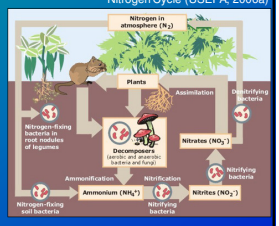
Nitrate (NOX-N)

- The Wekiva River and contributing springs are impaired because of elevated nitrate (FDEP)
  - DEP's TMDL calls for ~80% reduction in nitrate in Rock and Wekiwa Springs
- Nitrogen exists in many chemical forms in the environment
- Nitrate is mobile, readily available to plants including aquatic plants and algae, and can cause eutrophication.

Nitrogen Cycle (USEPA, 2006a)



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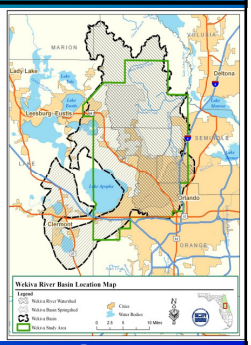
Study Area – Wekiva Basin

- Wekiva Basin = Watershed + Springshed
- Wekiva Basin ≠ Wekiva Study Area (WSA)
- WSA (defined by statute) overlaps Wekiva Basin, but not the same



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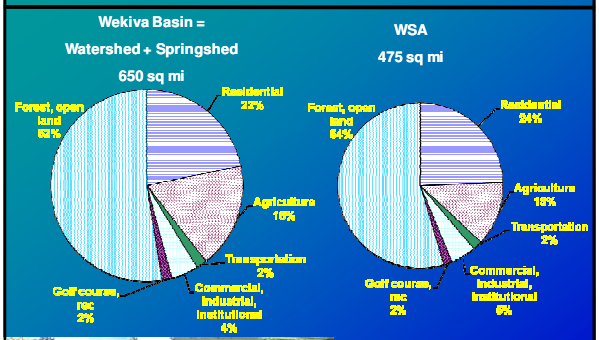
Land Use (2004)



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Phased Study – Phase I (2006-7)

- Desk top study / best available info
  - More than 250 technical publications
  - Data from St. Johns District, FDEP
  - Developed computer applications that estimate nitrate loadings
  - Phase I report recommended field studies

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Stakeholder Response to Phase I

- Not based on local data
- Overestimated residential fertilizer use & impacts
- Underestimated atmospheric deposition
- Underestimated impacts of reclaimed water
- Some inputs expressed as Total Nitrogen (TN) other as Nitrate-Nitrogen (NOX-N)
  - "comparing apples and oranges"

⇒ Phase II

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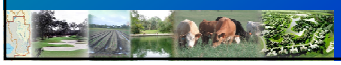
Phased Study – Phase II (2008-9)

- DOH focused on septic systems
  - Groundwater monitoring at 3 sites (Orange, Lake, and Seminole)
- DEP focused on residential fertilizer impacts
  - Groundwater monitoring in Wekiwa springshed (St. Johns District, MACTEC, USGS)
  - Residential Fertilizer User Survey (UCF)



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Phased Study – Final Report (2010)

- Responded to stakeholder comments on Phase I report
- Updated Phase I with new local data
  - Phase II (DOH and DEP studies)
  - Other recent publications
- Results on FDEP website

  http://www.dep.state.fl.us/water/wekiva/index.htm

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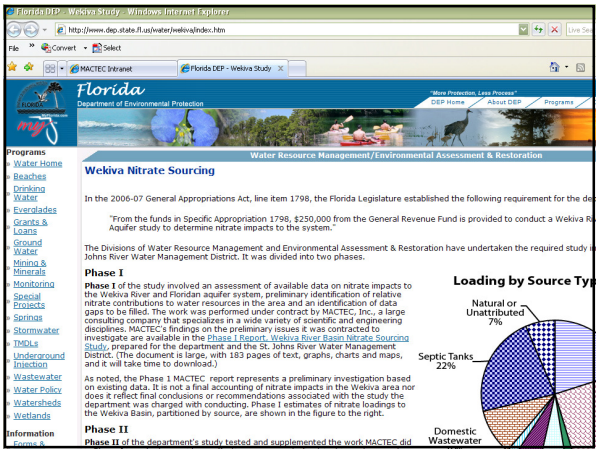
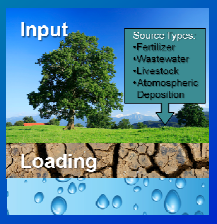


Phase I

Conceptual Loading Model

- Estimated Inputs & Loadings
  - Input = Nitrogen into Basin
    - Total Nitrogen (TN) applied as fertilizer
  - Loading = Nitrate reaching surface or groundwater
    - Nitrate Nitrogen (NOX-N) leaching to groundwater



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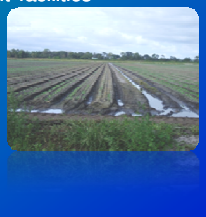
Source Types

- Treated Domestic Wastewater
  - Permitted wastewater treatment facilities
  - Septic systems
- Fertilizer
  - Agriculture
  - Residential
  - Golf course
  - Other
- Livestock
- Atmospheric Deposition



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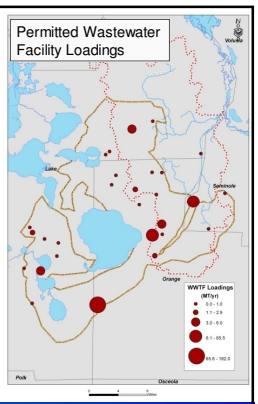
Domestic and Industrial Wastewater

- DEP data
- 28 facilities reviewed
- Industrial discharges are negligible
- >99% of total discharge to groundwater



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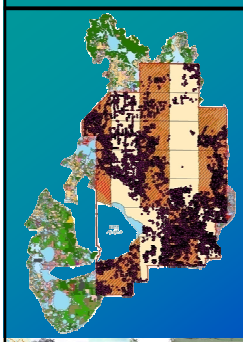
Septic Systems



- Data from FDOH for WSA
- 65,000 systems in Basin
- Loading per system based on FDOH guidance

MACTEC

Loadings from Fertilizer Are Based on Land Use

Stormwater Runoff Model	Groundwater Loading Model
Runoff Rate x NOX-N Concentration	**Recharge Rate x NOX-N Concentration**
Used existing model, previously accepted	Recharge rate from SJRWMD East-Central Florida model Concentrations from relevant monitoring (mostly Florida)

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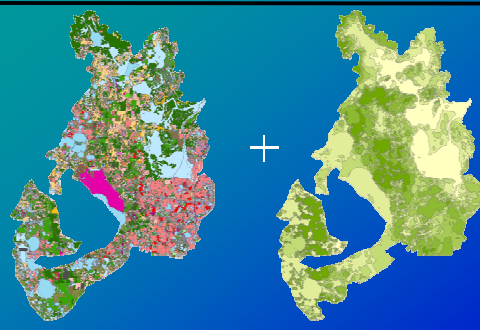
Release and Loading Estimation Procedures
2004 Land Use and Recharge Layer Union



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Release and Loading Estimation Procedures
Land Use and Recharge Layer Union

Landuse Type	No data	Discharge Area	0 to 4 in	4 to 8 in/yr	8 to 12 in/yr	12 to 20 in/yr	more than 20 in/yr
1100: Residential, low density - less than 2 dwelling units/acre	241.44	400.31	4,845.28	8,241.87	5,466.69	5,853.05	3,765.96
1200: Residential, medium density - 2-5 dwelling units/acre	515.78	1,759.15	5,349.74	11,695.34	10,868.18	10,502.13	2,814.45
1300: Residential, high density - 6 or more dwelling units/acre	3.61	134.95	1,137.73	1,863.70	1,978.62	2,374.81	855.26
1400: Commercial and services	588.03	81.18	614.18	1,876.70	2,333.42	2,453.95	368.19
1500: Industrial	209.05	36.13	263.29	721.46	962.53	1,266.32	214.67
1600: Extractive	214.43	11.24	77.42	658.39	694.66	575.96	182.47
1700: Institutional	50.40	-	175.06	573.74	815.88	817.59	327.73
1800: Recreational	11.41	99.67	160.99	267.83	388.63	230.78	62.33
1820: Golf courses	-	387.38	690.38	296.35	633.22	816.18	596.38
1900: Open land	86.15	72.02	1,053.13	1,861.41	1,256.87	1,432.37	727.80
2100: Cropland and pastureland	-	-	0.25	8.90	-	-	2,231.74
2110: Improved pastures (monocuft, planted forage crops)	1.32	1,374.00	7,349.38	6,855.66	3,766.03	3,925.17	573.79
2120: Unimproved pastures	-	484.64	1,289.53	970.24	394.32	470.07	292.19
2130: Woodland pastures	0.08	15.60	723.63	807.06	422.79	447.63	8.88
2140: Row crops	-	-	272.15	990.88	60.01	61.97	385.26
2150: Field crops	24.43	291.33	1,821.92	1,544.93	697.64	1,161.94	2,402.18
2200: Tree crops	1,074.46	72.83	2,335.68	5,247.45	2,739.63	3,752.28	-
2300: Feeding operations	-	5.59	17.57	66.55	27.26	56.41	-
2400: Nurseries and vineyards	0.00	-	28.25	14.57	6.90	40.14	8.82
2410: Tree nurseries	-	0.35	17.19	10.22	19.16	12.42	1.35
2420: Sod farms	-	-	303.22	1,098.19	-	-	-
2430: Ornamentals	42.15	3.89	536.41	20.21	933.34	1,815.58	1,076.37
2450: Floriculture	-	-	10.05	117.84	17.08	15.17	-
2500: Specialty farms	-	-	13.22	395.70	173.06	7.85	-
2510: Horse farms	-	7.10	338.95	12.78	1.21	219.25	71.48
2600: Other open lands - rural	52.75	-	9.78	56.20	20.37	7.98	3.15
3000: Upland Nonforested	1,675.43	1,545.64	9,087.75	8,136.44	5,866.83	7,880.35	6,975.97
4000: Upland Forests (25% forested cover)	511.87	8,946.41	15,810.16	18,099.81	10,828.41	14,249.32	10,102.13
5000: Water	797.14	2,017.55	23,165.00	6,337.14	2,147.12	1,359.19	143.70
6000: Wetlands	462.36	34,414.43	21,379.62	10,014.21	2,304.17	1,589.33	361.96
7000: Barren land	4.65	117.86	10,022.33	475.94	312.91	303.85	314.25
8000: Transportation, Communication, and Utilities	287.99	56.29	602.02	1,275.41	1,129.01	1,280.26	477.48
9000: Special Classification	-	-	2.14	34.40	5.46	0.57	-

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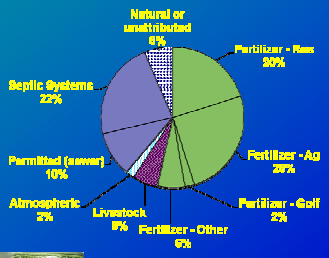
Phase I Findings

- Fertilizer – 54%
  - Ag – 26%
  - Res – 20%
- Contribution from residential fertilizer use was most uncertain piece of the pie
- Domestic Wastewater – 32%
  - Septic Systems – 22%



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Phase II –
Field Studies in the Wekiva Basin

- FDOH focused on septic systems
  - Monitored ground water at 3 sites
- DEP focused on residential fertilizer use
  - Supported UCF survey of residential fertilizer use
  - Monitored ground water at 28 residential sites in Wekiwa Springshed

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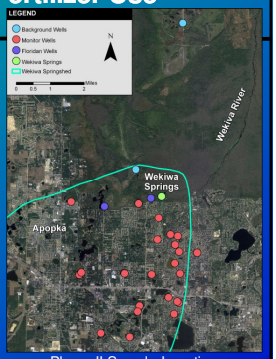
Impacts of Residential Fertilizer Use
Wekiwa Springshed

- Sites selected to avoid other sources of nitrate
  - Residential > 5 years
  - Far from septic systems
  - Never in citrus
- 30 wells installed
  - 28 residential
  - 2 on conservation land
- Sampled 4 times each

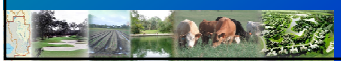


Phase II Sample Locations

MACTEC

Impacts of Residential Fertilizer Use
Wekiwa Springshed

- Residential > Undeveloped
  2 mg/L > 0.3 mg/L
- Residential impacts NOT caused by sewage
  - Stable isotope studies (MACTEC and USGS)
  - Microbial studies (USGS)
- Residential impacts ARE caused by fertilizer
- Observed Impact 33% Less than Phase I estimate
  - Phase I assumed residential NOX-N at 3 mg/L



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Final Report

Final Report

- Responded to stakeholder comments on Phase I report
  - All inputs now expressed as Total Nitrogen
  - Improved accounting for reclaimed water
  - These changes increased Basin inputs of
    - Atmospheric deposition
    - Permitted wastewater facilities

MACTEC

Final Report

- Updated Phase I with newer information
  - Especially new monitoring data within the Wekiva Basin (DEP and DOH Phase II)
- Use of these data increased confidence in the results and
  - Reduced relative effect of residential fertilizer use
  - Increased relative effect of domestic wastewater

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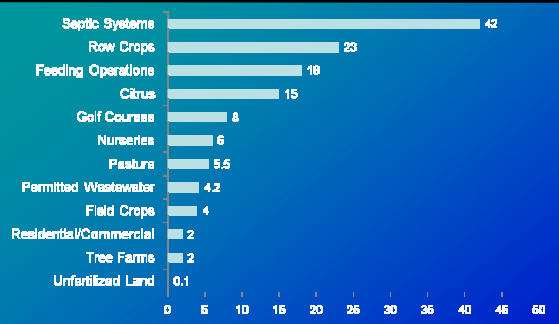
Representative NOX-N Ground Water Concentrations



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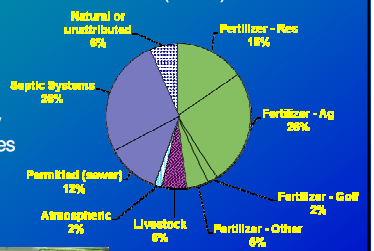
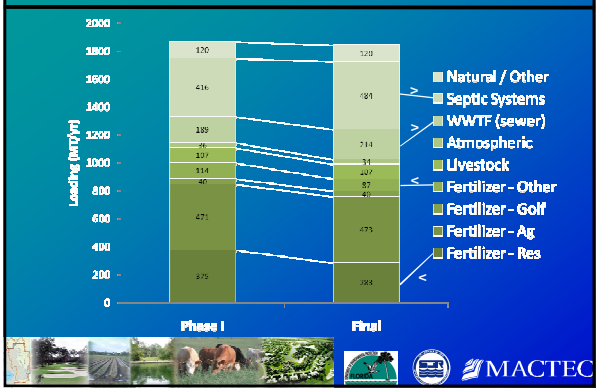
Final Results

- Fertilizer – 48%
  - Ag – 26%
  - Res – 15%
- Domestic wastewater – 38%
  - Septic Systems – 26%
  - Permitted (sewer) – 12%
- New data from Wekiva Basin reduced uncertainty in major source types



MACTEC

Compare Phase I and II Results