

Reedy Creek
Wildlife Management Conservation Area
Fecal Coliform Bacteria Source Reduction Plan



Reedy Creek Improvement District
February, 2013

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EXECUTIVE SUMMARY

On November 2, 2010, the Department of Environmental Protection (FDEP or Department) issued its Order Revising Verified List of Impaired Waters for Group 4 Basins. Among the waters verified as impaired in the order was Reedy Creek North Segment (WBID 3170F2) which the Department listed as impaired for fecal coliform bacteria. Reedy Creek Improvement District (RCID) staff members advised the Department that there were no known anthropogenic sources of fecal coliform bacteria affecting WBID 3170F2 and confirmed the WBID is located in a portion of the RCID land holdings maintained as a wildlife preserve and the seasonal spikes in fecal coliform bacteria counts directly correlated to the presence of large flocks of migratory birds.

RCID engaged the services of Environmental Research & Design, Inc. (ERD) to review historical data on bacteria, water flow, and bird survey counts. ERD concluded fecal coliform exceedances in WBID 3170F2 were naturally occurring. RCID also retained an expert in Fecal Indicator Bacteria (FIB) and Microbial Source Tracking (MST), Dr. Valerie Harwood, who prepared an analysis of historical data suggesting that fecal coliform exceedances in WBID 3170F2 were likely related to migratory bird populations. RCID performed additional FIB and MST sampling and analyses for Dr. Harwood to validate the suspected source of the fecal coliforms in WBID 3170F2. Dr. Harwood prepared an additional report, once again linking fecal coliform concentrations to migratory bird populations, which was submitted to the Department on November 14, 2011.

By letter dated January 11, 2012, the Department indicated an interest in coordinating with RCID and combining efforts to pursue additional confirmation that fecal coliform levels in WBID 3170F2 were related to migratory bird populations. Soon thereafter, the Department changed the designation of the WBID from WBID 3170F2 to WBID 3170F7. Throughout the remainder of this document, Reedy Creek North Segment will be referred to as WBID 3170F7.

The Department and RCID initiated a joint microbial source investigation with samples collected in February and March of 2012. Microbial source tracking using various biomarkers has been inconclusive; although a low strength signal for a human biomarker (HF183) was detected. RCID contends that the presence of the human biomarker (HF183) is not cause alone for non-compliance as the marker has been identified from wildlife sources as well.

RCID asserts that upstream fecal coliforms—even if from anthropogenic origin—are not resulting in violations of the numeric thresholds set out in the criteria. In actuality, fecal

coliform levels associated with the Reedy Creek WMCA bird roosting areas are similar to those found in other Florida State Parks, and have been significant enough that the removal of upstream bacteria concentrations would not achieve attainment of fecal coliform criteria in the Reedy Creek WMCA. Based on this rationale, RCID requested WBID 3170F7 be placed in the Department's assessment category 4c as due to naturally occurring conditions or pollution in lieu of a pollutant.

In lieu of a TMDL, RCID is proposing this plan, the Reedy Creek Wildlife Management Conservation Area Fecal Coliform Bacteria Source Reduction Plan (SRP). This effort will be undertaken to evaluate the contribution of fecal coliforms from wildlife and anthropogenic sources within the watershed. If anthropogenic sources are identified in the plan which fails to meet the Department's fecal coliform criteria, RCID will work to ensure that remediation action is implemented to bring sources into compliance. Sources identified in the plan that fall outside the jurisdiction of RCID and fail to meet the Department's fecal coliform criteria will be brought to the attention of the Department, or local governmental agency, so that the sources may be addressed.

RCID based the SRP upon the Department's Implementation Guidance for the Fecal Coliform Total Daily Maximum Loads Adopted by the Florida Department of Environmental Protection. The proactive "weight of evidence" approach of the plan was created to be dynamic and evolving as to address fecal coliform impairment within WBID 3170F7. RCID intends to maximize its efforts, applying the latest and most robust methodologies, with the goal of identifying fecal coliform sources and abating anthropogenic fecal coliform sources violating the Department's criteria in the Reedy Creek WMCA. Progress reports will be distributed annually in February to the Department under this plan.

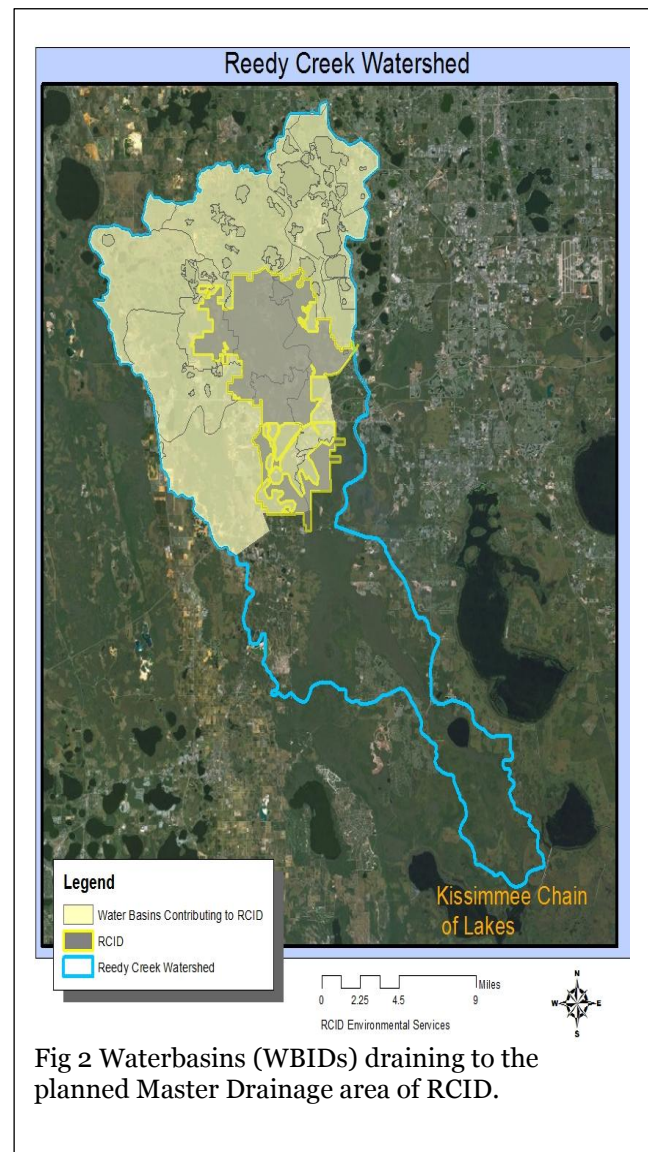
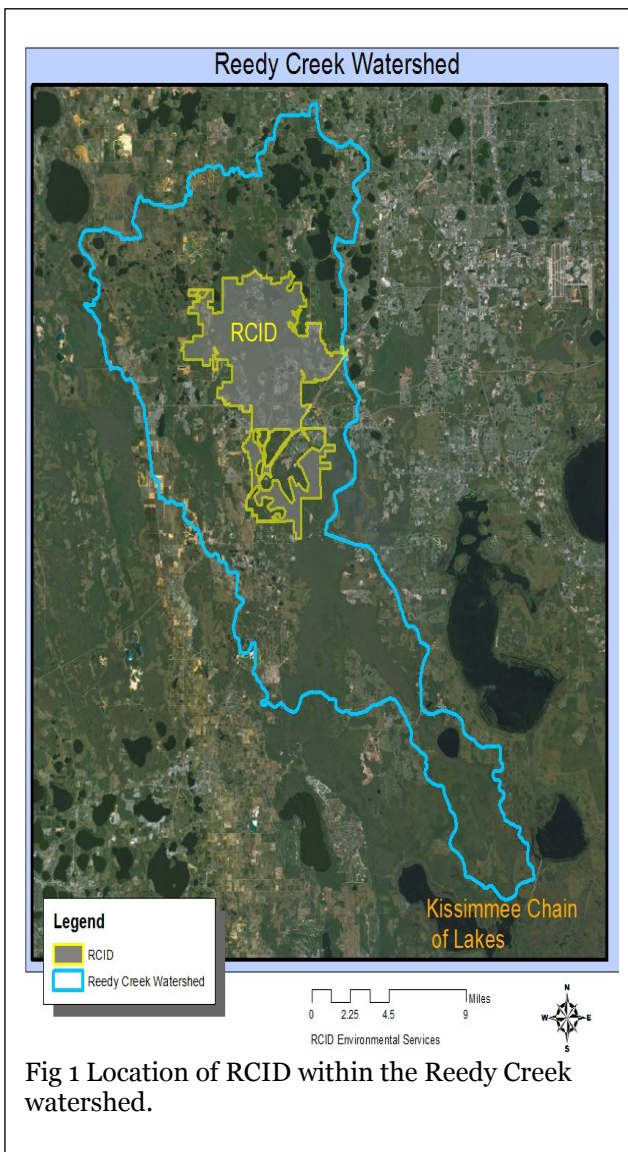
With this plan in place, RCID asserts that WBID 3170F7 qualifies for placement in the Department's assessment category 4e (restoration activities completed or ongoing) unless the Department approves a 4c category designation.

UNDERSTANDING THE BASIN

REEDY CREEK WATERSHED CHARACTERISTICS

The Reedy Creek watershed spans 35 miles and is one of the most diverse watercourses in the Upper Kissimmee Planning Unit (HUC 03090101). This tributary is recognized as the western headwaters of the Kissimmee Chain of Lakes (KCOL) and an important conservation corridor for Lake Okeechobee and the National Florida Everglades (Fig 1).

The upper 17 miles of the watershed drain into the Reedy Creek Master Drainage system (Fig 2) which controls the discharge of water to Reedy Creek through a single engineered structure, S-40 [ASCE, 1972]. Reedy Creek flows naturally below this structure.



HISTORICAL WATERSHED ALTERATIONS

Reedy Creek Development District and the South Florida Water Management District (SFWMD) constructed a continuous levee system in the upper section of the Reedy Creek watershed in the 1960s. Historically, two swamp floodplains made up the Reedy Creek watershed: the Bonnet Creek wetland thread and the Reedy Creek swamp.

BONNET CREEK WETLAND

The Bonnet Creek wetland was utilized to develop the C-1 canal system as a 50-foot wide, 8-foot deep linear stormwater conveyance canal that crisscrossed 12 miles from Orange County to Osceola County (Fig 3). Hydraulic flow through this canal is regulated by a series of engineered aml gates and a sheet-pile weir.

Highway 192 in Osceola County divides the C-1 canal into an upper, urbanized segment and a lower, wildlife conservation segment. The upper segment receives drainage from RCID, Orange County, and three watersheds: Cypress Creek, South Lake, and Lake Mabel. The lower segment receives drainage from RCID and Osceola County, where levees bifurcates the Reedy Creek wetland into two separate wetlands, both of which contributes to the 7,000-acre Wildlife Management Conservation Area (WMCA) wetland.



Fig 3 Bonnet Creek was used to develop the C-1 canal under the RCID Master Drainage Plan.

REEDY CREEK WETLAND

The Reedy Creek wetlands function as a three-part watershed which receives drainage from both Reedy Creek and the C-1 canal. The upper segment of Reedy Creek is located in Orange County and is channelized for flood protection and incorporated into the RCID levee system. The lower segment is located at the Orange County/Osceola County line and remains a natural creek floodplain for the RCID (Fig 4). Both segments of Reedy Creek and the C-1 canal are used to regulate the drainage of 174 square miles of land for RCID, Orange County, Lake County, Osceola County, Polk County, and Florida Department of Transportation (FDOT).

RCID's levee system regulates the final discharge of comingled surface waters from Bonnet Creek and Reedy Creek through the engineered water control structure S-40. Normal discharge rates average less than 20 cubic feet per second (cfs), and peak discharges rates average less than 250 cfs (source: USGS).



Fig 4 Lower Reedy Creek in the WMCA where protected bird species routinely inhabit portions of the RCID Master Drainage Plan.

WATER FLOW PATTERN

Water flow through the Reedy Creek watershed has two distinct patterns: the upper drainage system that was controlled under the Reedy Creek Master Drainage Plan (Fig 5) and the lower, natural portion of Reedy Creek which is only controlled by the topographical elevation of the stream bank. The Reedy Creek Master Drainage Plan utilizes a series of water control structures to convey stormwater from 172 acres of tributaries through the final control point structure S-40. Below this structure, Reedy Creek flows naturally to the Kissimmee Chain of Lakes. The unique drainage scheme of RCID's levees and water control structures prevents sheetflow from lands outside the District and concentrates surface and stormwater runoff through engineered structures. Hydraulic flow rates are managed by RCID Planning and Engineering at ranges designed by drainage agreements with adjacent landowners and counties.

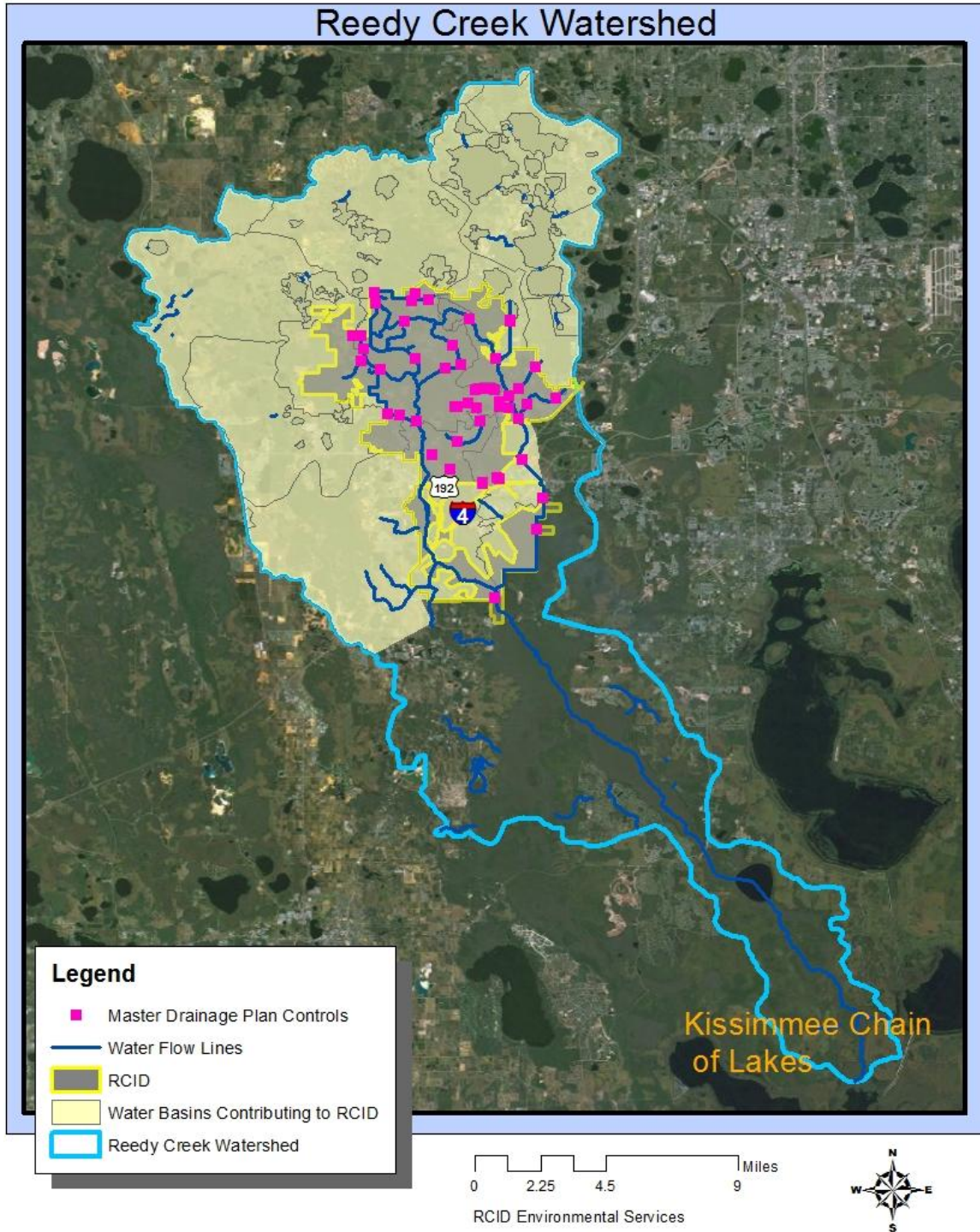


Fig 5 Water control structures managed under the Reedy Creek Master Drainage Plan for the upper portion of the Reedy Creek watershed.

HYDROLOGIC INPUTS

Hydrologic input to the Reedy Creek Master Drainage portion of the Reedy Creek watershed originates from two counties, Orange and Polk (Fig 6), with two streams entering from the eastern boundary and three on the western.

EASTERN DRAINAGE

Cypress Creek contributes approximately 20% of the mean hydrologic input to the Reedy Creek discharge via Bonnet Creek (structure S-103A). This water originates from the Butler Chain of Lakes in Windermere, Florida. Bonnet Creek is channelized as part of the Reedy Creek Master Drainage Plan and modified to act as a stormwater conveyance system for RCID. This nine-mile canal system moves water south and converges with Reedy Creek, approximately 2,000 feet upstream of the final RCID water control structure S-40.

WESTERN DRAINAGE

The upper portion of Reedy Creek is channelized into the S-405 canal as part of the Reedy Creek Master Drainage Plan. This portion receives water from both Boggy and Whittenhorse Creeks through structures S-410 and S-411, respectively. Boggy Creek contributes an estimated 8% of the mean hydrologic input to Reedy Creek, and Whittenhorse Creek contributes an estimated 6%.

The lower portion of Reedy Creek below the Osceola Parkway remains as a natural, meandering stream and floodplain. Water from Davenport Creek contributes approximately 26% of the mean hydrologic input to Reedy Creek discharge.

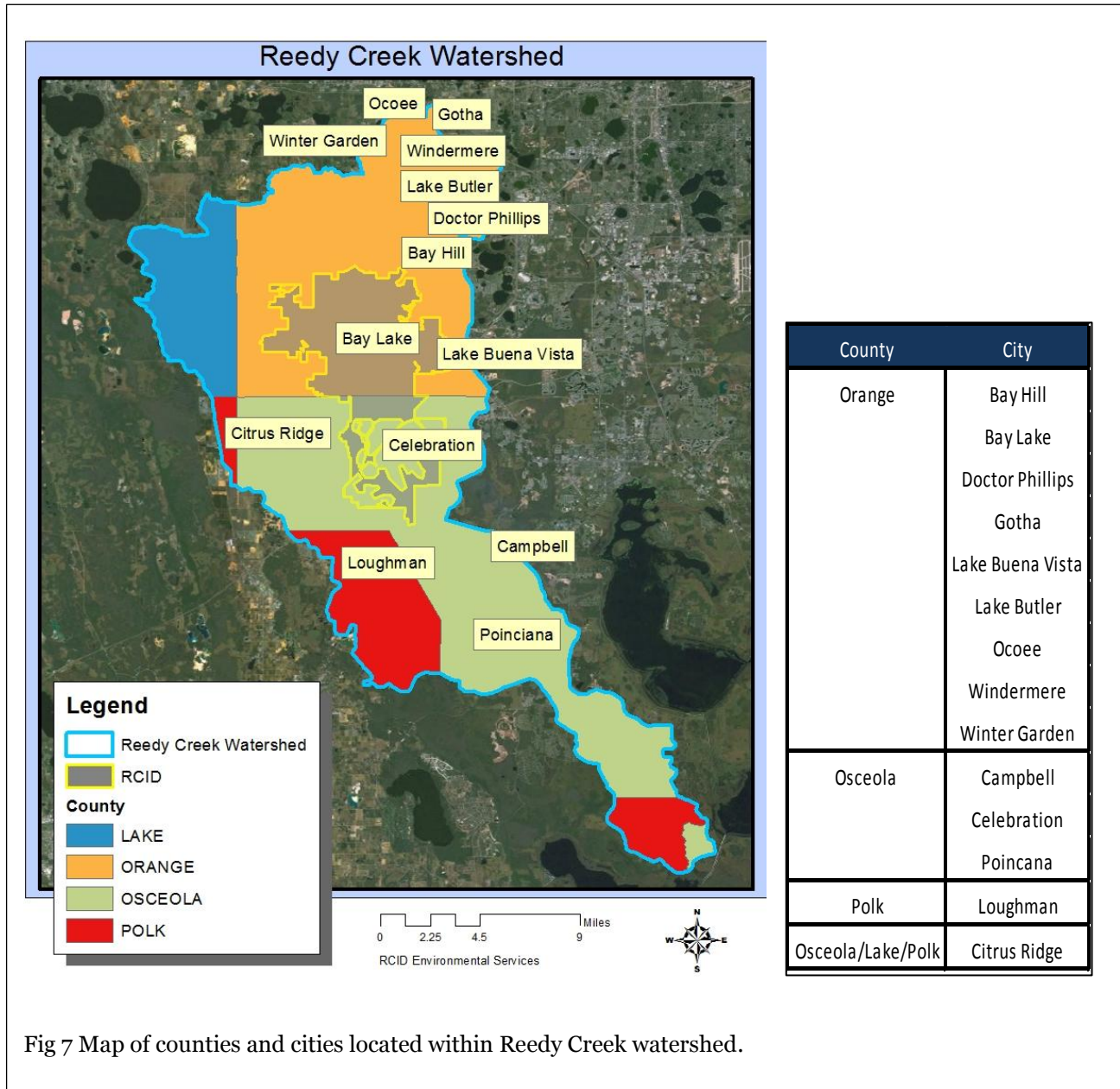
| County | Creeks | Mean Hydrologic Inputs |
|---------------|--------------------|------------------------|
| Orange | Boggy Creek | 8% |
| | Bonnet Creek | 22% |
| | Cypress Creek | 20% |
| | Whittenhorse Creek | 6% |
| | Reedy Creek | 18% |
| Polk | Davenport Creek | 26% |

Fig 6 Mean hydrologic contributions from adjacent counties draining into the Reedy Creek Master Drainage area above the final control structure S-40.

JURISDICTIONS

The Reedy Creek watershed spans four counties: Lake, Polk, Orange, and Osceola. These counties maintain jurisdiction over all except 24,747 acres, which are under the legislatively-created jurisdiction of RCID. A total of fourteen cities reside in the watershed, from Ocoee to Poinciana, Florida (Fig 7).

Permitting and regulatory jurisdictions extend over three water management districts: South West Florida Water Management District, South Florida Water Management, and St. Johns Water Management District.



TOPOGRAPHY

The 35-mile watershed exhibits elevations that traverse from 140 feet above mean sea level (MSL) down to 54 feet above MSL. The most prominent topographical feature is a natural ridge that effectively divided the drainage of RCID and the upper Reedy Creek floodplain. Soil characteristics on the western side of the crest are highly-drained, sandy soils, and the eastern portion was commonly comprised of rich, organic, poor-draining soils (Fig 8).

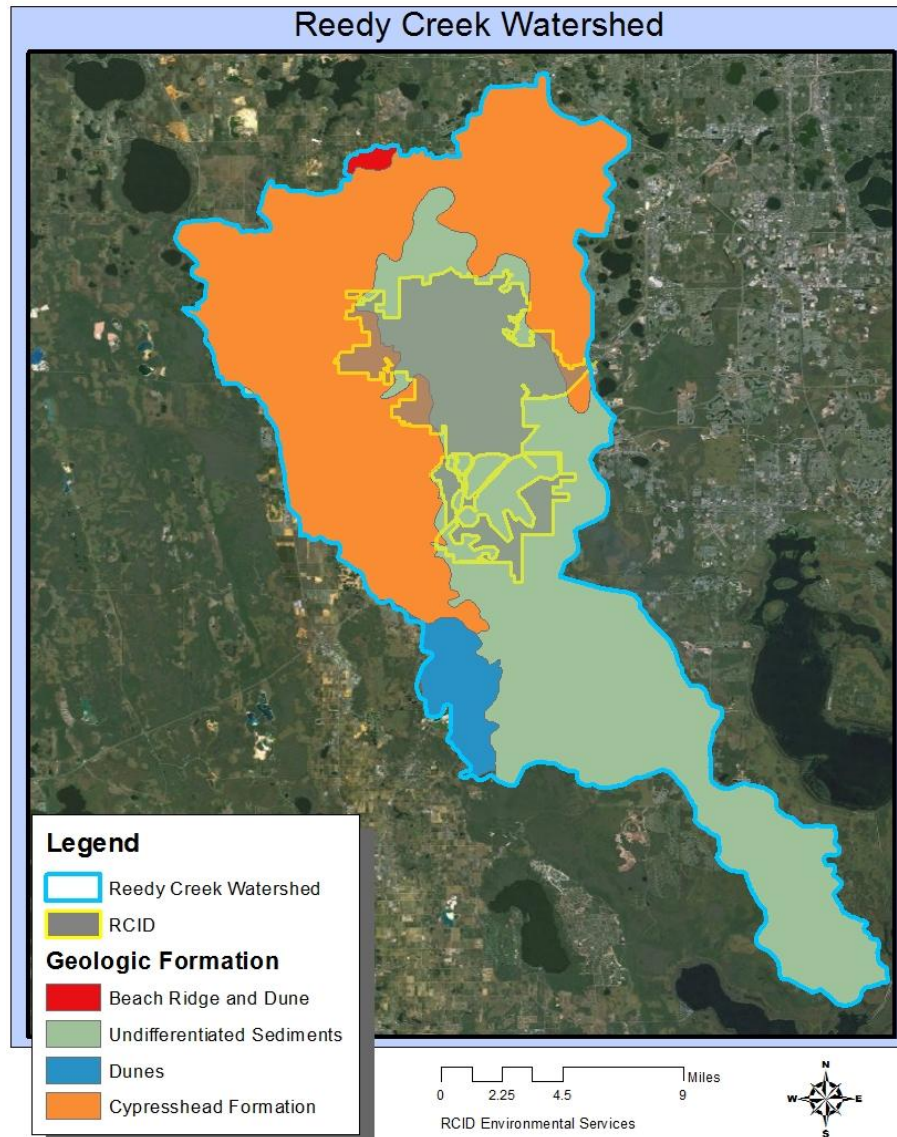


Fig 8 Florida Geological Survey soil formation map of the Reedy Creek watershed.

WETLAND TYPES

Wildlife diversity in the Reedy Creek watershed is attributed to the continuous corridor of conservation wetlands ranging over most of the 35-mile watershed (Fig 9). The Florida Natural Areas Inventory (FNAI) listed the Reedy Creek watershed to contain an extensive area of natural communities such as cypress swamps, pine flatwoods, mixed hardwood wetlands, scrub, scrubby flatwoods, mesic hammocks, baygall, floodplain forest, floodplain marsh, wet prairie, and wet flatwoods.

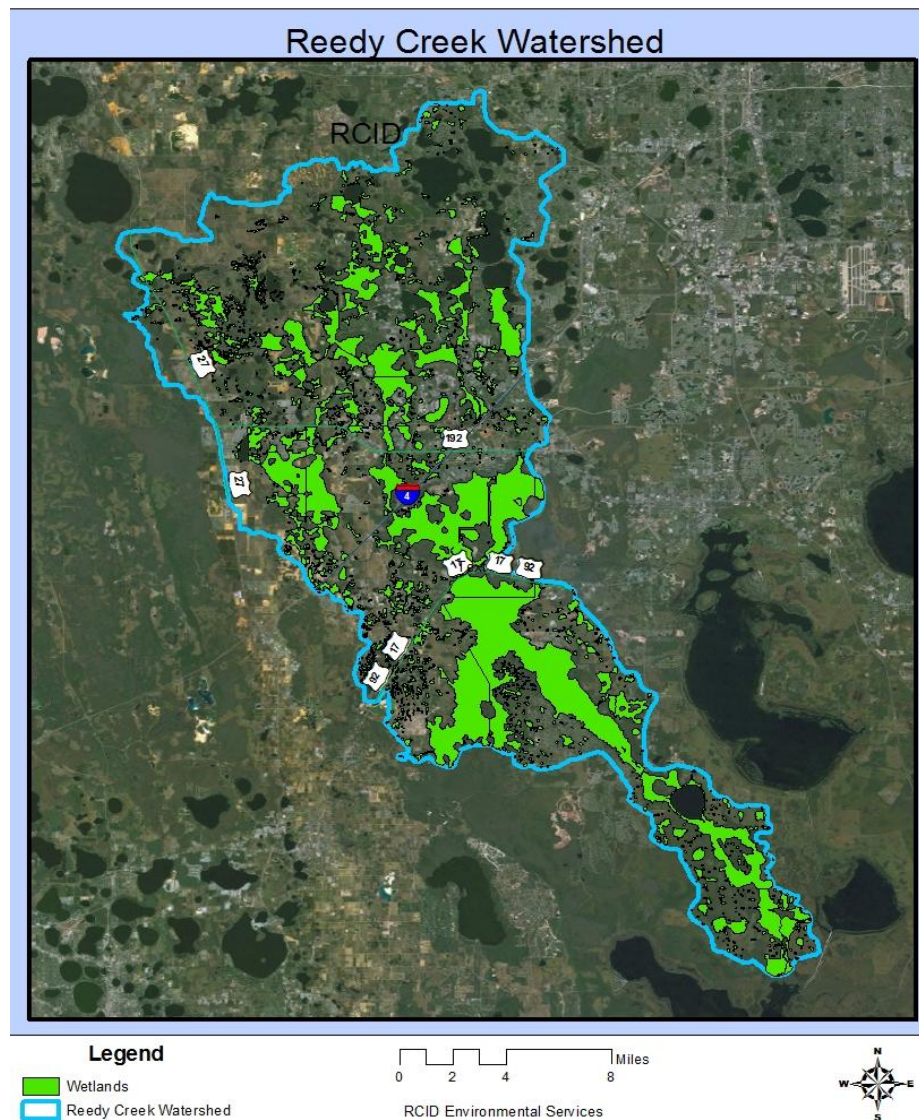


Fig 9 Wildlife corridor and wetlands identified within the Reedy Creek watershed.

WILDLIFE CONSERVATION AND GREENWAYS

Wildlife Conservation Management Areas are an integral part of the Reedy Creek ecosystem. A large segment of the Reedy Creek watershed is part of the legislatively-adopted Florida Greenways Plan administered by the Office of Greenways and Trails (OGT) of the Department (Florida Statutes, Chapter 260). The lower portion of Reedy Creek below the Osceola Parkway is delineated by Florida Ecological Greenways Network (FEGN) as an ecological component of a Statewide Greenways System Plan developed by the OGT and University of Florida (Fig 10).

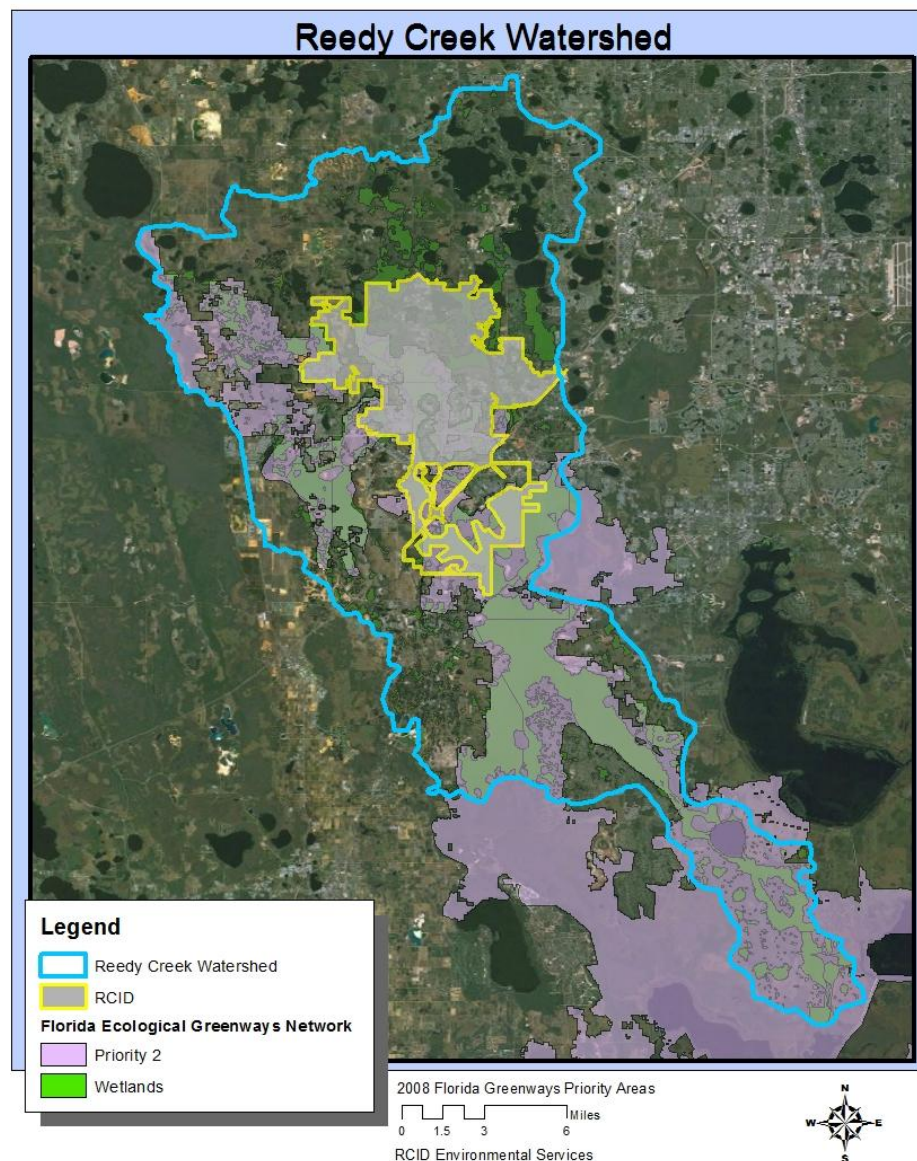


Fig 10 Priority ranking of the Reedy Creek Basin by the Florida Ecological Greenways Network (FEGN) and Office of Greenways and Trails (OGT).

The 2008 Critical Lands and Waters Identification Project identified portions of the Reedy Creek watershed as Priority 1 and Priority 2 areas (Fig 11). All priority levels within the FEGN were potentially important at the regional and local scales for identifying large, connected landscapes and wildlife corridors. Collectively, both Critical 1 and 2 Linkages and Priority 1 and 2 Linkages were the areas with the highest state and regional significance. The Reedy Creek WMCA was located at the head of this important wildlife corridor.

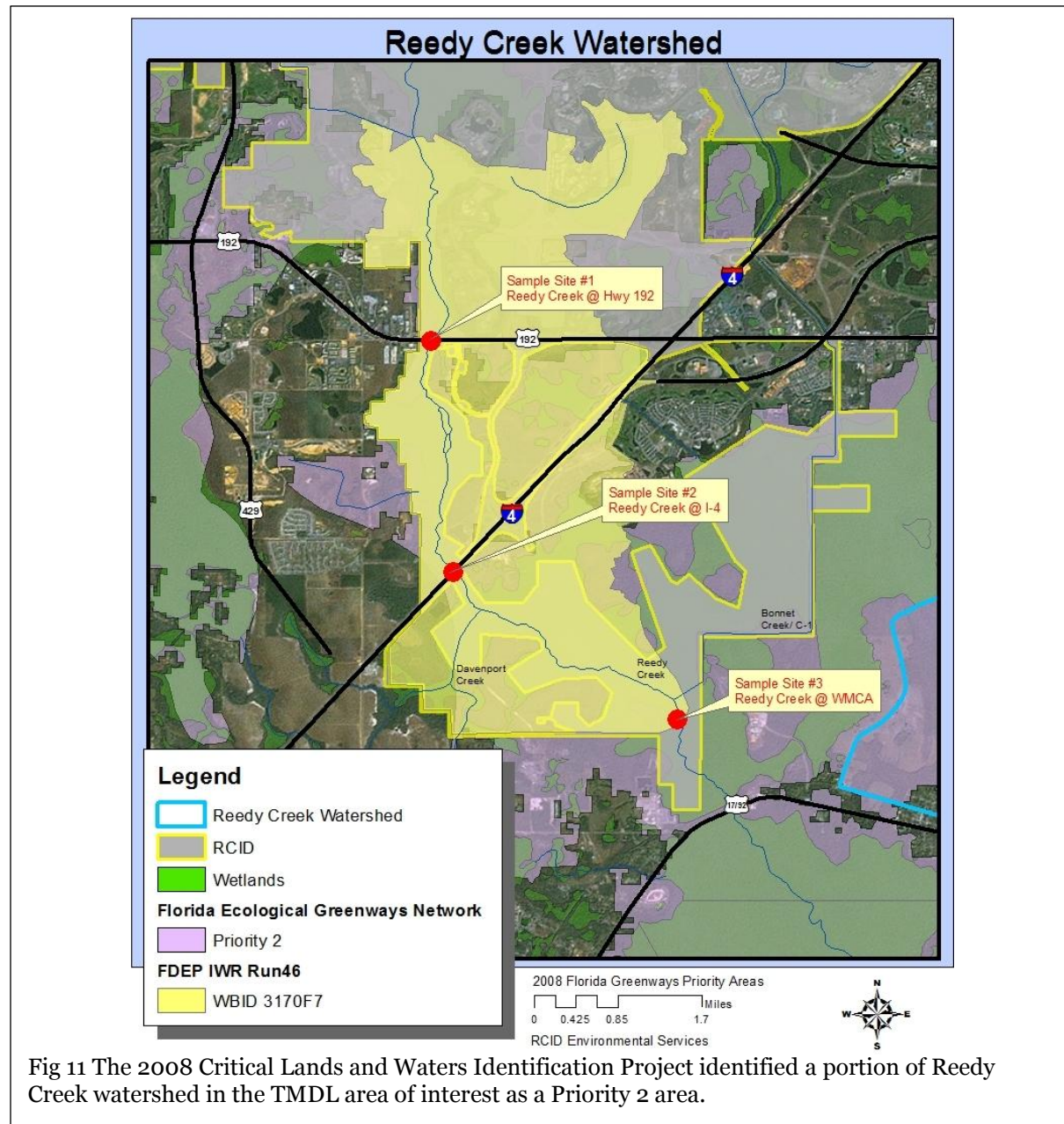


Fig 11 The 2008 Critical Lands and Waters Identification Project identified a portion of Reedy Creek watershed in the TMDL area of interest as a Priority 2 area.

HABITAT USE ZONES

Wildlife utilization of habitat in the WMCA was monitored by Disney's Animals, Science & Environment team from Animal Kingdom. Ornithologists and trained volunteers

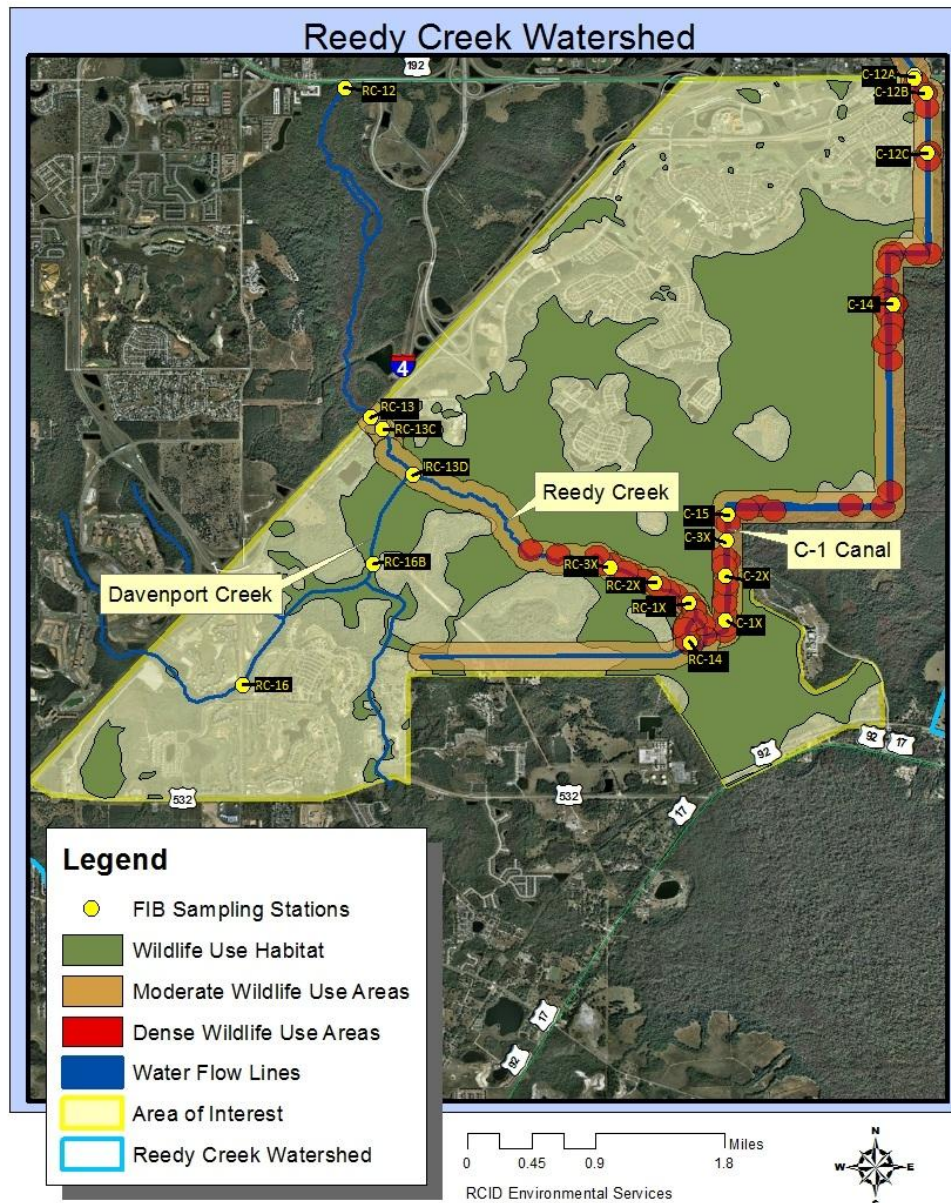


Fig 12 Map of water quality sampling stations and wildlife clusters documented in the Reedy Creek WMCA by RCID and Disney's Animals, Science & Environment team during monthly sampling events from 2010 through 2012.

performed monthly transect counts of bird species along the C1 canal. Additionally, RCID biologists conducted random surveys of wildlife locations recording gps locations to estimate habitation areas and zones of highest wildlife utilization. Heavy use areas (determined as zones where birds and animals occupied space within at least 10ft of one another) were found near the RCID levees as shown in the Fecal Indicator Bacteria sampling map (Fig 12).

WILDLIFE

The most dominant wildlife group observed in the WMCA was bird species. To document bird activity in the WMCA, surveys were conducted monthly in the lower portion of WBID 3170F7 along the C1 canal of Bonnet Creek. From May 2007 – Oct 2012, Disney's Animals, Science & Environment team counted a total of 36,734 birds comprising 115 species in the Reedy Creek WMCA (Fig 13).

| Bird Species | % Freq | Bird Species | % Freq | Bird Species | % Freq |
|------------------------------|--------------|--------------------------|-------------|--|--------------|
| American Coot | 0.02% | Eastern Screech Owl | 0.01% | Pine Warbler | 0.12% |
| American Crow | 0.04% | Eastern Towhee | 0.01% | Prairie Warbler | 0.01% |
| American Goldfinch | 0.5% | Eastern Wood-Pewee | 0.01% | Prothonotary Warbler | 0.06% |
| American Kestrel | 0.02% | Eurasian Collared-Dove | 0.003% | Purple Martin | 0.04% |
| American Redstart | 0.04% | European Starling | 0.04% | Red-bellied Woodpecker | 1.01% |
| American Robin | 6.8% | Fish Crow | 1.0% | Red-eyed Vireo | 0.25% |
| Anhinga | 4.3% | Glossy Ibis | 0.2% | Red-headed Woodpecker | 0.06% |
| Bald Eagle | 0.04% | Gray Catbird | 1.6% | Red-shouldered Hawk | 0.83% |
| Barn Owl | 0.02% | Great Blue Heron | 1.5% | Red-tailed Hawk | 0.04% |
| Barn Swallow | 0.03% | Great Crested Flycatcher | 0.3% | Red-winged Blackbird | 2.4% |
| Barred Owl | 0.1% | Great Egret | 2.4% | Rock Dove | 0.03% |
| Bay-Breasted Warbler | 0.1% | Great Horned Owl | 0.01% | Ruby-crowned Kinglet | 0.15% |
| Belted Kingfisher | 0.3% | Green Heron | 0.8% | Ruby-throated Hummingbird | 0.00% |
| Black Vulture | 13.8% | Hermit Thrush | 0.01% | Sandhill Crane | 0.06% |
| Black-and-white Warbler | 0.1% | Hooded Merganser | 0.02% | Sedge Wren | 0.01% |
| Black-bellied Whistling Duck | 0.7% | House Finch | 0.1% | Sharp-shinned Hawk | 0.01% |
| Black-crowned Night-Heron | 1.6% | House Wren | 0.2% | Snowy Egret | 1.18% |
| Black-throated Blue Warbler | 0.01% | Killdeer | 0.1% | Summer Tanager | 0.01% |
| Blue Jay | 0.2% | Limpkin | 0.3% | Swainson's Thrush | 0.00% |
| Blue-gray Gnatcatcher | 0.9% | Little Blue Heron | 4.1% | Swallow-tailed Kite | 0.22% |
| Blue-headed Vireo | 0.1% | Mallard | 0.1% | Tree Swallow | 0.55% |
| Blue-winged Teal | 0.02% | Merlin | 0.003% | Tricolored Heron | 1.07% |
| Boat-tailed Grackle | 0.4% | Mottled Duck | 0.1% | Tufted Titmouse | 1.13% |
| Broad-winged Hawk | 0.00% | Mourning Dove | 0.3% | Turkey Vulture | 2.8% |
| Brown Thrasher | 0.02% | Muscovy Duck | 0.01% | White Ibis | 19.1% |
| Carolina Chickadee | 0.00% | Northern Bobwhite | 0.003% | White-eyed Vireo | 0.39% |
| Carolina Wren | 2.1% | Northern Cardinal | 2.6% | White-winged Dove | 0.01% |
| Cattle Egret | 3.5% | Northern Flicker | 0.04% | Wild Turkey | 0.44% |
| Cedar Waxwing | 0.3% | Northern Harrier | 0.003% | Wilson's Snipe | 0.01% |
| Chuck-will's-widow | 0.003% | Northern Mockingbird | 0.4% | Wood Duck | 1.44% |
| Common Grackle | 4.0% | Northern Parula | 1.2% | Wood Stork | 0.38% |
| Common Moorhen | 0.6% | Northern Waterthrush | 0.01% | Yellow-bellied Sapsucker | 0.06% |
| Common Nighthawk | 0.01% | Orange-crowned Warbler | 0.02% | Yellow-billed Cuckoo | 0.02% |
| Common Yellowthroat | 0.4% | Osprey | 1.2% | Yellow-crowned Night Heron | 1.05% |
| Cooper's Hawk | 0.02% | Ovenbird | 0.03% | Yellow-rumped Warbler | 1.50% |
| Double-crested Cormorant | 0.4% | Palm Warbler | 1.5% | Yellow-throated Vireo | 0.01% |
| Downy Woodpecker | 0.5% | Peregrine Falcon | 0.01% | Yellow-throated Warbler | 0.04% |
| Eastern Bluebird | 0.02% | Pied-billed Grebe | 0.1% | | |
| Eastern Phoebe | 0.6% | Pileated Woodpecker | 0.8% | | |
| | | | | Red highlights indicate top-10 highest frequency | |

Fig 13 Table of 115 documented bird species found taking refuge in the Reedy Creek WMCA (May, 2007-Oct, 2012). Top-10 most frequently observed species highlighted in red.

Trend analysis of bird counts showed higher averages during cold months (Dec-Feb) and lower averages during warm months (Mar-Nov), fig 14. Total annual bird counts in the WMCA peaked in 2010 during the cold months, a year that monitoring data measured the lowest water temperatures recorded over the five-year period.

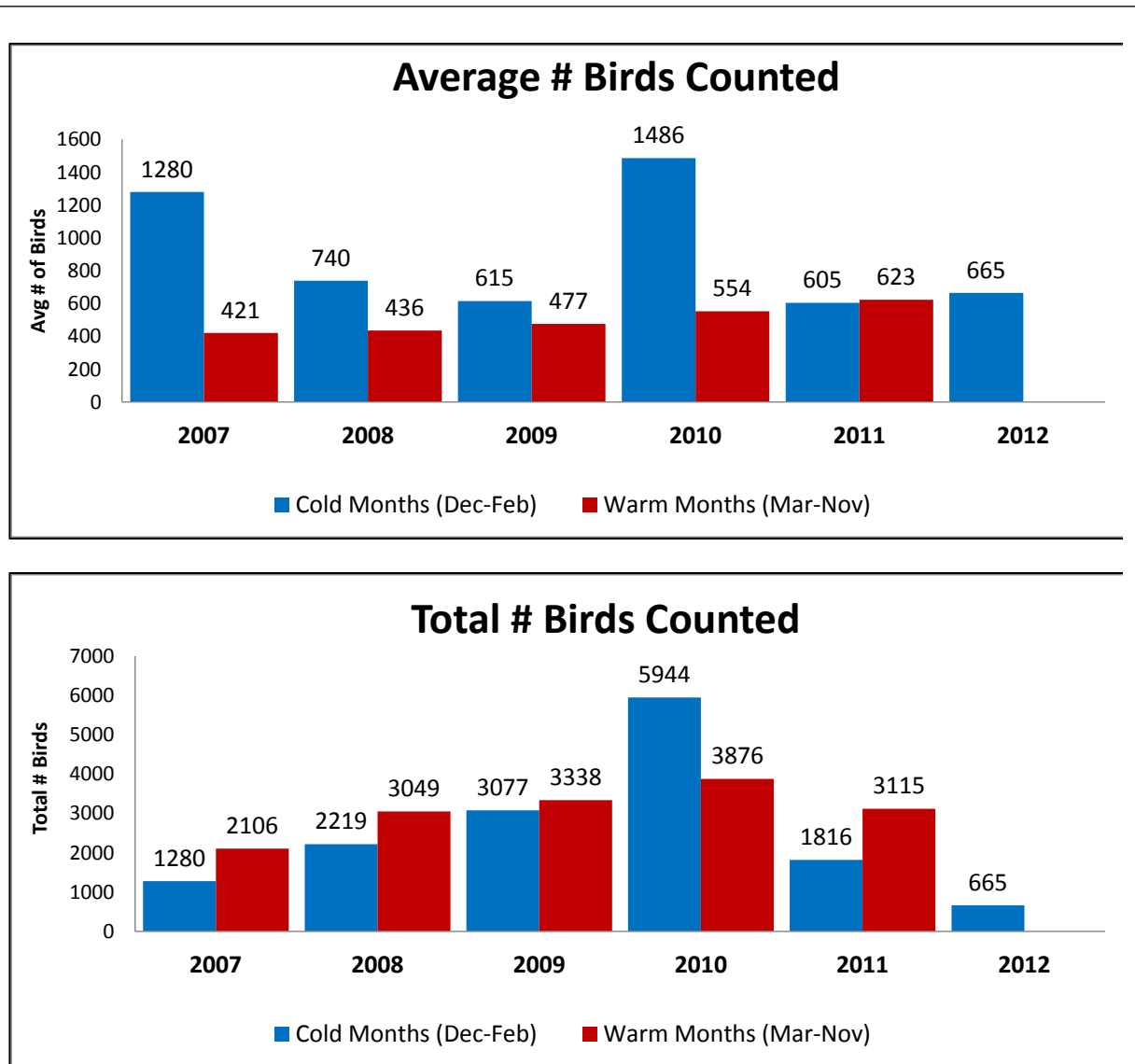


Fig 14 Seasonal trend of the bird species inventoried in WMCA. Top graph displaying average number of birds observed per survey. Bottom graph displaying cumulative annual bird counts. Cold month category (Dec-Feb), warm month category (Mar-Nov).

Photographic documentation of various wildlife species found in the WMCA:
(photos courtesy of Eddie Snell (RCID) and Osceola County Public Works)



Black Vulture



Great Blue Heron



Anhinga



Cattle Egrets



Black-Bellied Whistling Duck



Pileated Woodpecker



Green Heron



Wood Duck



Swallow-Tailed Kite



Sandhill Crane



White Ibis



American Bald Eagle





Northern River Otters



American Alligator



Gopher Tortoise



Eastern Gray Squirrel



White-tailed Deer



Red Fox

FECAL COLIFORM BACTERIA

TMDL IMPAIRMENT LISTING

Water basin identification (WBID) units are used by the Department to compartmentalize the hydrologic areas of Florida for sampling and assessment purposes under the Total Maximum Daily Load (TMDL) program (FS Chapter 403.067: Rule Chapter 62.303). The Reedy Creek Basin was broken into 80 unique WBIDs to describe the hydrology of Reedy Creek (Fig 15).

On November 2, 2010, the Department Secretary adopted a verified list of impaired waters that included WBID 3170F2 as impaired for exceedance of fecal coliform bacteria standards. This WBID was later split by the Department in 2011 and re-identified as WBID 3170F7. RCID maintains that the science behind the impairment verification failed to adequately account for ambient background conditions and natural variations from seasonal wildlife activity (Rule 62-303.320 (4) (d)).

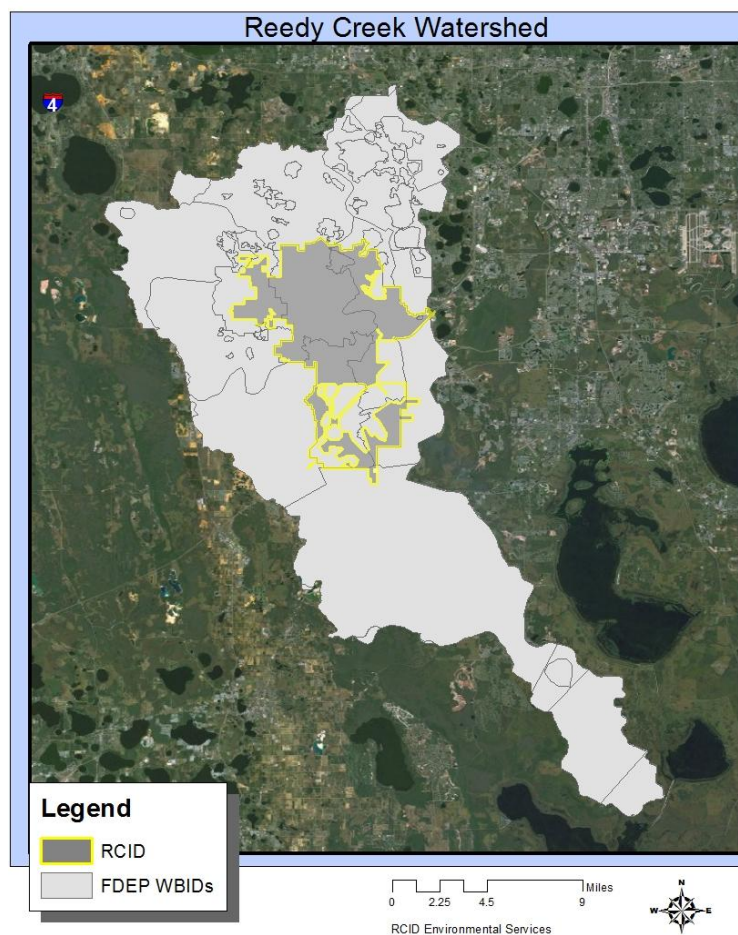


Fig 15 Unique water basin identification units (WBIDs) for the Reedy Creek watershed.

Water basin 3170F7 was assessed mainly based on data from three tributary monitoring sites on Reedy Creek (Fig 16), referred to in the remainder of this document as Site #1, Site #2, and site #3. Site #1 and #2 are monitoring sites on Reedy Creek, proper. Site #3 remains an important monitoring site as it represents the Reedy Creek stream segment after it receives surface water inputs from adjacent Davenport Creek and Bonnet Creek. The direction of water flow was south, from site #1 to site #3.

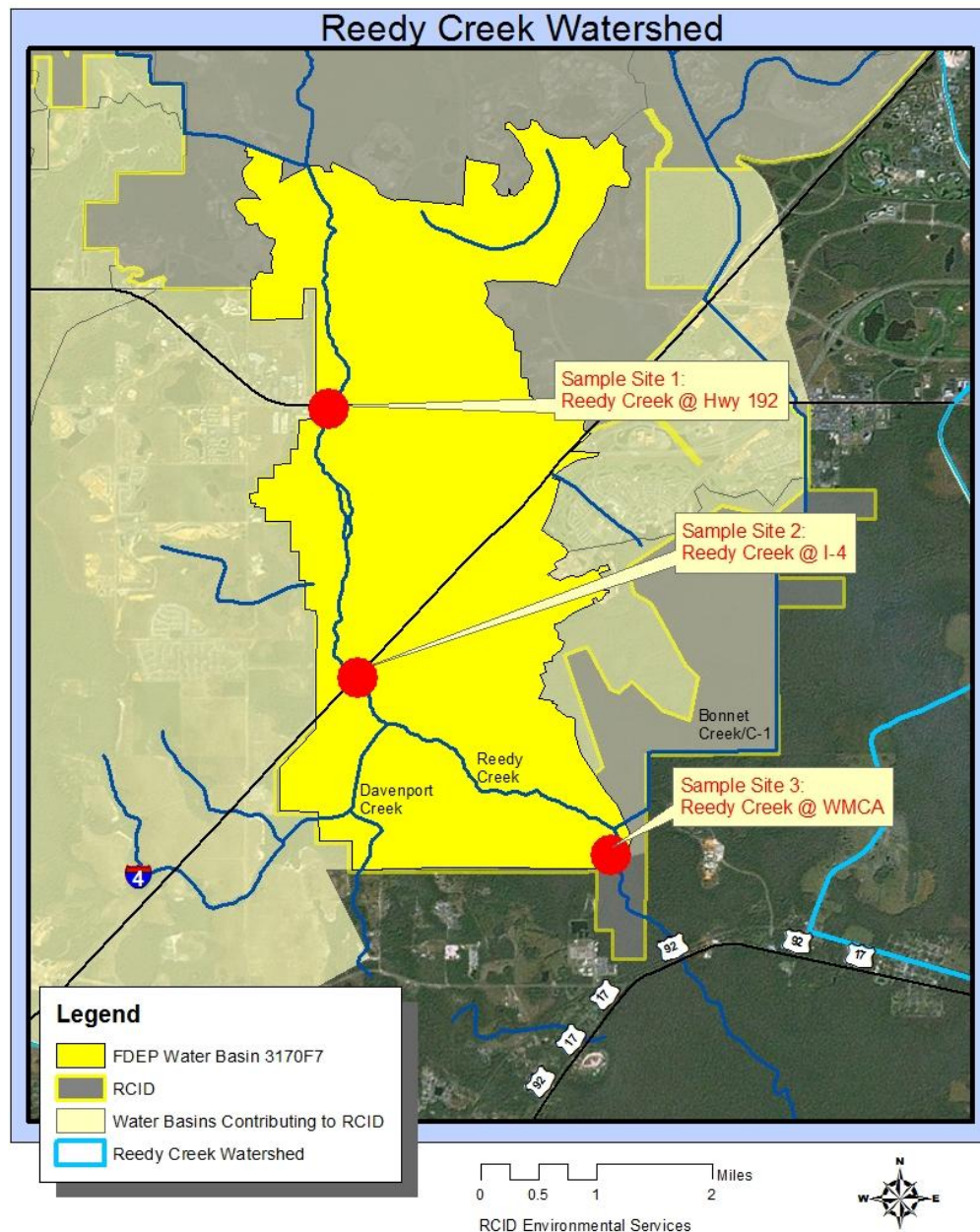


Fig 16 Primary water basin monitoring sites (red markers) used by the Department to assess WBID 3170F7 as verified impaired for fecal coliform bacteria. Site #1 and #2 are on Reedy Creek, proper. Site #3 represents the Reedy Creek stream segment after receiving surface water inputs from Davenport Creek and Bonnet Creek.

Analysis of the individual sample site results used to assess WBID 3170F7 showed one site disproportionately raised the frequency of exceedances for the entire water basin (Fig 17). The site of concern, site# 3, was located at the furthestmost downstream segment of Reedy Creek, a stream segment that represented coliform concentrations from Reedy Creek after comingling with Davenport Creek and Bonnet Creek.

| Site 1: Reedy Creek @ Hwy192 | | | |
|------------------------------|---------------------------|------|--------|
| YEAR | #Exceedences/ #Samples | Freq | Status |
| 1998 | 0/ 4 | 0% | PASS |
| 1999 | 0/ 3 | 0% | PASS |
| 2000 | 0/ 4 | 0% | PASS |
| 2001 | 0/ 4 | 0% | PASS |
| 2002 | 0/ 4 | 0% | PASS |
| 2003 | 0/ 4 | 0% | PASS |
| 2004 | 1/ 5 | 20% | FAIL |
| 2005 | 0/ 4 | 0% | PASS |
| 2006 | 0/ 4 | 0% | PASS |
| 2007 | 0/ 4 | 0% | PASS |
| 2008 | 0/ 5 | 0% | PASS |
| 2009 | 1/ 3 | 33% | FAIL |
| Grand Total | | 4% | |

| Site 2: Reedy Creek @ I-4 | | | |
|---------------------------|---------------------------|------|--------|
| YEAR | #Exceedences/ #Samples | Freq | Status |
| 1998 | 0/ 5 | 0% | PASS |
| 1999 | 0/ 3 | 0% | PASS |
| 2000 | 0/ 4 | 0% | PASS |
| 2001 | 0/ 3 | 0% | PASS |
| 2002 | 0/ 4 | 0% | PASS |
| 2003 | 0/ 4 | 0% | PASS |
| 2004 | 2/ 5 | 40% | FAIL |
| 2005 | 0/ 3 | 0% | PASS |
| 2006 | 0/ 2 | 0% | PASS |
| 2007 | 0/ 1 | 0% | PASS |
| 2008 | 0/ 3 | 0% | PASS |
| 2009 | 0/ 3 | 0% | PASS |
| Grand Total | | 5% | |

| Site 3: Reedy Creek @ WMCA | | | |
|----------------------------|---------------------------|------|--------|
| YEAR | #Exceedences/ #Samples | Freq | Status |
| 1998 | 0/ 0 | 0% | PASS |
| 1999 | 2/ 7 | 29% | FAIL |
| 2000 | 0/ 8 | 0% | PASS |
| 2001 | 0/ 8 | 0% | PASS |
| 2002 | 2/ 8 | 25% | FAIL |
| 2003 | 5/ 9 | 56% | FAIL |
| 2004 | 3/ 10 | 30% | FAIL |
| 2005 | 2/ 5 | 40% | FAIL |
| 2006 | 5/ 7 | 71% | FAIL |
| 2007 | 1/ 5 | 20% | FAIL |
| 2008 | 2/ 5 | 40% | FAIL |
| 2009 | 1/ 3 | 33% | FAIL |
| Grand Total | | 31% | |

Fig 17 Individual sampling frequencies and exceedance rates showed sites #1 and #2 (see Fig 16) passed the Department's fecal coliform criteria. These two sites represented Reedy Creek, proper. The site of concern with the highest failures, site# 3, represented the comingled waters of Reedy Davenport Creek, and Bonnet Creek after passing through bird rookeries in the WMCA. Site #3 was located in the core of the wildlife management area, an area lacking anthropogenic sources nearby.

While site #3 on Reedy Creek showed a series of annual coliform failure rates, the overall failure rate at this site was consistent with the approximate 30% failure rate measured in a State Park study conducted for the Department by ERD [ERD, 2009]. Based on the study, Reedy Creek WMCA's mixed hardwood forest would most likely contribute fecal coliform concentrations in excess of 6,000 colony forming units/100mL to the watershed from the endemic wildlife sources (Fig 18).

| State Park | Monitored Land Classification (FNAI) | No. of Sites | No. of Samples |
|---------------------|--------------------------------------|--------------|----------------|
| Alfred B. McClay | Mixed Hardwood Forest | 2 | 39 |
| Fakahatchee | Wet Prairie / Marl Prairie | 4 | 12 |
| Faver Dykes | Mesic Flatwoods / Scrubby Flatwoods | 7 | 60 |
| Johnathan Dickinson | Wet Flatwoods / Hydric Hammock | 7 | 93 |
| Lake Louisa | Ruderal/Upland Pine | 1 | 2 |
| Myakka River | Dry Prairie | 2 | 12 |
| Paynes Creek | Xeric Hammock / Hydric Flatwoods | 2 | 2 |
| San Felasco | Upland Mixed Forest/Upland Pine | 1 | 16 |
| Silver River | Upland Hardwood | 5 | 79 |
| Wekiva River | Xeric Scrub/ Xeric Hammock | 3 | 3 |
| | Total | 33 | 318 |

Fig 18 Natural vegetation communities in ten Florida State Parks were evaluated for parameters such as fecal coliform bacteria. (2009, Harper, HH. *Stormwater characteristics of natural vegetation communities in Florida.*)

An additional analysis of fecal coliform trends was conducted at site #3 by ERD and found evidence of a strong seasonal trend relating to higher concentrations in winter months, December through February [HARPER, 2010].

The Reedy Creek WMCA remains an important natural area and over-wintering refuge to many threatened and endangered migratory birds.

POTENTIAL SOURCE IDENTIFICATION

Common fecal coliform sources listed by the Department's implementation guidance document for fecal coliform TMDLs include: (1) sanitary sewer systems, (2) onsite sewage treatment and disposal systems (OSTDS, septic tanks), (3) stormwater, (4) nonpoint sources, and (5) wildlife.

To investigate potential contributors to the exceedances of bacteria in the Reedy Creek watershed, RCID developed a list of potential sources and probabilities that were considered applicable to the stream segment in the WMCA (Fig 19).

| | Known Sources of Fecal Coliform | Probability of Cause | Weight of Evidence | Data Source |
|-----------------------------------|---------------------------------|----------------------|---|--|
| (1) Sanitary Sewer Systems | Sanitary Sewer Overflow | Low | Lack of nearby sources, lack of reported spill incidences | GIS databases, state database |
| | Biosolid Spreadfields | Low | Lack of nearby sources, lack of upstream impairment | State permit records, FDEP WWTF database |
| (2) OSTDS | Septic Tank Leachate | Low | Lack of septic tanks in watershed | State permit records |
| (3) Stormwater | Domestic Animal Waste | Low | Lack of nearby sources, upstream results met criteria | GIS |
| | Illicit Discharges | Low | Lack of nearby sources | GIS |
| | Homeless Populations | Low | Sporadic evidence, 2.7 miles from nearest roadway | Staff observations, Osceola County Sheriff records |
| (4) Nonpoint Sources | Wetlands | High | Active 7,000 acre WMCA | GIS, RCID, SFWMD |
| | Grassed Levee | Medium | Wildlife feces on levee | Wildlife surveys and counts |
| (5) Wildlife | Wildlife | High | Wildlife counts, species lists, photographs | Animal surveys, RCID, FWS, SFWMD, Nature Conservancy |

Fig 19 Potential fecal coliform sources and their probability of causing coliform impairment in the Reedy Creek WMCA.

POTENTIAL SOURCES AND EXISTING MANAGEMENT ACTION PLANS

Management efforts in surface waters and sewer infrastructure within RCID are fully documented to meet compliance of each applicable operational permit. The following management action plans are conducted on the listed frequency:

Summary of Effort: Sewer System

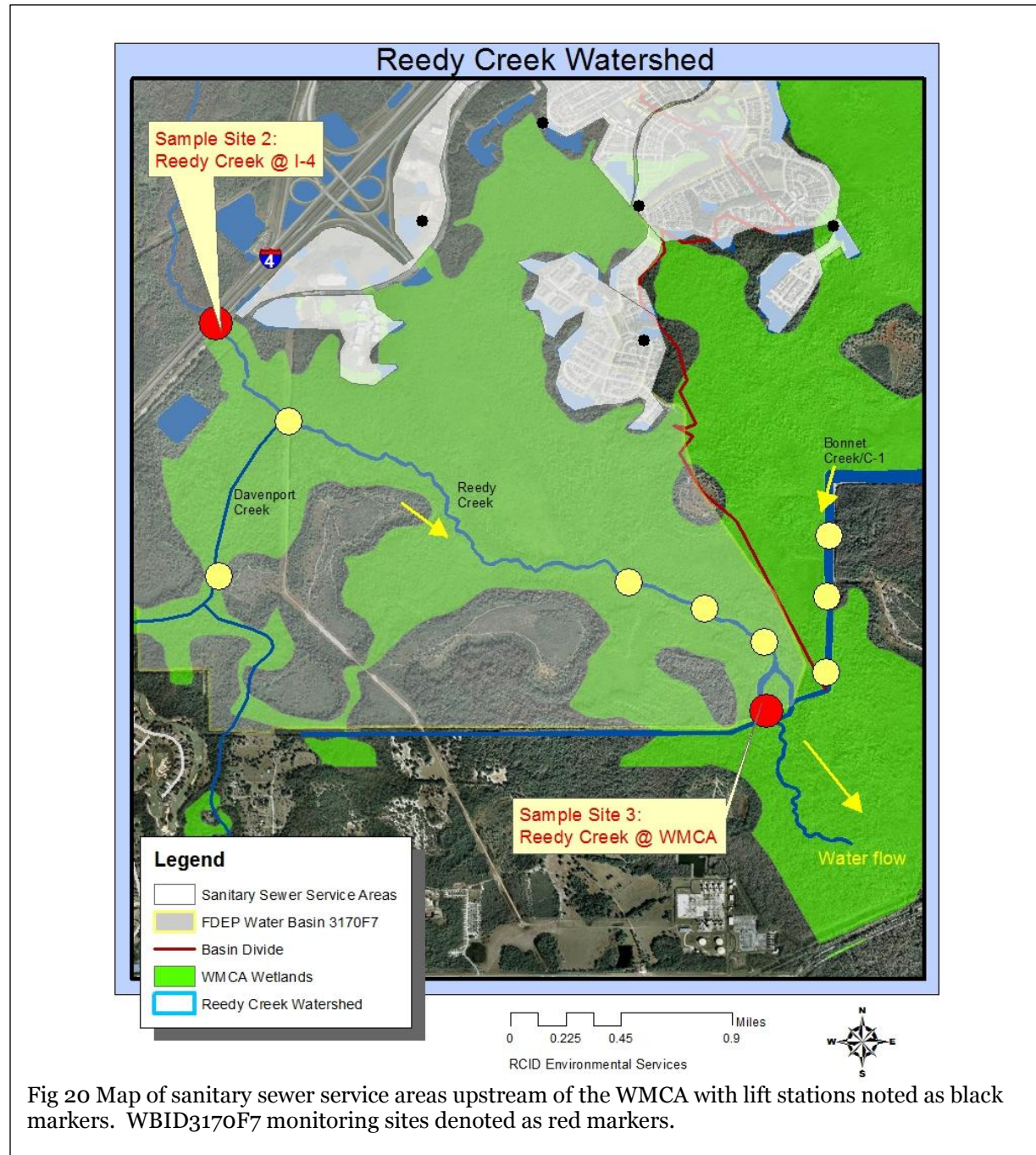
| SOURCE/ACTION | FREQUENCY |
|--|-----------|
| ARV Inspection and Rehab | ANNUALLY |
| Manhole Inspection and Rehab | ANNUALLY |
| Private Lift Station Inspections and Enforcement | ANNUALLY |
| Pump Station Inspection and Maintenance | ANNUALLY |
| Pump Station Rebuild | ANNUALLY |
| Sewer Line Upgrades | ANNUALLY |
| SSO Investigations | ANNUALLY |
| Surface Water Sampling for Conditions and Trends | QUARTERLY |

Summary of Effort: Stormwater

| SOURCE/ACTION | FREQUENCY |
|---|-----------|
| Capital Projects/Stormwater Water Quality BMPs | ANNUALLY |
| Flood Control Capital Projects | ANNUALLY |
| Illicit Connection Removal | ANNUALLY |
| Potential Illicit Connection (PIC) Identification | ANNUALLY |
| Public Education and Outreach | ANNUALLY |
| Stormwater Pipe Cleaning and Maintenance | ANNUALLY |
| Stormwater Pond Maintenance | ANNUALLY |
| Stormwater System Ditch and Canal Maintenance | ANNUALLY |
| Surface Water Sampling for Conditions and Trends | QUARTERLY |

SEWER INFRASTRUCTURE

Both public and private sewer systems have been documented in the Reedy Creek watershed upstream of the WMCA (Fig 20). Toho Water Authority maintains the closest sanitary sewer service zone upstream of site#3 which includes reclaimed water services.



SURVEY ACTIVITIES

Long-term monitoring of WBID 3170F7 continues to be conducted by RCID Environmental Services, FDEP, SFWMD, FWS, Nature Conservancy, and Disney's Animals, Science & Environment team.

Due to the remoteness of the monitoring sites in the WMCA, field investigations have been limited to accessible areas using vehicles, small powerboats, canoes, hiking, and wading.

Stormwater conveyance structures, such as levees, aynl gates, control structures, culverts, ditches, and stormwater ponds, have been identified as part of the RCID's Master Drainage Plan and were commonly used for access points. FDOT also maintained a series of similar conveyance structures along highways approximately 3.7 miles upstream of site #3 in the WMCA which allowed additional access for field sampling crews.

Preliminary wildlife and bird surveys were conducted monthly on the C1 canal portion of Bonnet Creek by Disney's Animals, Science & Environment team to supplement RCID's water quality data. In addition, joint water quality sampling events were conducted in 2012 with RCID and FDEP to further survey upstream of the primary site #3 for WBID 3170F7.

MONITORING APPROACHES AND PRELIMINARY FINDINGS

Surface waters assessed within WBID 3170F7 cover a six-mile segment of Reedy Creek (Fig 21). Sites #1 and #2 were located on Reedy Creek, proper. Sampling site #3 was located on Reedy Creek at the S-40 structure, a significant water control structure and final discharge point for RCID.

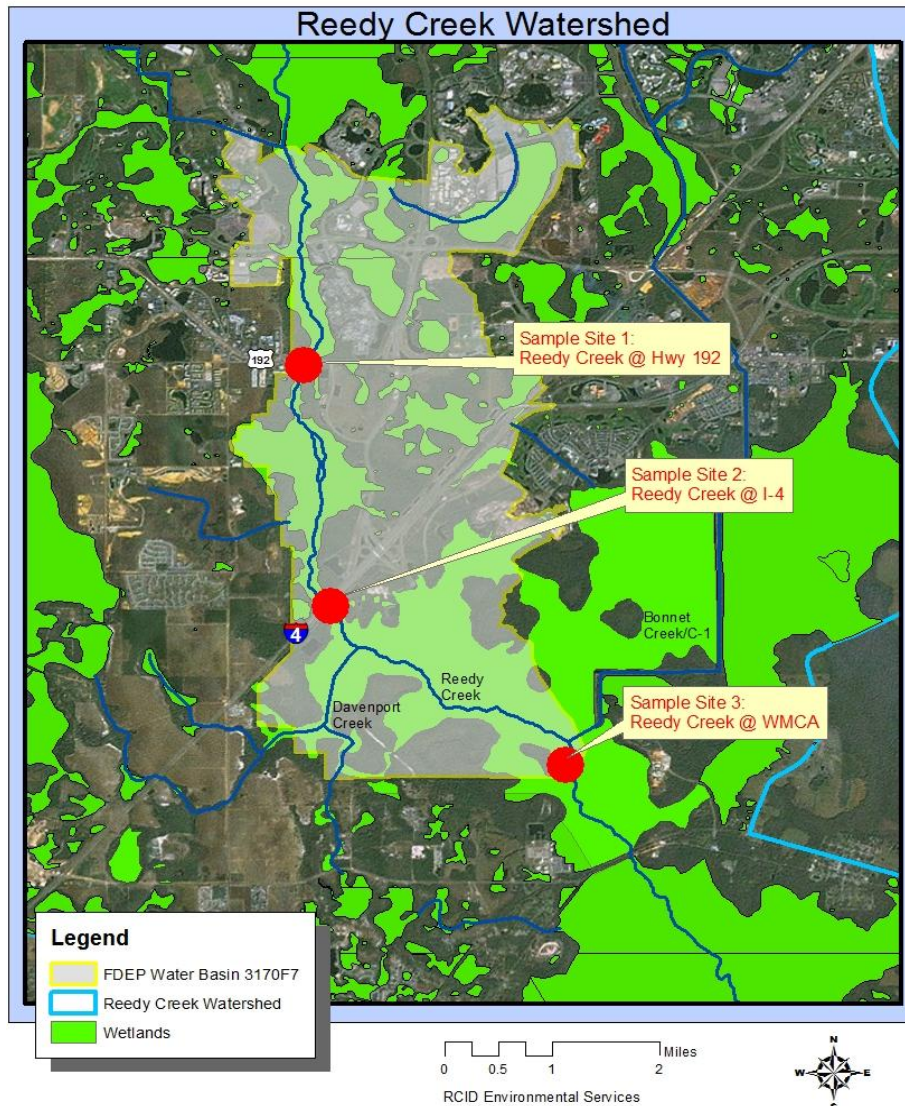


Fig 21 Three primary sampling sites (red markers) used by the Department to represent WBID 3170F7. Sample site# 3 is located on Reedy Creek, upstream of the final discharge point at water control structure S-40, used by RCID to regulate upstream flow rates. Wildlife conservation wetlands are designated in green.

The Department's impairment listing was primarily based on the summary of three sample sites within WBID 3170F7 (Fig22). RCID re-evaluated the data on an individual sample site basis to determine the origin of the sources of impairment. This individual analysis found that site #3, located in the lower segment of the Reedy Creek WMCA, was the primary cause for failure of the Department's fecal coliform criteria and disproportionately raised the exceedance frequency for the entire WBID.

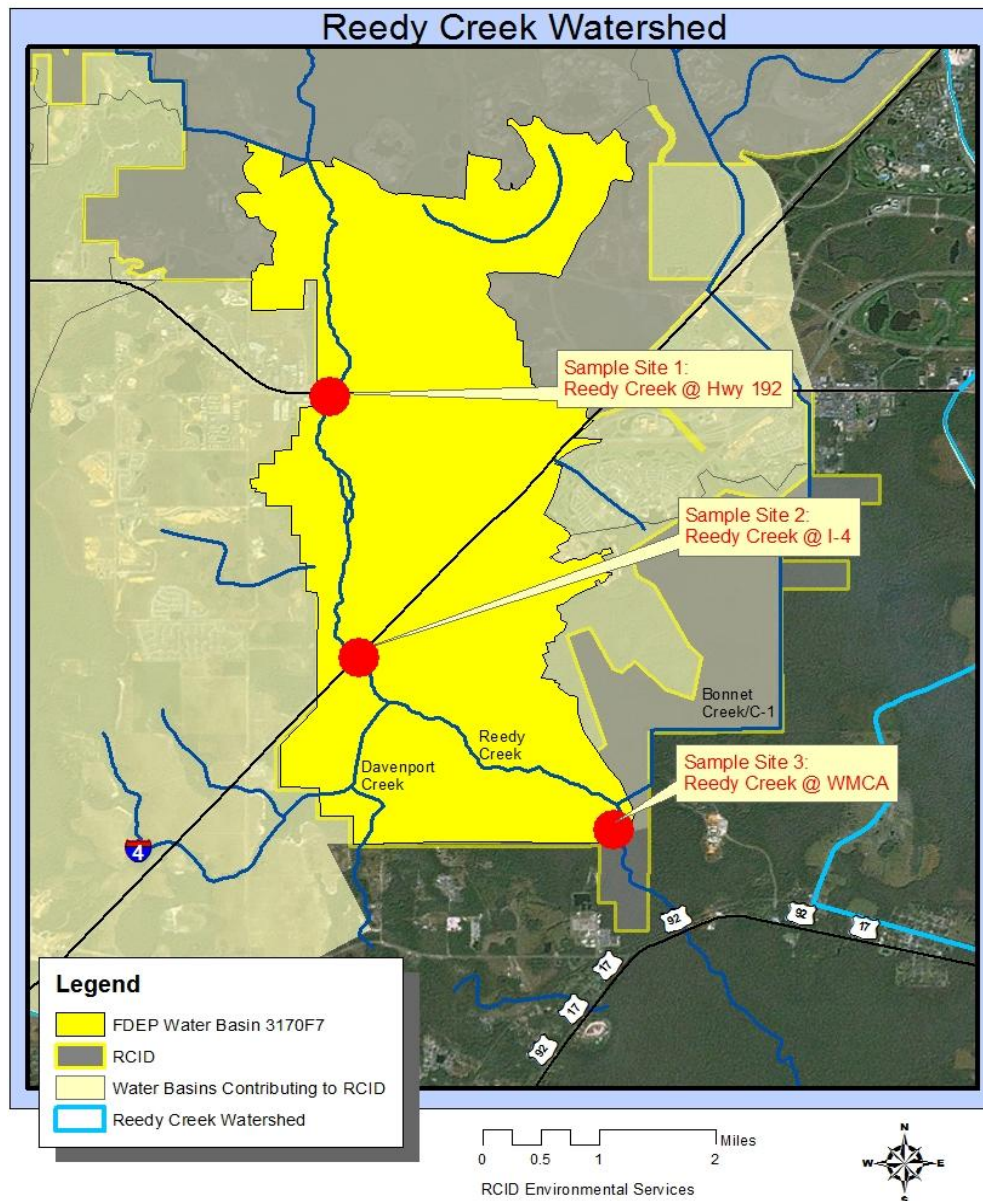


Fig 22 Map of Reedy Creek WBID 3170F7 showing the three primary sample sites (red markers) used by the Department to list the WBID as impaired for fecal coliform bacteria. Note sites #1 and #2 were located on Reedy Creek proper, whereas site #3 was located after the confluence of Davenport, Bonnet, and Reedy Creek segments.

Individual sample site results in WBID 3170F7 indicated the following:

Fecal coliform concentrations in the uppermost stream segment at Site# 1 passed the Department's criteria on average 96% of the sampling events over the eleven-year assessment period.

| Site 1: Reedy Creek @ Hwy192 | | | |
|------------------------------|---------------------------|------|--------|
| YEAR | #Exceedences/ #Samples | Freq | Status |
| 1998 | 0/ 4 | 0% | PASS |
| 1999 | 0/ 3 | 0% | PASS |
| 2000 | 0/ 4 | 0% | PASS |
| 2001 | 0/ 4 | 0% | PASS |
| 2002 | 0/ 4 | 0% | PASS |
| 2003 | 0/ 4 | 0% | PASS |
| 2004 | 1/ 5 | 20% | FAIL |
| 2005 | 0/ 4 | 0% | PASS |
| 2006 | 0/ 4 | 0% | PASS |
| 2007 | 0/ 4 | 0% | PASS |
| 2008 | 0/ 5 | 0% | PASS |
| 2009 | 1/ 3 | 33% | FAIL |
| Grand Total | | 4% | |

Fecal coliform concentrations in the middle stream segment at Site# 2 passed the Department's criteria on average 95% of the sampling events over the eleven-year assessment period.

| Site 2: Reedy Creek @ I-4 | | | |
|---------------------------|---------------------------|------|--------|
| YEAR | #Exceedences/ #Samples | Freq | Status |
| 1998 | 0/ 5 | 0% | PASS |
| 1999 | 0/ 3 | 0% | PASS |
| 2000 | 0/ 4 | 0% | PASS |
| 2001 | 0/ 3 | 0% | PASS |
| 2002 | 0/ 4 | 0% | PASS |
| 2003 | 0/ 4 | 0% | PASS |
| 2004 | 2/ 5 | 40% | FAIL |
| 2005 | 0/ 3 | 0% | PASS |
| 2006 | 0/ 2 | 0% | PASS |
| 2007 | 0/ 1 | 0% | PASS |
| 2008 | 0/ 3 | 0% | PASS |
| 2009 | 0/ 3 | 0% | PASS |
| Grand Total | | 5% | |

Bacteria levels at Site #3, below bird rookeries in the Reedy Creek WMCA, showed concentrations high enough to fail the Department's fecal coliform criteria an average of 31% of the sampling events over the eleven-year assessment period.

| Site 3: Reedy Creek @ WMCA | | | |
|----------------------------|---------------------------|------|--------|
| YEAR | #Exceedences/ #Samples | Freq | Status |
| 1998 | 0/ 0 | 0% | PASS |
| 1999 | 2/ 7 | 29% | FAIL |
| 2000 | 0/ 8 | 0% | PASS |
| 2001 | 0/ 8 | 0% | PASS |
| 2002 | 2/ 8 | 25% | FAIL |
| 2003 | 5/ 9 | 56% | FAIL |
| 2004 | 3/ 10 | 30% | FAIL |
| 2005 | 2/ 5 | 40% | FAIL |
| 2006 | 5/ 7 | 71% | FAIL |
| 2007 | 1/ 5 | 20% | FAIL |
| 2008 | 2/ 5 | 40% | FAIL |
| 2009 | 1/ 3 | 33% | FAIL |
| Grand Total | | 31% | |

Based on this breakdown by individual sample sites, the microbial water quality in the WMCA did not accurately represent the upper, developed segments of WBID 3170F7. Site #3 showed increased fecal coliform impacts, a consistent finding in the wilderness area of the Reedy Creek WMCA. This segment of Reedy Creek continues to show unique water quality characteristics not observed to originate from the other two upstream sample sites #1 and #2.

STREAM SEGMENT REVIEW

RCID reviewed detailed sampling data in an attempt to determine if any of the stream segments (Bonnet Creek or Davenport Creek) contributed the bacteria. The stream segments converge and come together to comprise Reedy Creek before reaching the monitoring site #3 (red marker fig 23) used by the Department to list WBID 3170F7 as impaired for fecal coliforms. A total fourteen sample sites were reviewed.

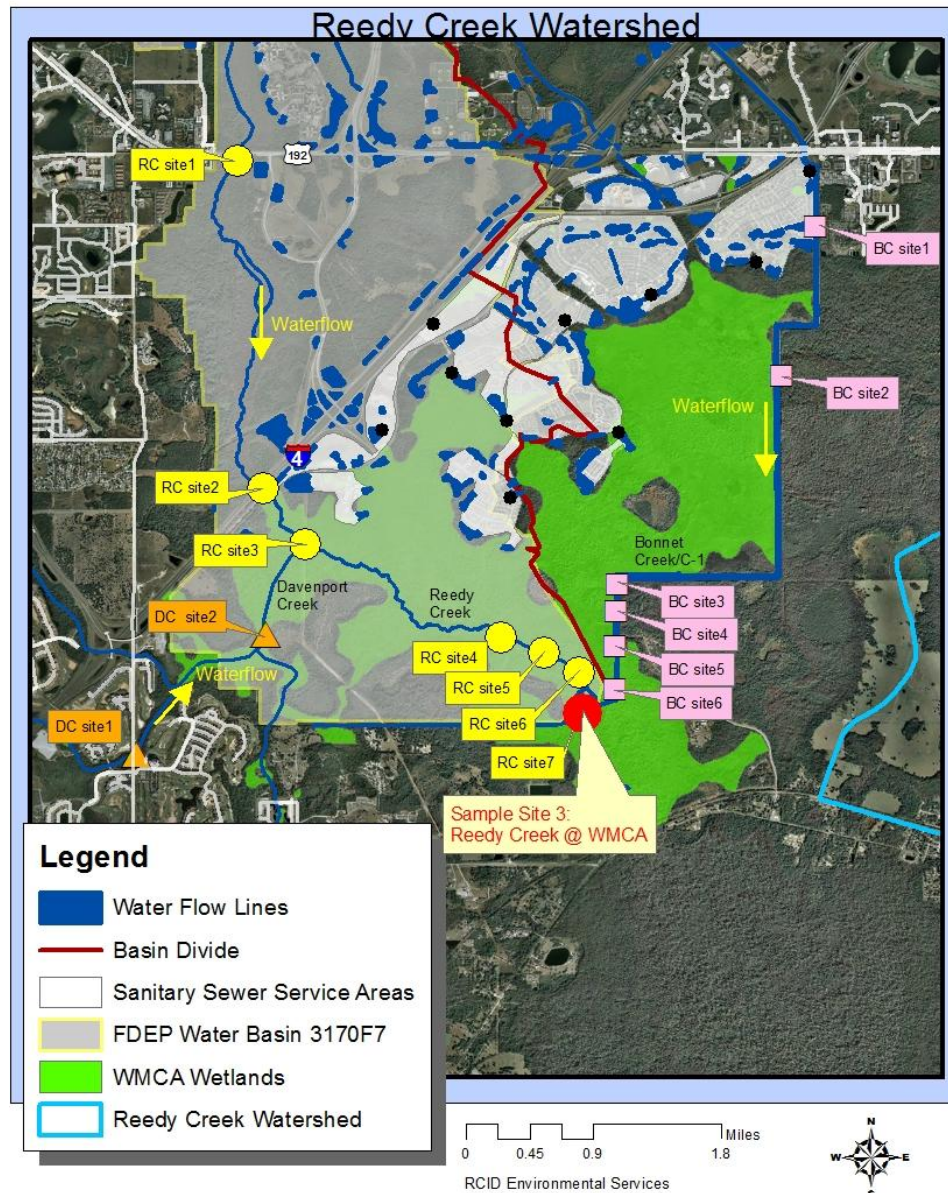


Fig 23 Map of stream segment sites reviewed to determine which segment contributed the most bacteria to Reedy Creek in WBID 3170F7. Contributing streams included: Davenport Creek (orange markers), Bonnet Creek (purple markers), and Reedy Creek (yellow markers). The downstream discharge point represented by Site #3 (red marker) was used by the Department to list WBID 3170F7 as impaired for fecal coliform bacteria.

Sampling stations located at various intervals along the three stream segments were incorporated into this review (Fig 24). Data was available from six sampling sites in Reedy Creek, six in Bonnet Creek and two in Davenport Creek (Appendix A). The closest sampling interval between sites was 1,500 feet, and the largest site interval was 2.5 miles on Reedy Creek.

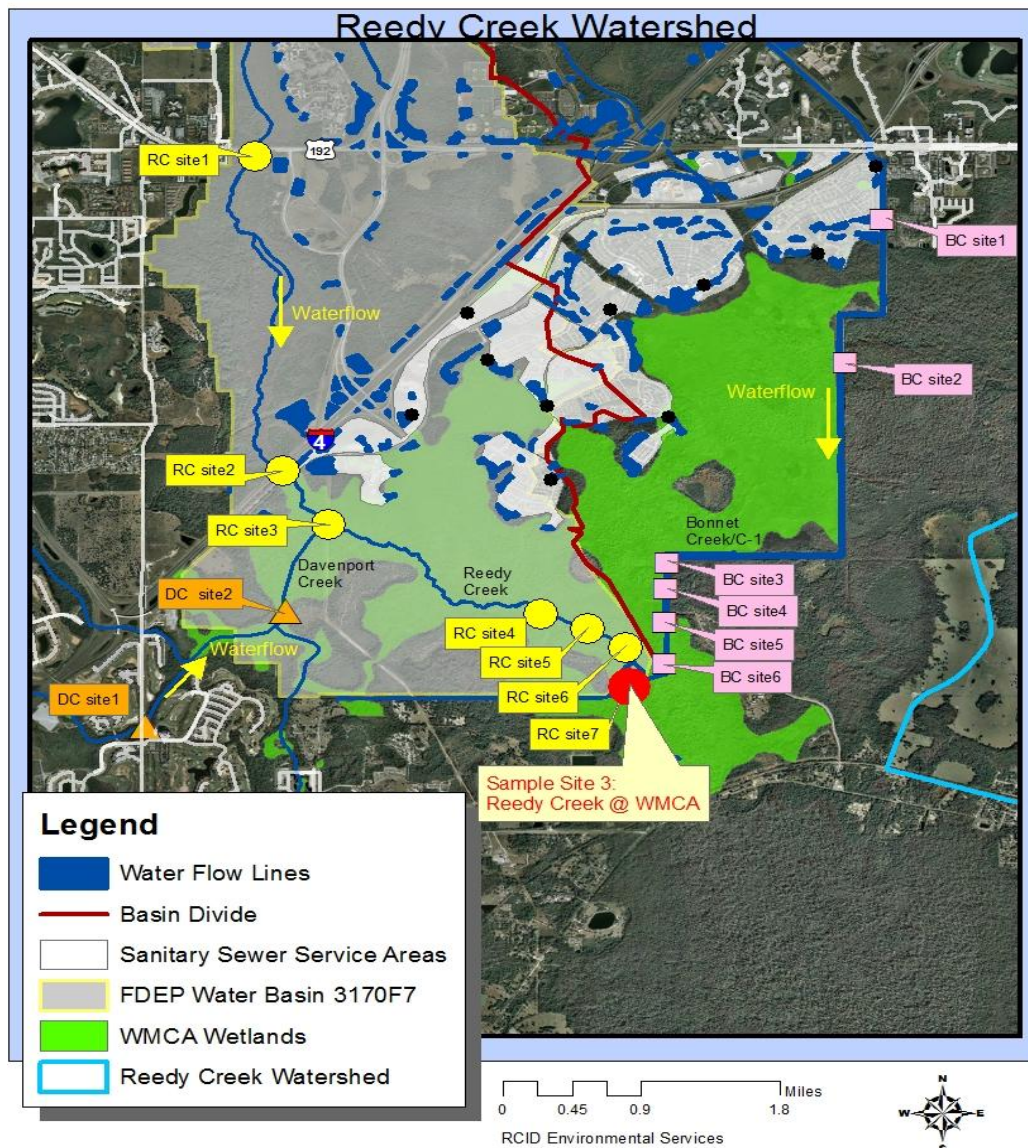


Fig 24 RCID conducted a data review to determine which of three stream segments contributed most to the fecal coliforms population measured at WBID 3170F7 site #3 (red marker) by the Department. *Map legend: Bonnet Creek designated BC prefix (purple markers); Davenport Creek designated DC prefix (orange markers), and Reedy Creek designated RC prefix (yellow markers).*

PRELIMINARY FINDINGS

Beginning with the Bonnet Creek stream segment, analysis of historical fecal coliform results showed occasional peaks of bacteria upstream in the watershed over the eight-year study period (Fig 25). However, contributions to downstream bacteria levels in Reedy Creek were not considered significant [HARWOOD, 2010].

Maximum fecal coliform levels in Bonnet Creek at the upper two sites (BC sites 1 & 2) were elevated yet did not appear to contribute greatly to the concentrations found downstream in the middle sites (BC sites 3-4). Results indicated that surface waters flowing through the lower Bonnet Creek segments (BC sites 5 & 6) increased in coliform concentrations, presumably from the wildlife sources in the WMCA as no anthropogenic sources exist in this remote area.

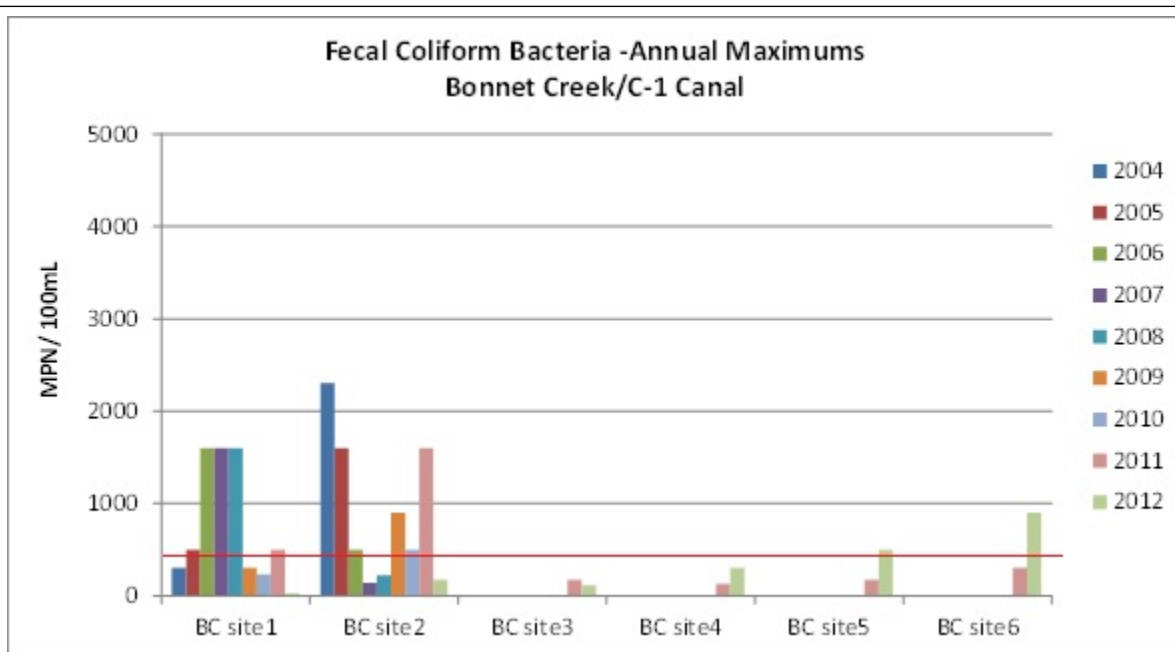


Fig 25 Annual fecal coliform maximums showed bacteria levels exceeded the limit (red line) in Bonnet Creek BC sites 1 & 2, yet concentrations stayed localized and did not particularly impact mid-segment sites BC 3 & 4. Results indicated that surface waters flowing through the lower Bonnet Creek segments (BC sites 5 & 6) increased in coliform concentrations, presumably from the wildlife sources in the WMCA as no anthropogenic sources exist in this remote area.

Maximum fecal coliform levels in Davenport Creek showed bacteria peaked above limits (red line) along Old Wilson Road (Fig 26). Results showed localized fecal coliform impacts to Davenport Creek and a potential to sustain downstream concentrations at DC site #2 near the discharge to Reedy Creek.

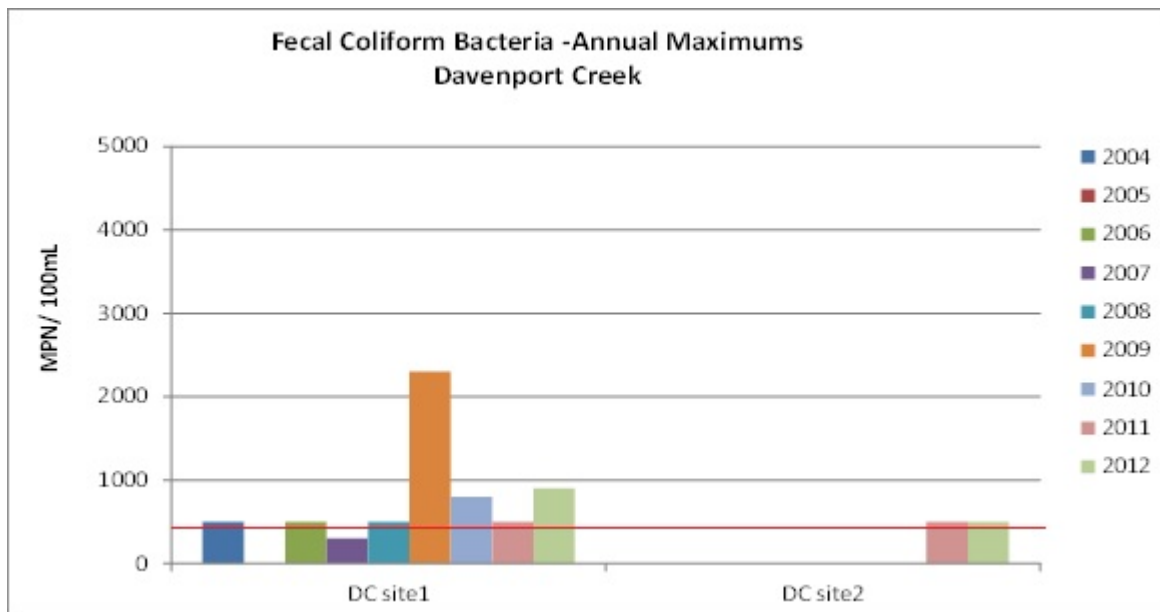
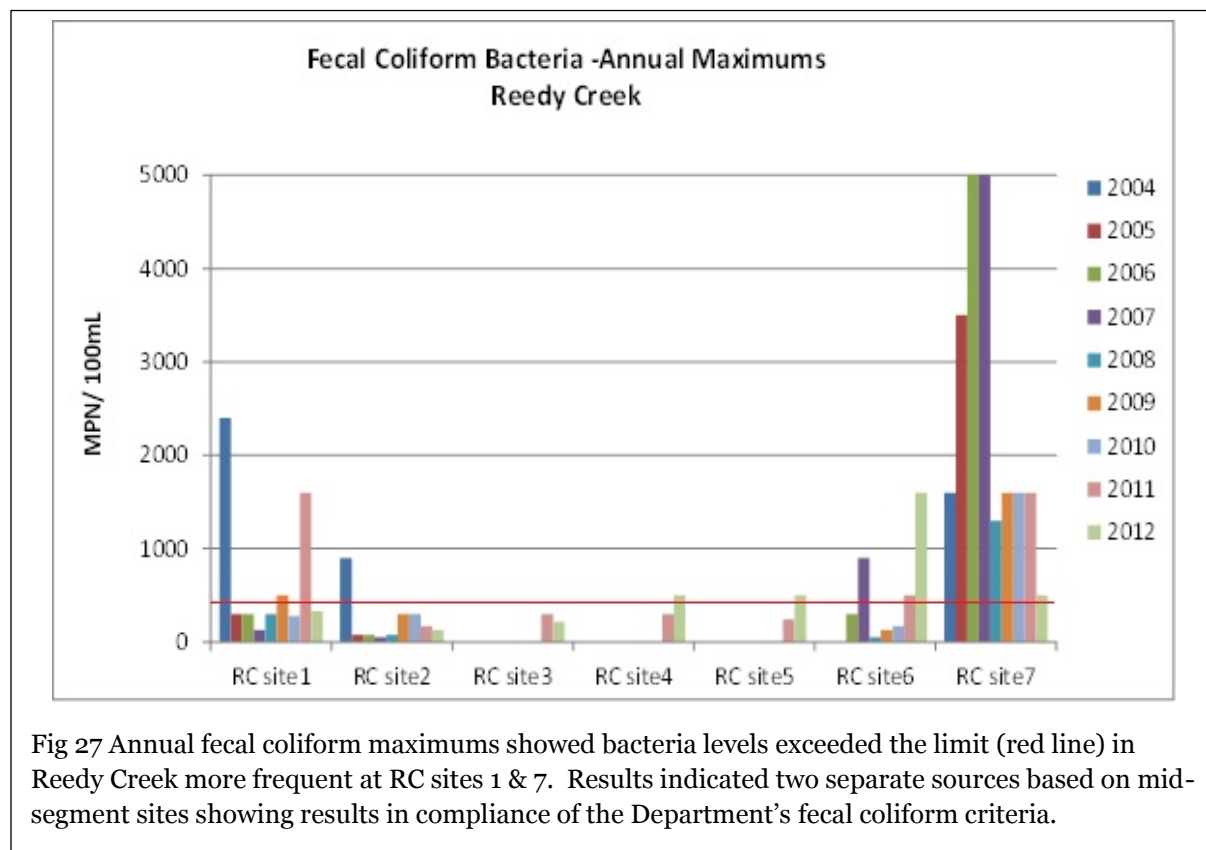


Fig 26 Annual fecal coliform maximums showed bacteria levels exceeded the limit (red line) at Old Wilson Road (DC site# 1). Results showed localized impacts to the Davenport Creek segment and a potential to sustain downstream concentrations at DC site 2 near the discharge to Reedy Creek.

Two sites (RC sites 1 & 7) were found to exceed the Department's criteria more frequently than other Reedy Creek sites, one at the upper end and one at the lower end (fig 27). Analysis of the results indicated two separate bacteria sources based on mid-segment maximums meeting fecal coliform compliance.



The upper end Reedy Creek site #1 exhibited high peaks of fecal coliforms three out of nine years. Fecal coliform concentrations measured downstream in the two successive sites (RC site 2 & 3) met the Department's criteria except in 2004. Davenport Creek discharges to Reedy Creek between RC site 2 and RC site 3, and the level of coliforms at these sites met the Departments criteria as well. This additional evidence indicates that Davenport Creek did not severely impact the bacteria levels found in Reedy Creek.

The lower end site that showed the highest frequency of fecal coliform peaks was at RC site 7, located at the water control structure S-40. Wildlife sources (large bird rookeries) between RC site 6 & 7 continued to be considered the most probable cause of the coliform peaks measured at RC site 7 as no anthropogenic sources exist in this inaccessible area.

SUPPLEMENTAL SAMPLING

RCID hosted two sampling events to collect supplemental data with Department biologists on February 7 and March 13, 2012 to further investigate the sources of fecal coliforms and to measure the impact of wildlife contributions to the fecal coliform levels found near site #3 (fig 28).

RCID provided access, staff, and boats. During each event, four distinct samples were collected by Department biologists for two certified laboratories (RCID & FDEP) to analyze independently. Sample site distances and intervals varied slightly between the two monthly sampling events.



Fig 28 Map of lower WBID 3170F7 showing water quality monitoring site #3 (red marker) used by the Department to list the WBID as impaired for fecal coliforms. This area was the focus of two joint-sampling events with RCID and Department biologists in February and March, 2012.

The initial joint sampling event occurred on February 7, 2012, performed upstream on Reedy Creek and Bonnet Creek in close proximity to site #3 (red marker), a site used in the initial WBID impairment listing by the Department (Fig 29).

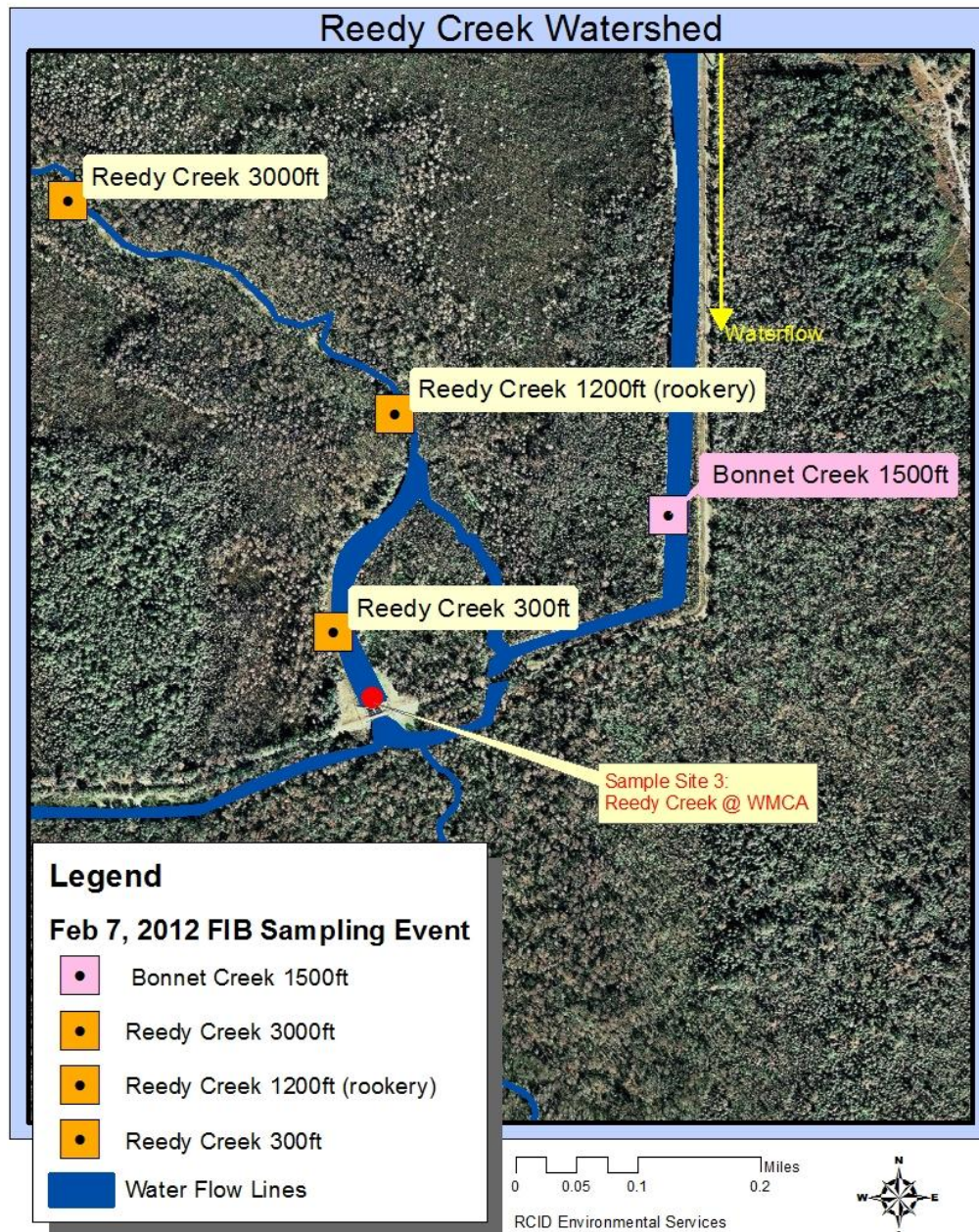
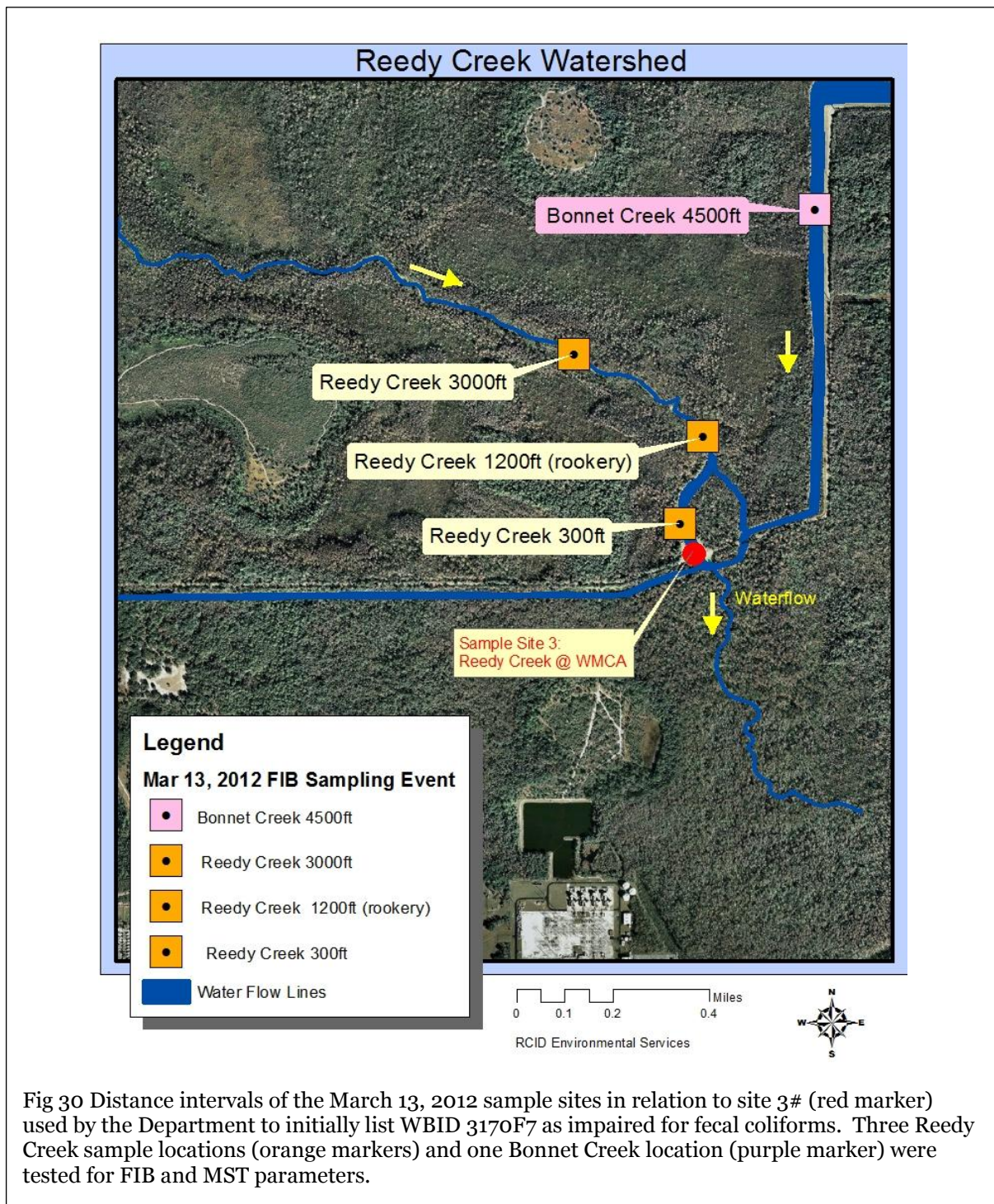


Fig 29 Distance intervals of the February 7, 2012 sample sites in relation to site 3# (red marker), a site used by the Department to initially list WBID 3170F7 as impaired for fecal coliforms. Three Reedy Creek sample locations (orange markers) and one Bonnet Creek location (purple marker) were tested for FIB and MST parameters.

The second sampling event occurred on March 13, 2012, and was conducted at sampling intervals on Reedy Creek shown in fig 30. Due to limited access, the Bonnet Creek site interval was altered an additional 3,000ft upstream.



During both joint sampling events the upstream portions of Reedy Creek (3000ft) and Bonnet Creek (1500ft & 4500ft) met the Department's fecal coliform criteria. Fecal coliform concentrations successively downstream at bird rookeries (1200ft) failed to meet the Department's fecal coliform bacteria criteria. Both sampling events confirmed the 1200ft Reedy Creek site (bird rookery area) as a localized source of elevated fecal coliforms in Reedy Creek.

| Sample Event 1 | | | Sample Event 2 | | |
|---|------|--------------|-----------------------------------|------|--------------|
| 7-Feb-12 | | | 13-Mar-12 | | |
| Bonnet Creek 1500ft | | RCID* FDEP** | Bonnet Creek 4500ft | | RCID* FDEP** |
| Fecal coliform-MPN | 220 | n/a | Fecal coliform-MPN | 13 | n/a |
| E.coli | 220 | 220 | E.coli | 8 | 23 |
| Fecal coliform-MF | 230 | 267 | Fecal coliform-MF | 40 | 21 |
| Enterococci | 130 | 240 | Enterococci | 2400 | 4333 |
| Reedy Creek 3000ft | | RCID* FDEP** | Reedy Creek 3000ft | | RCID* FDEP** |
| Fecal coliform-MPN | 220 | n/a | Fecal coliform-MPN | 110 | n/a |
| E.coli | 220 | 74 | E.coli | 110 | 58 |
| Fecal coliform-MF | 110 | 70 | Fecal coliform-MF | 110 | 87 |
| Enterococci | 170 | 233 | Enterococci | 290 | 250 |
| Reedy Creek 1200ft (Bird Rookery) | | RCID* FDEP** | Reedy Creek 1200ft (Bird Rookery) | | RCID* FDEP** |
| Fecal coliform-MPN | 1100 | n/a | Fecal coliform-MPN | 1100 | n/a |
| E.coli | 1100 | 817 | E.coli | 100 | 1400 |
| Fecal coliform-MF | 1200 | 1117 | Fecal coliform-MF | 2000 | 1433 |
| Enterococci | 410 | 617 | Enterococci | 770 | 1267 |
| Reedy Creek 300ft | | RCID* FDEP** | Reedy Creek 300ft | | RCID* FDEP** |
| Fecal coliform-MPN | 130 | n/a | Fecal coliform-MPN | 800 | n/a |
| E.coli | 130 | 140 | E.coli | 800 | 273 |
| Fecal coliform-MF | 130 | 147 | Fecal coliform-MF | 290 | 270 |
| Enterococci | 130 | 183 | Enterococci | 550 | 410 |
| *RCID methodologies: E. coli-MPN (SM20 9221F), Enterococcus-MPN (ENTEROLERT); Fecal coliform-MPN (SM20 9221E), -MF (SM20 9222 D). | | | | | |
| **FDEP methodologies: E. coli-MF (SM 9213 D), Enterococci-MF (EPA 1600), Fecal coliform-MF (SM 9222 D). | | | | | |

Fig 31 RCID and Department biologist worked jointly to sample bacteria in the Reedy Creek WMCA. High fecal coliform levels were found 1200ft upstream of site 3#, a site used by the Department to originally list WBID 3170F7 as impaired for fecal coliform bacteria. Bonnet Creek and Reedy Creek both showed upstream bacteria levels that met the Department's criteria, once again demonstrating the lack of upstream bacteria sources.

Fecal coliform concentrations downstream of the bird rookery on Reedy Creek (300ft) showed mixed results, with the February results passing the Department's fecal coliform criteria and the March results failing. These results indicated the bird rookery had the ability to occasionally contribute high levels of fecal coliforms to the primary WBID sampling site 3# used to assess WBID 3170F7 on Reedy Creek.

The fact that upstream fecal coliform concentrations met the Department's criteria supported RCID's previous findings. Evidence continues to suggest no upstream anthropogenic sources cause non-compliance of fecal coliform criteria at site #3 in WBID 3170F7 of the Reedy Creek WMCA.

The locations of individual wildlife encountered in the study area were recorded by RCID staff using GPS on several occasions in 2012 (Fig 32). While several species were found in the WMCA that contribute fecal coliform bacteria, migratory birds were found to be the most dominant type. A location map of the individual animals showed larger numbers of wildlife concentrated in the area of Bonnet Creek and Reedy Creek within roughly 3,000 feet upstream of the Department's primary site #3 (red marker) used to list WBID3170F7 as impaired for fecal coliforms.

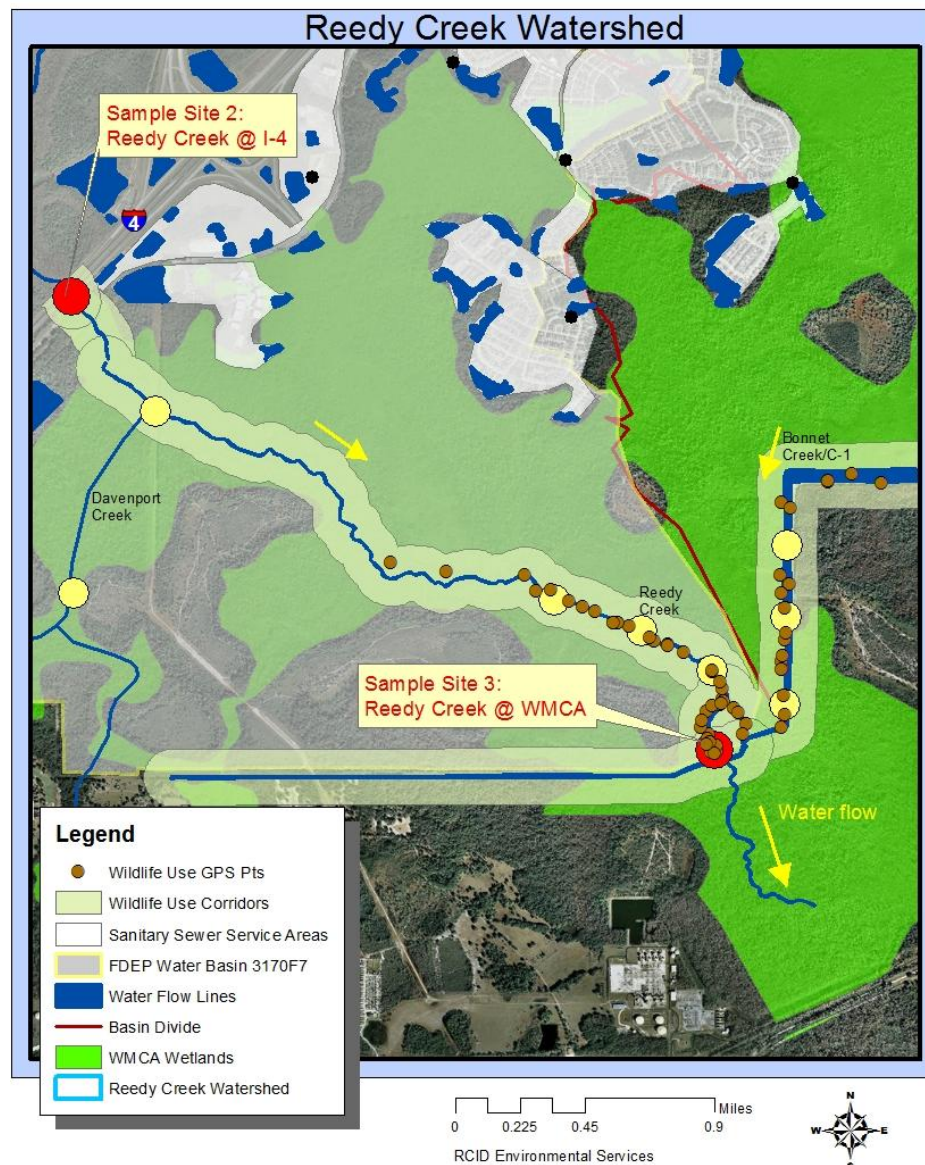


Fig 32 Summary map of individual animals (primarily birds) documented in the Reedy Creek WMCA during sampling events in 2012. Large numbers of birds were found to occupy tree canopies upstream of the primary sampling site #3 (red marker) used by the Department to list WBID3170F7 as impaired for fecal coliform bacteria. Bird populations were considered to be the largest source of fecal coliforms in the WMCA.

Microbial Source Tracking (MST)

Microbial source tracking techniques for detecting potential pathogens in surface waters were based upon fecal coliform bacteria methods. The new science of molecular fingerprinting allows watershed monitoring programs to show detection as well as fecal source identification. The MST process typically required isolation of a suite of markers (*Bacteroides* and *Enterococcus*). Several scientific studies have found cross-reactivity between human-associated *Bacteroides* markers and human-associated *Enterococcus* gene markers originating from wildlife (marsupials, rabbits, etc.). Ruminant-specific (livestock) *Bacteroides* markers have also been found to express some cross-reactivity with other DNA markers.

While the science of isolating markers continued to be developed, analysis for the presence of human markers BacHumUCD and Bacteroidales HF183 remained the most accepted methods by the Department for indicating the presence of anthropogenic waste in the fecal coliform population.

A preliminary MST study was conducted by RCID on a split-water sampling event performed by FDEP on March 13, 2012. RCID's analysis of the sample using the Bacteroidales HF183 marker showed a moderate presence of the human markers in Reedy Creek upstream of the bird roost (Fig 33). Further studies on the environmental duration and fate of these markers needs to be cataloged within the WMCA.

Reedy Creek

Samples collected 3/13/12

| Sample | Conventional PCR | | | qPCR (copies \times 100ml ⁻¹) | |
|----------------------------------|------------------|----------|----------|---|-------------------|
| | GenBac | 16S rRNA | GFD Bird | HF183 | Gull-2 |
| N1 (Reedy Crk Upstream of roost) | + | + | + | 1.0×10^3 | 1.2×10^8 |
| N2 (Bird roost) | + | + | + | 9.6×10^2 | 1.8×10^1 |
| N3 (S40 near RC-14) | + | + | + | Not detected | 8.2 |

Fig 33 Preliminary qPCR analysis of samples taken in Reedy Creek WMCA near a bird roosting site. "HF183" target shows the possible anthropogenic contributions from dead and live cells, whereas "Gull-2" target shows possible avian contributions from dead and live cells.

Legend: S40 (RC-14 or site #3 (red marker)) is water control structure sampled in WBID 3170F7

N1 located 3,000 feet upstream of site #3 on Reedy Creek

N2 located 1200 feet upstream of site #3 at bird roost on Reedy Creek

N3 located 300 feet upstream of site #3 on Reedy Creek

Sanitary, septic, and On-site Treatment and Disposal Systems (OSTDS) were known sources of fecal coliform bacteria listed by the Florida Department of Health (FDOH). Operational wastewater spills and lift-station overflows were listed as bacteria sources in most urban watersheds. Scientific research on markers for wastewater contamination investigations found that sucralose and gadolinium were two important markers of sanitary water that were normally absent in surface waters. Therefore, simple analytical techniques could be used to determine whether wastewater or reclaimed water sources existed in the watershed. By using a ratio between the two components, researchers at the University of Florida Water Institute found that sources could be differentiated between reclaimed and septic-tanks.

RCID conducted a pilot-monitoring program to prescreen for the presence of chemical source tracking (CST) markers sucralose and gadolinium in the surface waters of the Reedy Creek WMCA. Initial GIS watershed research confirmed the presence of reclaimed-water service areas upstream of the WMCA. Since both markers were known to be recalcitrant in their transport fate, it was expected to find such markers in Reedy Creek waters due to the presence of these reclaimed-water service areas (Fig 34).



Fig 34 Sampling in Reedy Creek and Bonnet Creek was conducted on July 31, 2012 to test for the presence of wastewater markers sucralose and gadolinium. Preliminary findings showed a lack of sucralose and a nominal level of gadolinium in the water. These initial results suggest a lack of septic or sanitary sewer contributions to the fecal coliform concentrations found at site 3# (red marker), one of three sites used by the Department to list WBID 3170F7 as impaired for fecal coliforms.

The chemical source tracking sampling event conducted by RCID at three sites on July 31, 2012 found undetectable levels of sucralose and a minor presence of gadolinium in the stream samples (Table 1).

Based on previous CST studies presented by St Johns River Water Management District, RCID's initial findings suggest the lack of urban wastewater contamination associated with the fecal coliform populations measured by the Department at site #3 for WBID 3170F7.

More studies need to be conducted to confirm these initial findings.

CST Sample Event 1

31-Jul-12

| Bonnet Creek (4500ft) | Result | MDL | Method |
|-----------------------|--------|--------|-----------|
| Sucralose (ng/L) | ND | 25,000 | EPA 1694 |
| Gadolinium (µg/L) | 0.056 | 0.028 | EPA 6020A |

| Reedy Creek (4500ft) | Result | MDL | Method |
|----------------------|--------|--------|-----------|
| Sucralose (ng/L) | ND | 25,000 | EPA 1694 |
| Gadolinium (µg/L) | 0.068 | 0.028 | EPA 6020A |

| Reedy Creek (site 3#) | Result | MDL | Method |
|-----------------------|--------|--------|-----------|
| Sucralose (ng/L) | ND | 25,000 | EPA 1694 |
| Gadolinium (µg/L) | 0.06 | 0.028 | EPA 6020A |

ND = No Detection

Table 1 Results of initial chemical source tracking project testing for sucralose and gadolinium in Reedy Creek and Bonnet Creek water samples. Initial findings indicated a lack of septic or sanitary sewer sources contributing to the fecal coliform concentrations measured at site 3#, one of the three primary sampling sites used by the Department to list WBID 3170F7 as impaired for fecal coliforms.

EXISTING REPORT SUMMARIES

Historical water-quality monitoring in WBID 3170F7 of the Reedy Creek WMCA has been conducted at various locations by RCID, Florida Fish and Wildlife Conservation Commission (FFWCC), FDEP, and SFWMD(Fig 35). Statistical reviews of available water quality and fecal coliform data was independently analyzed by two experts contracted by RCID.

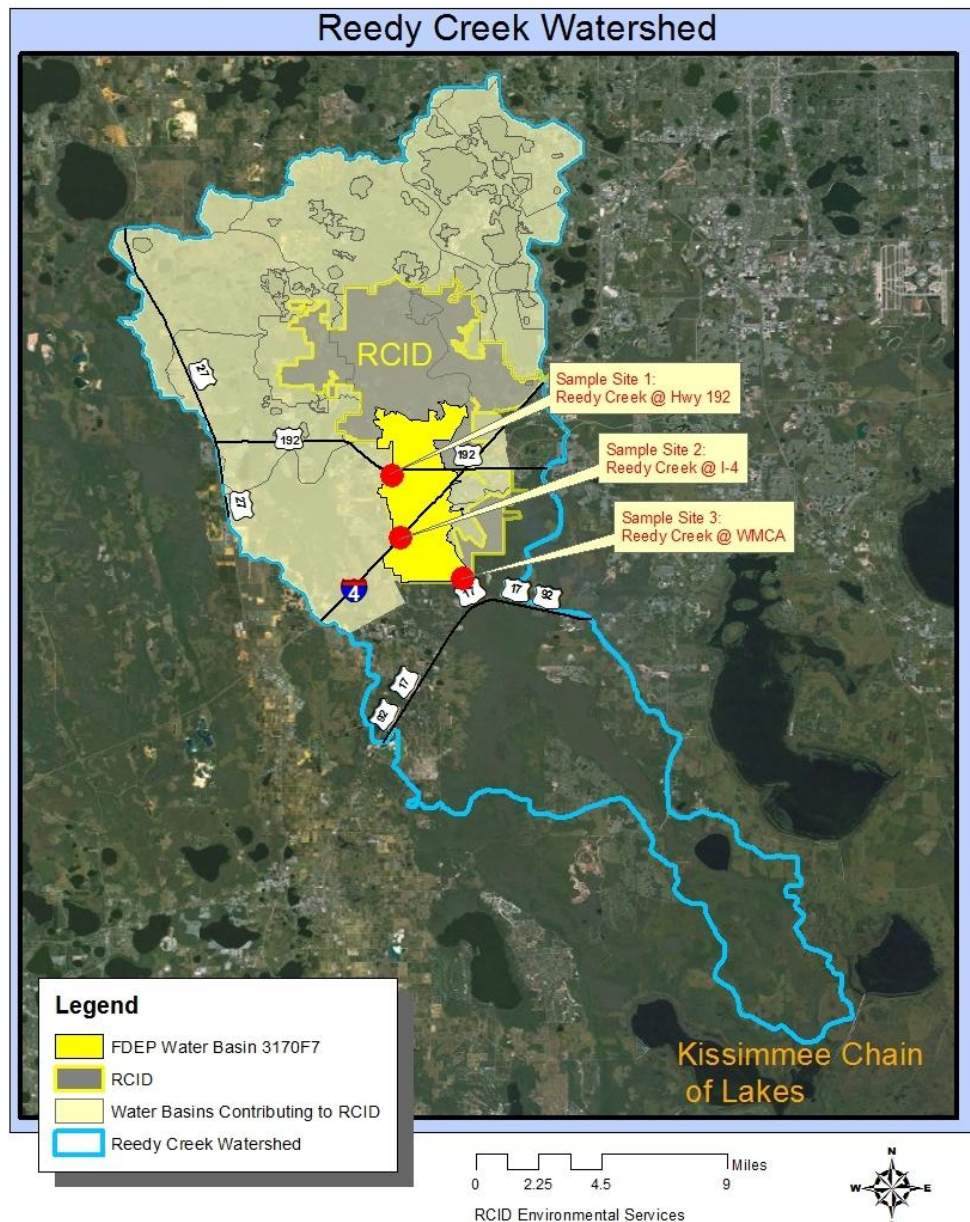


Fig 35 Map of Reedy Creek watershed showing three primary monitoring sites (red markers) used by the Department to list WBID 3170F7 as impaired for fecal coliforms. RCID contracted with two experts to analyze and report on historical water quality trends and to assess current trends.

1) REEDY CREEK (WBID 3170F2/WBID 3170F7) WILDLIFE MANAGEMENT
AREA FECAL COLIFORM STUDY FINDINGS

Dr. Valerie J. Harwood (University of South Florida) examined fecal coliform data from 2010 and 2011 to determine whether or not human-induced activities upstream of site #3 (red marker fig 36) were significantly influencing the fecal coliform population.

RCID conducted bacteria sampling [APHA, 1992] monthly at seven sites within a one-mile radius upstream of Site #3 from April through October 2011. Dr. Harwood evaluated fecal coliform concentrations using an analysis of variance (ANOVA) to determine differences in coliform levels among sample sites, and developed correlations of coliform concentrations with bird counts, stream flow rates, and rainfall prior to sampling.

The study found a negative correlation between fecal coliform concentrations, flow rates, and rainfall, leading to the conclusion that the wet-season rain events did not play a major role in fecal bacteria transportation in the waters upstream of Site #3.

The study was conducted outside the January – March window of historically elevated bacterial levels and only found two samples out of 46 that failed to meet regulatory limits.

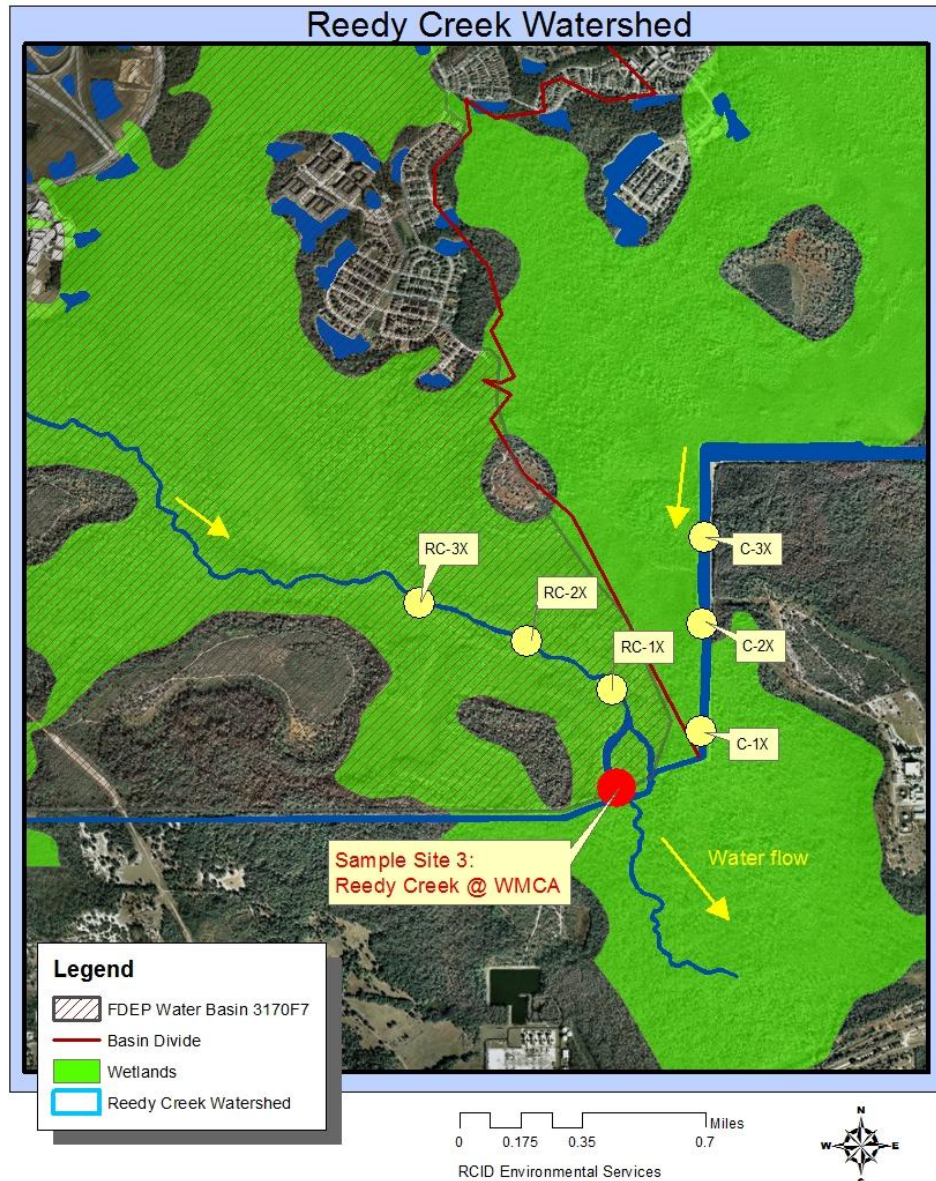


Fig 36 Dr. V Harwood conducted a seven-month study to measure the significance of human-induced activities upon fecal coliform concentrations found at site #3 (red marker), one of the primary sites used by the Department to list WBID 3170F7 as impaired for fecal coliforms.

2) EVALUATION OF FECAL COLIFORM CONCENTRATIONS AND RELATIONSHIPS IN THE REEDY CREEK/ BONNET CREEK CONFLUENCE (WBID 3170F2/ WBID 3170F7)

Dr. H. Harper evaluated the historical water quality characteristics of the Reedy Creek/ Bonnet Creek confluence waters [HARPER, 2010]. Fecal coliform concentration results for site #3 (red marker fig 36) were evaluated for long-term trends from point of record (1977 – 2010). In addition, monitoring results from three new locations (RC-1X, RC-2X, RC-3X) on Reedy Creek upstream of site #3 were evaluated for their contributions to coliform levels measured at site #3.

Dr. Harper characterized the area near site #3 as a shallow, slow moving, forested wetland system of a large magnitude. The area was noted as a designated WMCA.

Dr. Harper concluded that the fecal coliform levels at three upstream sites (RC-1X, RC-2X, RC-3X) did not appear to be an issue. While periodic exceedances of the fecal coliform criteria occurred during the study period, the frequency was a stark contrast to the exceedances observed in the WMCA area at site #3. A statistical relationship of significance (90% confidence interval) was found between the fecal coliform levels at site #3 and bird counts in the vicinity. Dr. Harper found that the lack of any man-induced sources in the WMCA indicated that elevated fecal coliform counts were primarily natural, presumably resulting from birds and other wildlife in the WMCA.

It was noted that the current methodology used to designate surface waters as impaired for fecal coliform bacteria was independent of whether the bacteria originated primarily as a result of human activities. As stated above, Environmental Research & Design found that runoff in natural-area Florida State Parks contained fecal coliform bacteria that exceeded criteria limits in approximately 30% of the samples.

In summary, Dr. Harper found very little evidence to support human-induced activities as the source for the elevated fecal coliform counts observed in the WMCA at site #3 and found substantial evidence to suggest a natural cause for the elevated fecal coliform values.

SOURCE REDUCTION SAMPLING PLAN (SRSP)

A source reduction plan was developed by RCID to identify and address sources of fecal coliforms in the Reedy Creek WMCA portion of WBID 3170F7.

The plan provides the framework for monthly monitoring of fecal indicator bacteria (FIB), microbial source tracking markers (MST), and chemical source tracking markers (CST) to further detect and evaluate any contribution of anthropogenic sources leading to the Reedy Creek WMCA.

If anthropogenic sources are identified, RCID intends to further monitor potential sources to assess the frequency and quantity of contributions to the fecal coliform levels in the Reedy Creek stream. If contributions are found in violation of the Department's criteria, such anthropogenic sources will be brought into compliance using RCID's jurisdictional authority.

The source reduction sampling plan (SRSP) will utilize five established sampling stations (RC-14, RC-1X, RC-2X, RC-3X, and C-1X) as the primary monthly monitoring sites for Reedy Creek (fig 37).

RC-3X represents the furthestmost upstream monitoring site on Reedy Creek. This segment of stream contains comingled waters of Davenport Creek / Reedy Creek before it traverses through the heaviest bird roosting areas of the Reedy Creek WMCA. The site is located deep in the tree canopies of the Reedy Creek WMCA 4500ft upstream of RC-14.

RC-2X is the next sequential downstream site which represents the comingled waters of Davenport Creek / Reedy Creek as it traverses under the heaviest bird roosting areas of the Reedy Creek WMCA. This site is located deep in the tree canopies of Reedy Creek WMCA 3000ft upstream of RC-14.

RC-1X is the next sequential downstream site which represents the comingled waters of Davenport Creek / Reedy Creek after it traverses under the heaviest bird roosting areas of the Reedy Creek WMCA. This site is located deep in the tree canopies of Reedy Creek WMCA 1500ft upstream of RC-14 and above the confluence of Bonnet Creek.

C-1X represents Bonnet Creek before it comingles with Reedy Creek below RC-1X. The C-1X site is located on Bonnet Creek (WBID 3170D2) in a bird rookery area 1500ft upstream of RC-14.

RC-14 represents all comingled waters of Davenport, Bonnet, and Reedy Creeks above the final point of discharge through the S-40 water control structure. This site is also one of the primary sample sites (site #3) used by the Department to assess WBID 3170F7 fecal coliform populations.



| Primary SRSP Monitoring Stations | | | | |
|----------------------------------|--------------------------------------|-----------|----------|-----------|
| RCID Station | Description | TMDL WBID | Latitude | Longitude |
| RC-3X | RC approx. 4500 ft upstream of RC-14 | 3170F7 | 28.2832 | -81.5532 |
| RC-2X | RC approx. 3000 ft upstream of RC-14 | 3170F7 | 28.2816 | -81.5488 |
| RC-1X | RC approx. 1500 ft upstream of RC-14 | 3170F7 | 28.2796 | -81.5452 |
| RC-14 | Reedy Creek above S-40 | 3170F7 | 28.2756 | -81.5451 |
| C-1X | BC approx. 1500 ft upstream of RC-14 | 3170D2 | 28.2779 | -81.5416 |

Fig 37 Five primary sampling sites (orange markers) developed for the source reduction sampling plan (SRSP) to investigate the microbial populations measured in the comingled waters of Davenport Creek, Reedy Creek, and Bonnet Creek. Map shows spatial relationship of the SRSP sites (orange markers) against two of the primary WBID monitoring sites (red markers) initially used by the Department to list WBID 3170F7 as impaired for fecal coliforms.

Should concentrations of fecal coliforms at the primary SRSP sites fail to meet the Department's fecal coliform criteria, further investigative sampling will be conducted at secondary sites outlined in fig 38, or at more localized sites, to be created as needed. Details of the established secondary sites are listed in Appendix A.



Fig 38 Secondary sites (white markers) developed for SRSP to further investigate sources of any bacteria levels found at the primary sites (orange markers) that exceed the Department's criteria. Map displays the spatial relationship of all SRSP sites (orange and white markers) against two of the primary WBID monitoring sites (red markers) initially used by the Department to list WBID 3170F7 as impaired for fecal coliforms.

Monitoring for the primary SRP sites will be conducted monthly for FIB, MST, CST, and physical field parameters as listed in figure 39. Daily measurements of precipitation and stream stage discharge will be gathered from RCID rain gauges and USGS water stage recorders, respectively. Both units are located at water control structure S-40 approximately 100ft from site RC-14.

| Test Group | Parameter | Method/Laboratory |
|--|---|---|
| Fecal Indicator Bacteria (FIB) | Fecal coliform (MPN/100 mL) | SM20 9221E/RCID |
| | Enterococcus (cfu/100mL) | ENTEROLERT/RCID |
| Microbial Source Tracking (MST) | qPCR Assay Target: human marker Bacteroidales HF183 | molecular analysis/ USF Dr. V. Harwood |
| | qPCR Assay Target: human marker pepper mild mottle virus (PMMov) | molecular analysis/ USF Dr. V. Harwood |
| | qPCR Assay Target: bird marker Helicobacter Gull-2 or equivalent | molecular analysis/ USF Dr. V. Harwood |
| Chemical Source Tracking (CST) | Gadolinium (µg/L) | 6020A/Outside Laboratory |
| | Sucralose (ng/L) | 1694/ Outside Laboratory |
| | Optical Brighteners | Fluorescence @250-550nm |
| Weather | Precipitation (inches) | RCID Personal Weather Station/ Onset HOBO datalogger |
| Stream Flow | Stage Discharge (cfs) | USGS Site 02266496 (Reedy Creek below S-40, near Loughman, FL) |
| Physical Field Tests | Water Temperature (°C) | FDEP SOP FT1400/RCID |
| | Dissolved Oxygen (mg/L) | FDEP SOP FT1500/RCID |
| | pH (pH su) | FDEP SOP FT1100/RCID |
| | Specific Conductance (µmhos/cm) | FDEP SOP FT1200/RCID |
| | Turbidity (NTU) | FDEP SOP FT1600/RCID |

Fig 39 Test parameters proposed for the primary monitoring sites of the SRSP in WBID 3170F7.

Based on preliminary studies, stream sediment and aquatic vegetation in the Reedy Creek WMCA have been found to harbor and transport fecal bacteria. RCID will additionally be investigating the duration and sustainability of fecal coliform populations that utilize this media in Reedy Creek.

The RCID SRP will monitor bacteria populations monthly and utilize a results-based, weight of evidence approach to further investigate bacteria populations that fail to meet the Department's fecal coliform criteria (>400 MPN/100mL). Flowcharts in fig 40 outline the process to be used at subsequent monthly sampling events should fecal coliform results be detected in exceedance of the Department's criteria. Since CST and MST parameters are derived from evolving sciences, RCID will work to establish baseline values in the Reedy Creek WMCA and develop more accurate triggers for subsequent sampling years.

Weight of Evidence Flowcharts

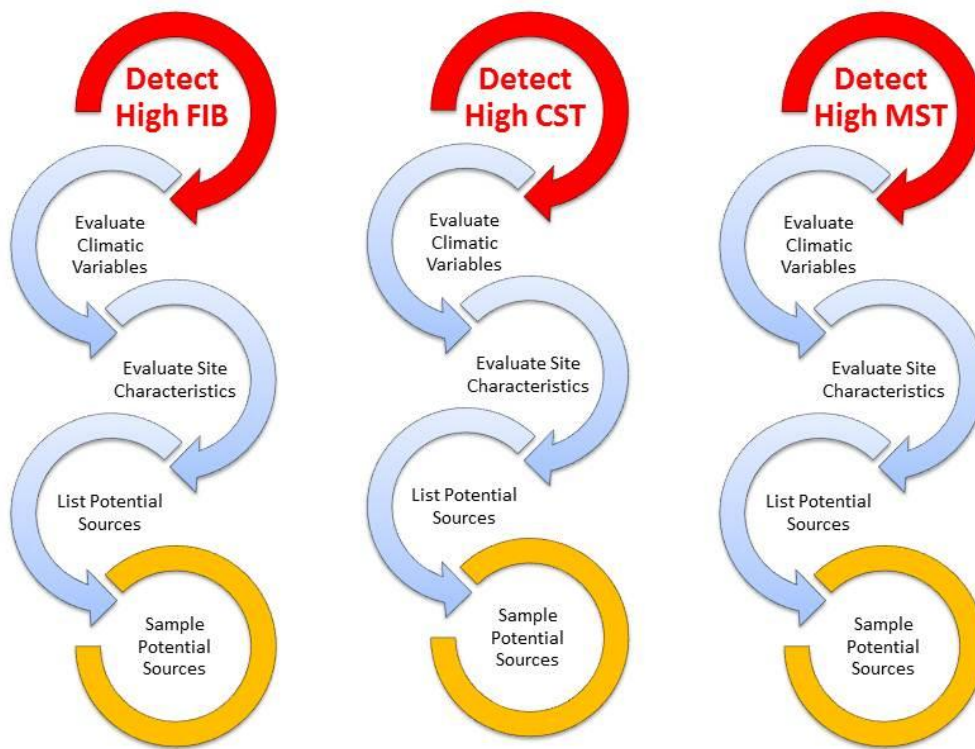


Fig 40. Process for which high FIB levels above the Department's criteria (>400 MPN/100mL) will be used to trigger additional sampling using a weight of evidence approach. CST and MST triggers will coincide with FIB processes until accurate triggers can be established in the WMCA during the initial year of the SRP.

The purpose of the Reedy Creek WMCA Fecal Coliform Bacteria Source Reduction Plan (SRP) is to document the history of the basin's watershed alterations, characterize the basin, identify potential fecal coliform sources, document sampling efforts, and catalog existing data reports and summaries.

The goal of the Source Reduction Sampling Plan (SRSP) is to increase the monitoring frequency for detecting fecal coliform sources and incorporate new and evolving source tracking methods. This effort will be undertaken to better understand the dynamics and contributions of fecal coliforms from wildlife and to assess any anthropogenic sources within the watershed. If anthropogenic sources are identified in the SRSP that fail to meet the Department's fecal coliform criteria, RCID will work to ensure that remediation action is implemented to bring sources into compliance. Sources identified in the SRP that fall outside the jurisdiction of RCID and fail to meet the Department's criteria will be brought to the attention of the Department, or local governmental agency, so that the sources may be addressed.

The SRP weight of evidence approach was designed to be dynamic and evolving, allowing for enhancements and reductions of parameters and sampling sites based on sound science and results. RCID aims to discuss any needed sampling modifications with the Department on a quarterly basis so as to maximize cost, science, and resources. Progress reports will be distributed annually in February to the Department under this plan.

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[APHA, 1992] American Public Health Association. Standard Methods for the Examination of Water and Wastewater. American Water Works Association. Water Environment Federation. 1992.

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APPENDIX A

Watershed sample location list showing station name, WBID, and gps locations.

| Flow Segment | RCID Station | Description | TMDL WBID | Latitude | Longitude |
|--------------|--------------|--|-----------|----------|-----------|
| BC Site 1 | C-12C | C-1 canal south of US 192 at (above) structure S-11 | 3170D2 | 28.3252 | -81.5210 |
| BC Site 2 | C-14 | C-1 canal at 48 | 3170D2 | 28.3099 | -81.5245 |
| BC Site 3 | C-15 | C-1 Canal at last left bend in S-40 Levee | 3170D2 | 28.2886 | -81.5413 |
| BC Site 4 | C-3X | BC approx. 4500 ft upstream of RC-14 | 3170D2 | 28.2859 | -81.5414 |
| BC Site 5 | C-2X | BC approx. 3000 ft upstream of RC-14 | 3170D2 | 28.2823 | -81.5415 |
| BC Site 6 | C-1X | BC approx. 1500 ft upstream of RC-14 | 3170D2 | 28.2779 | -81.5416 |
| DC Site 1 | RC-16 | Davenport Creek at SR 545, east side of bridge (near Loughman) | 3170F7 | 28.2712 | -81.5905 |
| DC Site 2 | RC-16B | Davenport Creek upstream of Reedy Creek confluence | 3170F7 | 28.2835 | -81.5773 |
| RC Site 1 | RC-12 | Reedy Creek north of US 192 intersection | 3170F7 | 28.3318 | -81.5802 |
| RC Site 2 | RC-13 | Reedy Creek southeast of Interstate-4 bridge | 3170F7 | 28.2984 | -81.5775 |
| RC Site 3 | RC-13D | Reedy Creek at Powerline Road SE of I-4 | 3170F7 | 28.2926 | -81.5732 |
| RC Site 4 | RC-3X | RC approx. 4500 ft upstream of RC-14 | 3170F7 | 28.2832 | -81.5532 |
| RC Site 5 | RC-2X | RC approx. 3000 ft upstream of RC-14 | 3170F7 | 28.2816 | -81.5488 |
| RC Site 6 | RC-1X | RC approx. 1500 ft upstream of RC-14 | 3170F7 | 28.2796 | -81.5452 |
| RC Site 7 | RC-14 | Reedy Creek above S-40 | 3170F7 | 28.2756 | -81.5451 |

Watershed sample location list showing segment name, spatial intervals, and distances upstream from site 3#, one of three primary sites used by the Department to list WBID 3170F7 as impaired for fecal coliforms.

| Flow Segment | Distance Downstream (ft) | Distance Upstream of TMDL Sample Site 3 (ft) | Distance Upstream of TMDL Sample Site 3 (miles) |
|--------------|--------------------------|--|---|
| BC site1 | 0 | 27,000 | 5.1 |
| BC site2 | 7,000 | 20,000 | 3.8 |
| BC site3 | 13,000 | 7,000 | 1.3 |
| BC site4 | 1,200 | 5,800 | 1.1 |
| BC site5 | 1,500 | 4,300 | 0.8 |
| BC site6 | 1,500 | 2,800 | 0.5 |
| DC site1 | 0 | 21,600 | 4.1 |
| DC site2 | 6,000 | 15,500 | 2.9 |
| RC site1 | 0 | 28,500 | 5.4 |
| RC site2 | 13,000 | 15,500 | 2.9 |
| RC site3 | 3,000 | 12,500 | 2.4 |
| RC site4 | 8,000 | 4,500 | 0.9 |
| RC site5 | 1,500 | 3,000 | 0.6 |
| RC site6 | 1,500 | 1,500 | 0.3 |
| RC site7 | 0 | 0 | 0 |