FINAL REPORT NOAA Award No. NA03NMF4720358

Initiative II: Assessing and ameliorating neighborhood effects on coastal marine habitats

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Bay Neighbor Project Summary

This collaboration between New College of Florida and the Indian Beach Sapphire Shores neighborhood had five specific goals (objectives):

• *Coordinated student and resident scientific/technical research to better understand neighborhood-bay connections.*

• *Produce a variety of educational materials based in part on neighborhood findings to promote private actions to reduce bay runoff*

• *Educate neighborhood residents regarding findings*

• *Assess neighborhood change*

• *Communicate both the process and results beyond the Neighborhood*

We've had success in reaching all of these goals and the project, now generally referred to as the "Bay Neighbor" project, shows every sign of continuing in various forms. NOAA's support has served as a fulcrum to lever increased neighborhood, city, county and possibly state and national interest in the relationship between coastal neighborhoods and the health of nearby water bodies.

We postulated that developing new information about a specific neighborhood is likely to generate a level of neighbor interest unlikely to result from the distribution of more generic educational materials. We are still testing this, but anecdotal experience confirms this is true. Yoking of neighborhood research with neighborhood educational outreach created a powerful synergy.

The primary research initiatives dealt with stormwater, generally recognized as the next frontier in terms of improving bay water quality. In addition to mapping stormwater from source to bay outfall, we also sought to understand the relationship between tree canopies and runoff and yard practices and runoff water quality.

This research created the basis for outreach and education focused on tapping the experience and insight of neighbors rather than promulgation of information unconnected to the neighborhood. This resulted in a variety of educational endeavors including a workshop, a Bay Neighbor Profile document featuring neighborhood landscaping lessons and a environmental history video of the neighborhood emphasizing the connection to the bay.

Indian Beach Sapphire Shores Neighborhood Context: Why start here?

While proximity to the College was powerful force determining the selection of a neighborhood to work with, we came to realize that the Indian Beach Sapphire Shores Neighborhood appears to pose a special threat to Sarasota Bay.

According the Sarasota Bay Estuary Program's 2006 State of the Bay Report, nitrogen is the principal pollutant in Sarasota Bay. The good news is that the City has reduced nitrogen entering the bay from sewage by 85 percent. That did a lot to improve Whitaker Bayou, the tidal creek that forms our neighborhood's southern boundary.

Unfortunately, according the SBEP, nitrogen loading to the bay remains at roughly twice historic levels. That means we can't get Sarasota Bay back to some semblance of what it was without removing more nitrogen. The dramatic improvements in treating sewage mean stormwater has become the major source of nitrogen reaching the bay - now more than three fifths of the nitrogen comes from stormwater runoff.

That means the actions and inactions of neighbors determine the majority of nitrogen reaching the bay. Several "realities" shape our understanding of the situation: first, no part of our Indian Beach Sapphire Shores Neighborhood is more than a half mile from the bay and many homes are right on the bay. Secondly, IBSS one of the steepest neighborhoods along the bay shorelines of Sarasota County, possibly the steepest. That's great when a hurricane threatens, but the slope speeds stormwater towards Sarasota Bay. Third, IBSS was one of the earlier residential areas developed in the City. That means most of the neighborhood has no real stormwater treatment, with most runoff entering the bay through one of forty-eight piped outfalls we counted.

Thus our particular neighborhood reality is that what runs off our roofs, yards and driveways into the gutters, stormdrains and bay probably gets there faster, with less treatment, than just about any other neighborhood in Sarasota County. In addition, because we are not likely to experience the severe freshwater flooding associated with creeks and other low-lying inland areas, we are not a priority area for stormwater improvements.

It came down to this -- the nitrogen draining through those 48 pipes into the Bay comes from yards, fertilizers, dogs (and some septic tanks). Efforts to ameliorate neighborhood effects on the bay have to start with neighbors. This was (and is) our challenge.

RESEARCH

<u>Objective 1</u>: Coordinated student and resident scientific/technical research to better understand neighborhood-bay connections.

In order to better understand the relationships between neighbors, the neighborhood landscape and the bay, we undertook three initiatives in order to characterize stormwater. NC Alumnus Jason Evans oversaw the stormwater mapping while alumna Amber Roux took responsibility for the tree canopy interception and yard runoff water quality work. This work built on earlier GIS coursework projects by students such as Jenna Smith.

INDIAN BEACH/SAPPHIRE SHORES STORMWATER MAPPING

INTRODUCTION

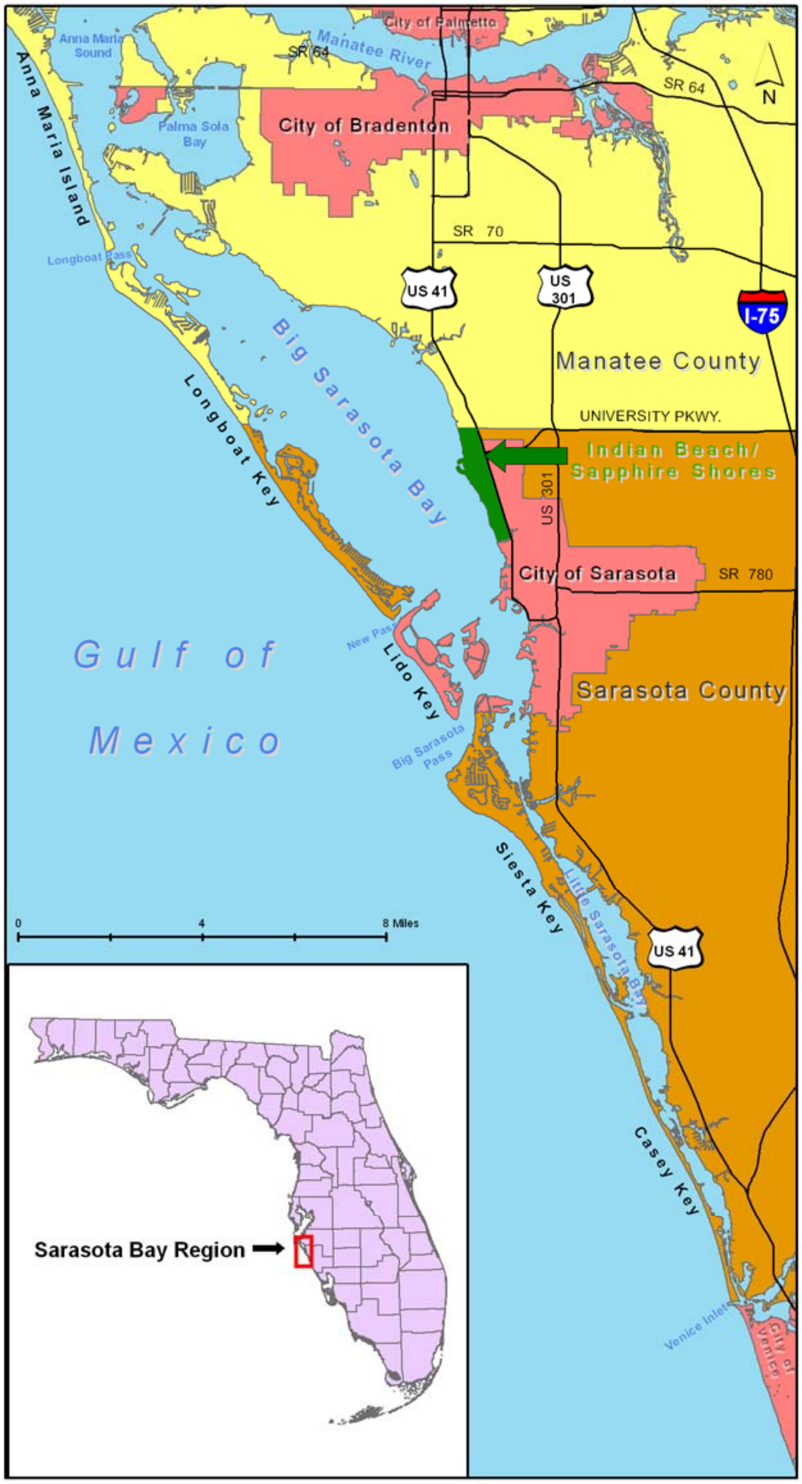
In this project, detailed geographic information system (GIS) databases of the current stormwater infrastructure for the IBSS neighborhood were developed. Non-point pollution from stormwater runoff has been identified as a primary cause of water quality degradation throughout Sarasota Bay (SWFWMD 2002), and areas such as IBSS that lack modern stormwater capture and treatment facilities are thought to pose a comparatively high risk of non-point pollutant loading into the bay. Previously available information about stormwater drainage in IBSS was known to be largely outdated and difficult to utilize for effective planning and outreach purposes. Thus, update of information about IBSS's stormwater infrastructure into an integrated GIS format provides an important new tool for ongoing and future programs that may help to lessen non-point pollutant loading from the neighborhood. All work for this project was made possible by funds provided to New College of Florida from the National Oceanic and Atmospheric Administration (NOAA) through grant award number NA03NMF4720358.

Indian Beach/Sapphire Shores (IBSS) is a historic neighborhood located adjacent to Sarasota Bay and west of US 41 in the northwest corner of the City of Sarasota (Map 2), IBSS is perhaps best known as the home of important cultural institutions such as the John and Mabel Ringling Museum of Art, New College of Florida, Asolo Theater, and Sarasota Jungle Gardens. IBSS is also notable for its many historic homes constructed over several development eras and in a variety of architectural styles. The neighborhood landscape contains remnant stands of native trees such as south Florida slash pine, southern magnolia, pignut hickory, and live oak, which intercept sunlight and rainfall and support native wildlife. Important archaeological sites are also known throughout the neighborhood and provide the origin of the name "Indian Beach." Culture, architecture and habitat aside, the primary defining characteristic of the neighborhood is its relation with Sarasota Bay.

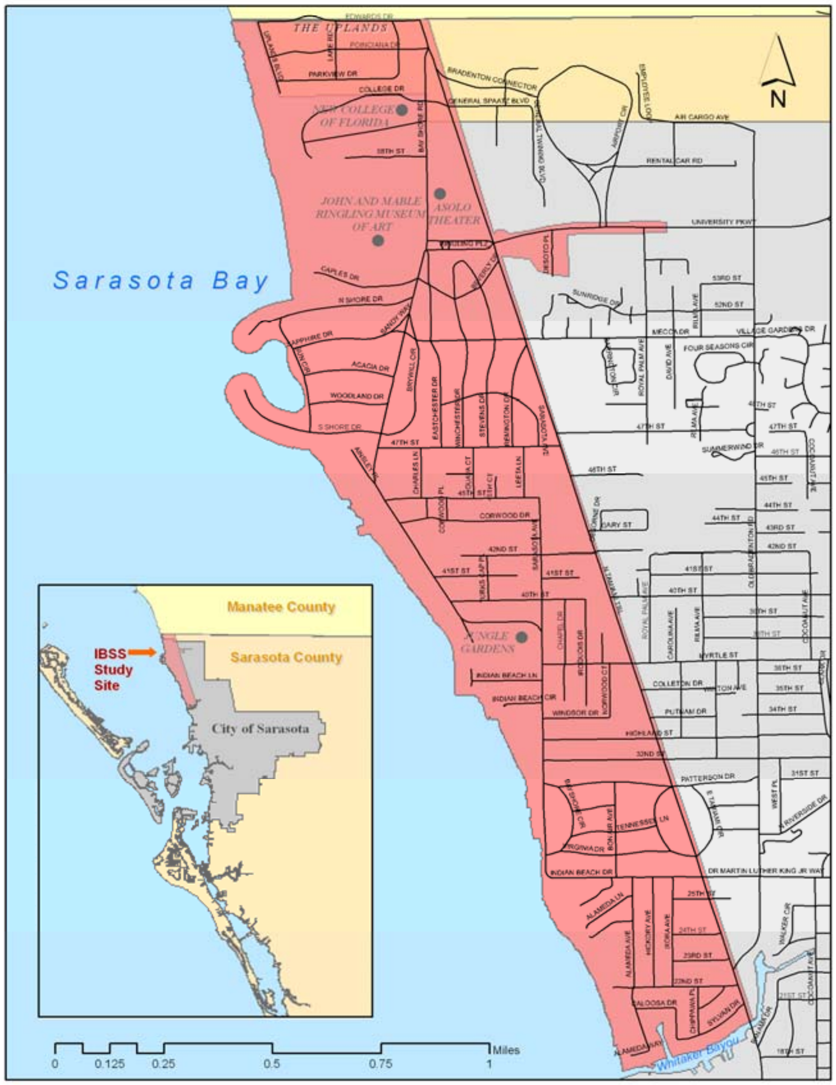
SARASOTA BAY

Sarasota Bay is a subtropical estuary that has been long renowned for its great natural beauty and bountiful marine resources. Separated from the Gulf of Mexico by several narrow barrier islands that encompass 30 miles of coastline from Anna Maria Island to Casey Key, the water body referred to as Sarasota Bay is generally defined as being nautically bounded by Anna Maria Sound and Palma Sola Bay in the north and Venice Inlet in the south (Map 1). Sarasota Bay has an open water area of approximately 52 square miles and a contributing watershed of approximately 150 square miles (SWFWMD 2002). The average depth of the bay is 6 feet, with many shallow bottom areas receiving adequate sunlight through the water column to support rich sea grass communities (SWFWMD 2002).

Map 1: Sarasota Bay Region



Map 2: Indian Beach/Sapphire Shores and Surrounding Areas



Like many other water bodies throughout Florida, the cumulative effects of increased pollutant loading and direct habitat disturbance are known to have caused substantial declines in Sarasota Bay's ecological condition over the past sixty years. In 1987, growing concerns about continuing ecological degradation led to Sarasota Bay being named an estuary of national significance by the United States Environmental Protection Agency (EPA). This federal designation resulted in a number of ecosystem research and recovery programs being implemented through the Sarasota Bay National Estuary Program, which was first formed in 1989 and later renamed as the Sarasota Bay Estuary Program (SBEP). The activities of the SBEP were complemented on a state level in 1995 when the Southwest Florida Water Management District (SWFWMD) designated Sarasota Bay as a priority water body under the auspices of its Surface Water Improvement and Management (SWIM) Program (SWFWMD 2002).

Cooperative actions taken by federal, state, and local governments in support of the SBEP and SWIM Program over the past two decades are known to have resulted in significant pollutant load reductions and habitat improvement within Sarasota Bay (SBEP 2006). For example, loadings of nitrogen, a primary plant nutrient that can feed deleterious algae blooms when present in excess amounts, were reduced by almost 50% in Sarasota Bay from1988 to 1998 (SWFWMD 2002). These reductions in nitrogen loading are thought to be responsible for increased water clarity and associated expansion of sea grass communities observed throughout some areas of the bay (SWFWMD 2002).

NON-POINT POLLUTION: AN OVERVIEW

Virtually all of the water quality improvements that have been achieved in Sarasota Bay over the past two decades can be attributed to reduction of loadings from highly regulated point sources such as wastewater treatment plants (SBEP 2006). Although these point source reductions are an important achievement, better control of non-point pollution loading from stormwater sources will be critical for the maintenance and achievement of additional water quality improvements throughout Sarasota Bay in future years (SBEP 2006; SWFWMD 2002). Slight but steady rises observed in nitrogen loading into Sarasota Bay since 1998 can be almost wholly attributed to increased non-point pollution sources (SBEP 2006).

Unfortunately, pollutant loading from non-point sources is known to be much more difficult to effectively control and mitigate than pollutant loading from regulated point sources. These difficulties are especially acute in a region, such as the Sarasota Bay watershed, that continues to experience rapid population growth and associated development. Modern development practices result in the replacement of native soils and established vegetation that naturally retain and filter significant amounts of rainfall with large areas of “impervious surfaces” such as roads, parking lots, and buildings. Because impervious surfaces do not retain rainfall, the volume of runoff associated with storm events is greatly increased after a given piece of land is developed. Impervious roads, parking lots, and driveways also serve as a primary source of non-point pollutants such as oils, greases, oxidized nitrogen, and heavy metals that are associated with the operation of automobiles (Tomasko et al. 1997). Furthermore, areas that do remain unpaved after development are often converted into lawns and other intensive landscapes typically maintained through the application of chemical herbicides, pesticides, and fertilizer nutrients such as nitrogen and phosphorus. These landscaping chemicals are often captured within stormwater runoff and loaded into nearby water bodies as non-point pollution.

Modern stormwater capture and treatment systems can partially mitigate the effects of non-point pollutant loading from newer developments. For example, a typical stormwater retention pond is designed to retain most metals, greases, and oils contained in runoff, while also reducing the amount of nitrogen that would otherwise be loaded into receiving water bodies by up to 44% (SPEB 2006). Recently developed stormwater treatment system designs and improved maintenance techniques for existing retention ponds have the potential to result in even larger load reductions of nitrogen and other typical contaminants found in runoff from developed areas (SBEP 2006). Outreach and education programs that result in decreased and appropriately timed application of landscaping chemicals are also thought to be an important tool for reducing non-point pollution.

Because the drainage infrastructure in IBSS was constructed before the advent of modern stormwater capture and treatment regulations, there is concern that the non-point pollution risks posed by neighborhood yards and roads may be higher than in more recently developed areas. Rather than entering into retention ponds or other treatment infrastructure, runoff throughout most of IBSS is drained from street inlets into underground pipe conveyance systems that directly discharge into Sarasota Bay. This drainage system can be expected to capture or treat very little of the runoff that enters into inlets, meaning that any contaminants that enter into the stormwater pipe system will be loaded directly into Sarasota Bay as non-point pollution.

Due to the high expense and other difficulties that would be associated with major infrastructural retrofits for stormwater treatment purposes in IBSS, outreach programs that educate residents about the direct connections their neighborhood has with Sarasota Bay and actions that they can take to help improve the bay’s water quality are likely to serve as the primary strategy for reducing non-point pollutant loading. It is expected that this project’s integration and update of knowledge about IBSS stormwater infrastructure into a GIS format can serve as an important tool for facilitating such outreach programs, while also assisting in efforts to more effectively measure the effects of these outreach programs on neighborhood landscaping practices and Sarasota Bay’s water quality over time.

MATERIALS AND METHODS

MATERIALS

The primary workspace for creating and analyzing spatial data about IBSS stormwater infrastructure was ESRI’s ArcGIS/ArcView 9 with Spatial Analyst and ArcHydro extensions. In addition, a Trimble GeoXT Global Positioning System (GPS) receiver with Trimble TerraSync was used to collect spatial locations and record field measurements of various stormwater features throughout IBSS. Trimble Pathfinder Office 3.00 provided the platform for upload and correction of GPS field data, and was also utilized to transform collected GPS data into ArcView’s native shapefile format.

Collection of extant GIS files relevant to stormwater drainage in IBSS was an initial work step undertaken for this project (Flowchart 1). GPS field data collected by NCF students from 2003 – 2005 on IBSS stormwater inlets, IBSS stormwater outfalls into Sarasota Bay, IBSS street curb locations, stormwater inlets in NCF West Campus, stormwater outfalls into Sarasota Bay from NCF West Campus, and retention areas in the NCF West Campus were obtained from NCF Environmental Studies. Soil type and watershed boundaries for Sarasota County were downloaded from the Florida Geographic Data Library website (www.fgdl.org). Sarasota County water bodies, streets, property boundaries, and regional coastline boundaries were downloaded from Sarasota County Government's GIS website (gis.co.sarasota.fl.us). GIS files with elevation contours delineated at 1 ft. intervals by SWFWMD in 2004 and partial coverage of IBSS stormwater pipes, stormwater inlets, bay outfalls, and surface drainage were obtained by compact disc from Sarasota County Stormwater Utility. A digital aerial photograph taken in February 2004 with 2 ft. pixel resolution was also obtained from Sarasota County Stormwater Utility. These files were uploaded into a new data file in the ArcMap program of Arc GIS 9. Files from NCF Environmental Studies and the Florida Geographic Data Library were transformed into the Transverse Mercator Florida State Plane projected coordinate system utilized by Sarasota County. All extant GIS files used in this project are summarized in Table 1.

Another initial project work step was collection of print maps and surveys containing additional information about IBSS stormwater infrastructure (Flowchart 1). Print maps with archival information of stormwater pipe extents for the IBSS neighborhood were obtained from the City of Sarasota's Engineering Department. A topographic survey with stormwater infrastructure throughout the NCF campus and detailed topographic surveys with stormwater infrastructure for the University Parkway corridor were both obtained from NCF Physical Plant. An infrastructural survey of the John and Mable Ringling Museum of Art containing stormwater pipe and inlet information was obtained from the Lawson Group, Inc. A summary of these print data sources is contained in Table 2.

PRELIMINARY DATA EXAMINATION AND SHAPEFILE CREATION

The next work step was examination and comparison of gathered GIS files and print source information (Flowchart 1). Detailed notes about clear gaps in digital files, conflicts among data sources, and other data needs were taken. This data examination process confirmed that existing GIS files lacked much of the stormwater infrastructure information found in the print sources. A polyline shapefile for stormwater pipe extents, polygon shapefile for surface drainage features, a point shapefile for stormwater outfalls, and a point shapefile for stormwater inlets were then created in ArcMap for the purpose of digitizing information contained within the print sources. A polygon shapefile for neighborhood boundary delineation was also created. Initial boundaries were drawn using the Sarasota/Manatee county line in the north, US 41 to the east, Sarasota Bay to the west, and Whitaker Bayou to the south. This boundary was later amended to include areas of the University Parkway corridor east of US 41 that drain into Sarasota Bay (see Map 2). The Transverse Mercator Florida State Plane coordinate system used by Sarasota County was imported as the spatial reference for all files. Table 3 contains a summary description of these files in their completed form.

GPS DATA COLLECTION

Collection of spatial coordinates for stormwater inlets, bay outfalls surface ditches, and retention ponds using the Trimble GeoXT GPS receiver was then undertaken throughout IBSS (Flowchart 1). Data collection efforts were concentrated on areas in which this information was known to be absent from existing GIS files, although some field data were also collected in areas with existing coverage for positional and attribute comparison purposes. Field attributes including drainage inlet structure type, bearing of visible pipes, construction material of visible pipes, shape of visible pipes, and miscellaneous comments about inlet and pipe condition were recorded for inlet points. Construction material, measured dimensions, and shape of pipe outfalls were recorded for outfall points. In addition, digital photographs were taken of all stormwater pipe outfalls into Sarasota Bay and Whitaker Bayou.

Upon completion of field data collection, files from the GPS receiver were transferred onto a computer hard drive and post-processed with the Pathfinder Office program (Flowchart 1). Differential correction post-processing was utilized for the purpose of improving positional accuracy (see Chivers 2003), with the continuously operating reference station (CORS) at Mac Dill Air Force Base in Tampa serving as the base point for the differential correction procedure. Differentially corrected data files were then exported from Pathfinder Office in shapefile form and loaded into ArcMap.

FILE INTEGRATION AND DIGITIZATION

Extant point shapefiles and newly collected GPS data shapefiles of stormwater inlets were next appended into one master file. Overlapping point features from NCF and Sarasota County GIS files were identified through 10 ft. buffer searches. Points from the Sarasota County files were used preferentially to resolve these initial data conflicts. Outlets from surface drainage features into stormwater pipes were defined as inlets and are contained in the master inlet file. An additional point shapefile of outfalls from pipes into surface drainage features other than Sarasota Bay and Whitaker Bayou (e.g., ditch, retention ponds, and swales) was also created. GPS data supplemented by print survey information were used as source for spatial and attribute information for outfalls into surface drainage features. Due to a number of identified conflicts, data errors, and omissions among existing bay outfall shapefiles, newly collected GPS data were used as the primary source for spatial and attribute information in the final bay outfall shapefile. Invert elevation data contained in print sources were manually entered into the attribute table for appropriate inlet and outlet features. Attribute tables were integrated and simplified for all shapefiles after performance of the append operation. Table 3 contains a summary of the inlet, bay outfall, and pipe outfall to surface drainage shapefiles with methods used.

The master inlet file and outfall files were then used to manually digitize stormwater pipe extents and attribute information for the IBSS neighborhood in the ArcMap program of ArcGIS 9 (Flowchart 1; Table 3). Extant GIS shapefiles of stormwater infrastructure and GPS point shapefiles of stormwater inlets were used as snapping points for the manual

Flowchart 1: Data Assembly and Construction

Table 1: Extant GIS Sources for IBSS Stormwater Infrastructure

File Name	Description	Source	Date Created
IBSS_infalls.shp	Point shapefile of stormwater inlets in IBSS	NCF Environmental Studies	2004
IBSS_outfalls.shp	Point shapefile of stormwater outfalls into Sarasota Bay in IBSS	NCF Environmental Studies	2004
IBSS_Curbs.shp	Polyline shapefile of curb data in IBSS	NCF Environmental Studies	2005
NCFW_Inlets.shp	Point shapefile of stormwater inlets in New College West Campus	NCF Environmental Studies	2005
NCFW_Outfalls.shp	Point shapefile of stormwater outfalls in New College West Campus	NCF Environmental Studies	2005
NCFW_Retention.shp	Polygon shapefile of stormwater retention areas in New College West Campus	NCF Environmental Studies	2005
ssoils58.shp	Polygon shapefile of soil types for Sarasota County	Florida Geographic Data Library (www.fgdl.org)	1990
basins58.shp	Polygon shapefile of watershed basins for Sarasota County	Florida Geographic Data Library (www.fgdl.org)	1998
WATERFEATURES.shp	Polygon shapefile of water features in Sarasota County	Sarasota County GIS (gis.co.sarasota.fl.us)	Unknown
STREETS.shp	Polyline shapefile of streets in Sarasota County	Sarasota County GIS (gis.co.sarasota.fl.us)	Unknown
PARCELS.shp	Polygon shapefile of property parcels in Sarasota County	Sarasota County GIS (gis.co.sarasota.fl.us)	Unknown
REGIONAL_ BOUNDARIES.shp	Polygon shapefile with detailed coastline, county, and city boundaries of Sarasota Bay region	Sarasota County GIS (gis.co.sarasota.fl.us)	Unknown
contours.shp	Polyline shapefile of 1 ft. contours for Sarasota County	SWFWMD (Obtained from Sarasota County Stormwater Utility)	2004
DrainagePipes2001PNT.shp	Point shapefile of stormwater drainage pipes and outfalls in IBSS	Sarasota County Stormwater Utility	2001
DrainagePipeline2001.shp	Polyline shapefile of stormwater drainage pipes in IBSS	Sarasota County Stormwater Utility	2001
DrainagePipeline2002.shp	Polyline shapefile of stormwater drainage pipes in IBSS	Sarasota County Stormwater Utility	2002
DrainageInlets2001.shp	Point shapefile of stormwater inlets in IBSS and other areas	Sarasota County Stormwater Utility	2001
DrainageInlets2002.shp	Point shapefile of stormwater inlets in IBSS and other areas	Sarasota County Stormwater Utility	2002
DrainageResidentialDitch2002.shp	Polyline shapefile of surface drainage in IBSS and other areas	Sarasota County Stormwater Utility	2002
DrainageOpenDitch2002.shp	Polyline shapefile of surface drainage in IBSS and other areas	Sarasota County Stormwater Utility	2002
aerial2004_color2ft.tif	Georeferenced TIFF aerial photo of IBSS and surrounding areas	Sarasota County Stormwater Utility	2004

Table 2: Print Sources for IBSS Stormwater Infrastructure

Print Map Name	Description	Project Contribution	Source	Date Created
City of Sarasota Drainage Atlas	Drainage and parcel blueprints, scaled at 1 in = 100 ft	Digitization of pipe extent and pipe size information in IBSS neighborhood	City of Sarasota Engineering Department	1955, 1970
Boundary and Topographic Survey of Leased Lands for the University of South Florida Sarasota Campus	Topographic survey with existing sanitary sewer and water distribution, scaled at 1 in = 150 ft	Digitization of pipe extent, pipe size, and inlet invert elevation information for New College of Florida West and Caples campuses	Mosby Engineering Associates, Inc. (obtained from New College of Florida Physical Plant)	1995
Desoto Rd. Survey, Project Number 8606	Detailed blueprints and topographic surveys for Desoto Rd. (University Pkwy.) widening and expansion, multiple scales	Digitization of pipe extent, pipe size, and inlet invert elevation information for University Parkway corridor	Post, Buckley, Schuh, and Jernigan, Inc. (obtained from New College of Florida Physical Plant)	1988, 1989
John and Mable Ringling Museum of Art Site Plan North	Topographic survey and infrastructural site plan for Ringling Museum of Art property, scaled at 1 in = 60 ft	Digitization of pipe extent, pipe size, and inlet invert elevation for Ringling property	Lawson Group, Inc.	2002

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digitization operation. A protractor was used to measure pipe intersection angles and a ruler was used to measure pipe extents on print surveys. These measurements were cross referenced with angle and distance measures displayed during the digitization operation in ArcMap to ensure correct matching of print survey information with spatial data contained in the GIS files. Distance anomalies between inlets that were measured to be over 10 ft. from survey measures were flagged for collection of GPS groundtruthing data. These GPS groundtruthing data files were uploaded into ArcMap through the method described above and used as the spatial control point reference for all noted anomalies. Upon completion of the manual digitization process, existing stormwater pipe shapefiles were then appended into the final stormwater pipe shapefile. The attribute table was integrated and simplified for this file after performance of the append operation. Table 3 contains a summary of this stormwater pipe shapefile and methods used.

Integration of information about surface drainage in IBSS into one polygon shapefile was the next data assembly step. Linear ditch drainage features in existing shapefiles were assumed to have an average diameter of 6 ft., transformed into polygon features using a 3 ft. buffer operation, and appended as polygon features into the surface drainage shapefile. Polygon features such as surface streams, ponds, and retention areas contained in extant GIS files and collected GPS data were appended directly into the new surface drainage shapefile. The attribute table for this shapefile was integrated and simplified after performance of the append operation. Table 3 contains a summary of this surface drainage shapefile and methods used.

Polygon shapefiles for manual digitization of tree canopy and impervious surface areas in IBSS were then created in ArcMap and spatially referenced using the Transverse Mercator Florida State Plane projected coordinate system. Tree canopy and impervious building, parking lot, sidewalk, and driveway polygons were manually digitized by visual inspection from the 2 ft. resolution aerial photograph described in Table 1. Impervious road surface polygons were first created through performance of a 10 ft. buffer operation on polyline street features, and then corrected as necessary for better visual fit with street extents represented in the aerial photograph. Although such manual digitization methods are known to be inherently time-consuming and prone to subjective operator judgments, the high cost of advanced image processing software and general accuracy (>90%) of manual digitization at the spatial scale of this project indicate that this was the appropriate method (see Rogers et al. 2004). Descriptions of the canopy and impervious surface shapefiles and methods used are contained in Table 3. Raster files with 5 ft. pixel size were later created from both the canopy and impervious surface shapefiles for use in Spatial Analyst calculations (Flowchart 2).

The final data assembly procedure performed for this project was delineation of stormwater basin boundaries (Flowchart 2). The first step in basin delineation was interpolation of polyline contours into a continuous raster elevation surface. A raster flow direction model was then created from the continuous raster elevation surface. This flow direction model was next used as the basis for creating raster basin and sink models. The raster basin model was converted into a polygon shapefile with smoothed edge, and then clipped by the neighborhood boundary. The raster sink model was converted into a point shapefile. Stormwater infrastructure data were then used in conjunction with sink points to manually modify the drainage basin model according to hydrologic behavior caused by surface drainage features not noted in elevation contours.

Three types of stormwater basins were identified in IBSS: pipe outfalls to Sarasota Bay or Whitaker Bayou, coastal sheet flow into Sarasota Bay or Whitaker Bayou, and surface water “sub-basins” for retention features. The stormwater basin file contains delineation of pipe outfall basins without separate sub-basin polygons. The stormwater sub-basin file contains sub-basins as distinct polygons. Canopy and impervious acreage and percentage coverage for all basins and sub-basins were calculated in Spatial Analyst using data from canopy and impervious surface raster files (Flowchart 2). The detailed procedures used to delineate stormwater basins and calculate attribute data are shown in Flowchart 2 and summarized in Table 3.

METADATA DOCUMENTATION

Metadata documentation was added into each file through the ArcCatalog program of ArcGIS 9 (Flowchart 2). Federal Geographic Data Committee (FGDC) standards for metadata were used for all files. These metadata contain detailed information about shapefile purpose, content, author, institutional funding, contact information, creation date, methods, attributes, and reference documents. Metadata also describe public access information and contain suggested time tables for shapefile update.

Flowchart 2: Basin Delineation and Attribute Calculation

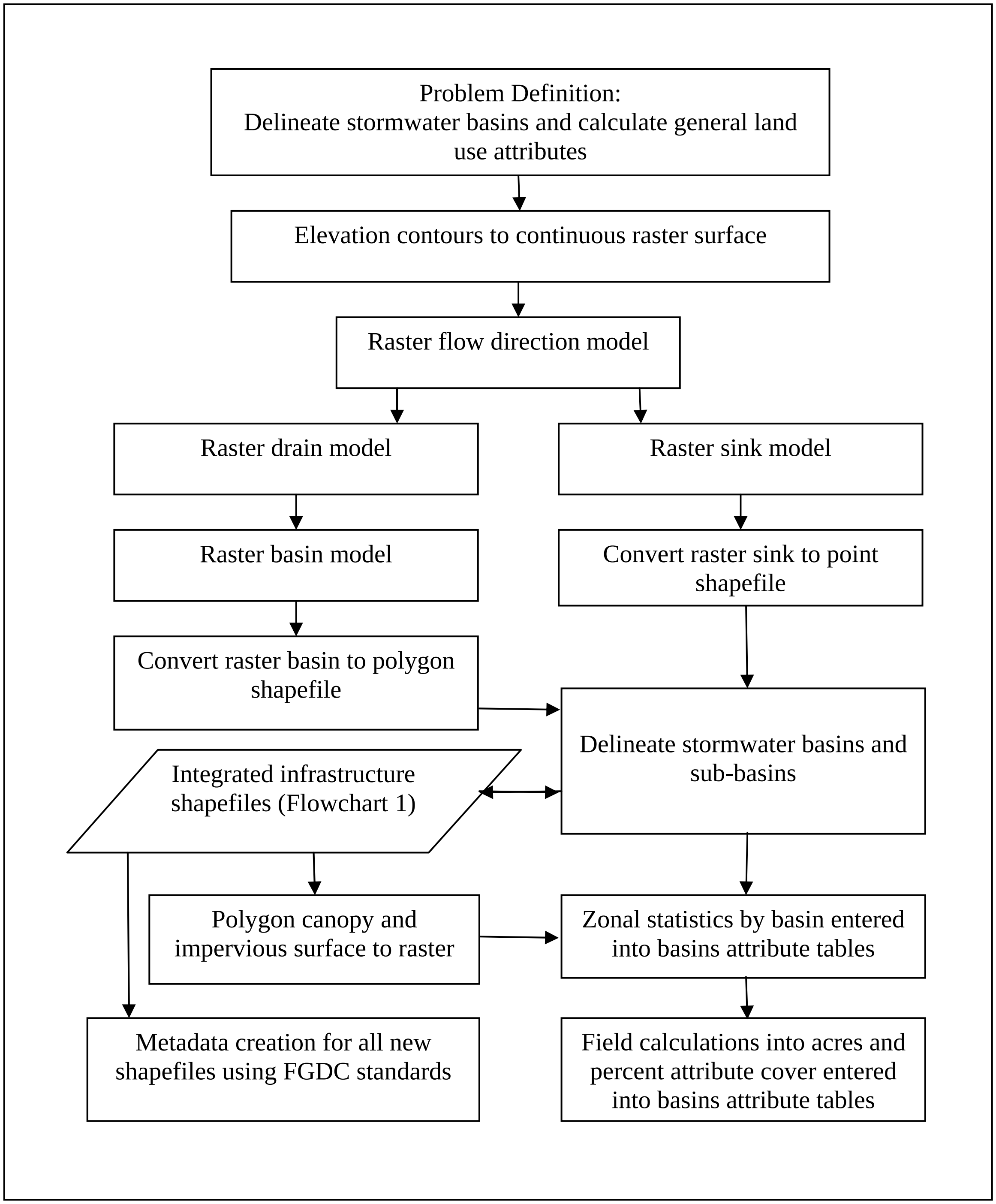


Table 3: IBSS Stormwater GIS Files

File Name	File Description	Methods Summary
IBSS_Boundary.shp	Polygon shapefile of IBSS boundary	Northern boundary manually snapped to county line (REGIONAL_BOUNDARIES.shp). Eastern boundary manually snapped to US 41 (STREETS.shp). Southern and western boundaries loosely drawn outside boundary and clipped by detailed coastline (REGIONAL_BOUNDARIES.shp). Eastern boundary later amended to include University Parkway corridor that discharges into Sarasota Bay.
IBSS_Curb_Gutter.shp	Polyline shapefile of IBSS curbs and gutters	Original NCF file groundtruthed and attribute table added.
IBSS_StormPipes.shp	Polyline shapefile of IBSS stormwater pipes	Spatial and attribute information from print sources manually digitized. GPS inlet and outlet data and existing GIS files (IBSS_infalls.shp; IBSS_outfalls.shp; DrainagePipes2001PNT.shp; DrainagePipeline2001.shp; DrainagePipeline2002.shp; DrainageInlets2002.shp; DrainageInlets2001.shp; NCFW_Inlets.shp; NCFW_Outfalls.shp) used as snapping points. Protractor angles and ruler measures of survey features used as cross reference to ensure positional accuracy. Additional GPS points collected to resolve measurement anomalies. Existing GIS pipe shapefiles appended into final shapefile. Attribute table integrated and simplified to contain pipe size, material, shape, and comments.
IBSS_Inlets.shp	Point shapefile of IBSS stormwater inlets	Append existing files (IBSS_infalls.shp; DrainageInlets2002.shp; DrainageInlets2001.shp; NCFW_Inlets.shp) and GPS data into one master file. Overlapping point features identified through 10 ft. buffer searches. Sarasota County points used preferentially to resolve overlaps. Invert data from print sources manually entered into attribute table for appropriate features.
IBSS_BayOutfalls.shp	Point shapefile of IBSS stormwater pipe to bay outfalls	GPS data used for spatial location and attribute information at outfall points.
IBSS_Pipe_Outflow.shp	Point shapefile of pipe outflows into IBSS surface drainage features	GPS data used for spatial locations. Print surveys and GPS data used for attribute information.
IBSS_SurfaceWater.shp	Polygon shapefile of IBSS surface drainage features, including retention ponds, culverts, and ditches.	Existing polyline shapefiles (DrainageResidentialDitch2002.shp; DrainageOpenDitch2002.shp) transformed into polygon through 3 ft. buffer operation and appended into file. Extant drainage feature polygons (WATERFEATURES.shp) for IBSS selected and appended into file. GPS data appended into file. Attribute data integrated and table simplified.
IBSS_Impervious.shp	Polygon shapefile of IBSS impervious surface	Street polyline features (STREETS.shp) for IBSS converted into polygon through 10 ft. buffer. Buildings, houses, and parking lots manually digitized from aerial photograph (aerial2004_color2ft.tif).
IBSS_Canopy.shp	Polygon shapefile of IBSS canopy	Canopy features manually digitized from aerial photograph (aerial2004_color2ft.tif)
IBSS_StormBasins.shp IBSS_Subbasins.shp	Polygon shapefile of IBSS stormwater basins	Polyline contours (contours.shp) interpolated into continuous raster surface. Raster flow direction model run from raster elevation surface. Raster basin and sink models run from flow direction model. Raster basin model converted into polygon shapefile (BasinModel.shp) and clipped by neighborhood boundary. Raster sink model converted into point shapefile. Stormwater infrastructure data (IBSS_Inlets.shp; IBSS_Outfalls.shp; IBSS_Surface_Drain.shp; IBSS_Curbs; IBSS_Impervious) used in conjunction with sink points to manually modify drainage model. Surface sub-basins within pipe outfall basins delineated in sub-basins file (IBSS_Subbasins.shp). Files clipped by

		neighborhood boundary. Raster models of canopy and impervious surface used to calculate canopy and impervious area by delineated basins.

ANALYSIS

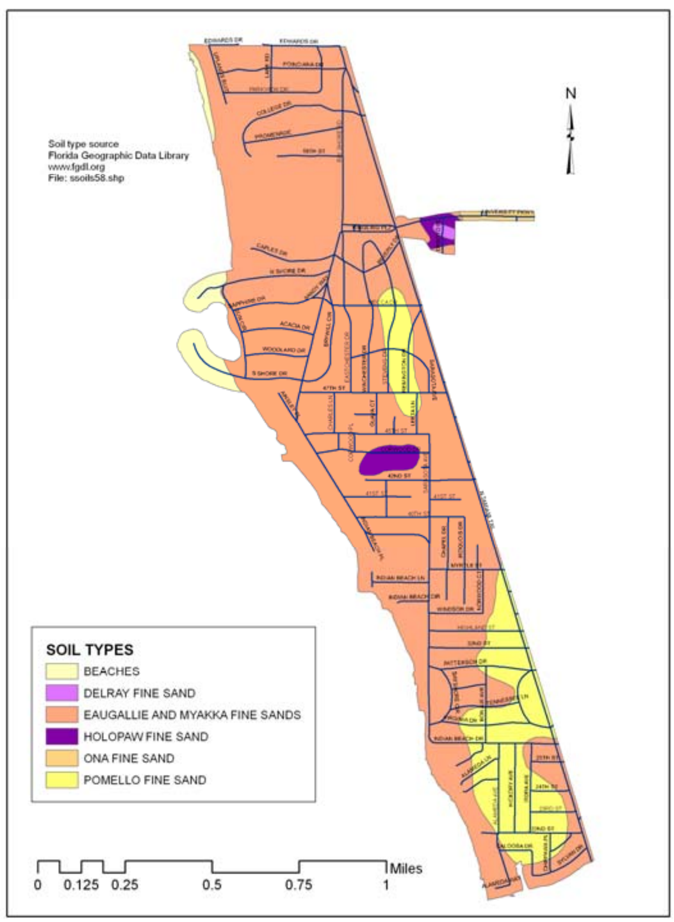
LAND AREA

Based upon the boundaries used in this project (see Map 2), the total land area of the IBSS study site is approximately 722 acres. This area is approximately 50 acres larger than the official boundaries of the IBSS neighborhood due to the inclusion of 36 acres contained within the Sarasota County portions of the Uplands neighborhood located directly north of the NCF west campus and 14 acres of the University Parkway corridor that are located east of US 41. The Uplands neighborhood was included from the outset in this study due to its geographic and hydrologic contiguity with the IBSS neighborhood. The University Parkway corridor was added into the study site after it was determined that this area is drained through stormwater infrastructure that discharges directly into Sarasota Bay within the IBSS boundary. No other area east of US 41 appears to have any direct hydrologic connection with stormwater pipe outfalls to Sarasota Bay located in IBSS. Some areas east of US 41 do drain into a stormwater pipe that discharges directly into Whitaker Bayou at the US 41 bridge.

SOILS

Like most coastal areas in Florida, the soils in IBSS are composed almost entirely of fine, marine-originated sands. Six major soil types are found within the study site boundary: EauGallie and Myakka fine sands, Pomello fine sand, Holopaw fine sand, Delray fine sand, Ona fine sand, and coastal beach sand.

Map 3: IBSS Soil Map



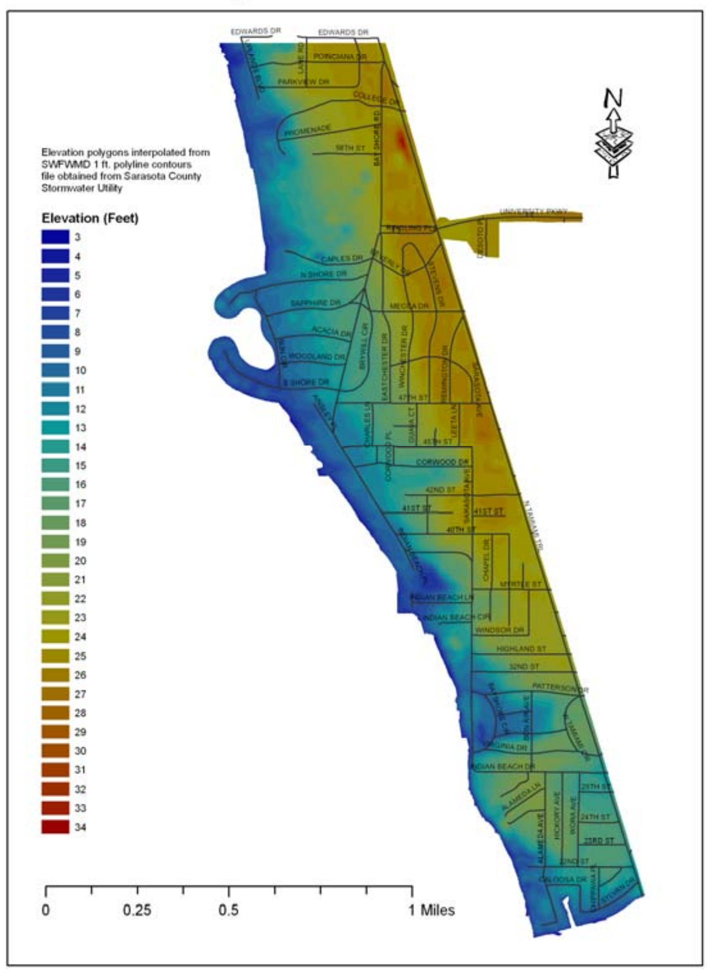
The dominant soil type throughout most of IBSS is undifferentiated EauGallie and Myakka fine sands, which are found on approximately 583 acres (81% of land area). EauGallie and Myakka are poorly drained soils that generally have high water tables (NRCS 2006). These soils are typically associated with Florida's pine flatwood vegetation community. The next most common soil type in IBSS is Pomello fine sand, which is found on approximately 100 acres (14% of land area). Pomello fine sand is generally associated with elevation ridges in pine flatwoods communities and tends to be somewhat better drained than the EauGallie and Myakka sands (NRCS 2006).

Other soil types occupy small percentages of IBSS land area. Coastal beach sands are located on approximately 18 acres (3% of land area) adjacent to Sarasota Bay, with most of this acreage associated with bay bottom fill deposited to create new land area for home development. Holopaw fine sands, located on approximately 11 acres (1.5% of land area), are poorly drained soils typically found in lowland depression and marginal wetland areas (NRCS 2006). Very small areas (<1% of land area) of Delray fine sand and Ona fine sand are found in the University Parkway corridor section of the study area. Delray sands are fairly permeable lowland soils that indicate seasonal wetlands and/or floodplain areas, while Ona fine sands are poorly drained soils commonly associated with coastal flatwood communities (NRCS 2006).

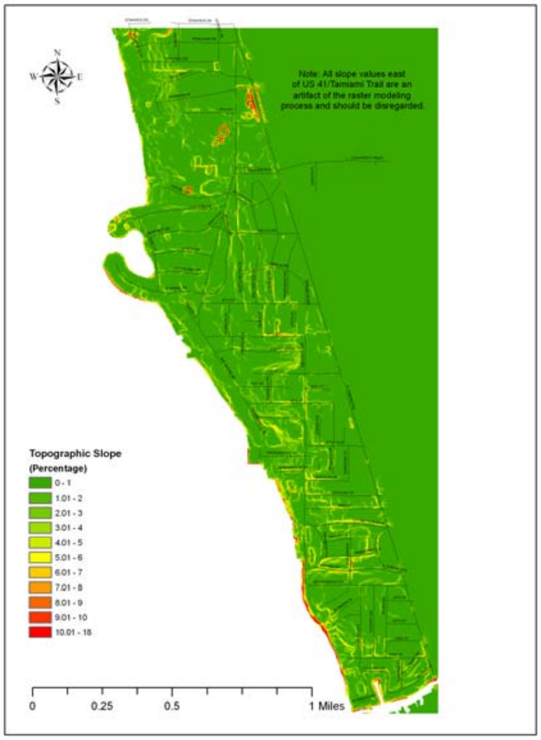
ELEVATION

Elevation in IBSS ranges from just above sea level on the coastline to 25 to 30 ft. on a ridge area located just west of US 41 (Map 4). The topographic slope throughout most of IBSS is under 1%, with significantly higher slopes generally found adjacent to roads, drainage features, and the coastline (Map 5).
Such a topographic slope profile is typical for a developed coastal flatwood landscape in Florida. However, the ridgeline and associated coastal elevation gradient are relatively high in IBSS as compared to most other coastal areas in Sarasota County (Map 6).

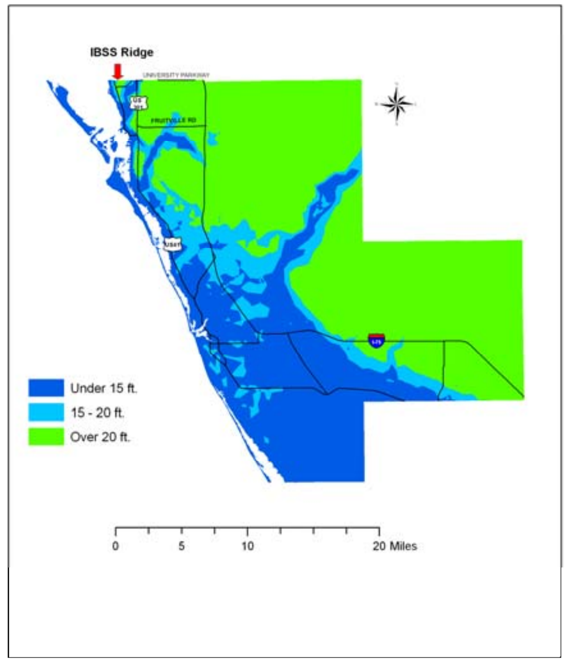
Map 4: IBSS Elevation



Map 5: IBSS Topographic Slope



Map 6: Sarasota County Elevation

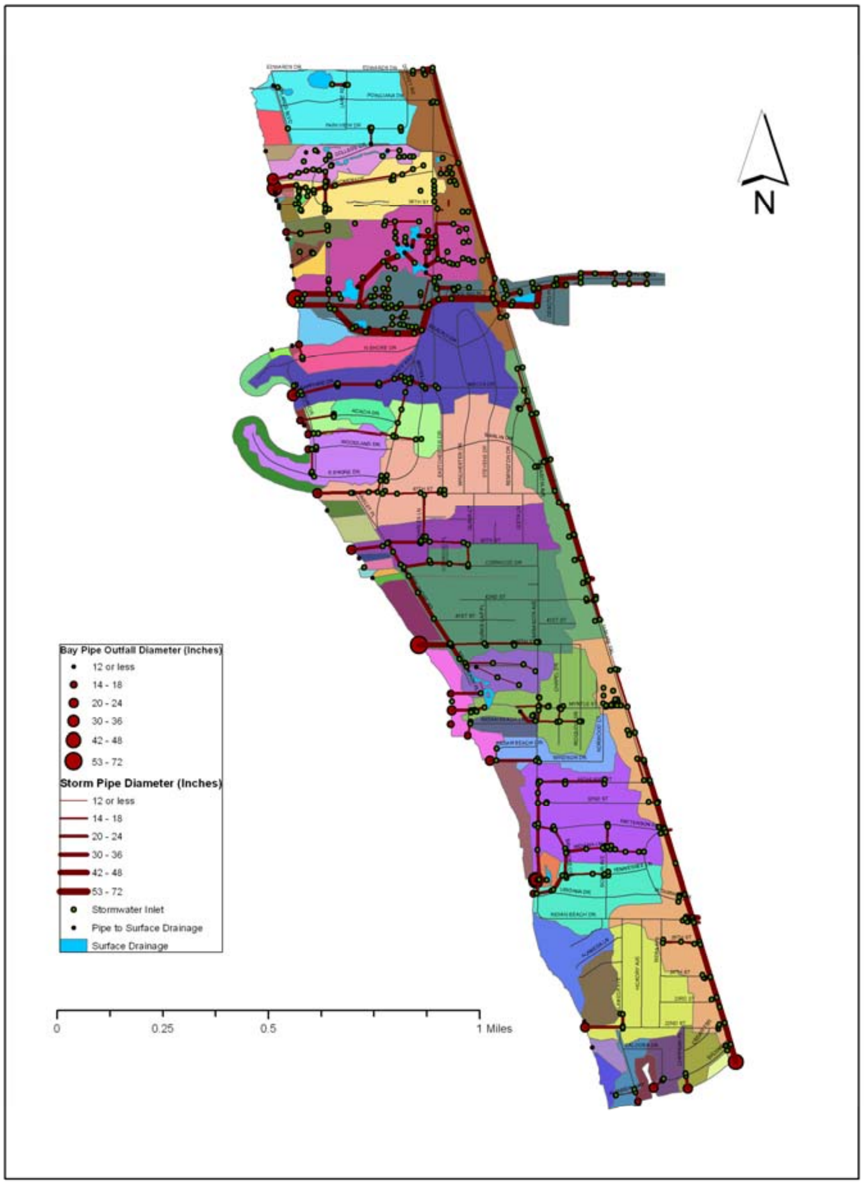


STORMWATER DRAINAGE

As described in Flowchart 2, elevation contours (Map 4) and stormwater infrastructure data together were used to delineate 62 distinct drainage basins within the IBSS neighborhood (Map 7). The drainage basins in IBSS vary greatly by size, with the largest measuring over 55 acres and the smallest measuring well under one acre. Of the 62 delineated basins, 47 are associated with outfall pipes that discharge into Sarasota Bay or Whitaker Bayou. These pipe outfall drainage basins occupy approximately 569 acres in IBSS, or about 79% of the total land area. Sarasota Bay is the receiving water for 43 of these pipe basins, accounting for 510 acres or 71% of neighborhood land area. The 4 pipe basins that discharge into Whitaker Bayou have an area of approximately 59 acres or 8% of total land area. Treatment areas such as swales and ponds that are hydrologically connected to bay outfalls capture stormwater for about 93 acres in IBSS, which amounts to about 16% of the area associated with stormwater pipe discharge and 13% of total area in the neighborhood.

Interestingly, 20 pipe outfalls to Sarasota Bay do not have any clear connection to surface inlets (Map 7). These pipe outfalls are small in diameter (generally less than or equal to 12 inches), and pipe extents associated with these outfalls mostly are not known. It

Map 7: IBSS Stormwater Drainage Basins



is likely that pipe features associated with these outfalls were installed for additional water table and landscape drainage by bay front property owners. Basins for these outfalls were drawn according to surface hydrology, with the assumption that coastal sheet flow in nearby areas would be preferentially channeled through subsurface conduits provided by drainage pipes. The total basin land area associated with these 20 outfalls is 24 acres, or approximately 3% of IBSS land area.

Most other basins in IBSS are composed of coastal sheet flow discharge into Sarasota Bay and Whitaker Bayou. These sheet flow basins account for just over 60 acres, or 8% of the total IBSS land area. In addition, a 26 acre basin in the US 41 commercial corridor from Mecca Dr. south to 40th St. drains east through a stormwater pipe that then discharges into a surface ditch hydrologically connected to Whitaker Bayou, and approximately 27 acres adjacent to US 41 north of Mecca Dr. to the Manatee County line is drained through pipe flow into a retention pond hydrologically connected to Bowlees Creek. These two commercial corridors together account for 7% of the total IBSS land area. The remainder of the drainage in the study area is provided by a surface creek slough into Sarasota Bay that receives both pipe and ditch flow from a 36 acre basin in the Uplands neighborhood.

TREE CANOPY

Tree canopy coverage in IBSS amounts to approximately 213 acres, or 30% of the total land area (Map 8). Percentage canopy coverage varies considerably among different areas and corresponding drainage basins in IBSS. For example, the large (55 acre) drainage basin that discharges into the pipe outfall near Bayshore Rd. and 40th St. contains approximately 31 acres of canopy cover, which amounts to over 56% of the basin area. Other significant canopy areas are found on the Ringling Museum grounds, Jungle Gardens, and the southwestern corner of the IBSS neighborhood. By contrast, more commercial areas adjacent to US 41 have well under 10% canopy coverage. Maintenance and expansion of tree canopy coverage in IBSS may be an important factor for mitigating non-point pollution from non-point

Map 8: IBSS Tree Canopy

Map 9: IBSS Impervious Surface

sources (see Keating 2002).

<u>IMPERVIOUS SURFACE</u>

Impervious surfaces cover approximately 283 acres in IBSS, which amounts to 39% of total land area (Map 9). Such a percentage of impervious surface coverage is fairly typical for a developed residential area such as IBSS (Rogers et al. 2004). As would also be expected, impervious surface percentages are much higher (70 – 80%) in the commercial corridors adjacent to US 41 than in other areas of the neighborhood. By contrast, relatively small percentages of impervious surface are found along the bay front from the Manatee County line to the NCF Caples campuses, in the Jungle Gardens attraction, and throughout the southwestern corner of the IBSS neighborhood. Areas with high percentage impervious surface cover can be expected to load greater volumes of contaminated stormwater runoff into receiving waters than areas with less impervious surface.

<u>CURBS AND GUTTERS</u>

Map 10: IBSS Roadside Curbs and Gutters

Map 10 contains a description of street side curb and gutter features in the IBSS neighborhood. Data for curbs and gutters were collected for approximately 20 miles of IBSS streets. These data indicate that 7.4 miles (36%) of IBSS roads have curbs or gutters on both sides, 6 miles (30%) have a curb or gutter on one side, and 6.6 miles (33%) do not have curbs or gutters on either side.

In areas without curbs and gutters, significant percentages of street runoff can be expected to seep into adjacent soils and vegetation along the side of the street. By contrast, curbs and gutters channel runoff along roadsides and prevent seepage into adjacent pervious areas. Thus, street areas with curbs and gutters will tend to have greatly increased amounts of direct runoff volume into stormwater drainage infrastructure and receiving waters compared to street areas that lack these features.

CONCLUSIONS AND RECOMMENDATIONS

This project developed detailed GIS databases of stormwater drainage in the IBSS neighborhood. Most of the IBSS neighborhood is drained through underground pipe conveyance systems that discharge stormwater runoff directly into Sarasota Bay and Whitaker Bayou with little treatment of runoff contaminants. Such a stormwater drainage system likely poses an inherently high risk of non-point pollutant loading into Sarasota Bay from neighborhood streets and yards.

Some features of the IBSS neighborhood may, however, mitigate contamination risks in certain areas. Previous research studies (Keating 2002) and ongoing research in IBSS both suggest that areas with significant canopy coverage may have less runoff onto impervious surfaces due to intercept by tree leaves, thereby lessening the amount of runoff that is loaded directly into Sarasota Bay. In addition, areas of the neighborhood without curbs or gutters generally can be expected to load significantly less runoff volume and associated runoff contaminants into stormwater inlets than areas that do have curbs or gutters.

Areas in which runoff is captured in swales, ditches, dry detention areas, and retention ponds before discharge into Sarasota Bay are likely to have a decreased risk of non-point loading due to attenuation of runoff volume and sequestration of pollutants within these facilities. However, further research and monitoring are needed to better understand roles that specific biotic communities, management practices, and design parameters associated with stormwater treatment areas in IBSS may have on treatment efficacy. For example, frequent blooms of nitrogen-fixing cyanobacteria observed in the retention pond located on the NCF Caples campus suggest that this pond may not be effectively reducing nitrogen and may actually even be serving as a source of additional nitrogen loading into Sarasota Bay (see SWFWMD 2005). Depending upon the management practices used in stormwater treatment areas, loading of herbicides, pesticides, nutrients, and organic matter as a result of maintenance in treatment areas may also be a significant concern (SWFWMD 2005).

Although additional construction of retention ponds or other large-scale stormwater treatment facilities is not feasible in most areas of IBSS due to the scarcity and high expense of undeveloped land, several neighborhood residents have expressed interest in removing street side curbs and constructing swale features to capture stormwater in their front yards. If designed and constructed appropriately, front yard swales could reduce stormwater runoff into Sarasota Bay and provide attractive landscaping amenities. However, such infrastructural retrofits should only be performed in coordination with Sarasota County Stormwater Utility, the City of Sarasota, SWFWMD, and surrounding homeowners.

More research into the effects of homeowner landscaping behavior on the quality of stormwater runoff discharged into receiving waters is clearly needed. The stormwater basins in IBSS may provide a fairly unique opportunity for detailed a study of landscaping behavior and associated quality of discharged stormwater at very fine spatial scales. For example, a protocol for measuring landscaping intensity could be developed and used to characterize the intensity of IBSS yards at the parcel level. Such landscaping characterization data would make it possible to calculate an aggregate landscaping intensity score for each delineated stormwater outfall basin, providing a numeric variable that could then be statistically related with water quality measures taken at outfalls following storm events. Ideally, measurable relationships between water quality and landscaping intensity could be used to develop scientifically rigorous landscaping standards for water quality improvement purposes. Re-characterization of landscaping intensity data throughout the neighborhood at periodic time-scale intervals would also provide a means of gauging changes in landscaping behavior over time. Patterns of landscaping behavior change could then be used to help evaluate, adjust, and refine outreach strategies in IBSS and other areas where homeowner outreach programs are expected to serve as the pillar of non-point pollutant reduction.

REFERENCES

Chivers, M. 2003. “Differential GPS Explained.” *ArcUser Online*. ESRI. http://www.esri.com/news/arcuser/0103/differential1of2.html. Site accessed July 3, 2006.

Keating, J. 2002. “Trees: The Oldest New Thing in Stormwater Treatment?” *Stormwater* 3(2). http://www.forester.net/sw_0203_trees.html. Site accessed July 5, 2006.

NRCS. 2006. “Soil Classification.” United States Department of Agriculture, Natural Resource Conservation Service. http://soils.usda.gov/technical/classification. Site accessed July 5, 2006

Rogers, J.N., M.M. Quigley, S.P. Roy, and T. Liddell. 2004. “Using Satellite Technology to Calculate Impervious Area in the Watershed.” *Stormwater* 5(4). http://www.forester.net/sw_0407_remote.html. Site accessed July 5, 2006.

SBEP. 2006. *State of theBay 2006: Celebrating Our Greatest Natural Asset*. Sarasota Bay Estuary Program. Sarasota, FL. http://www.sarasotabay.org/pdf/StateOfTheBay_06.pdf. Site accessed June 12, 2006.

SWFWMD. 2002. *Sarasota Bay Surface Water Improvement Management (SWIM) Plan*. Southwest Florida Water Management District. SWIM Section, Resource Management Department. Tampa, FL. http://www.swfwmd.state.fl.us/documents/plans/sarasota_bay_2002.pdf. Site accessed May 21, 2006.

SWFWMD. 2005. *Stormwater Research: Summary of Research Projects, 1990 – 2005*.

Southwest Florida Water Management District. Resource Management Department. Brooksville, FL.

Tomasko, D.A., M. Alderson, E. Estevez, P. Clark, M. Heyl, J. Culter, S. Lowrey, K. Dixon, Y.P. Sheng, R. Edwards, and J. Stevely. 1997. *Technical Synthesis of Sarasota Bay*. Sarasota Bay National Estuary Program. Sarasota, Florida. http://www.stormwaterauthority.org/assets/093PLSarasotaBay.pdf. Site accessed June 30, 2006.

RAINFALL INTERCEPTION BY OAK, PINE, AND PALM TREE CANOPIES

INTRODUCTION

Indian Beach/Sapphire Shores (IBSS), a historically significant neighborhood of Sarasota, Florida, resides on the eastern shore of Sarasota Bay. As summarized earlier, the actions and inactions of neighbors currently determine the majority of nitrogen reaching the Sarasota Bay. The IBSS neighborhood is directly adjacent to the bay with topographic relief uncommon further south. Much of the stormwater infrastructure for this neighborhood has not yet been modernized and directs stormwater runoff, untreated, directly to the bay. Opportunities to reduce the amount of stormwater reaching the bay and its nitrogen load are limited, so there is a need to investigate all avenues. These include retrofitting stormwater treatment where possible, reducing impervious surfaces, changing yard care practices and reducing the amount of runoff through canopy interception.

Anyone who has dashed under a tree during a sudden rainstorm knows that tree canopies intercept rainfall and, at least for modest events, significantly reduce the amount of rain falling to the ground. Studies elsewhere in the US document this effect, but we were unable to find studies that evaluated the rainfall interception potential of canopies of common landscape tree species in Southwest Florida stormwater. The major thrust of this study was to document interception rates for local trees.

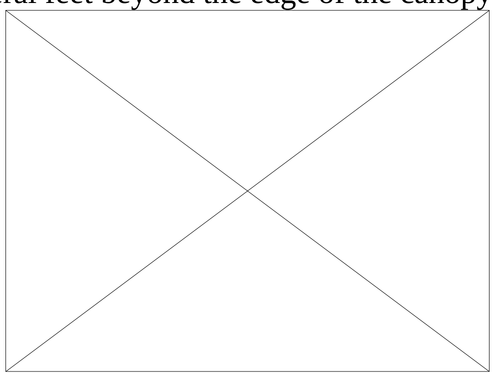
In this project, the percentages of interception by eight tree canopies were estimated during rainfall events of varying volumes between June 2005 and August 2006. Initial data was collected under the canopy of a Laurel Oak, *Quercus laurifolia*, located on the New College of Florida campus. During the following year data collection methods were determined and the study expanded to include a Live Oak *Quercus virginiana* , three slash pines *Pinus elliottii*, and three sabal palms *Sabal palmetto* also located on the New College of Florida campus. The information from this study provide preliminary documentation of canopy interception rates of four Florida tree species. It is hoped that this research will lead to increased valuation of establishing and maintaining tree canopies for stormwater management, adding weight to canopy creation in low impact development projects and further research.

MATERIALS AND METHODS

MATERIALS

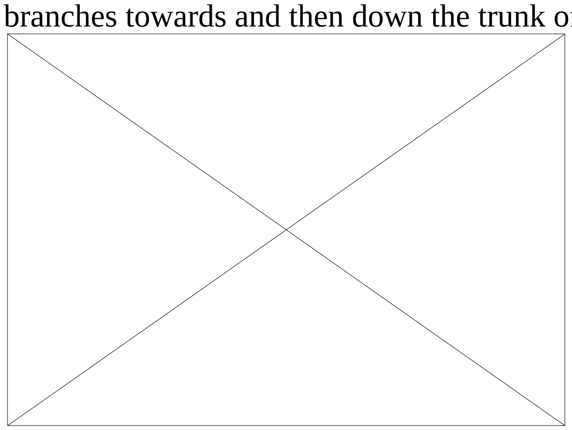
All data collection occurred on the New College of Florida campus. Materials included plastic bins (25” x 18” x 6”),milliliter measuring cylinders, large funnel, plastic mesh material (as a leaf/debris filter for the funnel), and data sheets with a diagram of the bin radii for recording measurements.

Preliminary research was conducted on a laurel oak, *Quercus laurifolia*. This tree was chosen because it was mature and stood alone, uninfluenced by additional interception from neighboring tree canopies. Bins were set end to end on the ground below the tree. The bins were arranged in three rows radiating from the trunk of the tree in different directions and extending several feet beyond the edge of the canopy.



This diagram shows an example of a bin arrangement below a tree canopy. Each radius of bins begins at the trunk of the tree and extends beyond the canopy.

The contents of each bin are measured immediately following a rainfall event. The volume of water in bins located furthest from the trunk in each row is recorded as the total amount of unintercepted rainfall. After six months of data collection, key bin locations were identified: the bin farthest beyond the canopy to measure unintercepted rainfall, bins located at the edge of the canopy to measure canopy edge drip, a bin located midway between canopy edge and the tree trunk to be used as an average for bins below the canopy, and a bin located nearest the trunk. This system does not attempt to measure stemflow that flows down branches towards and then down the trunk of the tree.



This is a diagram of the bin arrangement using key locations, reducing the total number of bins required to sample the tree and calculate percentage of interception.

Interception percentages were calculated for each design to determine if using a reduced number of bins in each row, thus placing bins at key locations, resulted in interception percentages comparable to using a continuous row of bins. Results usually differed by 0-3% between the two methods – a difference small enough to enable us to use a reduced number of bins for each tree; remaining bins were used to simultaneously study additional trees.

Additional trees were chosen by the same guidelines as the first oak, and bins were set up in the method of utilizing key locations.

Data from preliminary research on the laurel oak was presented to employees of Sarasota county stormwater management as well as sent to faculty of the hydrology departments at the University of Florida and the University of Central Florida for response and additional ideas. All groups positively received the project. Feedback provided direction for analyzing the data and creating charts and graphs that are of interest to their endeavors.

METHODS

Since it is impractical to collect all the rain beneath a tree canopy, this project relied on sampling. Data was collected after rainfall events of varying volumes of precipitation to improve understanding of how interception rates may vary with rainfall volume and duration. It is of interest to county stormwater management groups and development projects to understand rainfall interception during rainfall events ranging in volume, and to estimate when a canopy may become saturated, resulting in negligible interception rates.

The water contents of each bin are measured immediately following rainfall events and recorded on a data sheet.

For each rainfall event, the following values are calculated and recorded: date, average total rainfall volume, the canopy's average interception rate, and the control bin volume, average volume under canopy, and percentage of interception for each radius of bins. On each data sheet, additional details about the rainfall event, such as time of day, humidity conditions, or if it was exceptionally windy or intense, are documented. If an event provides unusual or unexpected results when values are calculated, knowledge of these variables may provide additional understanding.

The canopy's average interception rate is determined for each rainfall event. The following procedure is followed to obtain this value:

- The interception rate is determined for each radius of bins under the tree: The difference between the volumes of water in each bin under the canopy compared to the last bin beyond the canopy edge (the control bin) is calculated. This difference expresses the volume of water intercepted by the canopy. The differences are added together to determine the total volume of water intercepted. The percentage of interception is calculated by dividing the total rainfall volume (value of control bin) into the total volume of water intercepted.

- Once the interception rate is determined for each of the three radii of bins, the three rates are averaged together for an average canopy interception rate.

Data has been collected for rainfall events with volumes ranging from 49 to nearly 10,000 milliliters. The laurel oak canopy interception rates for these events were 91 and 20 percent respectively. 96 percent is the highest interception rate identified thus far, and 0 percent, recorded for an intense 2640-milliliter event, is the minimum. The data displays a trend that the interception rate of a laurel oak canopy is generally very high for low-volume rainfall events, and decreases as the volume of the rainfall event increases.

Wind and rainfall intensity are variables that affect interception by the canopy. Wind creates greater differences between the interception rates of differing sides of the tree canopy because precipitation is not falling straight down onto the canopy. This variation affects the overall average canopy interception rate. For example, during a particularly windy rainfall event the northern radius intercepted merely 1 percent, while the southwestern radius intercepted 76 percent. Because of variables additional to rainfall volume, the canopy’s average interception rate does not always decrease proportionally as rainfall volume increases, but a significant trend remains clear in the existing data. Collecting data from multiple sides of the tree aids our understanding of these variables and their effect upon rainfall interception.

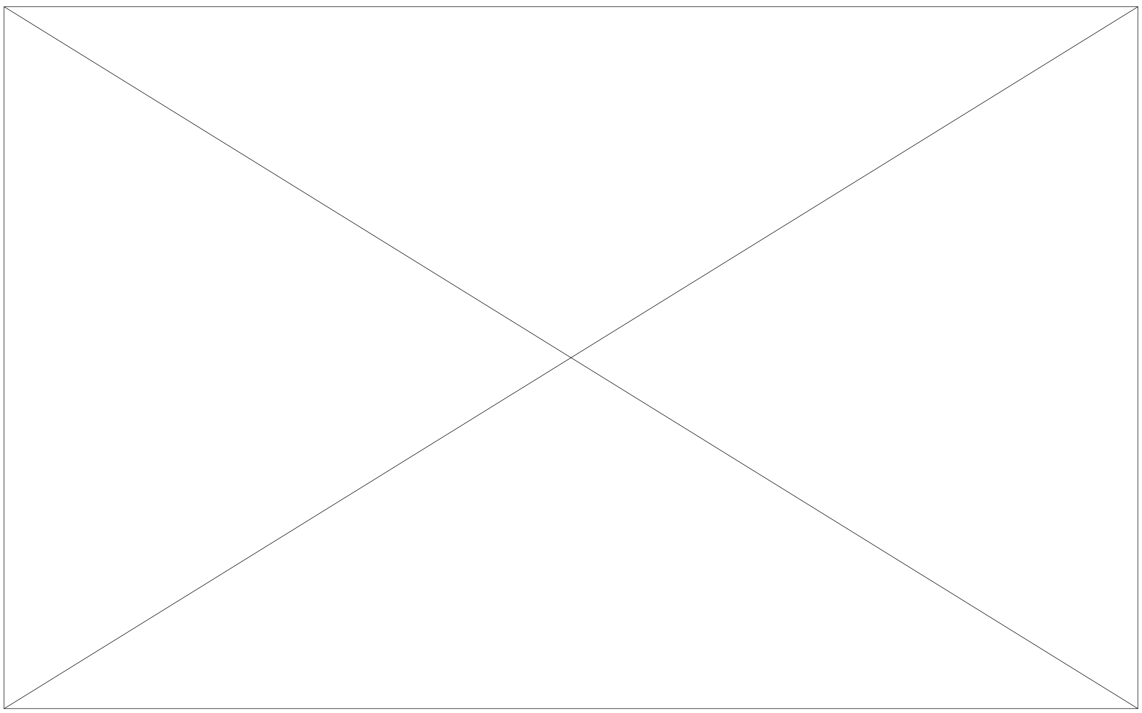
The chart in this image is created from four rainfall events with varying total volumes of precipitation. The tree in the photograph is the actual laurel oak; however, the black bins are drawn to illustrate the approximate location of each bin under the canopy. Each color series represents a separate rainfall event. The data was collected from a complete transect of bins lined end to end, as illustrated. Each horizontal black segment represents one bin, and the height of each bar above it indicates the volume of water in the bin.

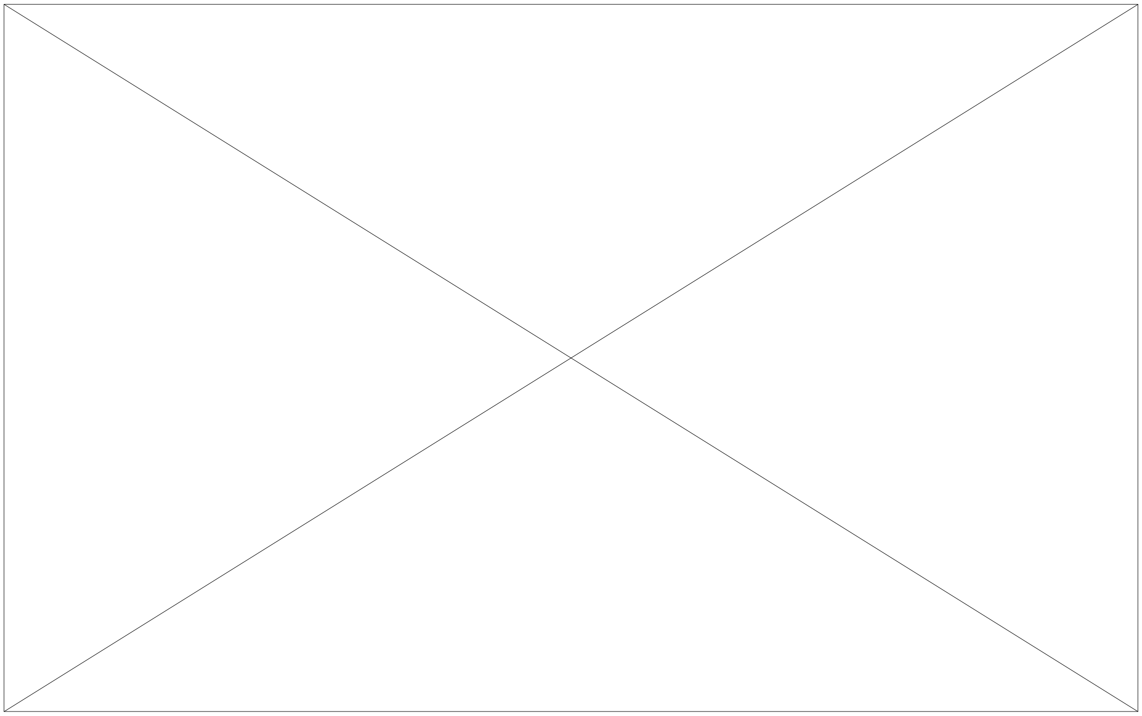
Note that the data in the blue series, representing the rainfall event with the lowest total volume of precipitation, is complete. There was 0 ml of water in the bins under the canopy after that rainfall event. As the chart shows, the rainfall event had a low total precipitation volume, and the canopy had nearly a 100 percent interception rate. The average rates of interception vary with the total volume of rainfall, usually along the trend of lower interception rates with higher rainfall volume.

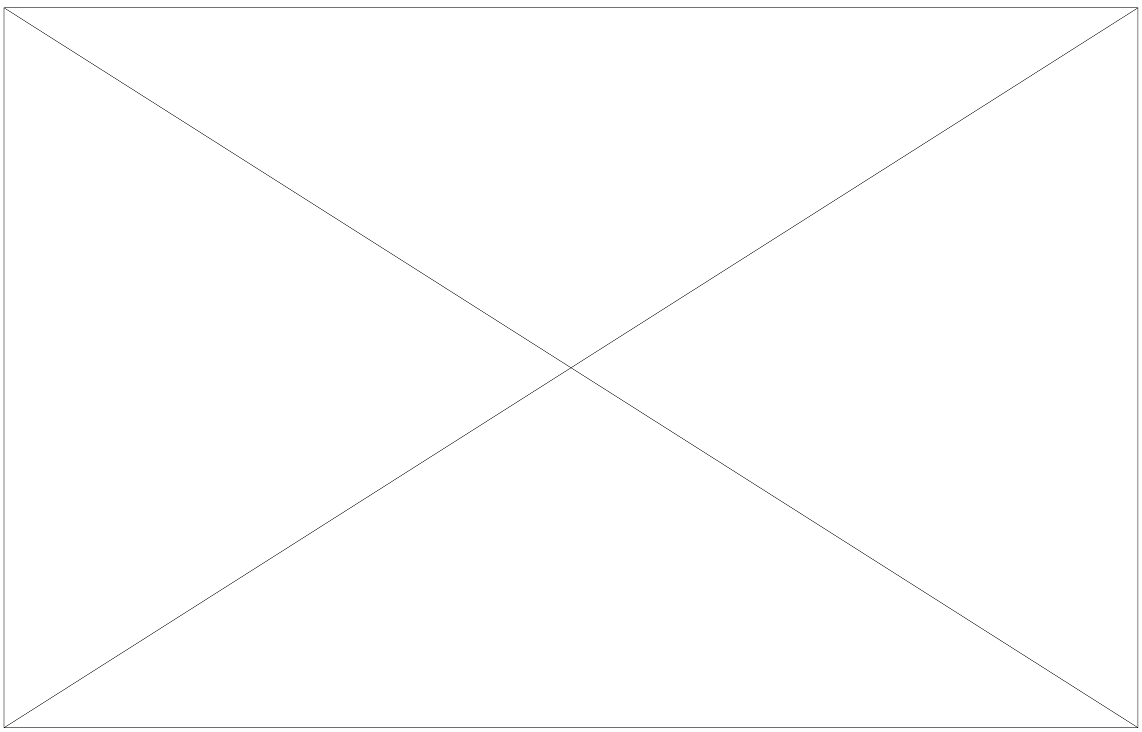
DATA

Included below is a collection of graphs comparing rainfall interception of the studied trees of each species. Two species of oak were included in this study, and they are compared to each other. The graphs do not represent all of the data collected for each tree. Each line represents one row of bins of one tree for a single rainfall event. In each graph, the individual rainfall events represented were selected because they display a common pattern of interception, as shown in the oaks graph, or a variety of different interception patterns, as shown in the palm trees, when results do not display a consistent pattern.

All references to “volume” or “total rainfall” (as seen in the data charts or graphs) refer to the total volume of rainfall, in milliliters, collected in the bins. “Total rainfall” refers to the total volume of rainfall collected in the control bin for that rainfall event. It is not “total rainfall” as commonly understood when discussing the total inches of rainfall as measured in a standard calibrated rain gauge.







DATA ANALYSIS

A photograph, table, and graph are included for each tree studied during this project. The table lists the average percentage of interception beside the corresponding total volume of rainfall for each of the rainfall events. The rainfall events are listed in order of total volume to provide better understanding of how interception changes as the volume of rainfall increases. The graph included does not show interception patterns for all rainfall events. Each of the rainfall events shown in the graph was chosen because it provided an example of an interception pattern. Some trees have more variety in these patterns than others. The combination of rainfall events chosen for each graph provides an understanding of the variety, or consistency, of interception patterns discovered for that tree canopy. In every graph, each line series represents one row of bins and data from one rainfall event.

OAK TREES

Two oak trees, one laurel oak and one live oak, were included in this study. Both oak trees intercepted a higher percentage of rainfall, more consistently, than the other tree species. The canopies of these trees are large and provide interception over a greater area than the other species included. The size of the canopy is not relevant when comparing the interception percentages presented in this study, (the method for calculating the percentage of interception utilized in this analysis is not affected by the size of a canopy's area of coverage), but is a consideration if calculating the number of trees necessary to provide interception in a given area.

LAUREL OAK

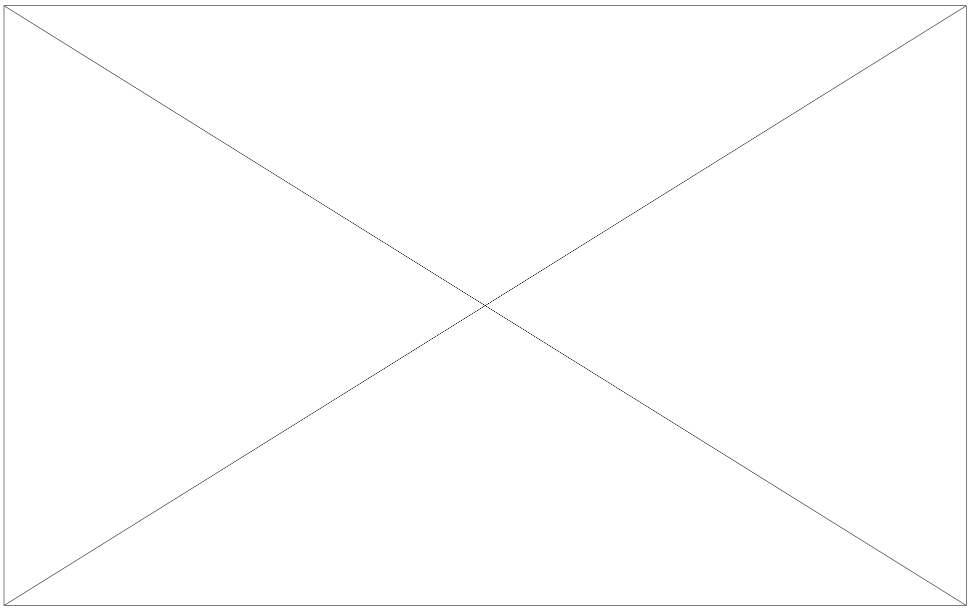
The laurel oak was the first tree from which data was collected, and the only tree that was studied throughout the duration of the project. The interception results were the most consistent of any tree included in this study.

This canopy is generally circular in shape and more evenly distributed around the trunk of the tree than any of the other trees in this study. Because the density of the canopy is also fairly consistent, the interception results were more uniform on all sides of the tree than the others. Wind direction influences interception on varying sides of the tree, but interception patterns remained similar on all sides due to the canopy's uniform structure.

The average interception percentages for this oak follow a clear trend -- the smaller the rainfall, the higher the rate of interception. The ratios of percentage of interception to total rainfall are not always similar, as interception rates are influenced by conditions such as the duration and intensity of the rainfall event. Several of the rainfall events recorded in this chart were collected prior to or during hurricanes.

AVG % INTERCEPTION	AVG TOTAL RAINFALL
91%	49
96%	254
84%	297
58%	320
56%	454
68%	530
64%	640
63%	680
41%	720
61%	787
45%	987
17.5%	1180
28%	1234
24%	1767
13%	2094
32%	2434
0%	2640
31%	2840
38%	2880

28%	3340
6%	3407
16%	4410
30%	5340
25%	8807
20%	9607

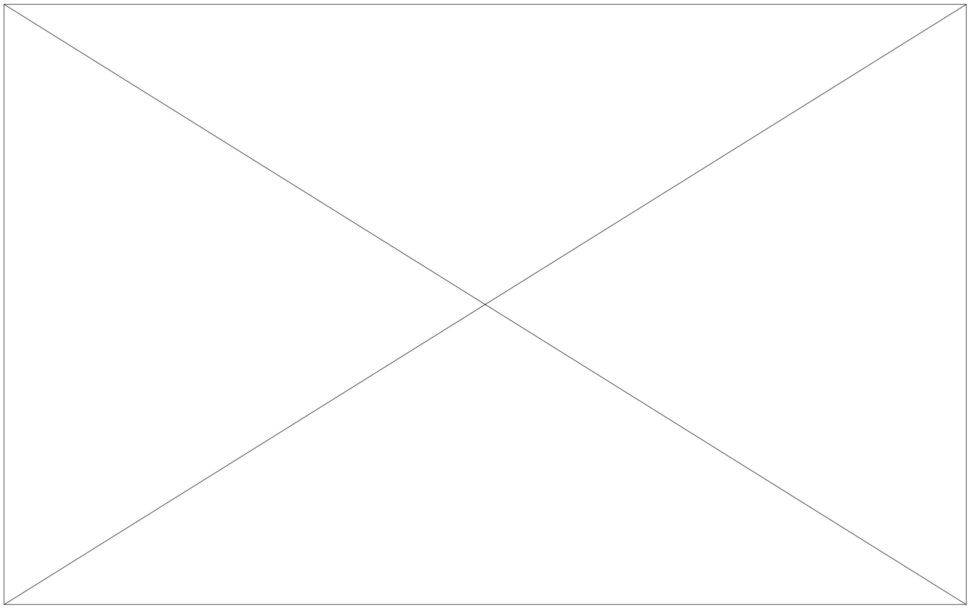


The lines in this graph show the volume of water in each bin (represented by a point) beginning from the trunk, at the left side of the graph, and moving out beyond the canopy edge, at the right side of the graph. The furthest point at right is the total volume of rainfall for the event; this bin is located beyond the canopy edge and uninfluenced by canopy interception. All of the following graphs can be interpreted in the same manner. There is little variety in the interception patterns for this laurel oak. Though the volume of water intercepted varied for each rainfall, the pattern of interception followed the same trend – a slope with the highest end beyond the canopy and the lowest end near the trunk. For many rainfalls a high point can also be seen at the edge of the canopy where canopy drip occurs, resulting in a higher volume of water collected in the bin. Many of the other trees in this study show more variety in interception patterns due to the inconsistent shape and density of their canopies.

LIVE OAK

The characteristics of this oak are similar to that of the laurel oak except that the canopy is larger in circumference and less dense in some areas. Inconsistent canopy density creates a greater variety of interception patterns, as found in the results from the other tree species, but overall the results from this tree are similar to those of the laurel oak.

AVG % INTERCEPTION	**AVG TOTAL RAINFALL**
17%	2400
32%	3200
24%	3700
20%	4480
28%	4980



PINE TREES

Three slash pine trees were included in this study. Similar to results found by previous research studies on conifer trees in California, these pine trees capture a surprising amount of water. Further research is needed to investigate how pine needles compare to leaves regarding rainfall interception, and whether or not it is another variable, such as bark or tree architecture, that enable slash pines to intercept a significant volume of rainfall despite their frequently sparse canopies.

All included pine trees are comparable in height, but vary in canopy size, shape, and density.

PINE ONE (HEISER PINE)

AVG % INTERCEPTION	AVG TOTAL RAINFALL
100%	33
77%	130
40%	350
32%	360
75%	370
40%	473
53%	527
56%	980
35%	1047
29%	1953
13%	3820
4%	4700
-29%	6333
15%	8660

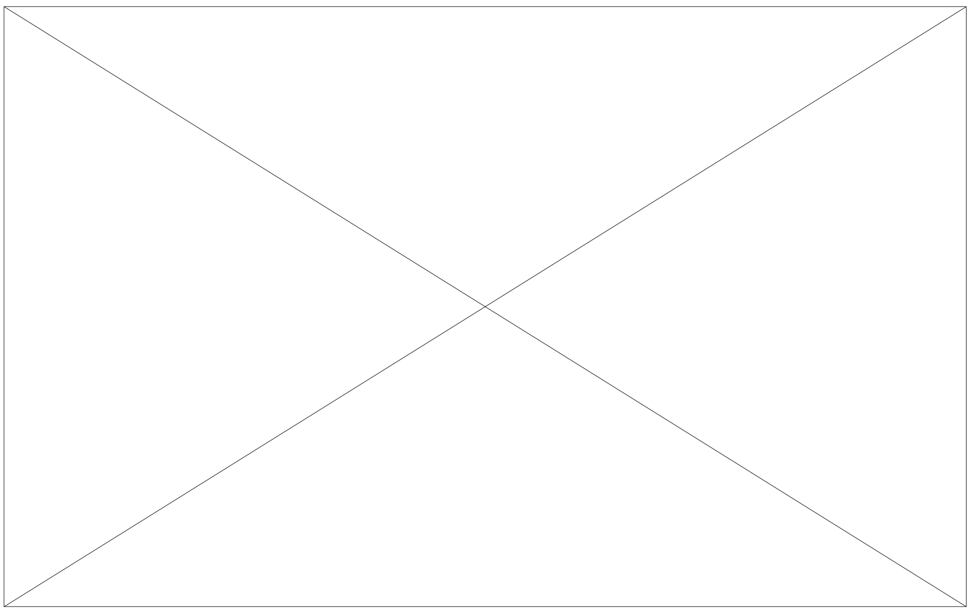
PINE TWO (HEISER PINE #2)

AVG % INTERCEPTION	**AVG TOTAL RAINFALL**
10%	2210
23%	2587
22%	3180
12%	3813
21%	4213
14%	7787

PINE THREE (ROADSIDE PINE)

AVG % INTERCEPTION	**AVG TOTAL RAINFALL**
62%	340

27%	920
47%	1400
6%	1660
-10.5%	2680
5%	2820
49.5%	2840
11.5%	3140
28%	4200
16.5%	8160



PALM TREES

The three sabal palms included in this study vary in height, age, and canopy. Two of the trees still possess their boots and have had their dead fronds removed. The third tree is taller than the others and has a full canopy. Each of the canopies is irregular in shape and has a side that is denser than the others, but because of the small size of each canopy the three radii of bins collected data from a high percentage of the canopy's area, resulting in data that accounts for the variety within the tree canopy.

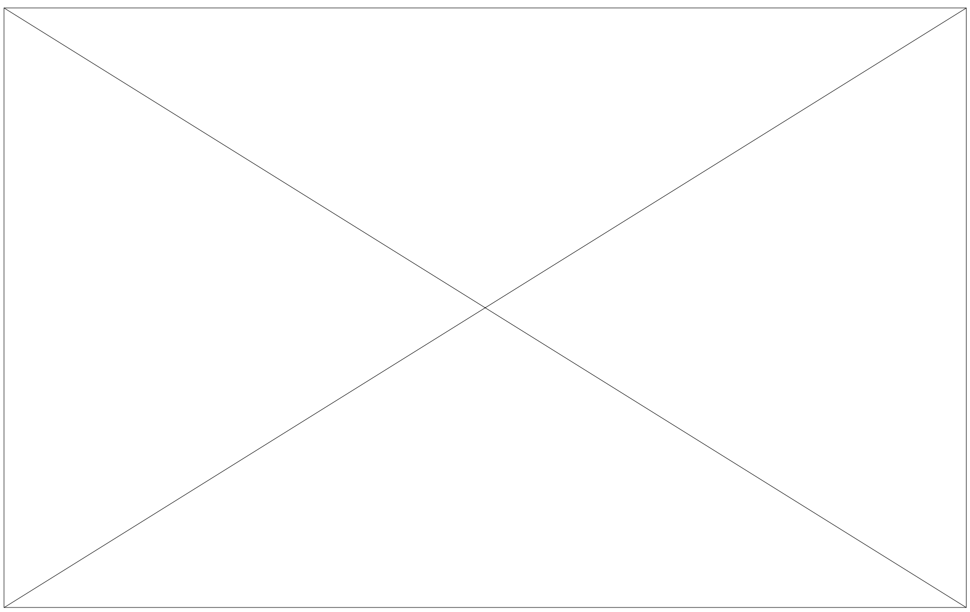
The graphs included below show a variety of interception patterns. Because of the irregular shape of the tree's canopy, each side of the tree has a different capacity for intercepting rainfall. Wind also has an influence on interception patterns of small trees. For example, if the wind was blowing from the north during a rainfall event, there may appear to have not been any interception on the north side of the tree (the rain was blowing under the canopy and into the collection bins), though it may be assumed that the fronds on that side of the tree influenced the data in the bins on the south side. Because data was collected in bins on the ground below the tree, the data for smaller tree canopies in this study is influenced by rain falling at an angle under the tree. (This was not a significant problem with trees possessing larger and lower canopies.) Wind is considerable variable influencing the interception patterns of these trees; not all variety is simply due to variety in the canopy shape or density.

PALM ONE (FOUNDATION PALM)

AVG % INTERCEPTION	AVG TOTAL RAINFALL
0.5%	7120
-11%	7920
46.5%	25
90%	180
-2.5%	380
29%	620
20.5%	1060
16%	1360
-28%	1740
1%	2200
61.5%	2840
-31%	3000
-3.5%	3140

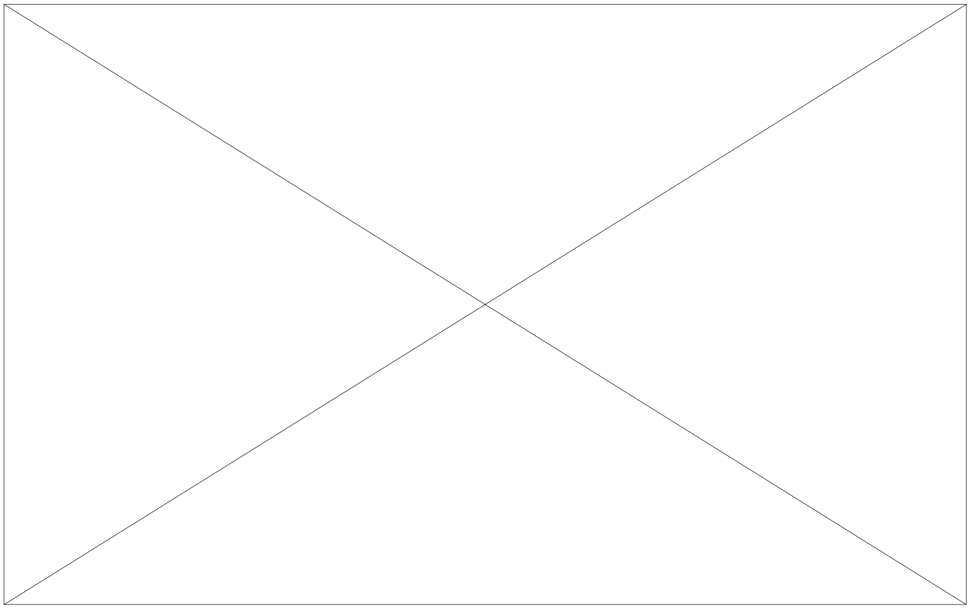
PALM TWO (4-WINDS PALM)

AVG % INTERCEPTION	**AVG TOTAL RAINFALL**
33%	30
58%	185
28%	580
24%	640
22%	920
3%	2220
14%	2600
10.5%	2720
13%	3120
3%	4480



PALM THREE (WALKWAY PALM)

AVG % INTERCEPTION	AVG TOTAL RAINFALL
15%	2480
9%	3600
10%	4220
13%	4540



CONCLUSIONS AND RECOMMENDATIONS

This project investigated rainfall interception by the canopies of four tree species commonly found in the Indian Beach Sapphire Shores neighborhood of Sarasota, Florida. Areas with canopy coverage capture and intercept a significant volume of rainfall, lessening the amount of runoff entering the stormwater infrastructure from impervious surfaces. The reduction of runoff is critical to the health of surrounding marine environments because most stormwater is discharged into local water bodies, such as Sarasota Bay, untreated. The untreated water contains detrimental nutrients and pollutants from neighborhood properties, and may be a key element in problems related to nutrient loading.

All tree canopies included in this study intercept a considerable volume of rainfall. The palm trees, however, proved to be more beneficial than projected. The data from these trees suggests that though the canopies of palms seem scarce compared to the more dense canopies of oaks and pines, the palm fronds are rigid and wide enough to capture a high volume of rainfall and channel it towards the trunk of the tree. Further research is needed to investigate the volume of water capable of being captured in the boots located on palm tree trunks.

Previous studies on the interception capabilities of conifer trees in California concluded that conifer trees are capable of capturing a substantial volume of rainfall. No similar research was conducted on conifer trees in Florida prior to this project, but the results also suggest significant interception potential. Further research is needed to investigate how pine needles compare to leaves regarding interception characteristics.

Existing studies suggest how canopy coverage and rainfall interception can reduce the volume of stormwater runoff. However, further research is needed to better understand the roles of individual variables, such as stormwater infrastructure and landscaping practices, which contribute to problems associated with stormwater discharge. A greater knowledge of these variables can result in more effective stormwater management and favorable lawn care.

Supplementary research on the interception capacities of a variety of tree species can contribute to the integration of effective tree canopies in urban design and planning. As the relationship between canopy coverage and runoff reduction is better understood, the use of water management funds for the inclusion of trees in parking lots and along roadways becomes a greater possibility.

Yard Stormwater Runoff

INTRODUCTION

This preliminary study sought runoff water data from existing yards resulting from real storm events. The goal was to collect surface flow from a variety of yard types and analyze nitrogen runoff. Subsurface flow was not collected.

Runoff samples were collected from nine yards with maintenance regimes ranging from that of a recognized Florida Yard, to no application of fertilizers or pesticides, to regular maintenance by a chemical landscaping company. Yards included in the study were chosen from basic descriptions of yard and landscaping practices provided by resident volunteers.

MATERIALS AND METHODS

The runoff collection devices were designed by the research team and based on a previous similar study ______________. Surface runoff is collected through funnels placed in the ground at surface level. The runoff then strains through a filter in the funnel and is stored in a bucket accessible by a threaded lid that is level with the ground surface. Samples are removed from the bucket after rainfall events; the bucket is subsequently emptied in preparation for the next rainfall event. There were two collection funnels per collection unit. Small raised roofs were placed over the collection funnels after preliminary data collection revealed that a high volume of direct rainfall entered the collection device. The roofs deflected rainfall away from the collection funnel, decreasing the amount of rainfall diluting runoff entering the device.

Kit placement was determined through compromise between the project research assistant and the resident. Therefore, kits were not always located in the most ideal location in the yard. But many were placed near the road or curb where most yards slope downward slightly and runoff from primarily the volunteered yard can be collected. In some cases the kit was placed near a yard boundary where runoff collection likely included runoff from a neighboring yard. Many of these yards, though not fertilized by the resident, may have become the "medium" category because of influence from a neighbor's fertilized yard.

A significant volume of rainfall was required to provide enough runoff collection to enable a complete set of samples from all included yards. Because the yards were distributed across the neighborhood not all yards were impacted equally by the same rainfall event – successful sample collection from all yards could not occur if an adequate volume of rainfall did not fall in all areas. Some kits collected runoff better than others, and some yards were more conducive to runoff collection due to their topography.

Pilot study. 6 complete sample sets were tested. Though not as many tests were conducted as originally planned, the results provide significant evidence that further research is warranted and that the impact of some landscaping practices may prove to be leading cause of nutrient loading in local water bodies.

TEST RESULTS

YARD TYPES

Green – non- fertilized
Purple - high
Black – med

GEH, NOS, YER = no fertilizer
EHC,AER, NEB = medium or special case
EHC = st Augustine, med fertilizers, neighbors fertilize
AER – yard used to be fertilized, neighbors fertilize
NEB – no fertilizer, neighbors fertilize
KEN, LAD, MIZ = regularly applied fertilizers

Test 1

Sample Site	**pH**	**NO_2^-**	**NO_3^-**
Caples Control	**6.0**	**0**	**0**
NEB	**6.2**	**0**	**0**
EHC	**7.0**	**.25**	**0**
LAD	**7.1**	**.25**	**5.0**
GEH	**6.0**	**0**	**0**
NEK	**6.9**	**0**	**0**
AER	**6.6**	**.25**	**0**

YER	**	**	**
LOC	**	**	**
NOS	**6.6**	**.25**	**0**
MIZ	**7.2**	**.50**	**10-20**

** no water collected; no test performed

Test 2

Sample Site	**pH**	**NO_2^-**	**NO_3^-**
Caples Control	**6.6**	**0**	**0**
NEB	**6.6**	**.25**	**5.0**
EHC	**7.4**	**0**	**
LAD	**6.8**	**0.5**	**5.0**
GEH	**7.0**	**0**	**0**
NEK	**7.6**	**.25**	**5.0**
AER	**6.6**	**.25**	**5.0**
YER	**7.5**	**0**	**0**
LOC	**	**	**
NOS	**6.8**	**0**	**0**
MIZ	**7.0**	**0**	**0**

** no water collected; no test performed
+ old water was collected, and the tests were inconclusive due to no color change detection

Test 3

Sample Site	**pH**	**NO_2^-**	**NO_3^-**
Caples Control	**6.4**	**0**	**0**
NEB	**	**	**
EHC	**7.0**	**.25**	**0**
LAD	**7.0**	**0**	**0**
GEH	**7.2**	**0**	**0**
NEK	**7.2**	**.50**	**5.0**
AER	**6.8**	**.50**	**5.0**
YER	**	**	**
LOC	**	**	**
NOS	**7.0**	**0**	**0**
MIZ	**7.6**	**.50**	**5.0**

** no water collected; no test performed

Test 4

Sample Site	**pH**	**NO_2^-**	**NO_3^-**
Caples Control	**6.6**	**0**	**0**
NEB	**6.6**	**2.0**	**5.0**
EHC	**7.0**	**0**	**0**
LAD	**7.6**	**0**	**0**
GEH	**7.2**	**0**	**0**
NEK	**7.6**	**.25**	**0**
AER	**7.0**	**0**	**0**
YER	**	**	**
LOC	**7.6**	**0**	**0**
NOS	**7.6**	**0**	**0**
MIZ	**	**	**

** no water collected; no test performed

Test 5

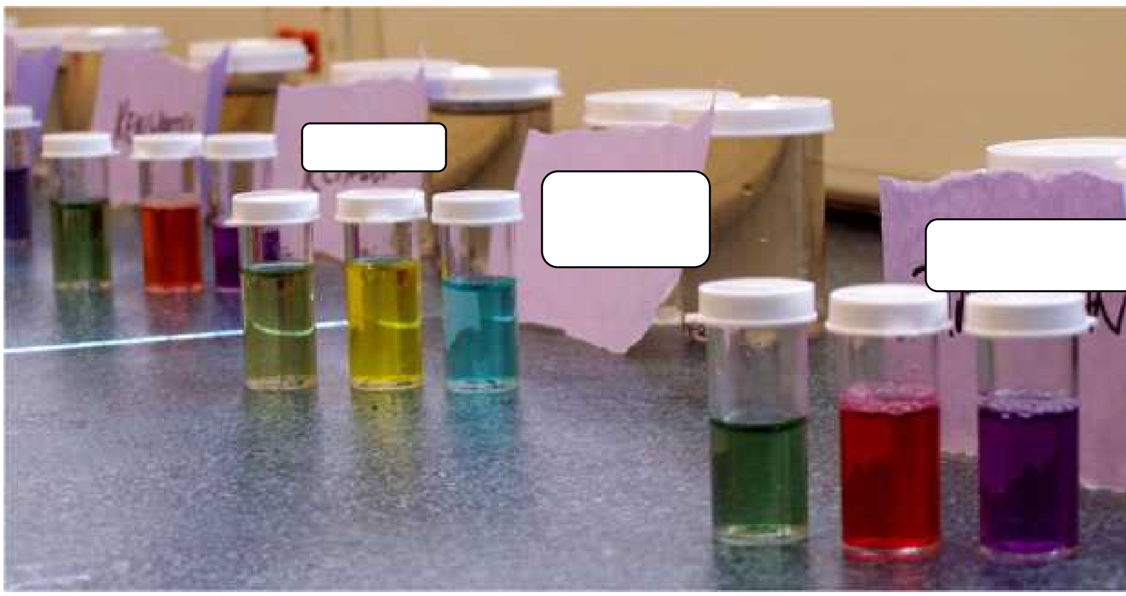
Sample Site	pH	NO_2^-	NO_3^-
Caples Control	**7.6**	**0**	**0**
NEB	**6.0**	**0**	**0**
EHC	**7.0**	**0**	**0**
LAD	**7.0**	**.25**	**5.0**
GEH	**7.6**	**0**	**0**
NEK	**	**	**
AER	**6.8**	**.50**	**5.0**
YER	**	**	**
LOC	**7.6**	**1.0**	**0**
NOS	**7.6**	**0**	**0**
MIZ	**7.2**	**0**	**0**

** no water collected; no test performed

Test 6

Sample Site	pH	NO_2^-	NO_3^-
Caples Control	**6.0**	**0**	**0**
NEB	**6.0**	**0**	**0**
EHC	**6.8**	**0**	**5.0**
LAD	**6.8**	**0.5**	**10-20**
GEH	**6.0**	**0**	**0**
NEK	**7.2**	**0.25**	**40**
AER	**6.6**	**1.0**	**5.0**
YER	**6.6**	**0**	**0**
LOC	**	**	**
NOS	**6.8**	**0.25**	**5.0**
MIZ	**6.6**	**1.0**	**20**

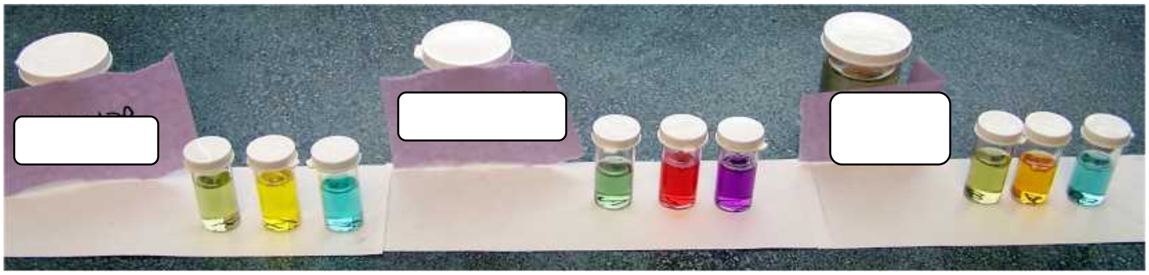
** no water collected; no test performed

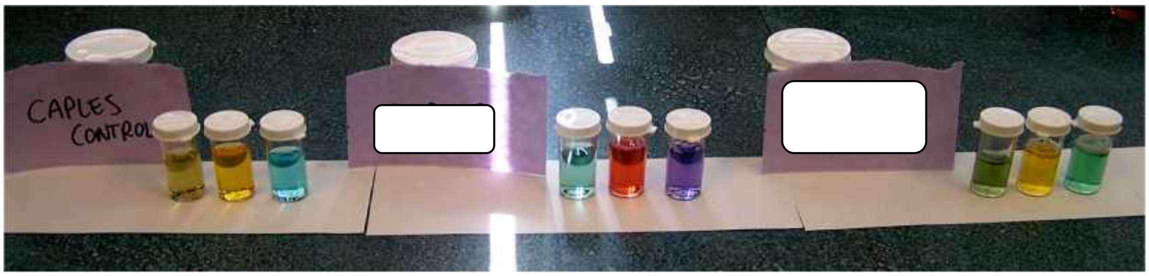


AER – medium yard GEH – Fl yard MIZ – chem. company

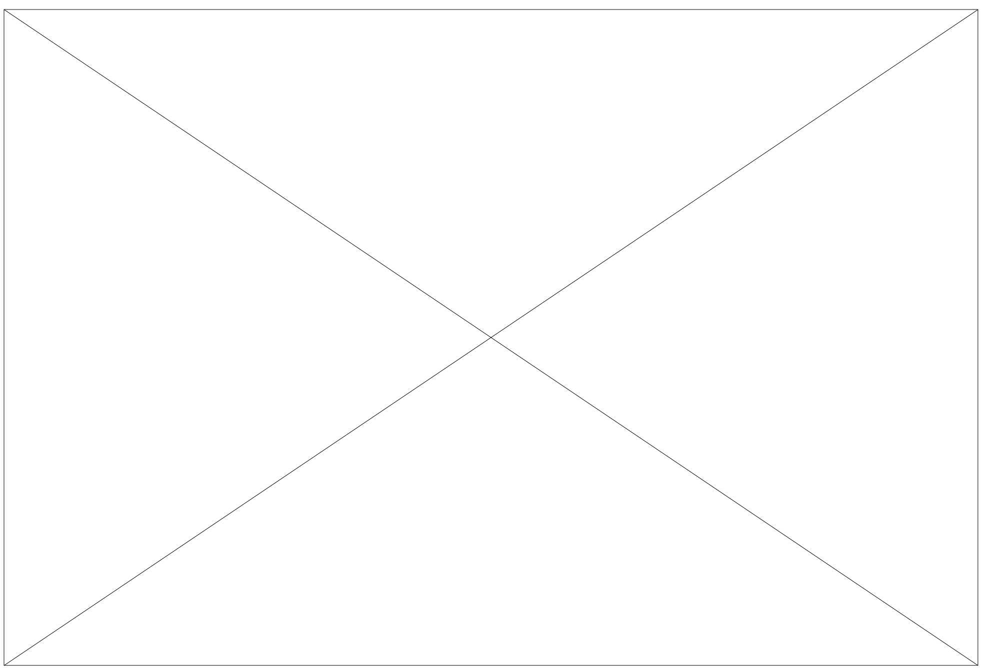
Photos of test results – green = pH
Yellow/red = no3
Blue/purple = no2

DATA

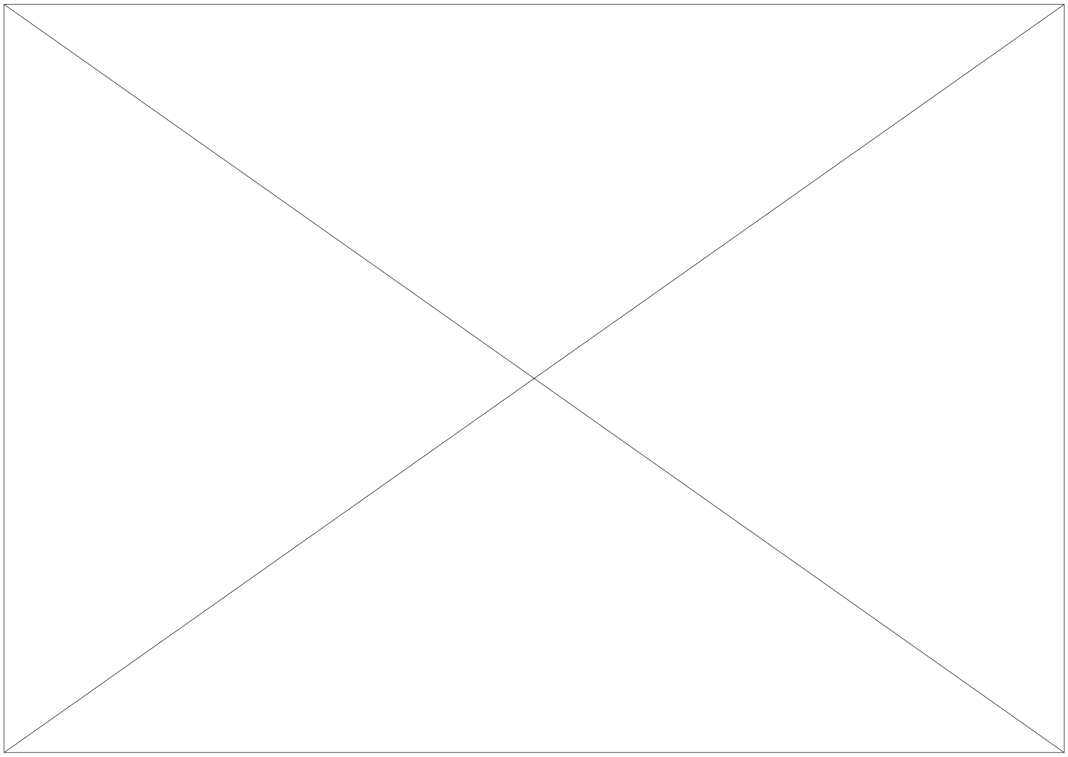




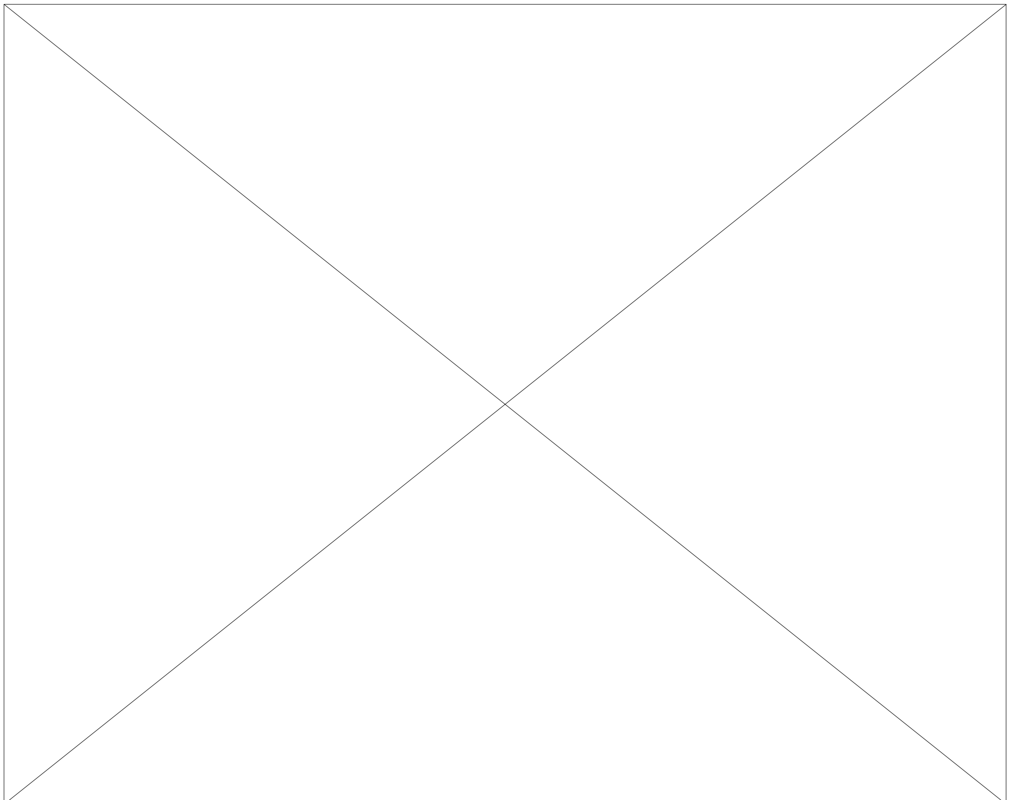
CONTROL

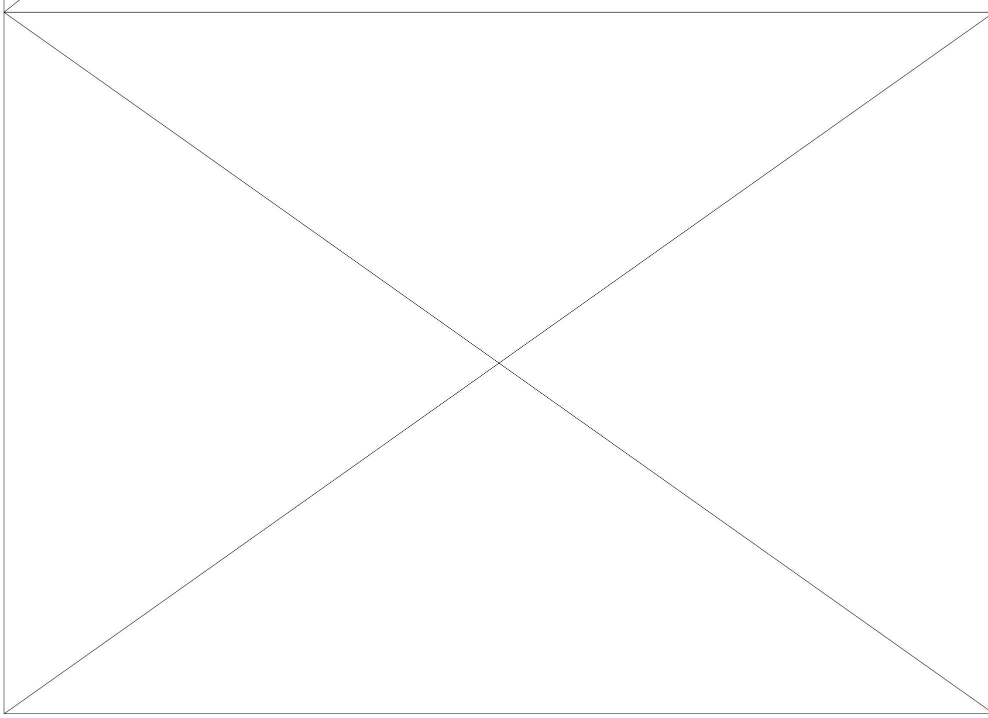


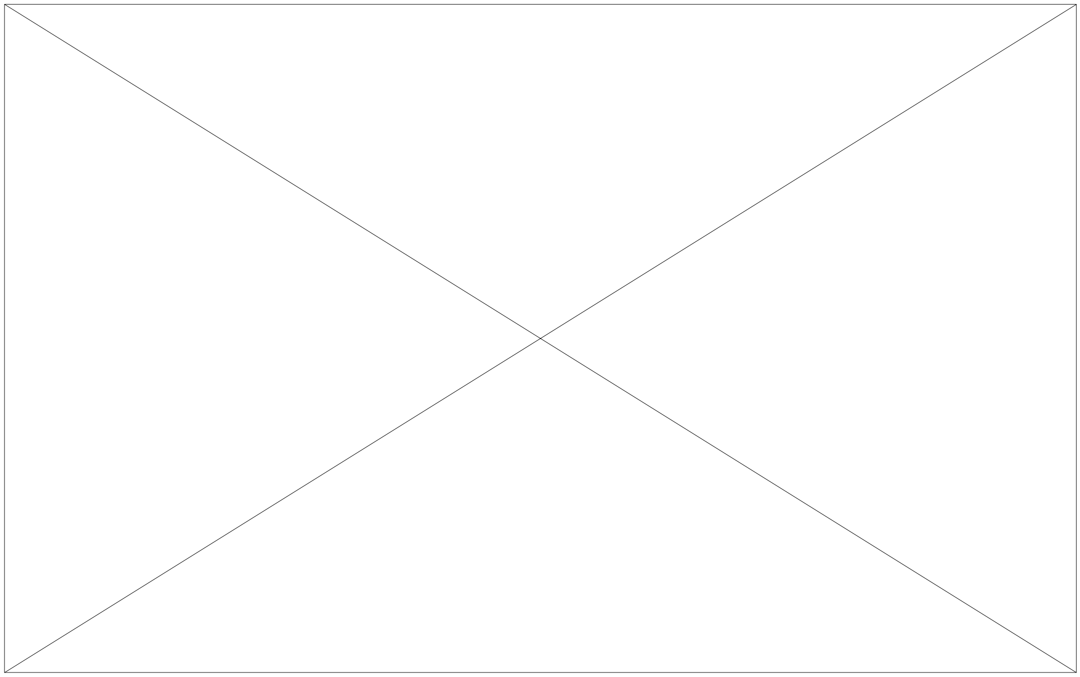
NO2: Nitrite



NO3: Nitrate







Discussion

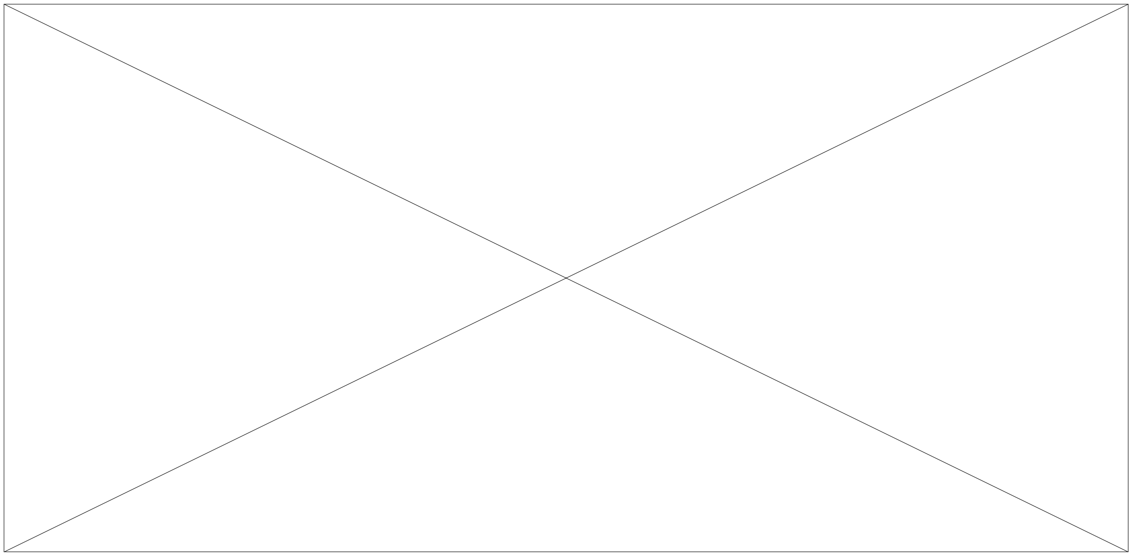
It is easy to see why tightly controlled experiments are so favored. This real world approach was fraught with challenges. We had no precise knowledge of neighbor's fertilizer use since we relying on self-reporting and no access to the concentrations, kinds, or amounts of fertilizer applied by either the owners or commercial operators. The sampling equipment was not placed optimally, but rather in consideration of landowner preference. Despite these obstacles several trends were observed.

NO2 Nitrite

Unfertilized yards and the control site had almost no nitrite runoff – the highest levels were less than .3. Yards characterized as 'medium' ranged from zero to 2.0, with several values above .2. The regularly fertilized yards only occasionally had zero values, with each yard having some values above .4 and one yard recording 1.0.

NO3 Nitrate

With the exception of one anomalous reading of 5, unfertilized yards and the control site showed no detectable levels of nitrate runoff. Yards characterized as 'medium' ranged from zero to 5.0, with several values above .2. The regularly fertilized yards had six zero readings, but these were offset six readings of 5, two of 15 and one of 20!



Recommendations

Despite the challenges it is recommended that additional research of this type be performed to corroborate these findings. More sophisticated analysis and better collection placement would increase the confidence in the findings.

EDUCATIONAL OUTREACH

Objective 2: Produce a variety of educational materials based in part on neighborhood findings to promote private actions to reduce bay runoff

Objective 3 Educate neighborhood residents regarding findings

The Bay Neighbor project has developed and implemented a wide variety of outreach methods and examples of many are included in the Appendix. This has included newsletter articles, presentations at regularly scheduled neighborhood meetings, special workshops, puppet shows, get-togethers, a video history and a website. In addition to local neighborhood education, several presentations have been made at statewide conferences. A summary appears below.

- Puppet play on neighborhood wildlife - A puppet play for grade school students was created by public high school students at PineView for public elementary school students at Bay Haven (the neighborhood elementary school) and Fruitville Elementary. The play targeted one of the original neighborhood habitats, coastal scrub, presenting information on scrub and the wildlife it supports. Puppets and costumes of snakes, an ox beetle, a gopher tortoise and fire were made for the puppet play. Set pieces of habitat plants, a gopher tortoise burrow, maps, and an arch with a 'keystone species' were complemented with projected slides. New College students joined the performance which took place before an audience of 80 Bay Haven 4th graders. The performance was so successful that it was exported to Fruitville Elementary, with improvements based on feedback from the original performance. The second play was viewed by 21 Fruitville Elementary 1st graders.

- Jono on IBSSA Board – Jono Miller joined the Board of Directors of the Indian Beach/Sapphire Shores Association (IBSSA) and attended their board meetings, providing valuable liaison and planning role.

- IBSSA Fall 2004 Picnic – We took advantage of a picnic hosted by IBSSA to set up a table with a map of the neighborhood, talk to residents and hand out our initial survey. Presented neighborhood stormwater maps and surveyed neighbors about yard practices at fall 2004 picnic.

- IBSSA semi-annual meetings - An IBSSA general meeting provided a forum in which to develop our strategy further. We gave a presentation on our plans and involved the neighbors in a public discussion about invasive plants in the neighborhood.

- Educational posters on focus priority plants and animals at Sun Circle – Target animals and plants included pileated woodpeckers, bats, ospreys, gumbo limbo, live oak, and others. Educational posters about these species were displayed in a popular neighborhood park. Information included how to identify the species, their needs, and what benefits they would bring to the neighborhood. The posters were illustrated with photographs.

- IBSSA Newsletter articles – An article introducing our project was printed in the IBSSA newsletter. A follow-up informational article about the project was written by a New College student and published in a subsequent issue of the newsletter.

- IBSSA party at Carriage House – We hosted a party for IBSSA board members and others to distribute our results and demonstrate possible responses to them. Many IBSSA board members attended, as well as other involved citizens and the Sarasota City mayor. Maps, photographs, posters, and information on soils and stormwater were presented, and students mingled with attendees to discuss the project.

- Micro-Irrigation Workshop – Our micro-irrigation workshop took place Earth Day 2005. We used a Southwest Florida Water management District (SWFWMD) grant to "anchor" a neighborhood Earth Day Event. This catalyzed an Earth Day event that would not have happened otherwise. The main focus was the micro-irrigation workshop and distribution of free micro-irrigation kits to those who had participated. This was supplemented with information about Florida Yards, worm composting and "the watershed pledge". We used student volunteers to train 69 people regarding how to assemble the micro-irrigation kits and then distributed 69 micro-irrigation kits to educated users. We "forwarded" leftover irrigation kits to Sarasota County for distribution at "e-fest". Each participant signed a card) that verified that they had stopped at all three training stations to understand the kit components and how they could be assembled. Neighborhood experts were on hand to demonstrate worm composting and provide information about Florida Yards. The SWFWMD grant supplemented the outreach initiative defined in this task and is part of a larger effort to create better "Bay Neighbors" -- a project conceived by New College of Florida and the neighborhood association and funded, in part, by our grant from NOAA. Florida yards, better irrigation practices, stormwater awareness, and educational materials are all part of the concept. The SWFWMD grant was specifically responsible for increasing the knowledge of and use of microirrigation as well as generating interest in creating more Florida Yards. Follow up phone calls helped document usage. Of the 69 IBSS residents who received kits, we were able to conduct follow-up interviews with 21. Of those, about half had installed their irrigation kits. The other half had put-off their installation until their new garden was up and running or had technical challenges connecting to their water supply.

  The up and running kits were used for both container and ground plantings. Users reported that watering was more targeted, plants were healthier, and time that had previously been spent hand-watering was now free for other activities. Several residents commented on the simple design and easy success of their micro-irrigation set-up.

- Jungle Gardens Bay Neighbors Workshop–Bay Neighbor Workshop, July 8th, 2006 – This free Saturday afternoon workshop took place at the Sarasota Jungle Gardens Education Building, centrally located in the IBSS neighborhood. Flyers about the workshop were mailed to the complete IBSS mailing list. Yard signs placed at key neighborhood intersections reminded residents of the time and place.

The featured speaker was Laurel Schiller, a well-known local native plant nursery owner. Her topic was "Landscaping for Wildlife" and she demonstrated her recommendations with numerous appropriate plants.

Following Laurel's talk, participants divided into three interest groups: the first reviewed maps of stormwater inlets and outlets and discussed how rainfall runoff reaches the bay; the second explained how trees serve as raincatchers, mitigating stormwater runoff; the third was an organizational meeting to establish a neighborhood plant exchange.

The whole group then reconvened for a panel discussion featuring four neighborhood residents discussing their personal landscaping joys and challenges. This panel used the idea of social marketing – residents are more likely to try techniques that neighbors are using than those promoted by outside experts.

The panel discussion was followed by a demonstration of how to plant a three gallon oak tree, and participants could receive a free oak tree to plant in their yards. Planting oak trees built on three major messages of the workshop: native trees support native wildlife; oak trees are great raincatchers; and part of being a good bay neighbor is taking actions to reduce stormwater runoff in residential yards.

60 neighborhood residents attended the workshop, and 30 left with tree-gallon oak trees to plant in their yards.

Bay Neighbors Environmental History Video–--- Motivation to be good bay neighbors arises from understanding the historic relationship between the bay and the neighborhood. Neighbors are a mix of a few long timers and many recent residents, and we envisioned the video as a way to share historical knowledge. This environmental history focuses on the natural character of the study area and describes how it has been modified by native Americans, early settlers, developers and government projects. Viewers learn how these changes influence Sarasota Bay, and the quality and health of the bay and surrounding environment are a theme throughout the video. The video starts with narration and historical artifacts from the Sarasota History Center describing local 19th century history. 20th century accounts are first person recollections drawn from 18 interviews with neighborhood residents and researchers. Included in the interviews are long time area fishing guide Johnny Walker, archeologist Miriam Almy, expert on the area stormwater system Jason Evans, and a near-pioneering couple Tom and Juanita Carr who attended the neighborhood elementary school nearly 70 years ago.

Neighborhood videographer Ed Ericsson shot the footage and downloaded all of it onto a computer, creating a rough cut using Windows Media. This was submitted to Julie Morris and Jono Miller for review. Changes in content were made. Sony Vegas Video was used to edit the final product. Russell Heath created original music and Heidi Harley narrated. Additional visuals, or B- roll footage, was shot to complement the audio. We also contacted the Harvard Peabody museum and bought the rights to use the painting by Seth Eastman of the *First Infantry Encampment at Sarasota, Florida 1841*. It took several weeks to edit the final video and we then made a DVD draft, and re-edited the video into its final 49 minute form. The premiere is scheduled to lead the semi-annual meeting of the neighborhood association on December 5, 2006 .

- Bay Neighbors Profiles booklet – In an effort to support local tree canopy and make connections within the neighborhood, student collected acorns from imposing neighborhood Live oaks. The acorns we collected were grown out in Micanopy at Urban Forestry Services Nursery and returned to Sarasota's Native Nurseries for an additional year of growth prior to planting. Once grown to suitable size they will be made available to neighbors.

  In order to assist in educating and motivating residents, we produced a 16 page brochure "Bay Neighbors Profiles", which profiled interesting yards utilizing varying strategies to make their landscapes more Florida-friendly and bay friendly. A copy of this brochure was mailed to every address in the neighborhood. The brochure featured profiles of nine yards and included photographs and specific information about the landscapes, who maintains it, how time is spent in the yard, basic maintenance routine, list of some plants included in yard, whether or not plants are exchanged between neighbors, dominant groundcover, special features, the residents' inspirations, and tips provided from the resident such as: most exciting current element or event in the landscape, biggest challenge, and problems or bonuses with animals/wildlife.

  This brochure helps residents learn about what people are doing in this neighborhood to make their yard more Florida-friendly. It was meant to complement the Florida Yards and Neighborhoods program that supplies useful information guides on the appropriate landscaping, but which are created for residents of all Florida areas, and consequently must be generic. People are interested in and inspired by what other residents are doing in their neighborhood, with conditions like their own, so we emphasized the "neighbor-to-neighbor" aspect of this information.

- Acorns to Oaks Project – In an effort to support local tree canopy and make connections within the neighborhood, student collected acorns from imposing neighborhood Live oaks. The acorns we collected were grown out in Micanopy at Urban Forestry Services Nursery and returned to Sarasota’s Native Nurseries for an additional year of growth prior to planting. Once grown to suitable size they will be made available to neighbors.

ASSESSMENT

Objective 4 *Assess neighborhood change*

INTRODUCTION

This year our education research began with a new focus in order to take advantage of our educational program's overarching theme, neighborhood cultural norms in yard management practices. (Roughly 80% of Florida's residents live in a coastal zone, however, many of these residents are not oriented towards ocean-friendly yard practices because of Florida's population transience; Florida gains almost 900 new citizens a day.) Through the grant, we worked to acculturate neighbors into bay-friendly yard management via workshops, brochures, and yard tours, but we also wanted to determine how to motivate them to get and use this information as well as inspiring them to act on it. An oft-suggested method of getting people to want to tailor their actions to respond to place demands is through creating in residents a stronger sense of place (SOP), i.e., a greater sense of attachment, dependence, and identity in relation to their geographical area. However, no data currently confirm a causal relationship between SOP and place-friendly behaviors or even a clear correlation between these two factors. Therefore, we designed a study to determine whether or not there was a correlation between SOP and a preference for information-seeking about local vs. non-local or unplaced attributes. To address this question, neighbor participants will take a standard SOP survey revised for our neighborhood. After each survey question, participants must choose between seeing/hearing a local vs. an unplaced/non-local animal/scene. A high level of SOP as measured by the survey and a high preference for experiencing the local animal/scene would indicate a positive correlation between SOP level and information seeking about local attributes. Other findings would indicate a different sort of relation in which case focusing on SOP would likely be irrelevant for enculturating neighbors into bay-friendly yard practices. At this point we have made the following progress on the study:

(1) We identified and revised a standard SOP survey instrument for our neighborhood.

(2) We obtained the equipment to create local stimuli for the information-seeking measure and de-bugged the system to make it useable.

(3) We created stimuli, photos and acoustic recordings of local fauna, for the information-seeking measure.

(4) We worked with a web designer to begin putting the survey and stimuli on the web.

(5) We began work on the IRB application to instantiate the study via the Bay Neighbor website.

BEYOND

Objective 5 Communicate both the process and results beyond the Neighborhood

Conference Presentations

- Poster Session at Jacksonville Florida Neighborhoods Conference - Three panel "poster" reported results at state of Florida Neighborhood Conference in Jacksonville, FL in September 2004. Several students accompanied Jono Miller to this conference.

- Panel member Lakeland Florida Neighborhoods Conference – Jono Miller was part of a panel a presentation "Using Community Environment to Bring Together Neighbors" at the 9th Annual Florida Neighborhood Conference in Lakeland, Florida, October. This panel featured several speakers from Sarasota County all speaking about neighborhood involvement in environmental issues.

- Presentation Sarasota Manatee Neighborhood Summit -- Julie Morris and Jono Miller gave a presentation and fielded questions about the Bay Neighbor Project at a local two county neighborhood summit held February 26 2005. Our topics was "Changing Neighbors, Changing Neighborhood Landscapes" Session Description follows: Social and environmental ingredients mix, shaping the character of neighborhoods. This workshop will introduce several concepts of neighborhood (neighboring activities, proximate strangers, place attachment, and defended boundaries) drawing on the personal experiences of the participants. With this background, the workshop will consider how neighborhoods change socially and environmentally as new residents with new notions of yard stewardship and the neighbor role move in. We'll look at yards from a neighborhood context, discussing how and why neighborhood landscapes change and the potential for going beyond yard-by-yard landscaping to reach broader neighborhood goals and preserve neighborhood social and environmental character. Additional examples will be drawn from a Sarasota bayfront neighborhood.

- Presentation Campus and Community Sustainability Conference – Jason Evans

- Presentation anticipated at the 2007 Florida Neighborhoods Conference, to be held in Sarasota (see Future Directions section)

Coordination with Partners.

- Neighborhood Environmental Stewardship Team (NEST) workshop - After meeting with staff in the City Department of Neighborhoods, we orchestrated and led a NEST (Neighborhood Environmental Stewardship Team) meeting in the city. Representatives from the City of Sarasota, the County of Sarasota, NGOs and neighborhood associations attended the meeting along with our team and a class of New College students. The group brainstormed neighborhood level environmental work that needs to be done (including information about greenways, invasive species removal, wildlife gardening, neighborhood stormwater pond use, and community involvement) and these ideas were incorporated into this project

- Presentation to SBEP Technical Advisory Committee, August 25, '06 – the project team presented results of the stormwater infrastructure, basin and subbasin maps, canopy maps, impervious surface maps, rainfall interception study, and yard stormwater quality studies to the Technical Advisory Committee of the Sarasota Bay Program. The TAC was enthusiastic about the results and made the following suggestions:
    - Convert rainfall interception data into inches for easy transfer to engineering calculations;
    - Choose two contrasting subbasins and create detailed maps of landscape intensity, and correlate water quality at the outlets;
    - Continue the yard stormwater sampling, incorporating accurate data on land maintenance practices and develop an agreement with Sarasota County to analyze samples.
    - Coordinate IBSSA stormwater data with a large outfall study conducted by Post Buckley Engineering under contract with SBEP;
    - Explore the feasibility of added treatment for two large outfalls that drain US 41 directly to Whitaker Bayou;
    - Examine whether algae in private outfalls from over fertilized bayfront lawns could be used as an indicator of nitrogen hot spots, with targeted outreach to these homeowners.

- Meeting with Sarasota County Staff to transfer files and discuss resident look-up link for website, May 24, 2006 – The project team met with Sarasota County neighborhood, stormwater, and GIS staff to present results, deliver ArcView files and plan a resident look-up feature for the Bayneighbor.org website. The project team asked the county staff to respond to a number of potential projects to improve stormwater quality in the IBSSA neighborhood. These projects included: removing curb and gutter to allow stormwater to pass over pervious surfaces; increase the tree canopy by planting trees in the right-of-way; restrict fertilizer use in the bayfront zone; convert more yards to "Florida Yard" standards; reduce the impervious area associated with commercial property along US 41; provide residents with outfall maps and photos showing their connection to the bay. County staff discussed a Water Quality Improvement Project which will eventually provide funding for baffle boxes to be installed in to retrofit existing storm drain systems

- Meeting with City of Sarasota Staff and SBEP to discuss use of stormwater data July 27 and July 31 '06 – City of Sarasota Office of Neighborhoods coordinated two meetings with city staff from the public works and engineering departments and representatives from the Sarasota Bay Estuary Program (SBEP). The New College team presented their study results and led a discussion to identify additional research and possible projects to improve stormwater management in the IBSSA neighborhood. Good ideas included:

- identify neighborhood mentors for residents who want to convert to a bayneighbor landscape;
- expand "recognition of Florida Yards" in neighborhood;
- for each subbasin in the neighborhood, identify intensity of lawn maintenance and correlate this with water quality and quantity at the outfall to the bay;
- partner with the City's green canopy program and identify neighborhood streets for potential planting;
- work with Sarasota County to mark stormdrain inlets with "drains to bay" signs;
- add sediment trapping structures to the neighborhood storm drains;
- evaluate the feasibility of removing curb and gutter on targeted streets. IBSSA could request that additional curb and gutter be prohibited in the neighborhood, and that additional water treatment swales be added.
- Identify undeveloped street right-of-ways and request that they be used for city-funded stormwater treatment;
- Report the locations of private stormwater outlets to the city building department.

Neighborhood stormwater field visit, Nov. '06 – IBSS neighbor Charlie Hegener has proposed 23 specific neighborhood locations for stormwater retrofit treatment. On November 21, 2006, Mr. Hegener and Jono Miller met with a number of representatives from Sarasota County and the City of Sarasota to explore both sites and techniques that may be employed when the County takes stormwater management (which has been focused on drainage and flooding) to the next level (water quality). In addition to looking at significant publicly owned lands the group also contemplated experimental curb removal and depressed infiltration areas in rights of way between the street and sidewalk.

Future Directions

Ongoing Bay Neighbor Efforts Resulting from the NOAA Grant

Although the official grant period has ended, the grant has initiated a number of ongoing efforts that persist. These efforts are testimony to the fact that NOAA grant, combined with latent neighborhood and agency interest has established the IBSS neighborhood as a focus for investigations and improvements regarding the relationship of neighbors to the bay. Nine specific actions follow – all are in the works with people actively pursuing them and are not merely potential ideas

• As reported, we are still pre-testing an online survey that will be featured on the website. This has delayed the posting of the new website format. The newly formatted website will be linked to the IBSSA website.

• The acorns to oaks project should reach fruition next year. These neighborhood oak seedlings will be made available to neighborhood residents.

• In a separate, but complementary, effort Sarasota County printed stormdrain inlet markers specifically referencing Sarasota Bay and has enlisted volunteers to affix them to stormdrain inlets in the neighborhood. That project is partially completed.

• The neighborhood association has requested reprinting of the Bay Neighbor Profiles booklet. It will also be made available as a pdf file on the website.

• The Sarasota Bay Estuary Program is interested in some follow-up studies. (See Meeting with Sarasota County Staff to transfer files and discuss resident look-up link for website, May 24, 2006 above)

• IBSS neighbor Charlie Hegener has proposed 23 specific neighborhood locations for stormwater retrofit treatment. (See Neighborhood stormwater field visit, Nov. '06 above)

• The 2007 Florida Neighborhood Conference will be held in Sarasota and we are planning a major presentation and possible field trip to feature the work done in the IBSS neighborhood.

• Sarasota County is planning to make sub-basin mapping available online so that residents can click and gain visual information about the basin they contribute to. Ideally this will be linked to a photograph of the bay discharge pipe – forming a visual link between a yard, a basin and the stormwater contribution to the bay. (See Meeting with Sarasota County Staff to transfer files and discuss resident look-up link for website, May 24, 2006)

• Continued interest from the county and other engineers leads us to believe our dramatic, but not definitive, results from stormwater runoff testing will lead to additional support for yard runoff testing.

APPENDICES

Study Topics Survey

Be Part of History in the Making

Shorelines (Neighborhood Newsletter)

Microirrigation Workshop materials

Acorns to Oaks flyer

Bay Neighbor Workshop materials

Bay Neighbor Profiles Booklet

Hegener Indian Beach Projects Draft

Neighborhood Environmental History DVD