SOUTH FLORIDA EAST COAST CORRIDOR STUDY

SOUTH FLORIDA EAST COAST (FEC)
ALTERNATIVES ANALYSIS

F.M. NO. 417031-1-22-01
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Conceptual Drainage Analysis Tech Memo

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STATE OF FLORIDA DEPARTMENT OF TRANSPORTATION

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MEMORANDUM

TO: Project File

FROM: Alina Fernandez, P.E.

DATE: March 10, 20010

SUBJECT: Drainage Technical Memorandum No. 2
Florida East Coast (FEC) Corridor Alternative Analysis
FDOT Financial Management Number: 417031-1-22-01

The purpose of this memorandum is to document a preliminary concept for the project stormwater management and drainage system, which has been designed in accordance with the SFWMD criteria specified in the May 1994 Management and Storage of Surface Waters, Permit Information Manual, Volume IV and the related documents from the other involved permitting agencies which include, Palm Beach County, Lake Worth Drainage District, Northern Palm Beach County Improvement District, Broward County Department of Planning and Environmental Protection (BCDPEP), Miami Dade County Department of Environmental Resources (DERM), and the City of West Palm Beach.

A good track drainage system is when moisture is drained quickly away from the track and not allowed to accumulate around the rails and ties. The shape of the section and the porous free draining properties of ballast materials provide immediate drainage thereby permitting the rapid percolation and runoff of all surface water. There is scarcely an item of maintenance cost that is not increased by poor drainage. Roadway stability depends on a well drained subgrade. With poor drainage, fouled ballast churns and pumps under loose ties and joints. Trackside swales are typically used to provide positive drainage by preventing standing water along the roadbed which could saturate the subgrade. A wet ballast section reduces the shearing strength of the ballast & also support the growth of vegetation which reduces the drainage capillary action of the ballast.

Types of trackside swales:

- Trapezoidal shape - preferred due to higher hydraulic efficiency
- Triangular shape – requires less ROW and readily maintained with a grader
- Rectangular used in cuts

The attached calculations and design parameters demonstrate that the project is consistent with the requirements for stormwater management as published by all agencies regulating stormwater within the corridor. It is noted that this conceptual design is based on current best available information. Conditions encountered in the field may warrant changes to this preliminary design.

This document includes the following:

- Drainage Design Narrative
- Hydrologic and Hydraulic calculations for the track improvement

1- STORMWATER MANAGEMENT

1.1-Introduccion

The Florida East Coast Railroad (FECRR) traverses through Miami-Dade, Broward and Palm Beach Counties and is generally parallel to Dixie Highway and US-1. Currently, in the tri-county area, the FECRR is used exclusively for freight movement. As redevelopment and infill in the older eastern communities of South Florida has been encouraged, discussion of returning passenger service to the FECRR has emerged. The study area follows the FECRR right-of-way from approximately West Flagler Street in downtown Miami to Indiantown Road in Jupiter. The project has advanced through numerous stages and milestones and is currently at beginning development of the Recommended Preferred Alternative that will lead toward a public hearing and filing of an FTA New Starts application in May 2010.

The current FECRR track configuration consists of a single mainline track with passing sidings, industrial sidings, team tracks, spur tracks and runaround tracks located within a 100-ft right-of-way, although the right-of-way is reduced to 50-ft just south of 71st Street in Miami Dade. For the most part the FECRR alignment is centered along the right-of-way. The proposed SFECC Project addresses several technology modes such as light rail, heavy rail, commuter rail and bus rapid transit. The proposed new track configuration may consist of either a 3-track or 4-track arrangement in which passenger trains could operate on dedicated passenger tracks or shared tracks with the FECRR. The existing FECRR mainline track would remain along its current alignment while new tracks would be constructed immediately adjacent to the existing track. This analysis addresses ballasted track only, since the location of the stations is still work in progress.

The purpose of the stormwater management system is to mitigate for the proposed construction of roadbeds consisting of ballast and subballast to accommodate the new track structure along the rail corridor while maintaining the existing level of drainage service. The proposed stormwater management system is not intended to improve drainage, particularly in areas subject to localized flooding. It is designed, however, so that existing flooding conditions would not be exacerbated as a result of the proposed improvements. Water quality treatment was considered in all of the stormwater analyses. The proposed stormwater system will the water quality criteria established by South Florida Water Management District (SFWMD) and the applicable local permitting agency. Water quality is further discussed in Section 1.4.

The design of the stormwater management system was based on a differential analysis of runoff volume for existing conditions versus proposed conditions. The system has been designed to account for and provide the same amount of storage as presently exists along the corridor as well as additional storage volume to compensate for the increased runoff volume resulting from the proposed track improvements. A more detailed description of the methodology is included in Section 1.6.

1.2- Pre-Development Conditions

The existing stormwater system, along the 85-mile rail corridor, was assessed from field reconnaissance and aerial photographs. The photographs indicate that there is an existing stormwater ditch system throughout much of the rail corridor. In general, the existing stormwater system is well defined and discontinuous with isolated sections of continuous drainage features such as parallel ditches or swales and the storage capacity was not specifically quantified for each drainage subbasin. An allowance, however, for that storage capacity was included in the proposed stormwater system by providing an average of 25% excess storage capacity.

Stormwater runoff emanating from the existing ballasted track structure consists of sheet flows across the adjoining pervious area within the right of way with much of the runoff infiltrating into the highly permeable sandy soils found throughout the corridor. Surface runoff draining to the right of way from off site is generally impounded by the rail bed and percolates into the ground or in certain isolated instances is conveyed across the rail bed via cross drain culverts. The FEC corridor has several culverts, although they are infrequent, to pass the flow thru the embankment sections from either trackside swales or natural depression in the surrounding terrain. The shape and type of culverts used along the corridor varies depending upon the amount of flow based on a specified storm frequency and also the available cover from top of culvert to bottom of crosstie. For example, the shape may consist of arch, box, oval and round type drainage structures in which the type of culvert may consist of RCP or corrugated metal pipes needed to drain isolated pockets in accordance with the existing drainage patterns. When constructing new tracks, these existing culverts may need to be extended. For natural and engineered canals, under-grade bridges are used to span over the canal from bank to bank

1.3- Post-Development Conditions.

The proposed improvements include the potential addition of three new rail lines parallel to the existing rail for the majority of the corridor. In most areas where new track construction is planned, a parallel stormwater collection/percolation ditch will be constructed. The ditch is sized for the incremental increase in runoff volume from the proposed improvements as compared to existing conditions plus an allowance to compensate for the existing storage volume. The purpose of this ditch is to collect all stormwater emanating from the new ballasted track and either allow for recovery through percolation into the underlying soils or to convey the collected stormwater to a discrete discharge point such as an existing outfall ditch. In instances where off site discharge may occur and the increased runoff volume cannot be totally retained within the proposed ditch system, a control structure placed in the ditch will be used to control the post development discharge rate to a value less than or equal to pre-development conditions or other applicable discharge criteria for the basin. In those areas where the parallel ditch cannot meet the treatment volume requirements, or a high water table is present, a new perforated collector pipe in a rock-filled trench will be constructed at the bottom of the ditch along the existing rail line within the same drainage basin to compensate for the new track segment.

1.4- Water Quality.

Water Quality treatment facilities are included to mitigate for impacts from this proposed project. Treatment is not considered or included for off-site flows that enter into this project's stormwater system. For the water quality analysis, the required treatment volume is based on the total area of ballast and sub-ballast within the defined drainage basin. In other words, the area of both the existing and proposed ballast and sub-ballast within the defined drainage basin are utilized in the determination of the required treatment volume. Retention or dry detention system are used unless the depth to the existing groundwater table is less than 1 foot from the proposed ditch bottom as will be determined from the geotechnical investigation for this project. All of the agencies with jurisdiction over the project follow SFWMD water quality criteria, with the exception of DERM (see Section 1.4.2).

1.4.1 South Florida Water Management District (SFWMD)

SFWMD requires that all projects meet State water quality standards, as stated in Chapter 62-302, Florida Administrative Code (FAC). To assure that these criteria are met, a project must meet the following volumetric retention/detention requirements, as described in the SFWMD Permit Volume IV:

The minimum treatment volume for water quality improvement has been estimated and provided as follows:

1. Wet detention- the required volume is computed as the first inch of runoff from the developed project, or the total runoff of 2.5 inches times the imperviousness area (i.e., ballast/sub-ballast is considered impervious for this analysis), whichever is greater. A wet detention system is a system, which maintains the bottom elevation one foot below the seasonal high groundwater elevation and does not bleed-down more than one-half inch of detention volume in 24 hours.
2. Dry detention systems must only provide 75 percent of the required wet detention volume. Dry detention systems maintain the bottom elevation at least one foot above the seasonal high groundwater elevation.
3. Retention systems (i.e. French Drains) must only provide 50 percent of the wet detention volume. A safety factor of two or more shall be applied to the design to allow for geological uncertainties.

1.4.2 Miami-Dade County Department of Environmental Resources Management (DERM)

DERM also requires that all projects meet the State water quality standards. To assure that this criterion is met, 100 percent of the first inch of runoff must be retained on site. This volume is equivalent to retaining one inch of runoff from the furthest hydrologic point in the project. The methodology for estimating this volume is outlined in DERM's Policy for Design of Drainage Structures dated December 1980 as follows:

$$V = 60CiAT_t$$

Where:

V = Required stormwater quality volume, cubic feet
C = Runoff Coefficient; 0.2 for pervious areas and 0.95 for Impervious areas
A = Total tributary area, acre
T_t= Duration of storm whose runoff is polluted and contaminated, minutes = $T_{1"} + T_c$

Where: $T_{1"}$ = Time to generate one inch of runoff, minutes

$$= \frac{2940F^{-0.11}}{308.5\,C - 60.5(0.5895 + F^{-0.67})}$$

Where: F = Storm frequency, years
C = previously defined

T_c = Time of concentration, minutes

i = Storm intensity, inches per hour

$$= \frac{308.5}{48.6F^{-0.11} + T_t\,(0.5895 + F^{-0.67})}$$

1.5- Water Quantity.

Stormwater detention/retention facilities are included to mitigate for impacts (i.e., increase site discharges) from this proposed project. The stormwater analysis is conducted considering the area of improvement along the rail corridor to estimate and compare the existing runoff volume to the proposed runoff volume following implementation of the proposed rail improvement. The stormwater facilities are designed to retain this incremental increase in runoff volume due to the proposed project for those sections where retention with percolation is appropriate.

In the majority of the locations along the corridor, the stormwater runoff from the rail corridor will be captured and stored in the adjacent parallel ditch system. This proposed ditch system acts as an absolute retention facility only and generally does not convey the stormwater to a discrete point of discharge. In these cases, the system recovers through evaporation and percolation only. The ditch storage volume is provided through excavation of a new ditch section, existing topography, and ditch block when required.

In those segments where the additional runoff cannot be totally retained within the ditch system and also have a defined point of off-site discharge, the stormwater management system limits the rate of this off-site discharge as follows:

1. Equal or less than historic discharge rates,
2. Equivalent to that determined in previous district permit actions, or
3. As specified in District criteria- allowable discharge formulas for SFWMD Canals.

During the final design phase it should be verified that, for a 10-yr design storm event and whenever the corridor runs parallel to a state road, there will be no adverse impact/flooding conditions to the adjacent road as a result of the proposed improvements.

1.6- Hydrologic Methodology.

Hydrologic Methodology: AdICPR Routing vs. Differential Pre/Post Analysis Approach via SCS Equation:

SFWMD approved the use of a differential approach where the pre- and post-conditions of the *incremental* basin area only was modeled using the SCS equation in lieu of flood routing. SFWMD attenuation requirements were satisfied by providing additional ditch volume to contain the incremental storage increase. This type of analysis approach was used for those sub-basins that were contiguous to the existing track centerline and the railroad right-of-way (typically 50-ft wide) and which had no off-site contributing areas (the design flood was contained in the post-condition so no pre-condition analysis was required), and those sub-basins that received significant off-site discharge as long as the proposed attenuation features, such as ditch blocks, did not adversely affect the conveyance of upstream systems discharging into the existing railroad ditch. A summary of the two methods used are below:

- **The SCS runoff curve number method** was used to calculate the depth of direct runoff for both the *pre-developed and post developed* conditions. This method was used in all cases where dry detention within the railroad row was appropriate. Some of the criterion used was:

  $R= ((P-0.2\ S)^2)/ (P+0.8\ S)$

  WHERE; R = ACCUMULATED RAINFALL EXCESS (OR RUNOFF), IN INCHES
  P = ACCUMULATED RAINFALL, IN INCHES
  S = MAXIMUM SOIL STORAGE, IN INCHES

  - The rainfall depth (**P**) utilized in the SCS runoff equation is associated w/ the design storm 25 years 72 hours. The rainfall depth, as determined from the isohyets maps for south Florida, for the 25 year 72 hour are approximately 14 to 17 inches, within the project area, with the greatest depth occurring in southern Palm Beach in the vicinity of Boca Raton.

  - Curve numbers used **(CN)**: A weighted curve number is computed for existing and proposed conditions, and is representative of the anticipated amount of runoff due to the land use and soil conditions within each drainage basin. The curve number used in this analysis is taken from SCS procedures provided in TR-55 and are include in the following table:

description	hydrologic soil group		
	A	B	C
Sub-ballast	83	89	92
Sodded areas	45	65	77

In addition to land use, the curve number is dependent upon the hydrologic characteristics of the soils in the project area. The soils maps indicate a general dominance of sandy soils with high permeability and hydrologic soil group classification of “A” throughout the project area, with small pockets of less permeable soils with hydrologic soil group classifications of “B” and “C” in certain areas.

For the typical section of the existing track, centered in the 100 ft right of way, the existing width of subballast for the single mainline is approximately 19 ft for the single mainline track where the existing width of sod is 81 ft This results in a weighted curve number of 52.2 for existing conditions based on hydrologic soil group “A”. It should be noted that out of the total 85 miles of corridor, 25 miles have sidings along each side of the mainline tracks in which the existing width of subballast is 33 ft and the existing width of sod is 67 ft. However, our analysis of the existing system was conservative and we did not include this condition in our CN calculations.

For the typical segment of track improvement, centered in the 100 ft right of way, the proposed total width of ballast is 65 ft and the proposed width of sod is 35 ft. The results in a weighted curve number of 69.7 for existing conditions based on hydrologic soil group “A”.

The weighted CN is used to empirically estimate the potential maximum retention after runoff begins as follow:

S = (1000/CN)-10 **Example Calculations:**

USING P= 14"

TOTAL WIDTH= 100 FT

	WIDTH	
	SUBBALLAST	SODDED
PRE	19	81
POST	65	35

CN	
BALLAST	SODDED
83.0	45.0

	CN WEIGHTED	P(in) 25Y72H
PRE	52.2	INCHES
POST	69.7	14.0

	S=(1000/CN)-10	$R=(P-0.2S)^2/(P+0.8S)$
		25Y72H
	(INCHES)	P=14.0
PRE	9.15	6.95
POST	4.35	9.86
INCREMENTAL RUNOFF (INCHES)		2.92

USING P= 17"

	S=(1000/CN)-10	R=(P-0.2S)^2/(P+0.8S)
		25Y72H
	(INCHES)	P=17.0
PRE	9.15	9.46
POST	4.35	12.71
INCREMENTAL RUNOFF (INCHES)		3.24

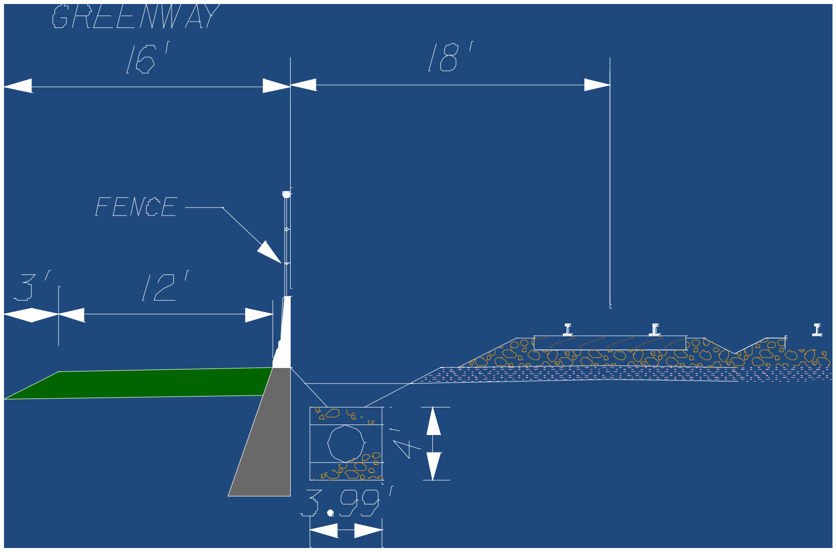
The incremental increase in runoff for (P=14") is 2.92" or a required storage volume of 24.33 cubic feet per linear foot of track, and the incremental increase in runoff for (P=17") is 3.24"or a required storage volume of 27 cubic feet per linear foot of track.

The standard ditch section generally utilized throughout the corridor consists of:

- **Left side of the track,** width of 2 ft, (2H: 1V and 1H: 1V) side slopes, and depth of 1.33 ft and provided a storage volume of 5.32 cubic feet per linear foot of track.
- **Right side of the track,** width of 6.7 ft, (2H: 1V and 1H: 1V) side slopes, and depth of 2.0 ft and provided a storage volume of 19.54 cubic feet per linear foot of track.

The total storage volume provided by the ditch will be of 24.87 cubic feet per linear foot of track. For the incremental runoff associated with P=17", a parallel ditch will not be in compliance with the volume requirement (27 in^3) and therefore, a new perforated collector pipe in a rock-filled trench will be constructed at the bottom of the ditch along the rail line, within the same drainage basin, to compensate for the new track segment. The total storage volume provided by ditch and trench varies from a minimum of 26.87 cubic feet per linear foot of track, to a maximum of 34.44 cubic feet per linear foot of track.

Since the trench is used to provide a volume of storage, and it capacity varies according to the water table elevation, the length of trench required for each section will be separately analyzed. These values of storage provided by the trench range from 9.57 cubic feet per linear foot of trench to 2.0 cubic feet per linear foot of trench. The difference of volume required that cannot be guaranteed in those areas will be compensated with an additional storage capacity that will be provided in the same or in other segment of the same drainage basin.



-Volume Provided in Trench Areas (Ac-ft)

$$s = [(w)du - Aa]0.5 + Aa$$

Storage (S)	(S)=	9.57 Cu ft/ft of Trench
Diameter (slotted pipe)(in)	(D)=	24 in
Water Table E.L (ft)	=	4 ft below of ditch bottom E.L
Non-Saturated Trench depth (ft)	(du)=	4
Width of Trench (ft)	(W)=	4

-Volume Provided in Swale Trench Areas (Ac.-Ft) V= **0.0002**

- <u>**Advanced Interconnected Channel and Pond Routing (Adicpr).**</u>

  This method will be used in all cases where dry detention cannot be accomplished and there is a discrete stormwater discharge point to an off-site stormwater conveyance system. Some of the criterion used for hydrological analysis includes:

  1. <u>Hydrologic Analysis</u>

  - Weighted CN
  - Basins based on improvements
  - Time of concentration
  - Rainfall depth based on 72 hour 25-year event

- Storm Duration and cumulative rainfall distribution-72 hours per SFWMD permit criteria.
- Unit Hydrograph-U256
- Peaking Factor-256

Curve Numbers:

The base CN values to be used in determining the pre and post-development composite curve numbers are 83 for sub-ballast, 45 for non-ballasted areas within the right-of-way and 98 for inundated areas (wet ditches).

Basins based on improvements:

Basins boundaries have been delineated based on the anticipated area of improvement along the rail corridor. In most cases, this area has 100 ft width along the track.

Time of concentration:

The minimum time of concentration will be assigned as 10 minutes and generally applied to all drainage basins that are linear and with no significant contributions in runoff from offsite areas. Otherwise the time of concentration will be computed in accordance with the FDOT Drainage Manual using the overland flow method velocity curves.

2. Hydraulic Analysis

The hydraulic analysis will include the routing of the anticipated runoff volume into the stormwater system and into off-site receiving waters, where applicable.

Input for the hydraulic analysis included stage-storage data for the stormwater retention/detention system. The stage-storage information will be generated based on the proposed stormwater ditch geometry or detention pond geometry. A ditch weir or other control structure will be used to control the peak rate of discharge for release off-site at or below the calculated pre-developed peak rate. These structures will be detailed in plans. Infiltration will be not considered due to saturation conditions and limited infiltration rates during the storm event. The resulting off-site discharge will be confirmed to be in accordance with the SFWMD and other agency permit criteria.

Geotechnical Tests Needed - The following tests will be performed to determine the hydraulic parameters of the existing soil with the area:

- Double Ring Infiltration Tests

- Constant Head Exfiltration Tests

1.6- Stormwater System Design.

Storm water Design of Track and Stations: Based on the above criteria and approaches the proposed drainage system was proposed for the project track and station improvements. Ditches adjacent to the rail were designed as follows:

	Left ditch	**Right ditch**
-	2-ft bottom width	6.7-ft bottom width
-	1.33-ft depth	2-ft depth
-	2H: 1V side slopes	2H: 1V side slopes

The expansion of the existing stations will be analyzed individually to determine the difference between pre-development and post-development. New stormwater ditches and/or detention ponds based on SFWMD and local (i.e. City of West Palm Beach) requirements will be designed to accommodate this runoff volume.

1.7- Conclusions.

The assumptions and methodologies presented in this report document that the proposed stormwater management features will provide the required water quality treatment and storage of additional runoff volumes for the proposed mainline railway improvements. The information and results presented in this report are based upon best available information at the time of this analysis, and should be updated once additional design information is obtained (i.e. sol borings, survey, dtm, etc)