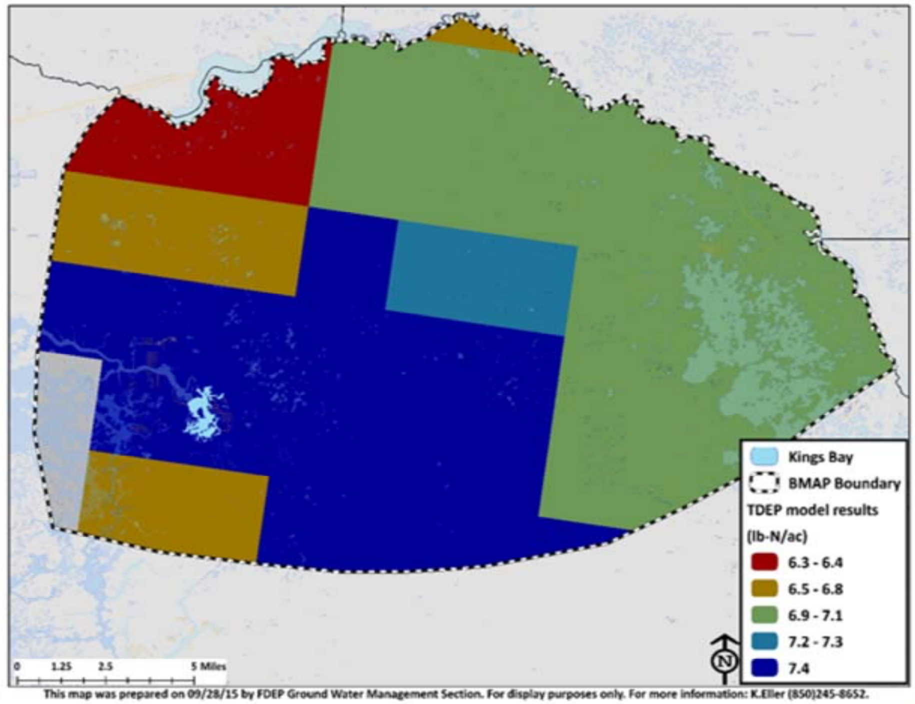
Here is the Kings Bay BMAP boundary and associated recharge rates to the Upper Floridan Aquifer. As you can see, the majority of the area has high recharge with over 10 inches of water every year infiltrating to the ground water.

Atmospheric Deposition

- TDEP model
  - U.S. EPA method to estimate spatially continuous atmospheric deposition
  - Nationwide total deposition model for N and S
  - Estimated deposition based on monitoring stations and modeled atmospheric concentrations
  - Model year is an average from 2011 to 2013
- Average TN deposition
  - Range 6.3-7.4 lb-N/ac/yr

Recharge Area	Input to Land Surface (lb-N)
Medium	123,373
High	815,247



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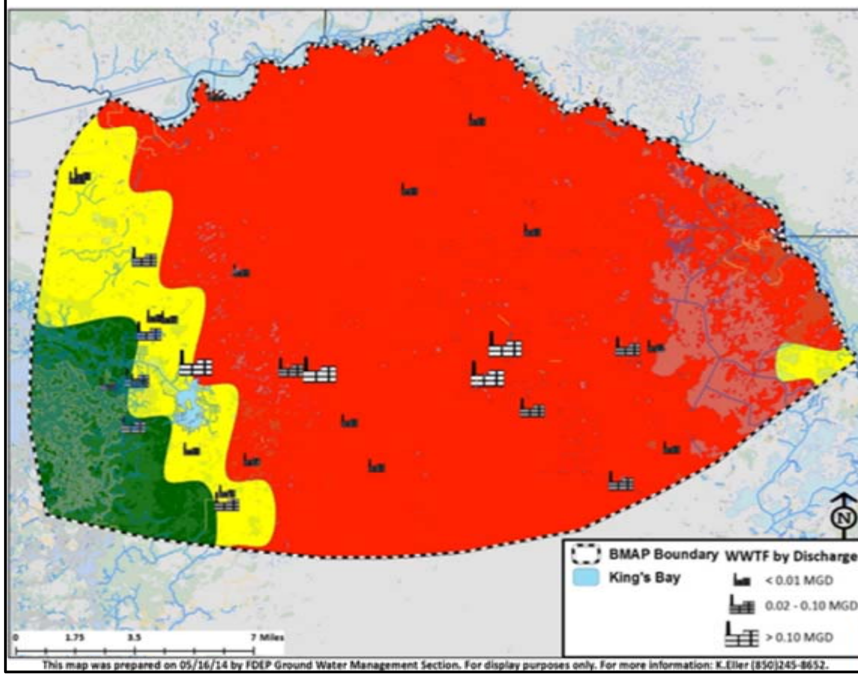
For atmospheric deposition, we rely on a nationwide model developed by EPA called the TDEP. This approach relies on data from monitoring stations as well as other atmospheric models. At the recommendation of the developers, the model results used included data from 2011 to 2013.

Wastewater Treatment Facilities

- 31 permitted facilities
  - 4 with discharge ≥0.1 MGD
  - 9 with discharge <0.1 & ≥0.01 MGD
  - 18 with discharge <0.01 MGD
- TN effluent concentrations as reported to DEP
- NO_3 used to project TN data, if necessary
  - Effluent data separated based on treatment type
    - RIBs, Absorption Fields
    - Sprayfields
    - Reuse



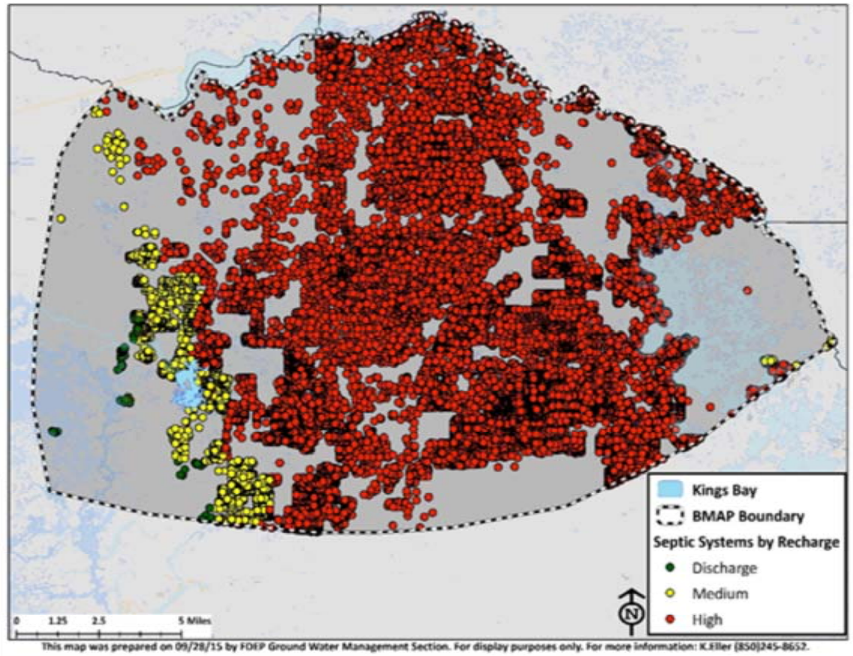
Treatment Type	Recharge Area	Input to Land Surface (lb-N)
RIB	Medium	2,751
Sprayfield		-
RIB	High	23,593
Sprayfield		6,800
Reuse		8,708

Wastewater treatment facilities are required to report various nutrient and flow data as part of their permits for operating. We use this data to estimate the input from these facilities to the land surface using the total nitrogen in the effluent as well as the actual flow rate from each facility. If nitrate data is available, but not total nitrogen, then the nitrate concentrations are projected to total nitrogen based on a 2009 DEP study. The estimated input to the land surface is separated based on the type of effluent treatment: rapid infiltration basins (RIBs), absorption fields, sprayfield or reuse.

Septic Tanks

- DOH model relying on tax parcel data and sewer service areas
- Accuracy of this data was verified using an aerial analysis
- In Citrus County, approximately 1.95 people per household rely on a septic system
  - 2010 US Census
  - US Labor Statistics
- 32,786 tanks in High and Medium Recharge areas
- Average annual input to septic tank = 9.012 lb-N/person (US EPA)

Recharge Area	Input to Land Surface (lb-N)
Medium	47,431
High	529,591



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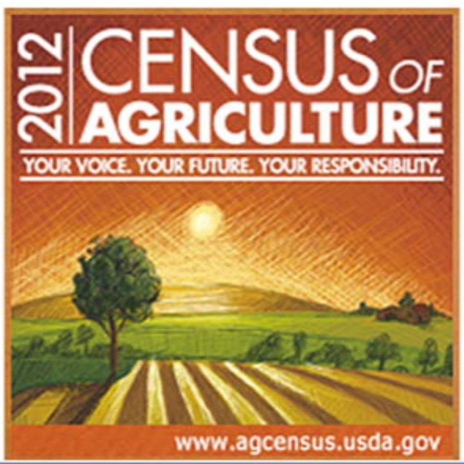
The number of septic tanks within the contributing area is estimated based on a DOH 2009 model. The effective population in each county is estimated based on the number of people per occupied household (2010 US Census) and the amount of time an average person will spend at home in a given year (US Labor Statistics). This data allows us to calculate the number of people using septic tanks and apply an annual N factor per person to estimate the input to land surface.

Nitrogen Input: Livestock Waste

- Literature review provided information on
  - Common livestock animals in Florida
  - Animal waste factors
- 2012 Census of Agriculture (CoA)
  - US Dept of Agriculture
  - Every 5 years
  - # of livestock (categorized by animal)
  - Full county data ONLY

Animal	Daily Waste Factor (lb-N/day)
Beef Cattle	0.337
Dairy Cow	0.977
Broiler Chickens	0.159
Goats	0.035
Hogs	0.190
Sheep	0.198
Turkey	0.006
Horses	.273



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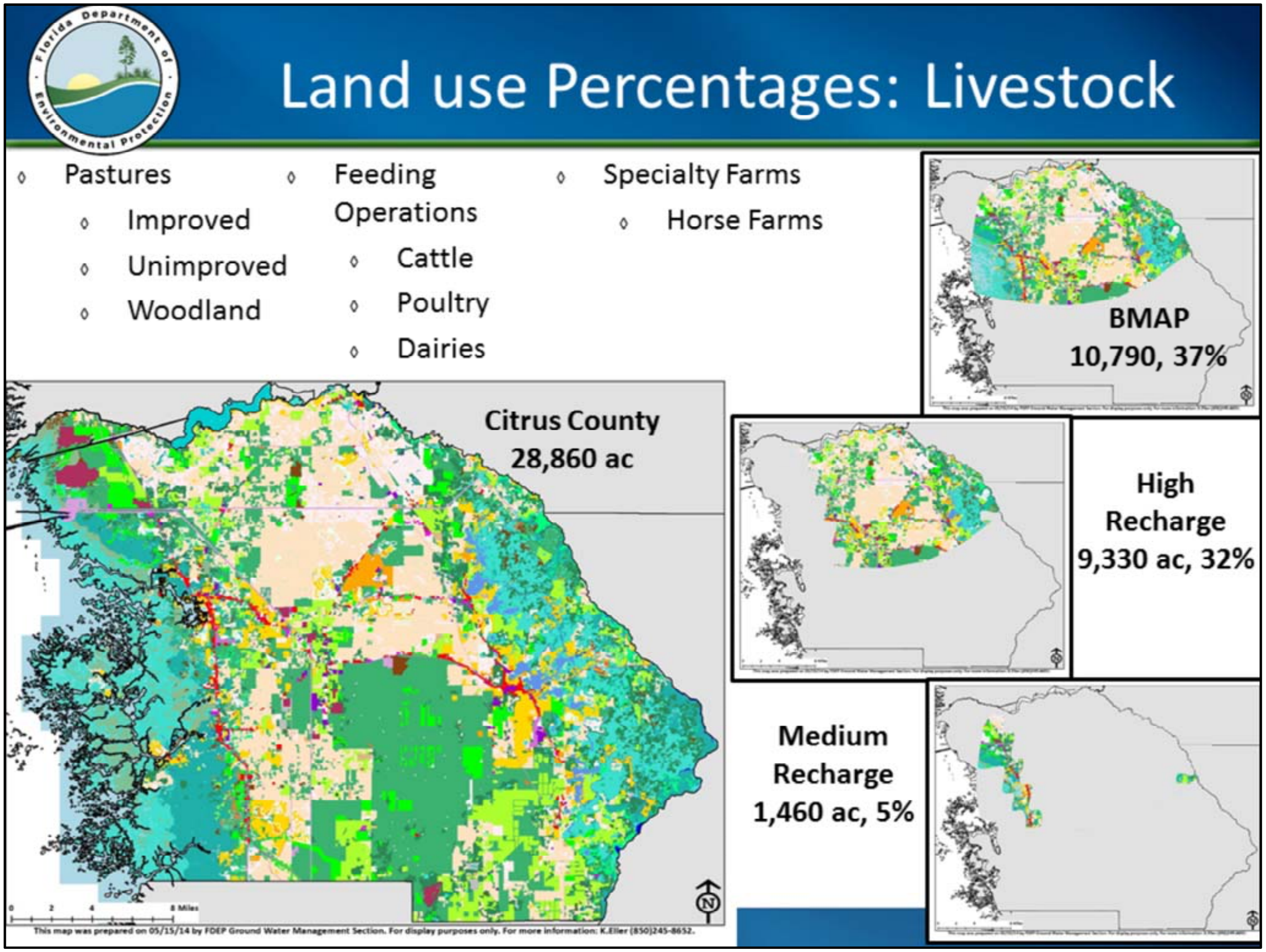
Full county livestock populations are taken from the 2012 Census of Agriculture. We use land use percentages to take the full county data and use it to estimate the populations within the contributing boundary. The full county data are listed in the table along with the daily waste factors associated with each animal.



- To calculate the land use percentages, we look at the land use for the entire county. Listed here are the land use categories which are likely to contain livestock animals.
- The total livestock land use acreage is a calculated for the entire county.
- The same calculation is made for just the BMAP boundary which indicates that 37% of all the livestock lands in Citrus County are also in the BMAP boundary.
- 32% of the Citrus County livestock lands are within the High recharge areas of the BMAP boundary.
- 5% of the Citrus County livestock lands are within the Medium recharge areas of the BMAP boundary.

Livestock Waste

Animal	Estimated BMAP population
Beef Cattle*	2,854
Horses	433
Broiler Chickens	130
Layer Chickens	664
Goats	338
Hogs	73
Sheep	104
Turkey	10

*Beef Cattle population estimated based on a stocking rate vetted by local agricultural producers of 8 ac per cow

Recharge Area	Input to Land Surface (lb-N)
Medium	**173,841**
High	**245,565**

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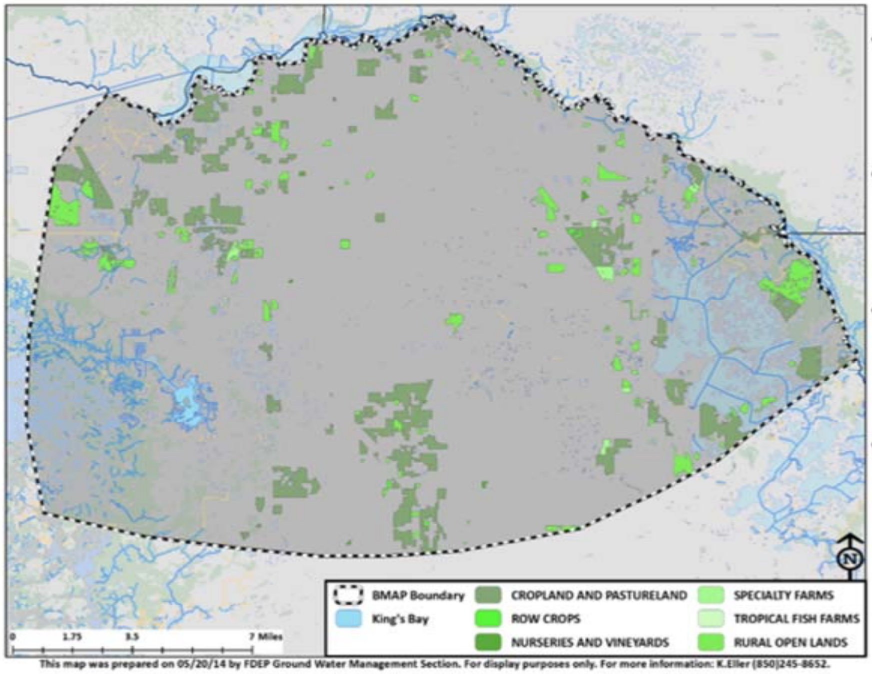
Those land use percentages are then applied to the total county livestock populations reported in the 2012 Census of Agriculture. This estimates the number of animals within the WW contributing area. Daily waste factors (see slide 12) are used to estimate the amount of nitrogen contributing to the BMAP boundary from these livestock populations. The largest nitrogen contribution is associated with cattle.

Farm Fertilizers



Recharge Area	Input to Land Surface (lb-N)
Medium	**62,319**
High	**358,121**

- Property appraised land use data was compiled
- Each county was evaluated individually
- Land areas for specific crops were estimated
- Application rates based on IFAS recommendations and farmer feedback
  - 25 lb-N/ac: Pastures
  - 80 lb-N/ac: Ornamentals
  - 80 lb-N/ac: Hay
  - 150 lb-N/ac: Orchards

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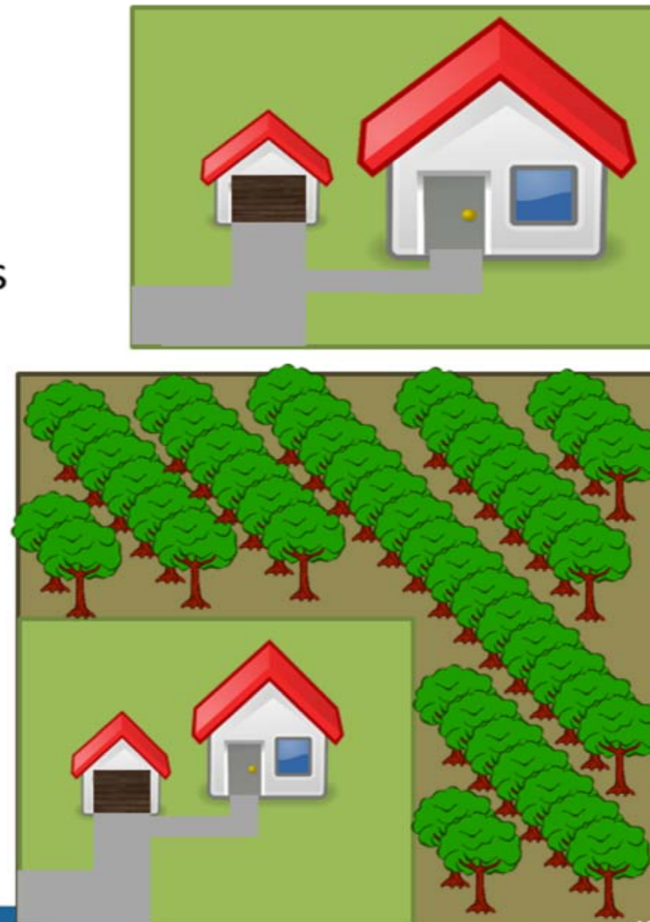
The land area for each crop is estimated based on property appraiser data as well as personal communication with the agricultural property appraiser. The application rates listed are based on the IFAS recommended rates as well as discussions which took place with agricultural producers throughout the state.

Urban Turfgrass Fertilizers

- Acreage likely to receive fertilizer estimated from PA data and property values
  - Residential
    - Single and Multi Family Homes
    - Condos
  - Non-residential
    - Schools and Colleges
    - Churches
    - Outdoor Recreational Areas
- Impervious surfaces estimated based on zoning laws
- Property values used to assess probability of fertilization



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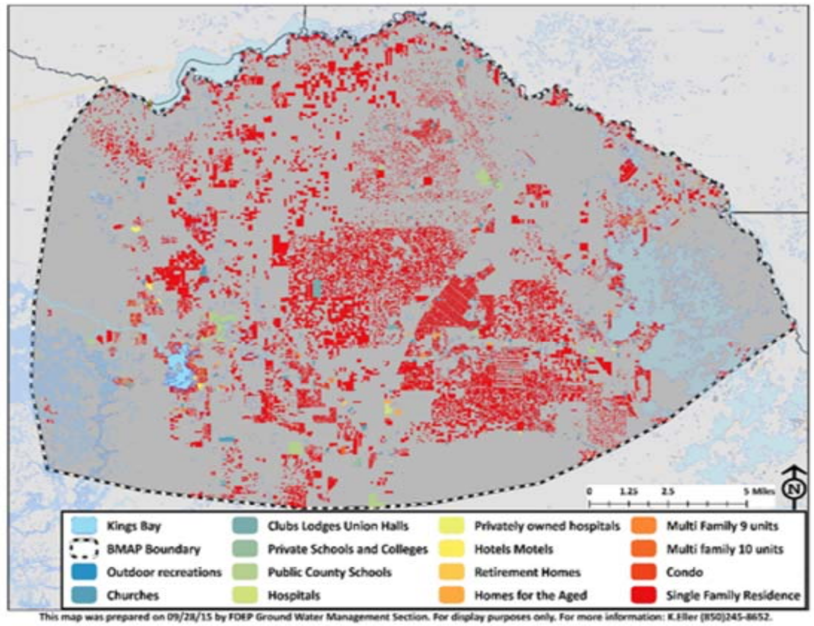
Urban fertilizers includes fertilizer application for residential purposes, businesses, parks, etc. Our process starts with assessing the property appraiser data for lands likely to be fertilized like homes and schools. In the county zoning laws, it specifies the land area that can be covered by buildings or impervious surfaces and we use this information to estimate the pervious acreages within the BMAP boundary. Next for residential areas, property value is used to determine the probability of an individual fertilizing their property. This is based on socioeconomic studies throughout the nation.

Urban Turfgrass Fertilizers

- Annual Application Rates based on SWFWMD study
  - 68% fertilized by owners
    - 15% @ 0.5 lb-N/1000 sq ft
    - 59% @ 0.8 lb-N/1000 sq ft
    - 27% @ 1 lb-N/1000 sq ft
    - 2.98 times year
  - 32% fertilized by lawn service
    - 0.5 lb-N/1000 sq ft
    - 2 times a year

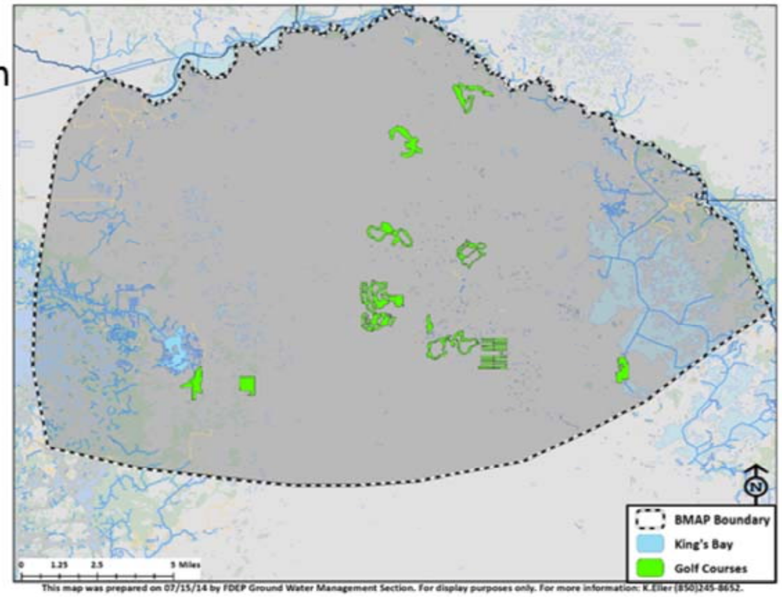
Recharge Area	Input to Land Surface (lb-N)
Medium	70,864
High	986,116



Finally, we take our estimated fertilized acreage and apply these fertilizer application rates which are derived from multiple SWFWMD studies completed in the Citrus county area. For non-residential properties, it is assumed fertilizer will be applied by a lawn service company and the above rates.

Sports Turfgrass Fertilizers

- Sports fields
  - Acreage estimates from aerial analysis of PA landuse data
  - Application rates based on lawn service company estimates
- Golf Courses
  - Acreage estimated through PA landuse data
  - Application rates based on data provided by golf courses
  - Annual application rate = 87 lb-N/ac



Recharge Area	Input to Land Surface (lb-N)
Medium	2,769
High	202,243

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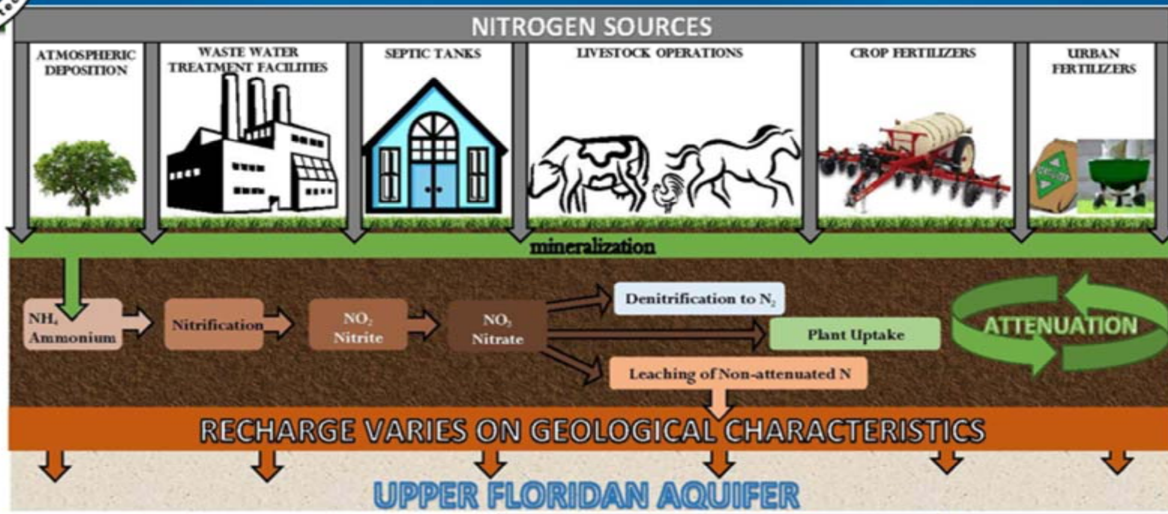
Sports turfgrass includes sporting facilities like baseball and football fields as well as golf courses. The acreage associated with sporting facilities was estimated based on an evaluation of PA landuses likely to contain these fields including schools, parks and recreational areas. The nitrogen application rate was estimated using the data for lawn service company fertilization practices (Urban Turfgrass Fertilizers slide).

Golf courses were estimated based on the acreage assessed by the PA offices. The fertilizer application rate is based on voluntary surveys completed by some of the golf course superintendents in the contributing area. For those courses which did not provide feedback, a standard application rate that was vetted by the golf course super

Biochemical Attenuation Factors



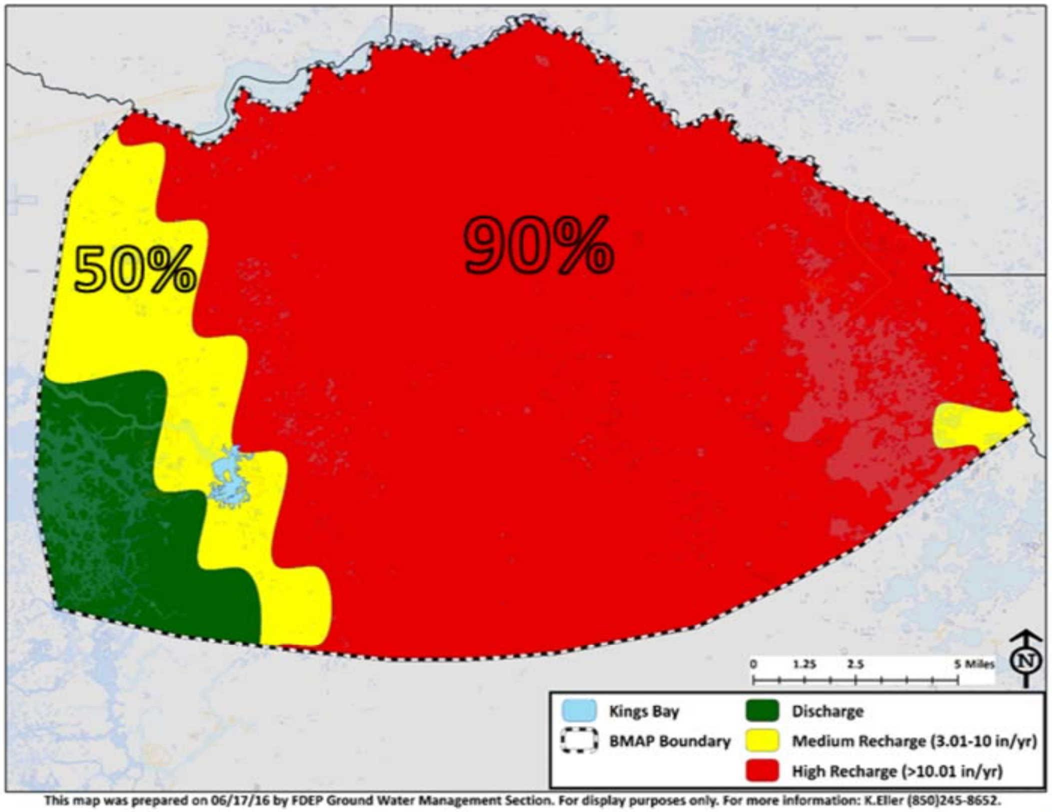
- Represent the percentage of N removed and therefore not available for leaching to groundwater
- Based on factors used in similar past studies and found in relevant literature

Loading Category	N Attenuation Factor	N Leaching
Atmospheric Deposition	90%	10%
Septic Systems	60%	40%
WWTF-RIB	25%	75%
WWTF-Sprayfield	60%	40%
WWTF-Reuse	75%	25%
Urban Turfgrass Fertilizers	80%	20%
Sports Turfgrass Fertilizers	80%	20%
Farm Fertilizers	80%	20%
Livestock Waste	90%	10%

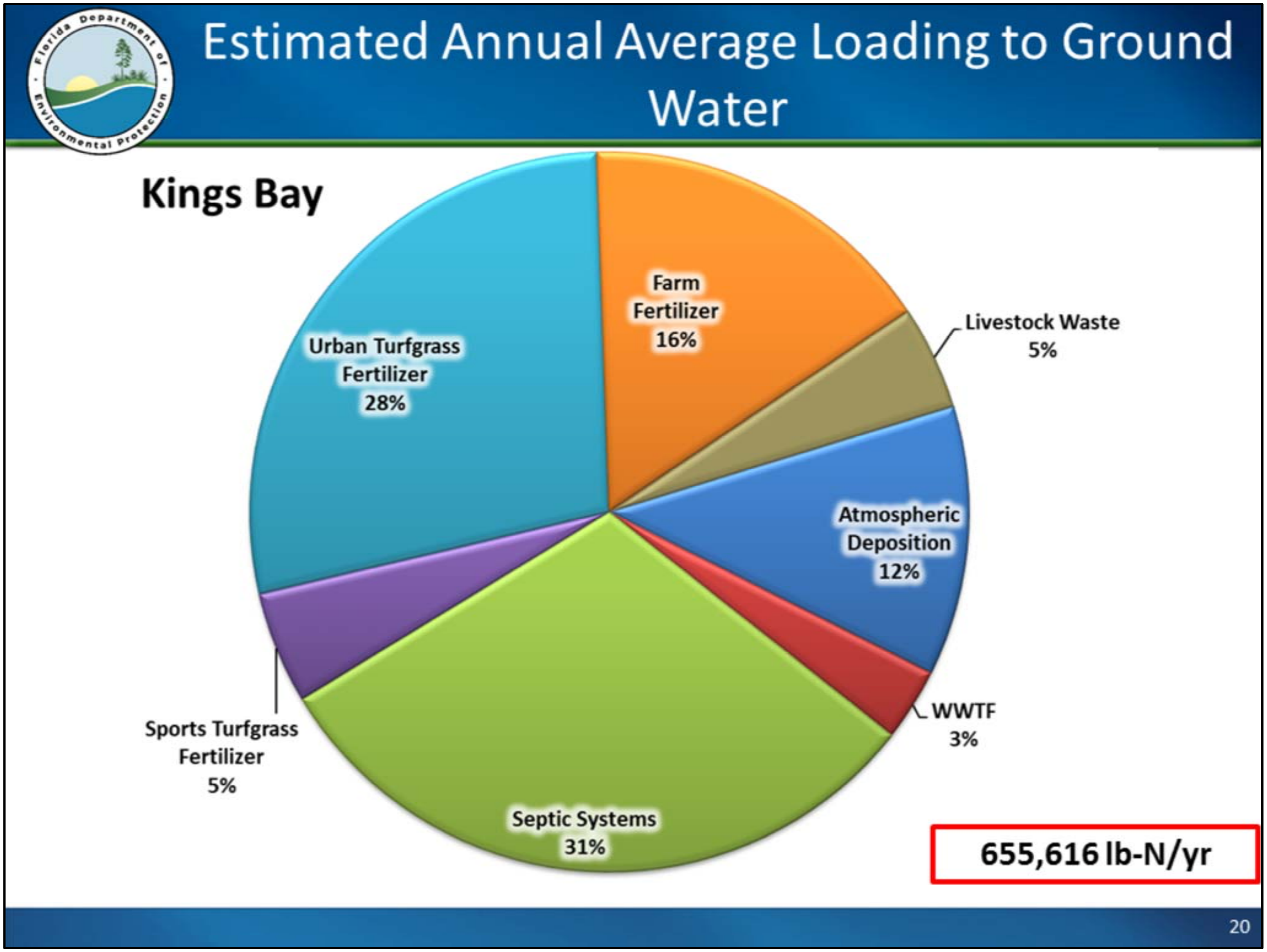
After all the nitrogen input to the land surface has been estimated, attenuation factors are applied. This table lists the attenuation factors for each nitrogen source. These factors are the result of an extensive literature and peer review. There is a range for all these factors however, these values represent an average attenuation expected given Florida's environmental conditions. These factors represent the amount of nitrogen which is taken up by the environment. For example, the 90% attenuation for atmospheric deposition means that 90% of all the nitrogen from atmospheric deposition that falls onto the land surface will be taken up by the environment and will not leach into ground water. This leaves 10% of the atmospheric nitrogen with the potential of leaching to the aquifer.

Hydrogeological Attenuation Factors Based on Recharge to UFA

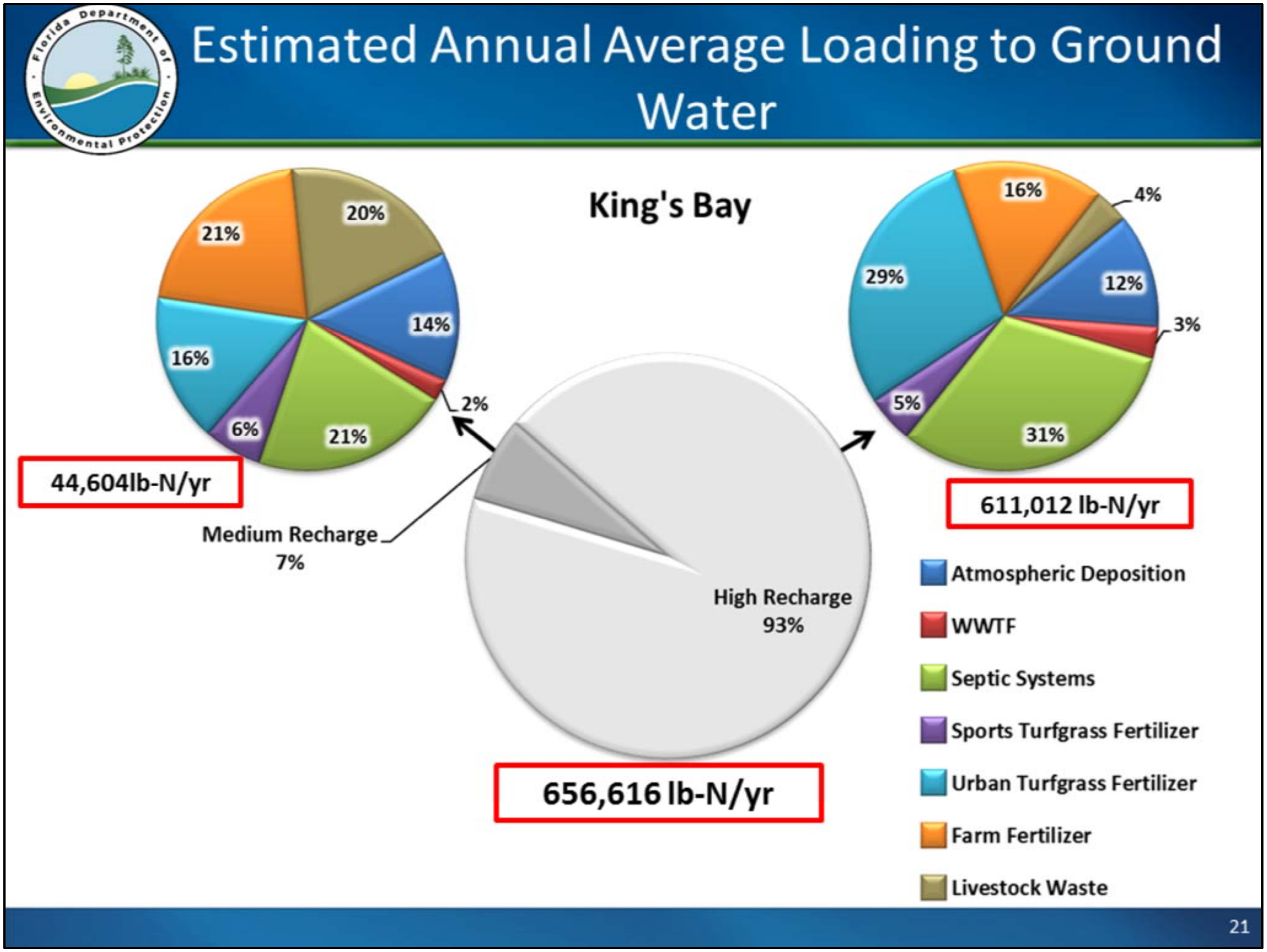
- Recharge factors are used to estimate the percentage of the non-attenuated nitrogen expected to reach the aquifer in a year



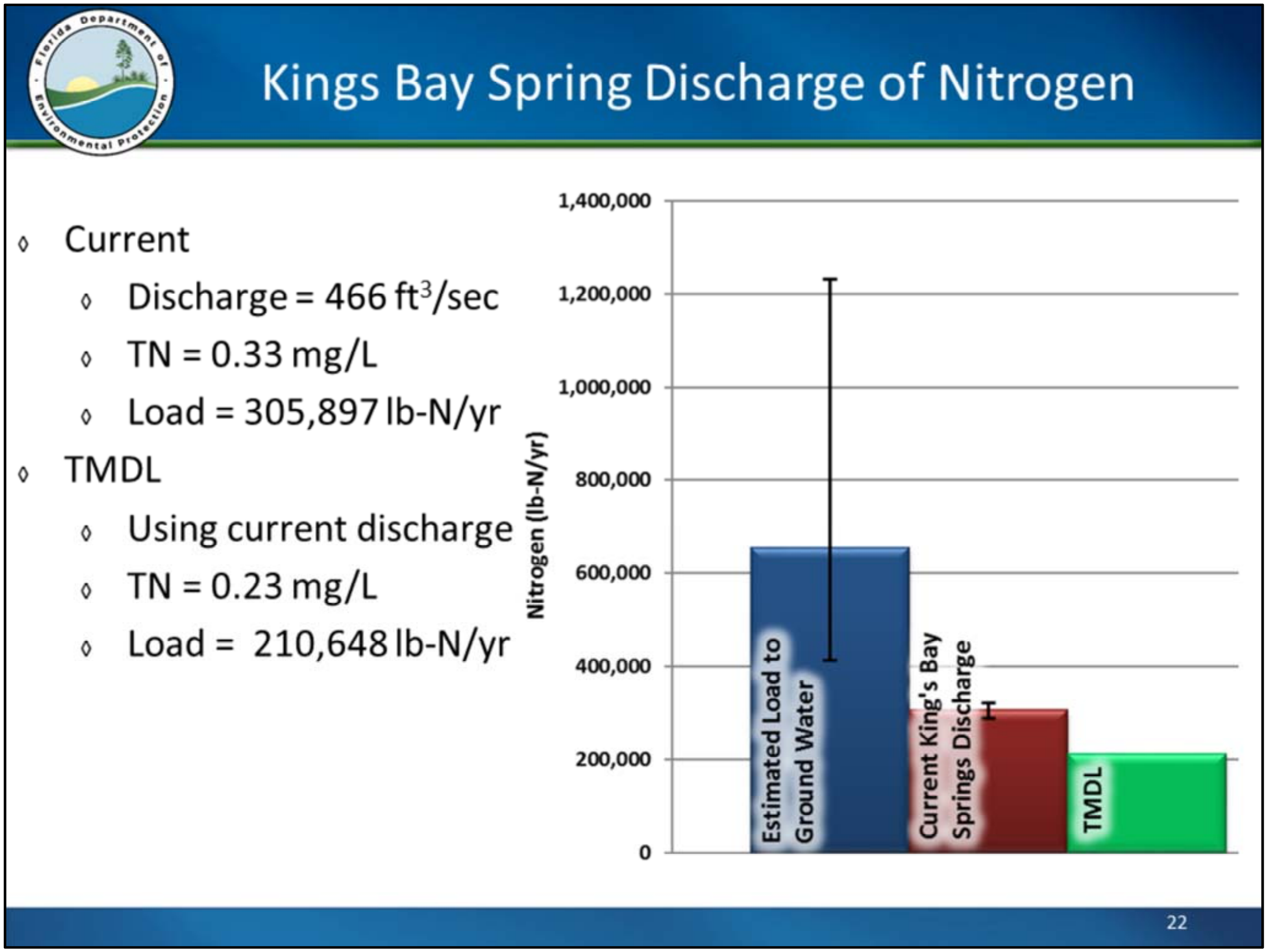
Our final step in estimating N loads to ground water is to apply the recharge factor based on where each contributing source is located within the BMAP boundary . In the high recharge area, we estimate that 90% of all the non-attenuated nitrogen will reach the aquifer, and 50% in the medium recharge.



Here are the current results illustrating the relative contribution of nitrogen from various nitrogen sources within the BMAP boundary. These results represent an estimation of the nitrogen currently entering the aquifer within the Kings Bay BMAP boundary and not an estimation of the concentrations exiting the springs. The spring discharge is a mixture of water which has entered the aquifer over a varied amount of time.



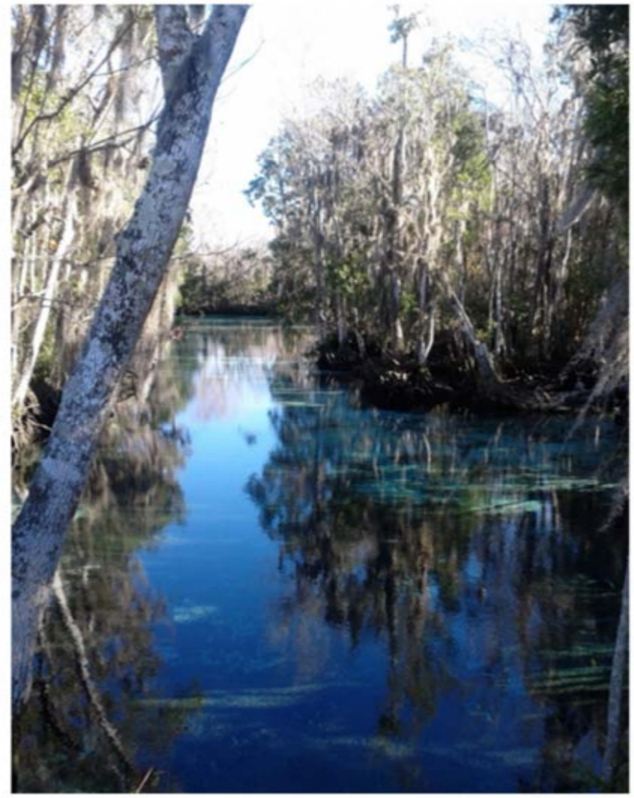
The majority of the nitrogen is entering ground water within the high recharge areas. Within just the high recharge, septic systems is the largest contributor followed by urban turfgrass fertilizers.



This plot illustrates that the estimated nitrogen load to groundwater is higher than what is currently discharging from the springs. The discharge measurement was estimated for all Kings Bay springs and the listed concentration is a 2009 average from Hunter Spring, House Spring, Idiot's Delight, Tarpon Spring and Black Spring. This may indicate that we are over-estimating the amount of nitrogen entering the subsurface within the Kings Bay BMAP area. Or, there could be considerable nitrogen storage in the subsurface, which may enter the aquifer slowly over time.

The most important thing to note is the nitrogen load discharging from the spring is higher than the target TMDL. The management practices implemented with the BMAP over time will help to improve the overall water quality of the Kings Bay springs. We are continually refining the NSILT methodology and results as new data become available. In the future, we hope to receive more detailed information about nitrogen application practices including those associated with urban fertilizer usage and storm water runoff to catchments.

QUESTIONS??



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