

# **A GIS Application for Monitoring Development Activity in Sensitive Areas**

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## **Abstract**

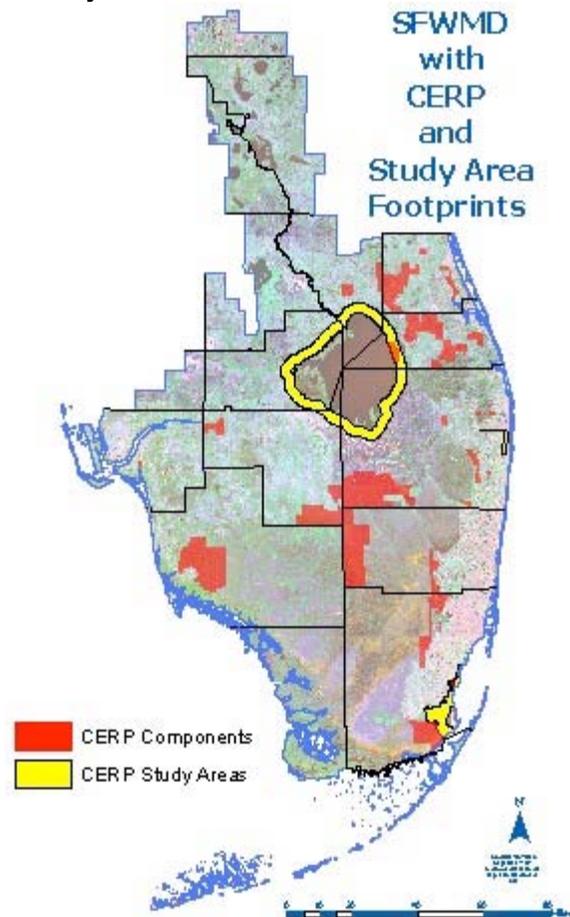
The South Florida Water Management District (SFWMD) has been challenged with the monumental task of reengineering the Florida Everglades via a plan called the Comprehensive Everglades Restoration Plan (CERP). This paper will describe how a GIS infrastructure is being utilized to prevent conflicts between various agency, land and water development mandates. Specifically, how it has bridged a critical communications gap between the Regulation Department, the CERP Project Managers and the USACOE. Through automation, this process tracks, coordinates and identifies private landowner permit applications that may conflict with the public interest efforts to "repair" the Everglades.

## **Introduction**

The South Florida Water Management District (SFWMD) spans 16 counties over an 18,000 square mile area and is responsible for the operation and maintenance of a complex canal and levee system that stretches from Orlando in central Florida to the Florida Keys in the south. The SFWMD's mission is to manage and protect the water resources of the region by balancing and improving water quality, flood control, natural systems and water supply. Multiple factors in south Florida contribute to the importance of balancing the fragile intersection between human development and that of water resources. While experiencing some of the highest growth rates in the nation, the SFWMD is also responsible for managing the health of the ailing Everglades. The Water Resources Development Act of 2000, tasks the federal government and the State of Florida with the creation and implementation of the \$ 7.8 billion Comprehensive Everglades Restoration Plan (CERP) over the next four decades. As approved, this plan "provides a framework and guide to restore, protect and preserve the water resources of central and southern Florida." In an effort to modernize the canal and levee system that drains and distributes water, "the CERP Plan was designed to capture, store and redistribute fresh water previously lost to tide and to regulate the quality, quantity, timing and distribution of water flows".<sup>1</sup> The plan contains 60 separate elements that aim to embody these reengineering goals and is being jointly planned and designed by the United States Army Corps of Engineers (USACOE) and the SFWMD. (Figure 1)

Some of the major project components include:

- 1) Surface Water Storage Reservoirs
- 2) Water Preserve Areas
- 3) Management of Lake Okeechobee as an ecological resource
- 4) Improved water deliveries to the estuaries
- 5) Underground water storage
- 6) Treatment wetlands (to remove excessive nutrients)
- 7) Improved water deliveries to the Everglades
- 8) Removal of barriers to sheetflow (roads and levees)
- 9) Storage of water in existing quarries
- 10) Reuse of wastewater
- 11) Pilot projects
- 12) Improved water conservation
- 13) Additional feasibility studies



**Figure 1**

Currently, a very large land acquisition program is underway to secure the necessary land parcels needed to build these project components. While some of the land has been purchased for the construction of the projects, many of the elements are still in their infancy and lack defined boundaries. To help compensate for this uncertainty, multiple

areas have been designated as “study areas” and are considered a set of “soft or fuzzy” boundaries in anticipation for component placement needs.

The impetus for the Arc Macro Language (AML) program outlined in this paper was the result of a conflicting agency action regarding the issuance of a land development permit (Environmental Resource Permit, ERP) in April of 2002. While the SFWMD’s Environmental Resource Regulation (ERR or Regulation) Department takes into account many variables when issuing a permit, considerations for conflicting private landowner development within CERP component areas had not yet been included in the permit review process. In this particular instance, an ERP permit was being issued for a large residential development in the same location that the CERP plan had designated placement for a critical flowway to restore the hydrologic connectivity of a coastal ecosystem. With the high growth rates being experienced in south Florida it is evident that this type of occurrence will not be an isolated incident. Upon discovery of these types of potentially conflicting agency actions it was determined that an early warning communications system was needed to identify and resolve these instances of spatial discord.

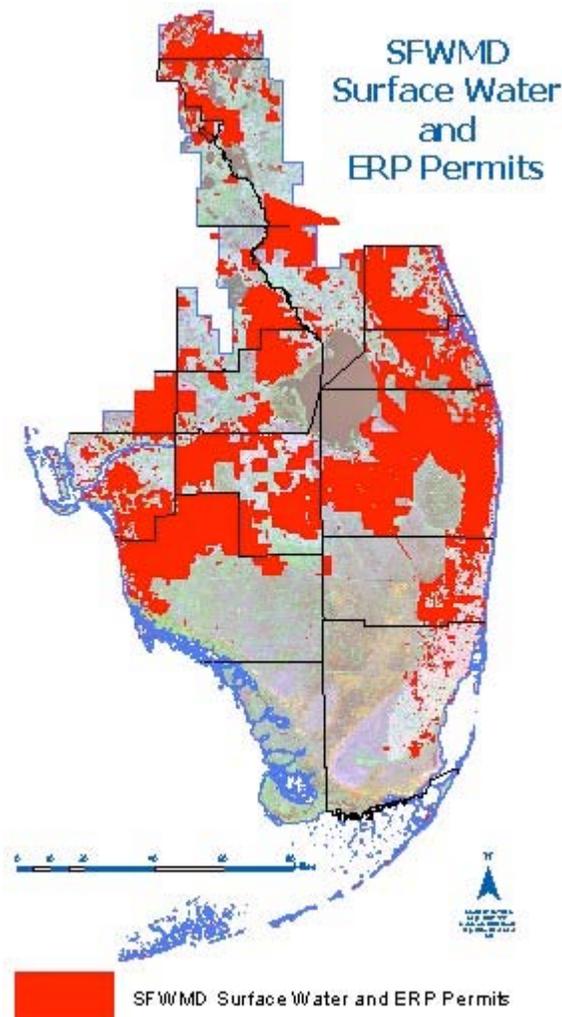
## **Organizational Goals and Framework**

The SFWMD is comprised of multiple departments that are tasked with separate functions in support of the overall agency mission. The newly adopted CERP program is guided by a project management team of SFWMD and the USACOE staff who coordinate the specializations of multiple departments in support of the overall project goals. Of particular interest to the focus of this paper, the CERP project managers work hand in hand with the geographic information systems (GIS) staff of the Land Acquisition Department to maintain a layer of geographic boundaries for the various project components. This GIS layer is recognized as the enterprise-wide, officially adopted set of boundaries for the CERP project. In addition to the spatial aspect of the components, this department is also responsible for the maintenance of the attribute data, including such information as; component project manager names, point of contact phone numbers, spatial accuracy and project component names. As the individual component plans mature, the Real Estate Division prioritizes and initiates the purchase of the necessary parcels. A key economic strategy of the CERP plan is to acquire the necessary land early in the project to avoid the anticipated increases in property values in the coming years. Consequently, this strategy has the potential to compete with private landowner proposals for new development activities that are permitted by the SFWMD’s Regulation Department.

The Regulation Department issues many types of permits, with the majority falling into two groups. The first, referred to as surface water or Environmental Resource Permits (ERPs) apply the state’s adopted rules and criteria to address flood protection, water quality treatment and wetland protection. To keep it simple it’s easy to think of these permits as “above the ground” or surface water management issue related. The other primary type of permit class is used for regulating water use consumption wells or issues affecting ground water supplies and flows.<sup>2</sup> For the remainder of this paper, the words

application and permit will focus entirely on ERP or surface water permits and can be interchanged. As of mid- 2003, the Regulatory GIS database contains approximately 21,000 surface water and ERP permits. (Figure 2)

When the aforementioned agency action conflict was identified, a critical and urgent request by upper management was issued to the regulatory GIS staff to immediately perform the analysis necessary to identify any other similar conflicts between pending permit applications and proposed CERP land acquisition efforts. This initial analysis was performed manually and resulted in an Excel spreadsheet that contained pertinent information about each permit application and its overlapping CERP component. This was a time sensitive, stop-gap remedy until a permanent automation solution could be devised.



**Figure 2**

In addition, the District's Governing Board now requires that "when an ERP application is filed, that falls within or adjacent to a planned CERP project or study boundary, that application is subject to additional internal agency review and coordination by the District's regulatory, CERP and land acquisition staff." Also, it is important to note that

“The purpose of this review is to provide the District Governing Board with the best information possible and a single, coordinated staff recommendation on the permit application.” To meet this requirement a system for new pathways of communication needed to be implemented to facilitate discourse amongst the independent departments. Before reviewing the specifics of how GIS automation is used to identify conflicting agency mandates, a cursory understanding of the regulatory GIS infrastructure is necessary.

## **Regulatory GIS Infrastructure**

The history of GIS in the Environmental Resource Regulation Department dates back to 1988. Over time, technological advancements have both streamlined existing functions while also creating opportunities to organize and visualize geographic data in new ways. By the simple nature of issuing permits, the Regulation Department has always had a vested interest in being able to locate or track the boundaries of permits it has issued. This was originally accomplished by drawing with colored pencils, the approximate permit boundary onto a United States Geological Survey (USGS) 7.5 min hardcopy quad sheet. As the GIS program developed within the department, there was a constant change in the technology, methodology and workflow used capture, edit and utilize this data.

Due to the stringent timelines and legal nature involved with issuing permits a strict workflow must be maintained in order to expeditiously process the necessary information by all relevant agency parties. When the permit application is received in-house, a thirty-day time clock starts ticking. The file is processed by an administrative staff member who assigns a unique application number to the project and then transfers the tabular data from the hardcopy file into an Oracle database. This step creates a unique record in the database and makes the administrative tabular data readily available to all interested parties. Upon completion, the administrative staff route hardcopies of the application to other departmental staff, which usually include the surface water management reviewer, natural resource management reviewer and the GIS staff member. This process usually takes a week to complete, but can take longer for applications that are processed off-site at an area office. The goal of the GIS staff is to scan the permit application file for the best available location map of the project’s boundary and then enter it into the appropriate ArcInfo coverage. Depending on the quality of the application package maps and the type or size of the permit being applied for, the amount of effort required by the GIS staff can vary greatly. Once the permit application boundary has been successfully entered into the GIS database it becomes available through a host of enterprise-wide GIS software applications to both internal and external clients. These user interfaces include custom ArcView, ArcIMS, J-Shape and FTP data download tools.

## **Basemaps**

A variety of techniques are utilized by the GIS staff members to enter or digitize the permit boundary into the appropriate ArcInfo coverage. As previously mentioned, many technological advancements have occurred since the beginning of the permit data capture program in 1988. To best understand the current methodology used for entering permit boundaries into the regulatory GIS database and other problems with data conflation, a

review of the historical chronology of base maps is appropriate. A brief GIS permit timeline would be as follows:

- Permit boundaries were drawn with colored pencil onto a 7.5 minute USGS quad sheet.
- Permit boundaries digitized into a data layer using Computer Vision and later transferred to Autocad.
- Boundaries were digitized on a tablet with ArcInfo and referenced to vector sources of varying positional accuracy.
- Heads-up digitizing using 10 meter SPOT Image data.
- Heads-up digitizing using 1 meter DOQQ aerial photography.
- (Current methodology) that utilizes cadastral and sub-meter georeferenced aerial photos.

With such a large areal land area, budgetary restrictions have limited the options of imagery and vector products available to the GIS staff. For many years, a resulting compromise to this dilemma was the district wide acquisition of SPOT Image products. While multiple departments benefited from this acquisition program, the Regulation Department's need for current and continuous data played a large role in the SFWMD's collection of one of the world's largest chronological archives of SPOT Image data for a given area.

It wasn't until two years ago that the agency received cadastral data for the entire 16 county area. The primary reason for such a "late blooming" in the enterprise GIS paradigm, was due to non-existing data, proprietary data sharing restrictions and the excessive costs involved with such a large scale cadastral implementation (16 counties). Although the regulatory GIS now has a highly positionally accurate base layer for current permit entry, the variable reference sources of the legacy database contribute to the current lack of a seemingly obvious automation solution to permit entry. This is primarily manifest in the topological or "overlap" problem inherent in the ArcInfo coverage model. Efforts to migrate from the coverage data model to the Geodatabase model are currently underway, and should be completed by the end of 2003.

## **GIS Data Entry**

When the GIS staff receive the hardcopy permit application file, they must review it's content to determine which coverage it should be placed in. The Regulation Department's coverages have been separated by county into 10 unique permit types to avoid the potential of overlapping permits for a given area. Currently, a set of ArcInfo and ArcEdit menus are being used to streamline the editing and attribution of the permit polygons being entered into the coverages. The ArcEdit menu provides the GIS staff with a plethora of GUI editing tools and basemap selection options for referencing the permit boundaries. While many permit application boundaries are coincident with cadastral data, others are not and require heads-up digitizing to aerial photography. Unfortunately, an automated solution for cadastral boundary input is not possible at this time due to the inaccuracy and high density of existing permit boundaries. After the

appropriate arcs have been selected or drawn into the correct location by use of a menu, the user enters a label and types the unique application number for the polygon.

The current attribute table for the editing version of the permit polygon coverages contains information specific to the data entry process of the polygon boundary. This version of the polygon attribute table is viewed only by the GIS staff and therefore contains attributes unrelated to other permit functionality. (Figure 3)

Fields	Sample Values	Definition
App_no	970113-19	Unique identifier to current project
Old_app_no		historical applications to permit
County_id	md	county abbreviation code
Permit_no	13-02003-P	project master permit number
Permit_cat	gp	permit category definition based on thresholds
Permit_type	erp	permit type base on permit function
Lu_code	com	predominant land use of project
Multi_lu_code		multiple land uses of project
Base_map	county_parcel_data	source layer to which permit is referenced
Entered_by	mbroker	GIS staff who digitized original boundary
Entered_date	12/31/1999	the date originally captured
Modified_by	mbroker	GIS staff who modified original boundary or attributes
Modified_date	01/01/2003	the date boundary or attributes were modified
Process_note	something important here	GIS staff comments pertaining to permit boundary
X-coord	878410.5464	Current x coordinate value of polygon centroid
Y-coord	562615.6724	Current y coordinate value of polygon centroid
Old-x-coord	878410.5464	Most recent x coordinate value of polygon centroid
Old-y-coord	562615.6724	Most recent x coordinate value of polygon centroid
Geo_flag	Y	If ready to be entered into geodatabase

**Figure 3**

After the user enters the application number through the menu interface and saves the data, a series of “behind the scenes” code completes the attribution of the remaining fields. At this point the user can continue to enter additional boundaries, modify existing ones or exit the coverage. On average, the five GIS staff members input or edit between 20 and 40 polygons per week.

During other times of the day and night, automated programs remove this “editing” attribute data used by the GIS staff and join the permit coverages with additional end-user defined tables from the Oracle database.

## The Application

As is common with many tasks in the geo-spatial world there are often a number of solutions possible for any given problem. In the following paragraphs an explanation will be given as to how the Regulation Department is currently automating the process to track, coordinate and identify those permit applications that may conflict with the long term goals of CERP. Due to the current regulatory GIS infrastructure an Arc Macro Language (AML) program was created for automating this process.

Each day at noon, the windows task scheduler runs a program to search for changes to the regulatory GIS database from the previous day that may coincide with the current CERP footprint. To start, the program makes copies of all the current permit and CERP Footprint coverages needed for the application. In addition the search date variable is set for the previous day and connections to Access and Oracle databases are made. First, the AML loops through each coverage checking for topology, and if necessary will clean and build the coverage. Next, the coverage is loaded as a table into Access in order to perform an SQL query on various values in the polygon attribute tables (PAT). The AML utilizes three criteria to identify search polygons. First, it searches each coverage (48) for polygons that contain the same *Entered\_date*, as that of the previous day. This is an automatic flag that indicates the permit is new and has not yet been checked. The second criteria would flag permits that have the same *Modified\_date*, value as that of the previous day. This helps to identify those permit boundaries that were altered and could now possibly be overlapping the CERP footprint. The *Modified\_date*, is only changed in the PAT when the polygon is edited by the attribution tools in the menu. The last criteria compares each polygon's centroid X-coord and Y-coord values to the Old-x-coord and old-y-coord centroid attributes in the PAT. Each evening an AML is run to reset the X-coord and Y-coord values for the polygon. This is accomplished by using the *Centroidlabels* and *addxy* command to update the Old-x-coord and Old-y-coord fields. If these values are different, the polygon is flagged for checking. If any of the above criteria have been met, the polygon is placed into a new "flagged" coverage that will be further investigated in the program.

The next step performs a *Union* on the "flagged" permit coverage with the three CERP footprint layers. This creates three new unioned coverages. These layers are queried for two specific values unique to each of the input coverages in the union sequence that would signal the application polygon falls inside the CERP Footprint. The fields are *App\_no* unique to the permit coverages and the *Name* field unique to the CERP footprint layers. These polygons are subsequently placed into new coverages and given the additional item and value of "In" indicating that the permit polygon is definitely located in the footprint. Finally, these PATs are loaded into the Access database.

As an additional security step, the flagged permit coverage is also analyzed for adjacency to the CERP component footprints by performing the same process to a 300 foot buffer around each CERP component. This helps to ensure that permits issued by the Regulation Department won't have negative secondary impacts on a nearby CERP component functionality. It also accommodates for inaccurate boundaries in any of the input layers and additionally provides a last chance review of CERP component land acquisition boundaries. A 300 foot buffer strip is created around each component, which is then unioned with the "flagged" permit coverage. If any of these polygons meet the same criteria, i.e. they contain an *App\_no* and *Name* value, they are copied into a new coverage and flagged as "Adjacent". These layers are also placed into an Access database for additional analysis.

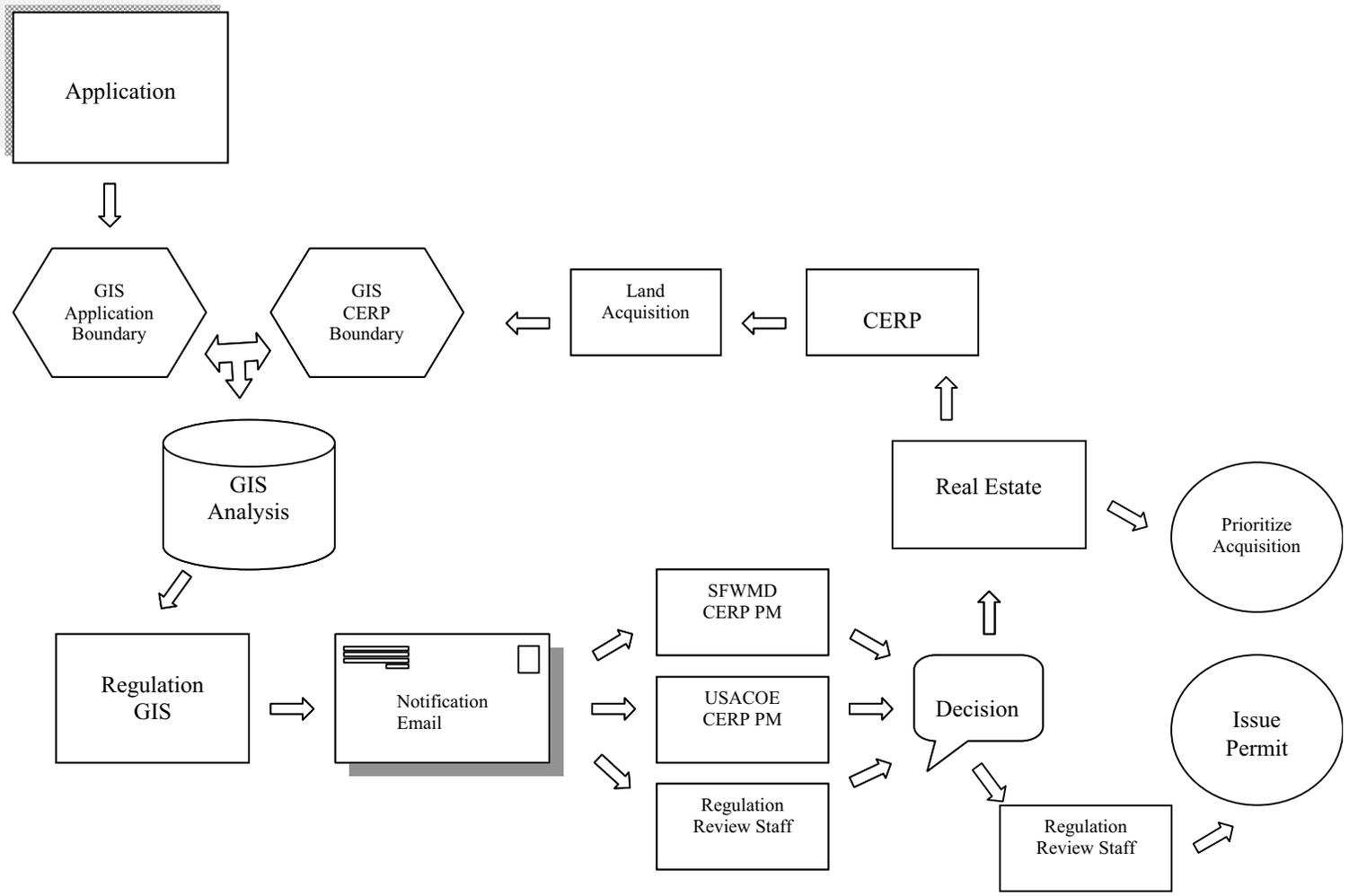
The final analysis necessary to determine if the permit application meets the final selection criteria entails determining if the type of permit being applied for justifies the additional coordination procedures. This is performed by querying the Oracle database to

determine the exact application purpose. This helps to weed out new insignificantly low impact projects or minor modifications to existing permits. If any of the records in the final “Unioned” Access tables meet this threshold requirement they are elevated to the final procedure. In this final step, additional application specific information is pulled from the Oracle database. This data includes the project and applicant’s names, the surface water and natural resource management reviewer’s names and the project acreage. Together with the polygon information inherent in the original layers (permit and CERP component) the attributes are formatted and placed in an email. The freeware program Blat, is then called to send an email out to various members of the GIS staff who perform a final review of the conflicting boundaries. Here is an example of the information that a notification email would contain. The source of the attribute data has also been added for clarity. (Figure 4)

Email Content	Data Source
Application Number: 030730-03	Permit coverage
Permit Number: 13-02003-P	Oracle
Land Use Code: RES	Oracle
CERP Level: 2	CERP coverage
CERP Name: Henderson Creek / Belle Meade Restoration	CERP coverage
County: COLLIER	Oracle
Project Name: FIDDLERS CREEK UNIT FOUR	Oracle
Acreage: 305.84	Oracle
Applicant Name:	Oracle
ERR SWM Reviewer:	Oracle
ERR NRM Reviewer:	Oracle
USACOE Project Manager:	CERP coverage
Phone Number for USACOE Project Manager:	CERP coverage
SFWMD Project Manager:	CERP coverage
Phone Number for SFWMD Project Manager:	CERP coverage
Status: in	Buffer coverage

**Figure 4**

The information contained in the notification email enables the staff from separate departments which are often located in different cities, the ability to coordinate a unified response to the conflicting projects. This information is delivered in a timely manner, usually before the permit review process begins, and allows all necessary staff the appropriate time to evaluate the permit criteria and its affect to the CERP goals. If the projects are deemed incompatible, the land acquisition staff can begin negotiations for purchasing the subject property. (Figure 5) Additional AML code has been written to automatically create a map of the project boundary in ArcPlot, but was never implemented in an effort to begin the migration into the Arc8 and VB/VBA environment. The next section of the paper will outline the various communication work products that are available to staff and other interested parties.



**Figure 5**

## Communication Work Products

In addition to the email, any new applications that meet the requisite criteria are automatically appended to a master Access database table that contains all active or pending permit applications that are “In” or “Adjacent” to the CERP Footprint. In housing all of the relevant information, this database has become the fulcrum of the coordination effort, joining the back-end analysis with the front-end work product deliverables. It provides the GIS staff with a single database table to manage and has the versatility to receive and generate input and output datasets. One of the original key requirements by management was the need for a master spreadsheet of all active projects that could be referenced by any interested party. This spreadsheet has been placed on the SFWMD intranet via .asp code for a real time link to the information and is exported as

an html document and manually placed on the external internet. The table can be viewed at this location: [http://www.sfwmd.gov/org/reg/rim/cerp/sheet1\\_1.html](http://www.sfwmd.gov/org/reg/rim/cerp/sheet1_1.html) .

The database has also proved very helpful for dynamically generating a set of GIS data layers. These data layers are being utilized in both desktop and web enabled mapping products. An AML program was written to generate an ArcInfo coverage by first creating a list of the application numbers contained in the database and then reselecting the polygons from their appropriate native coverage location (48 possible coverages). This data is then used for multiple applications. A customized ArcMap application has been created which allows the user to enter an application number which then automatically generates a layout showing the subject application in relation to the conflicting CERP component. The resulting map is exported as a JPEG and is utilized for the notification email attachments as well other internal coordination communiqués.

The coverage was also originally converted into shapefile format for utilization by a SFWMD intranet ArcIMS service. This option proved cumbersome due to the frequent updates to the shapefiles which would require manual adjustments to the map service and ArcIMS server. A recent enhancement to this procedure has been the inclusion of this datalayer into the enterprise GIS data library and SDE server. Now, each time a change is made to the coverage generated from the Access table, an SDE server side script automatically updates the SDE layer. These transparent updates to the SDE server eliminate the previously necessary manual adjustments to the map service and ArcIMS server. This helps to avoid any IMS interruptions while also freeing up time for GIS staff members to work on other projects. For reference purposes, a list of SFWMD, Environmental Resource Regulation and CERP internet links has been included in the Appendix.

## **In the Future**

To date, the coordination results achieved by this program have generated multiple inquiries and requests for additional “early warning” notifications regarding the spatial interaction between permitting data and other geographic entities. With only minimal changes, this model of infrastructure and application could also be applied to a wide range of other geographic phenomena including other environmental, municipal, emergency management and Homeland Defense related communications.

In reality though, with the current technological trend, the future for this type of application will be best managed using the new strengths and features provided by the ESRI Geodatabase data model or other spatial database technology. Upon completing the migration of the SFWMD’s regulatory GIS data into a Geodatabase, many of the functions currently performed by AML, will be inherent in the topological capabilities of the Geodatabase model. Improvements to the regulatory GIS infrastructure will also be realized through the adoption of new web enabled GIS interfaces to enhance the current model for permit application boundary inputs. It is hoped that future data input models can capitalize on internet map services, cadastral data resources and future models of private/public partnerships to alleviate the current demand placed on the in-house GIS staff. These models could provide the tools and requirements to allow non-GIS users the ability to enter application boundaries while also harnessing the energy and CAD work products created by the permit applicant’s consulting engineers. Unfortunately, rigid

budgetary restrictions in place create an atmosphere of increased demands with limited resources, resulting in the unfunded mandate for an online Permit GIS interface. While multiple third party software solutions currently exist in the permitting GIS arena, the State of Florida has embarked on a statewide approach for a single online permitting system to be shared amongst the state's five water management districts. Currently, this effort has resulted in a beta tabular interface but has yet to create an on-line spatial component. In time, these issues will be resolved and the evolution to the new GIS technologies will be complete.

## **Conclusion**

With the GIS world being in a current and seaming constant state of flux, a hybrid set of new and old GIS solutions was tapped to solve the coordination needs of the SFWMD's vast undertakings. In order to best balance the ever critical economic and ecological needs of the south Florida anthrosphere, timely communication and open government policies are fundamental to achieving a successful harmony. It is not known at this time, how long the exact program covered in this paper will exist. What is known is that some form of this communication and coordination model will persist. While the SFWMD regulatory GIS program has served many needs over the years, its ability to provide highly responsive and flexibly driven analytical results is paramount. Overall, the District is continuing to move forward into the Enterprise GIS paradigm, by adopting the Spatial Data Standard for Facilities, Infrastructure and Environment, centralizing data resources, writing reusable object-oriented code and creating interagency data sharing agreements. In addition to the technological realm of the "look what we can do" benefits of GIS, the direct cost savings benefit associated with well coordinated policy decisions while optimizing staffing efficiencies are the visibly critical results necessary for upper management support.

## **Acknowledgements**

Special acknowledgement goes to Carlos Piccirillo for his years of tireless AML programming and the rest of the Regulation GIS Team.

## **Appendix**

SFWMD Web Site: <http://www.sfwmd.gov>

CERP Web Site: <http://www.evergladesplan.org>

Environmental Resource Regulation Web: <http://www.sfwmd.gov/org/reg/index.html>

SFWMD Regulation GIS Web Site <http://www.sfwmd.gov/org/reg/geoinfo.html>

SFWMD GIS Web Site <http://www.sfwmd.gov/org/gisit>

## End Notes

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<sup>1</sup> [http://www.evergladesplan.org/about/rest\\_plan.cfm](http://www.evergladesplan.org/about/rest_plan.cfm)

<sup>2</sup> [http://www.sfwmd.gov/organ/2\\_permitting.html](http://www.sfwmd.gov/organ/2_permitting.html)

## References

[http://www.evergladesplan.org/about/rest\\_plan.cfm](http://www.evergladesplan.org/about/rest_plan.cfm)

[http://www.sfwmd.gov/organ/2\\_permitting.html](http://www.sfwmd.gov/organ/2_permitting.html)

<http://www.evergladesplan.org/>

*(Florida Audubon Society, Inc., et al., v. SFWMD and Lennar Homes, Inc., SFWMD Order No. 2003-013 FOF ERP; DOAH Case No. 02-1629 and Florida Audubon Society v. South Florida Water Management District, FLWAC Case No. WMD RFR-98-001 (Nov. 30, 1998).*

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