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ORIGINAL ARTICLE

Unaccounted infrastructure needs for transit-oriented developments

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ABSTRACT

Increasingly, U.S. cities are focusing on transit-oriented development (TOD) policies to expand the stock of higher-density, mixed-use development near public transit stations within the context of a transit corridor and, in most cases, a regional metropolis. A TOD zone relies on a regulatory and institutional environment, public and private participation and investment, and development incentives to create vibrant, people-oriented communities and mobility options and to support business development. TODs provide local governments with more tax revenues due to increased property values (and, as applicable, income and sales tax revenues), but most planning for TODs ignores the non-transit infrastructure costs of increasing development density. This study focused on determining the water and sewer infrastructure costs for TOD zones along a rail line in southeast Florida. The finding was that millions of dollars in funds are needed to meet those water and sewer needs and that few are currently planned as a part of community capital improvement programs.

Keywords: *transit; transit-oriented development; infrastructure; water; sewer; development*

1. Introduction

This project was developed to evaluate the economic impacts and infrastructure requirements of creating a series of transit-oriented development (TOD) zones along the Florida East Coast (FEC) Railway corridor from Jupiter, north of the city of West Palm Beach, through downtown Fort Lauderdale, to downtown Miami. The plan calls for 27 stations to be located at various points, most in downtown areas of small communities, such as Dania Beach, Hallandale Beach, Boca Raton, North Miami and Lake Worth Beach. The plan proposes building upon 77,262 existing units with a projected 115,738 new housing units, primarily due to residential infill along the corridor (see **Figure 1**). This level of infill development is lower than the projected goal of 15 dwelling units (DU)/acre because many local governments face opposition to increased density and greater building heights. Based on these projections, a value capture model was created, which determined that the property tax revenue for all land-use types along the corridor is $438 million in property valuation using the low growth rates from a study provided to Miami-Dade County by Government Services Group

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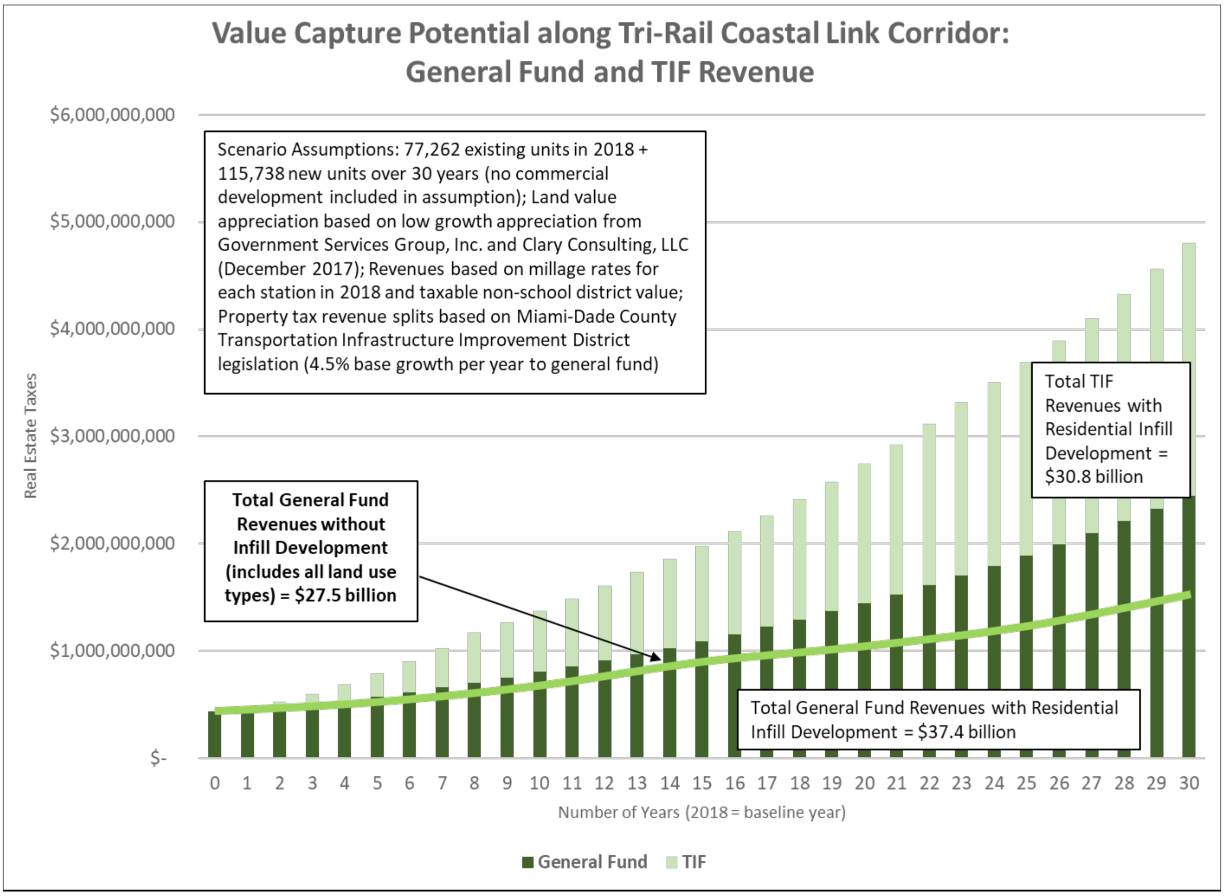

Figure 1. Value Capture Potential along Rail Corridor.

(GSG) and Clary Consulting Corp (CCC).

The projection indicated that infill residential development distributed equally over a 30-year period could capture as much as $30 billion across the three counties of Broward, Miami-Dade and Palm Beach. Tax increment financing (TIF) revenues could be the source of financing horsepower to design, build, operate and maintain the infrastructure. Moreover, a portion of these funds, which is dedicated to affordable housing, could offset transit-induced gentrification created by the train system. However, most planning for TODs ignores the non-transit infrastructure costs of increasing development density. This study focused on determining the water and sewer infrastructure costs for TOD zones along a rail line in southeast Florida. Without appropriate consideration for non-transportation infrastructure needs, TOD implementation to achieve transportation-related goals is likely to be compromised.

2. Review of literature

After World War 2, Congress funded highways that facilitated the migration of people from the inner cities to the suburbs, causing considerable density drop. Shortly afterward, Congress approved legislation to reduce the amount of time corporations could depreciate commercial properties. The results included more use of automobiles, more road-building costs, more traffic congestion and more energy use (Newman and Kenworthy, 1999; Burchell et al., 2002). The desire to reduce these issues had given rise to the concept of transit-oriented developments (TODs) (Renne et al., 2016).

TODs most often entail a significant investment of locally derived funds in the form of general or specific-purpose funds, such as tax increment financing (TIF) and community redevelopment agencies (CRAs), as means to pay for transportation improvements including landscaping, pedestrian walkways, bicycling lanes and bus circulation around rail stations. Salat and Ollivier (2017) noted that TODs are a means to transform urban spaces to increase efficiency in development, reduce power use and improve traffic congestion.

Over the last 20 years, the concept has been implemented in cities across the globe. The goal is to encourage higher-density development close to transportation systems (Warren, 2014). Suzuki et al. (2015) outlined the World Bank's recommendations for creating and financing TODs. Multi- and mixed-use developments encourage people to live and shop in the same neighborhood, which generates more accessibility, while reducing energy costs (Levine et al., 2019). Compact neighborhoods generate more accessible job opportunities, mixed land uses and diverse activities at the street level and encourage pedestrian traffic, stimulating the local economy (Calthorpe, 1993). Locating affordable housing in transit corridors allows households to reduce expenses, while increasing access to employment, educational opportunities and services (Renne et al., 2016; Hamidi et al., 2016).

Although most TODs include both bus transit and rail, comparisons between bus rapid transit and rail systems were made by Currie (2006) after noting that most TOD zones focused only on rail. The U.S. Environmental Protection Agency (EPA) (2015) noted that the costs for TOD developments are significant—specifically with respect to sidewalks, on-street parking, bike lanes, transit and trains, but there has been little consideration related to the cost for other infrastructure systems. Schlossberg and Brown (2004) outlined additional requirements for TOD zones for walkability indicators. Pedestrian integration is a key to TOD success.

When the principles of multi-modal transportation options are in place, the results of a TOD zone can be significant with respect to economic development and property values. While the benefits to local governments include an increase in tax revenues, a national study revealed that it is increasingly expensive to live near public transit (American Public Transportation Association, 2019). House prices and rents within a half-mile of transit facilities are increasing at a faster rate than those in neighborhoods farther away. Public transit zones can increase property values near high-capacity rail stations by as much as 150%, and office spaces per square foot in transit-proximate areas in Boston, Hartford, Los Angeles and Phoenix are 5% to 43% more expensive than offices in non-transit locations. In Boston, office sales prices increased by 38% in the transit zone compared with the region, which only increased by 3%. Similar patterns were found in Hartford, Los Angeles and Phoenix (American Public Transportation Association, 2019).

Recent studies assessing the implementation of TOD zones as achieving truly equitable, mixed and economically accessible transit neighborhoods have found that a new market-rate development in station areas is not usually affordable to very low-, low- or even moderate-income households, unless developers take advantage of affordable housing subsidies. Locating affordable housing in transit corridors allows households to reduce expenses, while increasing access to employment, educational opportunities and services (Renne et al., 2019).

A TOD zone is often more expensive than a comparable suburban development due to the expense of upgrading local infrastructure, where a suburban development is not designed to handle higher-density housing or offices. Parking, for example, is often constructed in surface lots in suburbs, whereas in TOD zones, parking is expected to be underground or in a structure. The cost to build underground or structured parking is typically 20–30 times more expensive than a parking lot, which is passed along to residents in the form of higher rents or more expensive housing units.

Utility upgrades, such as water and sewer upgrades, can be very expensive, and in growing suburbs, municipalities are often more willing to subsidize these expenses to encourage growth compared with retrofitting infill TOD zone locations where local governments are dominated by an anti-development mindset and thus less willing to subsidize the costs of new developments (Arrington and Cervero, 2008).

In the U.S., such TOD funds provide catalytic, risk-tolerant private capital that aligns objectives to maximize impact and leverage. A shifting paradigm for financing equitable TOD funding means federal dollars are no longer the driving catalyst. Increasingly, the model of structured, multi-investor loan funds has proliferated for acquiring strategic properties in transit corridors to create and preserve affordable housing. The creation of TOD funds provides a novel investment vehicle that pools capital from a cross-sector coalition of public, private and philanthropic investors with different risk profiles to provide low-interest sub-loans and largely non-recourse, revolving lines of credit (Renne et al., 2019).

3. Methodology

The purpose of evaluating the South Florida Transit-Oriented Development project for the South Florida Regional Planning Council was to evaluate water and sewer utility infrastructure to determine if the infrastructure is sufficient within a one-half-mile radius around the proposed station site. The types of potential train station area (station) enhancements considered as a part of this study were City Centers (12,500 units), Town Centers (5,000–8,000 units) and Neighborhood Zones (4,000 units). Three City Center stations already exist but could be developed beyond the current conditions (Downtown West Palm Beach, Broward Blvd. in Fort Lauderdale and Government Center in downtown Miami). The remainder were proposed stations. The goal of this study was to review the utilities around each of the 27 stations to determine the potential for development, and the limitations each site might face if the development were to move forward.

To conduct the assessment, the methodology included developing data from a series of public sources, including:

- Raw water supplies: Data were generated from permit data from the South Florida Water Management District (SFWMD) permit files and the most recent draft of the Lower East Coast Water Supply Plan.
- Water treatment plant capacity: Data were generated from the most recent draft of the Lower East Coast Water Supply Plan and Florida Department of Health files for each plant.
- Average daily water demands: Data were from the most recent draft of the Lower East Coast Water Supply Plan and Florida Department of Health monthly operating reports (now with the Florida Department of Environmental Protection (FDEP))
- Wastewater capacity: Note that several of these stations are connected to regional utilities; data were gathered from utility websites and monthly operating reports filed with the Florida

Department of Environmental Protection.

- Wastewater demands: Note that the capacity in regional stations is harder to analyze, especially if a regional plant serves more than one of the potential station enhancement sites. Data were gathered from monthly operating reports filed with the Florida Department of Environmental Protection or directly from the utilities.

For each of these station areas, the utilities were asked to provide geographic information system (GIS) data for their water and sewer piping to allow evaluation of the ability to provide service based on pipe size and looping. Each station area was analyzed based on the assumption that either a City Center site or a smaller station size (either a Town Center or Neighborhood Zone station) would be constructed to determine the magnitude of needed improvements.

For water treatment plant capacity, the current demand plus the new TOD demands were combined. If this value exceeded 90 percent of the plant capacity, added capacity was assumed to be necessary based on water resources best practices. This capacity was estimated at a cost of $8 million per million gallons per day (MGD) or $8 per gallon. Likewise, for raw water supply, the existing demand plus the added projected demand were multiplied by 1.04 to account for lost water during the treatment process at an estimated cost of $7 million per MGD or $7 per gallon. The same analysis for wastewater treatment was performed with an estimated projected cost of $7 million per MGD or $7 per gallon. Underground water and sewer piping needs were determined with assumptions as follows:

- If the water distribution piping was 12 inches or less and/or not looped, new piping was suggested.
- Based on the distance to the water plant or large piping, a looped pipe length was created.
- The estimated cost per foot was $275 for water distribution piping.
- Likewise, for sewer pipes, it was assumed that large force mains and lift stations were needed.
- If these were not present, lift stations and force mains were estimated at $250/ft.

For each of the stations, the same analysis was made and a table was created based on the City Center station plus either a Town Center or Neighborhood Zone station based on the prior corridor analysis of the proposed station size. Cost data were developed based on the personal knowledge of the industry by author Bloetscher. The results were then peer-reviewed by two utility managers familiar with the systems. Reviewer feedback was collected during two utility group phone calls with additional utility staff in May 2019. Each county was represented, and the reviewers had direct knowledge of at least eight of the systems involved, which encompassed nearly all the stations (for example, West Palm Beach serves three stations with water and six with sewer; Fort Lauderdale is similar). Finally, tables were created to develop the following:

- Current development limitations (units).
- Restrictions to current development.
- Needs and costs for future development, noting that the costs are a magnitude of scale, not detailed costs estimates, based on two scenarios of TOD development.
- County-level needs.

To define the characteristics that might limit TOD development, statistical techniques of principal component analysis, linear regression and logistic regression were used with the goal of identifying those variables most likely to predict costs or challenges. It should be noted that a critical component of the statistical analysis used in this effort was the need for a complete dataset. Linear regression and logistic regression models were run on the complete dataset using the XLSTAT® statistical software. With linear regression, the goal is to develop a series of weights for the independent variables (all but the outcome variable defined for success) to determine which variables impact the outcome of success the most. For this analysis, linear regression can be used as a tool to predict the limiting factors for TOD development. Logistic regression was preferred when the dependent variable was used to predict whether there are challenges for the development at the TOD zone. More discussion can be found in Bloetscher et al. (2014) and Bloetscher (2019).

4. Results

Based on the analysis of GIS pipelines for the area, most stations require piping infrastructure to some degree. Several sites will need water supply, water treatment capacity or wastewater treatment capacity. Note that water systems were deemed to need expansion if the station brought total use above 90% of capacity. Wastewater was 80% of capacity based on FDEP guidelines and industry best practices. The anticipated needs outlined in **Table 1** were estimated.

There are four stations with current limitations that restrict development: Riviera Beach, Pompano Beach, Dania Beach and Hallandale Beach. The latter has to do with the water supply. All four involve wastewater treatment plant capacity issues. The total cost for the infrastructure for the proposed stations is just over $400 million based on the proposed station type, as shown in Table 1. The highlighted areas are those where capacity issues arise with TOD development. Note that for all stations served by Miami-Dade County, adequate water treatment and wastewater treatment capacity exists, although raw water is a concern (the volume exceeds 90% capacity although the system size is huge). Hence, while the 90% threshold is exceeded in Miami-Dade County, this does not prevent any particular station from being developed.

Table 2 shows the cost for each site based on the proposed station location (also illustrated in **Figure 2**). **Figure 3** shows the cost by county. The regional system in Miami-Dade County resolves many issues that are present in Broward County. Miami-Dade has a large, well-developed, large-capacity system that is fully interconnected between sites. The southeast region of Broward County is particularly challenged due to saltwater intrusion that limits raw water supplies and due to the outfall issues with the Hollywood's wastewater plant. However, the penny sales tax for transportation may be a source of funds to address some of these needs.

Table 3 outlines the current potential for development. While many of the sites have the water supply, water treatment capacity and wastewater capacity to serve the area, piping and other limitations may prove to be a challenge. Those with current challenges were noted. The Miami-Dade numbers are large because there is a lot of capacity in the system. Other utilities are smaller but raw water and sewer disposal options are likely large expenditures that need to be planned by the affected utilities.

In reviewing the variable analysis, the highest correlation (0.922) indicated that wastewater

Table 1. Summary of infrastructure data for each proposed station

Sta. No.	1	2	3	4	5
Station Location	TONEY PENNA	PGA BLVD	PARK AVE	13TH ST	45TH ST
City	JUPITER	PALM BEACH GARDENS	LAKE PARK	RIVIERA BEACH	WEST PALM BEACH
Station Goal	TC	TC	NC	NC	TC
Potential Units For Planning Purposes	6500	6500	4000	4000	6500
Restrictions for WTP, WWTP or Raw Water Capacity				yes	
Raw W (MDG)	24.41	26.92	26.92	9.08	41.2
Raw Source	Floridan	Surficial Aq	Surficial Aq	Surficial Aq	Surface Water
WTP Cap (MGD)	26	30.5	30.5	17.5	47
WTP Demand (MGD)	16.13	18.02	18.02	7.81	29.49
WWTP Cap (MGD)	11	12	12	70	70
WWTP Demand (MGD)	6.5	8	8	41.45	41.45
Disposal Method	Reuse	Reuse/Inj Well	Reuse/Inj Well	Reuse/Inj Well	Reuse/Inj Well
# of Existing Residential Units within Half-Mile of Station (2018)	1474	1660	1066	1168	2178
Max Density Scenario within Half-Mile of Station	-1474	-1660	-1066	N/a	-2178
Add Water Demand	-0.442	-0.498	-0.320	N/a	-0.653
Add WW Demand	-0.295	-0.332	-0.213	N/a	-0.436
Available Capacity Water	9.87	12.48	12.48	9.69	17.51
Available Capacity Raw Water	8.28	8.9	8.9	1.27	11.71
Available Capacity Wastewater	4.5	4	4	28.55	28.55
% Capacity Water Teatment	0.60	0.57	0.58	N/a	0.61
% Capacity Water Supply	0.67	0.68	0.68	N/a	0.73
% Capacity Needed Wastewater Treatment	0.56	0.64	0.65	N/a	0.59
Capacity Needed Water MGD	0.00	0.00	0.00	0.00	0.00
Water Supply Capacity Needed MGD	0.00	0.00	0.00	n/a	0.00
Wastewater Treatment Plant Capacity Needed MGD	0.00	0.00	0.00	0.00	0.00
16+ WM - LF	0	0	0	20000	8000
Force Main LF	2500	0	0	10000	5000
Sewer Lift Station	1	0	0	4	4
Gravity Sewer Revisions	0	0	0	0	0
Lift Station Upgrades	1	0	0	1	1
Capacity Water (per MGD)	$7,000,000	$7,000,000	$7,000,000	$7,000,000	$7,000,000
Raw Water (per MGD)	$6,000,000	$6,000,000	$6,000,000	$6,000,000	$6,000,000
Capacity Sewer (per MGD)	$8,000,000	$8,000,000	$8,000,000	$8,000,000	$8,000,000
16" or More Water Main - $/LF	$275	$275	$275	$275	$275
Force Main $/LF	$200	$200	$200	$200	$200
Sewer Lift Station Cost	$500,000	$500,000	$500,000	$500,000	$500,000
Gravity Sewer Installtion /LF	$250	$250	$250	$250	$250
Lift Station Upgrades Cost	$250,000	$250,000	$250,000	$250,000	$250,000
Capacity Water	$-	$-	$-	$-	$-
Water Supply	$-	$-	$-	$-	$-
Capacity Sewer	$-	$-	$-	$-	$-
16+ WM /LF	$-	$-	$-	$5,500,000	$2,200,000
Force Main/ LF	$500,000	$-	$-	$2,000,000	$1,000,000
Sewer Lift Station	$500,000	$-	$-	$2,000,000	$2,000,000
Gravity Cost	$-	$-	$-	$-	$-
Lift Station Upgrades	$250,000	$-	$-	$250,000	$250,000
Total Cost	$1,250,000	$-	$-	$9,750,000	$5,450,000
Total Cost Millions	$1.25	$-	$-	$9.75	$5.45

Table 1. (Continued)

Sta. No.	**6**	**7**	**8**	**9**	**10**
Station Location	EVERNIA ST/ DOWNTOWN	GREGORY RD	LAKE AVE	BOYNTON BEACH BLVD	ATLANTIC AVE
City	WEST PALM BEACH	WEST PALM BEACH	LAKE WORTH	Bontyon Beach	DELRAY BEACH
Station Goal	CC	NC	TC	TC	TC
Potential Units For Planning Purposes	12500	4000	6500	6500	6500
Restrictions for WTP, WWTP or Raw Water Capacity					
Raw W (MDG)	41.2	41.2	41.2	20.86	19.1
Raw Source	Surface Water	Surface Water	Surficial Aq	Surficial Aq	Surficial Aq
WTP Cap (MGD)	47	47	17.4	34	24
WTP Demand (MGD)	29.49	29.49	5.31	13.51	16.15
WWTP Cap (MGD)	70	70	70	24	24
WWTP Demand (MGD)	41.45	41.45	41.45	9.5	6.7
Disposal Method	Reuse/Inj Well	Reuse/Inj Well	Reuse/Inj Well	Reuse/Inj Well	Reuse/Inj Well
# of Existing Residential Units within Half-Mile of Station (2018)	5111	852	3695	2944	2740
Max Density Scenario within Half-Mile of Station	-5111	-852	-3695	-2944	-2740
Add Water Demand	-1.533	-0.256	-1.109	-0.883	-0.822
Add WW Demand	-1.022	-0.170	-0.739	-0.589	-0.548
Available Capacity Water	17.51	17.51	12.09	20.49	7.85
Available Capacity Raw Water	11.71	11.71	35.89	7.35	2.95
Available Capacity Wastewater	28.55	28.55	28.55	14.5	17.3
% Capacity Water Teatment	0.59	0.62	0.24	0.37	0.64
% Capacity Water Supply	0.71	0.74	0.11	0.63	0.83
% Capacity Needed Wastewater Treatment	0.58	0.59	0.58	0.37	0.26
Capacity Needed Water MGD	0.00	0.00	0.00	0.00	0.00
Water Supply Capacity Needed MGD	0.00	0.00	0.00	0.00	0.00
Wastewater Treatment Plant Capacity Needed MGD	0.00	0.00	0.00	0.00	0.00
16+ WM - LF	0	0	8000	0	0
Force Main LF	0	8000	0	0	0
Sewer Lift Station	0	2	1	1	0
Gravity Sewer Revisions	0	10000	20000	500	0
Lift Station Upgrades	0	1	1	1	0
Capacity Water (per MGD)	$7,000,000	$7,000,000	$7,000,000	$7,000,000	$7,000,000
Raw Water (per MGD)	$6,000,000	$6,000,000	$6,000,000	$6,000,000	$6,000,000
Capacity Sewer (per MGD)	$8,000,000	$8,000,000	$8,000,000	$8,000,000	$8,000,000
16" or More Water Main - $/LF	$275	$275	$275	$275	$275
Force Main $/LF	$200	$200	$200	$200	$200
Sewer Lift Station Cost	$500,000	$500,000	$500,000	$500,000	$500,000
Gravity Sewer Installtion /LF	$250	$250	$250	$250	$250
Lift Station Upgrades Cost	$250,000	$250,000	$250,000	$250,000	$250,000
Capacity Water	$-	$-	$-	$-	$-
Water Supply	$-	$-	$-	$-	$-
Capacity Sewer	$-	$-	$-	$-	$-
16+ WM /LF	$-	$-	$2,200,000	$-	$-
Force Main/ LF	$-	$3,600,000	$4,000,000	$100,000	$-
Sewer Lift Station	$-	$1,000,000	$500,000	$500,000	$-
Gravity Cost	$-	$2,500,000	$5,000,000	$125,000	$-
Lift Station Upgrades	$-	$250,000	$250,000	$250,000	$-
Total Cost	$-	$7,350,000	$11,950,000	$975,000	$-
Total Cost Millions	$-	$7.35	$11.95	$0.98	$-

Table 1. (Continued)

Sta. No.	**11**	**12**	**13**	**14**	**15**
Station Location	NE 2ND ST	HILLSBORO BLVD	ATLANTIC BLVD	38TH ST	26TH ST
City	BOCA RATON	DEERFIELD BEACH	POMPANO BEACH	OAKLAND PARK	WILTON MANORS
Station Goal	TC	TC	TC	TC	TC
Potential Units For Planning Purposes	6500	6500	6500	6500	6500
Restrictions for WTP, WWTP or Raw Water Capacity			yes		
Raw W (MDG)	51.54	14.74	17.75	61.19	61.19
Raw Source	Biscayne	Biscayne	Biscayne	Biscayne	Biscayne
WTP Cap (MGD)	70	34.8	50	82	82
WTP Demand (MGD)	35.02	10.42	14.56	40.89	40.89
WWTP Cap (MGD)	17	7	15.71	55.7	55.7
WWTP Demand (MGD)	14	6.5	16.1	37.5	37.5
Disposal Method	Reuse/Inj Well	Outfall/Reuse	Outfall/Reuse	Inj Well	Inj Well
# of Existing Residential Units within Half-Mile of Station (2018)	3401	2011	3682	2272	3978
Max Density Scenario within Half-Mile of Station	-3401	-2011	N/a	-2272	-3978
Add Water Demand	-1.020	-0.603	N/a	-0.682	-1.193
Add WW Demand	-0.680	-0.402	N/a	-0.454	-0.796
Available Capacity Water	34.98	24.38	35.44	41.11	41.11
Available Capacity Raw Water	16.52	4.32	3.19	20.3	20.3
Available Capacity Wastewater	3	0.5	-0.39	18.2	18.2
% Capacity Water Teatment	0.49	0.28	N/a	0.49	0.48
% Capacity Water Supply	0.69	0.69	N/a	0.68	0.67
% Capacity Needed Wastewater Treatment	0.78	0.87	N/a	0.67	0.66
Capacity Needed Water MGD	0.00	0.00	0.00	0.00	0.00
Water Supply Capacity Needed MGD	0.00	0.00	0.00	0.00	0.00
Wastewater Treatment Plant Capacity Needed MGD	-0.28	0.50	n/a	0.00	0.00
16+ WM - LF	0	5000	3000	2000	2000
Force Main LF	1000	5000	500	2500	2500
Sewer Lift Station	2	2	2	2	2
Gravity Sewer Revisions	0	10000	5000	2500	1000
Lift Station Upgrades	1	1	1	1	1
Capacity Water (per MGD)	$7,000,000	$7,000,000	$7,000,000	$7,000,000	$7,000,000
Raw Water (per MGD)	$6,000,000	$6,000,000	$6,000,000	$6,000,000	$6,000,000
Capacity Sewer (per MGD)	$8,000,000	$8,000,000	$8,000,000	$8,000,000	$8,000,000
16" or More Water Main - $/LF	$275	$275	$275	$275	$275
Force Main $/LF	$200	$200	$200	$200	$200
Sewer Lift Station Cost	$500,000	$500,000	$500,000	$500,000	$500,000
Gravity Sewer Installtion /LF	$250	$250	$250	$250	$250
Lift Station Upgrades Cost	$250,000	$250,000	$250,000	$250,000	$250,000
Capacity Water	$-	$-	$-	$-	$-
Water Supply	$-	$-	$-	$-	$-
Capacity Sewer	$(2,241,600)	$3,982,400	$-	$-	$-
16+ WM /LF	$-	$1,375,000	$825,000	$550,000	$550,000
Force Main/ LF	$200,000	$3,000,000	$1,100,000	$1,000,000	$700,000
Sewer Lift Station	$1,000,000	$1,000,000	$1,000,000	$1,000,000	$1,000,000
Gravity Cost	$-	$2,500,000	$1,250,000	$625,000	$250,000
Lift Station Upgrades	$250,000	$250,000	$250,000	$250,000	$250,000
Total Cost	$(791,600)	$12,107,400	$4,425,000	$3,425,000	$2,750,000
Total Cost Millions	$(0.79)	$12.11	$4.43	$3.43	$2.75

Table 1. (Continued)

Sta. No.	**16**	**17**	**18**	**19**
Station Location	BROWARD BLVD	FLL INTERNATIONAL AIRPORT	DANIA BEACH	HOLLYWOOD BLVD
City	FT. LAUDERDALE	Broward Co/Hollywood	DANIA BEACH	HOLLYWOOD
Station Goal	CC	P&R	TC	TC
Potential Units For Planning Purposes	12500	0	6500	6500
Restrictions for WTP, WWTP or Raw Water Capacity			yes	
Raw W (MDG)	61.19	61.19	2.58	39.38
Raw Source	Biscayne/ Floridan	Biscayne/ Floridan	Biscayne	Biscayne/ Floridan
WTP Cap (MGD)	82	46	5.04	46
WTP Demand (MGD)	40.89	23.22	2.18	23.22
WWTP Cap (MGD)	55.7	3.5	4.15	48.75
WWTP Demand (MGD)	37.5	2.5	2.9	41.5
Disposal Method	Inj Well	Inj Well	Outfall	Outfall
# of Existing Residential Units within Half-Mile of Station (2018)	6136		2332	5648
Max Density Scenario within Half-Mile of Station	-6136	0	N/a	-5648
Add Water Demand	-1.841	0	N/a	-1.694
Add WW Demand	-1.227	0	N/a	-1.130
Available Capacity Water	41.11	22.78	2.86	22.78
Available Capacity Raw Water	20.3	37.97	0.4	16.16
Available Capacity Wastewater	18.2	1	1.25	7.25
% Capacity Water Teatment	0.48	0.50	N/a	0.47
% Capacity Water Supply	0.66	0.39	N/a	0.57
% Capacity Needed Wastewater Treatment	0.65	0.71	N/a	0.83
Capacity Needed Water MGD	0.00	0.00	0.00	0.00
Water Supply Capacity Needed MGD	0.00	0.00	n/a	0.00
Wastewater Treatment Plant Capacity Needed MGD	0.00	0.00	n/a	1.37
16+ WM - LF	0	0	0	0
Force Main LF	0	0	5000	0
Sewer Lift Station	0	0	1	1
Gravity Sewer Revisions	0	0	0	5000
Lift Station Upgrades	0	0	0	0
Capacity Water (per MGD)	$7,000,000	$7,000,000	$7,000,000	$7,000,000
Raw Water (per MGD)	$6,000,000	$6,000,000	$6,000,000	$6,000,000
Capacity Sewer (per MGD)	$8,000,000	$8,000,000	$8,000,000	$8,000,000
16" or More Water Main - $/LF	$275	$275	$275	$275
Force Main $/LF	$200	$200	$200	$200
Sewer Lift Station Cost	$500,000	$500,000	$500,000	$500,000
Gravity Sewer Installtion /LF	$250	$250	$250	$250
Lift Station Upgrades Cost	$250,000	$250,000	$250,000	$250,000
Capacity Water	$-	$-	$-	$-
Water Supply	$-	$-	$-	$-
Capacity Sewer	$-	$-	$-	$10,963,200
16+ WM /LF	$-	$-	$-	$-
Force Main/ LF	$-	$-	$1,000,000	$1,000,000
Sewer Lift Station	$-	$-	$500,000	$500,000
Gravity Cost	$-	$-	$-	$1,250,000
Lift Station Upgrades	$-	$-	$-	$-
Total Cost	$-	$-	$1,500,000	$13,713,200
Total Cost Millions	$-	$-	$1.50	$13.71

Table 1. (Continued)

Sta. No.	**20**	**21**	**22**	**23**
Station Location	SE 4TH ST	192ND ST	163RD ST	125TH ST
City	HALLANDALE BEACH	AVENTURA	NORTH MIAMI BEACH	NORTH MIAMI
Station Goal	TC	NC	TC	NC
Potential Units For Planning Purposes	6500	4000	6500	4000
Restrictions for WTP, WWTP or Raw Water Capacity	yes			
Raw W (MDG)	6.5	386.07	38.38	17.27
Raw Source	Biscayne	Biscayne	Biscayne	Biscayne
WTP Cap (MGD)	10	464	32	16
WTP Demand (MGD)	6.07	338.12	20.55	7.82
WWTP Cap (MGD)	9.2	376	376	376
WWTP Demand (MGD)	9.2	195.8	195.8	195.8
Disposal Method	Outfall	Outfall	Outfall	Outfall
# of Existing Residential Units within Half-Mile of Station (2018)	2613	1281	1492	3048
Max Density Scenario within Half-Mile of Station	N/a	-1281	-1492	-3048
Add Water Demand	N/a	-0.384	-0.448	-0.914
Add WW Demand	N/a	-0.256	-0.298	-0.610
Available Capacity Water	3.93	125.88	11.45	8.18
Available Capacity Raw Water	0.43	47.95	17.83	9.45
Available Capacity Wastewater	0	180.2	180.2	180.2
% Capacity Water Teatment	N/a	0.73	0.63	0.43
% Capacity Water Supply	N/a	0.91	0.54	0.42
% Capacity Needed Wastewater Treatment	N/a	0.52	0.52	0.52
Capacity Needed Water MGD	0.00	0.00	0.00	0.00
Water Supply Capacity Needed MGD	n/a	0.00	0.00	0.00
Wastewater Treatment Plant Capacity Needed MGD	n/a	0.00	0.00	0.00
16+ WM - LF	0	0	0	5000
Force Main LF	0	1000	1500	1500
Sewer Lift Station	0	1	4	4
Gravity Sewer Revisions	0	0	0	0
Lift Station Upgrades	0	0	1	1
Capacity Water (per MGD)	$7,000,000	$7,000,000	$7,000,000	$7,000,000
Raw Water (per MGD)	$6,000,000	$6,000,000	$6,000,000	$6,000,000
Capacity Sewer (per MGD)	$8,000,000	$8,000,000	$8,000,000	$8,000,000
16" or More Water Main - $/LF	$275	$275	$275	$275
Force Main $/LF	$200	$200	$200	$200
Sewer Lift Station Cost	$500,000	$500,000	$500,000	$500,000
Gravity Sewer Installtion /LF	$250	$250	$250	$250
Lift Station Upgrades Cost	$250,000	$250,000	$250,000	$250,000
Capacity Water	$-	$-	$-	$-
Water Supply	$-	$-	$-	$-
Capacity Sewer	$-	$-	$-	$-
16+ WM /LF	$-	$-	$-	$1,375,000
Force Main/ LF	$-	$200,000	$300,000	$300,000
Sewer Lift Station	$-	$500,000	$2,000,000	$2,000,000
Gravity Cost	$-	$-	$-	$-
Lift Station Upgrades	$-	$-	$250,000	$250,000
Total Cost	$-	$700,000	$2,550,000	$3,925,000
Total Cost Millions	$-	$0.70	$2.55	$3.93

Table 1. (Continued)

Sta. No.	**24**	**25**	**26**	**27**	**28**
Station Location	79TH ST	55TH ST	36TH ST	11TH ST	GOVERNMENT CENTER
City	MIAMI	MIAMI	MIAMI	MIAMI	MIAMI
Station Goal	TC	TC	CC	CC	CC
Potential Units For Planning Purposes	6500	6500	12500	12500	12500
Restrictions for WTP, WWTP or Raw Water Capacity					
Raw W (MDG)	386.07	386.07	386.07	386.07	386.07
Raw Source	Biscayne	Biscayne	Biscayne	Biscayne	Biscayne
WTP Cap (MGD)	464	464	464	464	464
WTP Demand (MGD)	338.12	338.12	338.12	338.12	338.12
WWTP Cap (MGD)	376	376	376	376	376
WWTP Demand (MGD)	195.8	195.8	195.8	195.8	195.8
Disposal Method	Outfall	Outfall	Outfall	Outfall	Outfall
# of Existing Residential Units within Half-Mile of Station (2018)	3514	2429	2336	3299	4902
Max Density Scenario within Half-Mile of Station	-3514	-2429	-2336	-3299	-4902
Add Water Demand	-1.054	-0.729	-0.701	-0.990	-1.471
Add WW Demand	-0.703	-0.486	-0.467	-0.660	-0.980
Available Capacity Water	125.88	125.88	125.88	125.88	125.88
Available Capacity Raw Water	47.95	47.95	47.95	47.95	47.95
Available Capacity Wastewater	180.2	180.2	180.2	180.2	180.2
% Capacity Water Teatment	0.73	0.73	0.73	0.73	0.73
% Capacity Water Supply	0.91	0.91	0.91	0.91	0.91
% Capacity Needed Wastewater Treatment	0.52	0.52	0.52	0.52	0.52
Capacity Needed Water MGD	0.00	0.00	0.00	0.00	0.00
Water Supply Capacity Needed MGD	0.00	0.00	0.00	0.00	0.00
Wastewater Treatment Plant Capacity Needed MGD	0.00	0.00	0.00	0.00	0.00
16+ WM - LF	0	10000	10000	5000	1500
Force Main LF	1000	0	0	2000	0
Sewer Lift Station	1	0	0	2	0
Gravity Sewer Revisions	0	0	0	5000	0
Lift Station Upgrades	0	0	0	1	0
Capacity Water (per MGD)	$7,000,000	$7,000,000	$7,000,000	$7,000,000	$7,000,000
Raw Water (per MGD)	$6,000,000	$6,000,000	$6,000,000	$6,000,000	$6,000,000
Capacity Sewer (per MGD)	$8,000,000	$8,000,000	$8,000,000	$8,000,000	$8,000,000
16" or More Water Main - $/LF	$275	$275	$275	$275	$275
Force Main $/LF	$200	$200	$200	$200	$200
Sewer Lift Station Cost	$500,000	$500,000	$500,000	$500,000	$500,000
Gravity Sewer Installtion /LF	$250	$250	$250	$250	$250
Lift Station Upgrades Cost	$250,000	$250,000	$250,000	$250,000	$250,000
Capacity Water	$-	$-	$-	$-	$-
Water Supply	$-	$-	$-	$-	$-
Capacity Sewer	$-	$-	$-	$-	$-
16+ WM /LF	$-	$2,750,000	$2,750,000	$1,375,000	$412,500
Force Main/ LF	$200,000	$-	$-	$1,400,000	$-
Sewer Lift Station	$500,000	$-	$-	$1,000,000	$-
Gravity Cost	$-	$-	$-	$1,250,000	$-
Lift Station Upgrades	$-	$-	$-	$250,000	$-
Total Cost	$700,000	$2,750,000	$2,750,000	$5,275,000	$412,500
Total Cost Millions	$0.70	$2.75	$2.75	$5.28	$0.41

Table 2. Costs by proposed station

Sta. No.	Station Location	City	Station Goal	Potential Units For Planning Purposes	Capacity water	Water supply	Capacity Sewer	16+ WM / LF
1	TONEY PENNA	JUPITER	Town Center	6500	$-	$-	$-	$-
2	PGA BLVD	PALM BEACH GARDENS	Town Center	6500	$-	$-	$-	$-
3	PARK AVE	LAKE PARK	Neigh. Center	4000	$-	$-	$-	$-
4	13TH ST	RIVIERA BEACH	Neigh. Center	4000	$-	$5,003,904	$-	$5,500,000
5	45TH ST	WEST PALM BEACH	Town Center	6500	$-	$-	$-	$2,200,000
6	EVERNIA ST/ DOWNTOWN	WEST PALM BEACH	City Center	12500	$-	$-	$-	$-
7	GREGORY RD	WEST PALM BEACH	Neigh. Center	4000	$-	$-	$-	$-
8	LAKE AVE	LAKE WORTH	Town Center	6500	$-	$-	$-	$2,200,000
9	BOYNTON BEACH BLVD	BONTYON BEACH	Town Center	6500	$-	$-	$-	$-
10	ATLANTIC AVE	DELRAY BEACH	Town Center	6500	$-	$-	$-	$-
11	NE 2ND ST	BOCA RATON	Town Center	6500	$-	$-	$8,158,400	$-
12	HILLSBORO BLVD	DEERFIELD BEACH	Town Center	6500	$-	$-	$14,382,400	$1,375,000
13	ATLANTIC BLVD	POMPANO BEACH	Town Center	6500	$-	$-	$32,764,800	$825,000
14	38TH ST	OAKLAND PARK	Town Center	6500	$-	$-	$-	$550,000
15	26TH ST	WILTON MANORS	Town Center	6500	$-	$-	$-	$550,000
16	BROWARD BLVD	FT. LAUDERDALE	City Center	12500	$-	$-	$-	$-
17	FLL INTERNATIONAL AIRPORT	BROWARD CO/ HOLLYWOOD	P&R	0	$-	$-	$-	$-
18	DANIA BEACH	DANIA BEACH	Town Center	6500	$-	$7,473,696	$3,308,800	$-
19	HOLLYWOOD BLVD	HOLLYWOOD	Town Center	6500	$-	$-	$21,363,200	$-
20	SE 4TH ST	HALLANDALE BEACH	Town Center	6500	$-	$10,053,264	$20,939,200	$-
21	192ND ST	AVENTURA	Neigh Center	4000	$-	$-	$-	$-
22	163RD ST	NORTH MIAMI BEACH	Town Center	6500	$-	$-	$-	$-
23	125TH ST	NORTH MIAMI	Neigh Center	4000	$-	$-	$-	$1,375,000
24	79TH ST	MIAMI	Town Center	6500	$-	$-	$-	$-
25	55TH ST	MIAMI	Town Center	6500	$-	$-	$-	$2,750,000
26	36TH ST	MIAMI	City Center	12500	$-	$-	$-	$2,750,000
27	11TH ST	MIAMI	City Center	12500	$-	$-	$-	$1,375,000
28	GOVERNMENT CENTER	MIAMI	City Center	12500	$-	$-	$-	$412,500

Table 2. (Continued)

Sta. No.	Station Location	City	Force Main/ LF	Sewer lift station	Gravity Cost	Lift station upgrades	Total cost
1	TONEY PENNA	JUPITER	$500,000	$500,000	$-	$250,000	$1,250,000
2	PGA BLVD	PALM BEACH GARDENS	$-	$-	$-	$-	$-
3	PARK AVE	LAKE PARK	$-	$-	$-	$-	$-
4	13TH ST	RIVIERA BEACH	$2,000,000	$2,000,000	$-	$250,000	$14,753,904
5	45TH ST	WEST PALM BEACH	$1,000,000	$2,000,000	$-	$250,000	$5,450,000
6	EVERNIA ST/ DOWNTOWN	WEST PALM BEACH	$-	$-	$-	$-	$-
7	GREGORY RD	WEST PALM BEACH	$3,600,000	$1,000,000	$2,500,000	$250,000	$7,350,000
8	LAKE AVE	LAKE WORTH	$4,000,000	$500,000	$5,000,000	$250,000	$11,950,000
9	BOYNTON BEACH BLVD	BONTYON BEACH	$100,000	$500,000	$125,000	$250,000	$975,000
10	ATLANTIC AVE	DELRAY BEACH	$-	$-	$-	$-	$-
11	NE 2ND ST	BOCA RATON	$200,000	$1,000,000	$-	$250,000	$9,608,400
12	HILLSBORO BLVD	DEERFIELD BEACH	$3,000,000	$1,000,000	$2,500,000	$250,000	$22,507,400
13	ATLANTIC BLVD	POMPANO BEACH	$1,100,000	$1,000,000	$1,250,000	$250,000	$37,189,800
14	38TH ST	OAKLAND PARK	$1,000,000	$1,000,000	$625,000	$250,000	$3,425,000
15	26TH ST	WILTON MANORS	$700,000	$1,000,000	$250,000	$250,000	$2,750,000
16	BROWARD BLVD	FT. LAUDERDALE	$-	$-	$-	$-	$-
17	FLL INTERNATIONAL AIRPORT	BROWARD CO/ HOLLYWOOD	$-	$-	$-	$-	$-
18	DANIA BEACH	DANIA BEACH	$1,000,000	$500,000	$-	$-	$12,282,496
19	HOLLYWOOD BLVD	HOLLYWOOD	$1,000,000	$500,000	$1,250,000	$-	$24,113,200
20	SE 4TH ST	HALLANDALE BEACH	$-	$-	$-	$-	$30,992,464
21	192ND ST	AVENTURA	$200,000	$500,000	$-	$-	$700,000
22	163RD ST	NORTH MIAMI BEACH	$300,000	$2,000,000	$-	$250,000	$2,550,000
23	125TH ST	NORTH MIAMI	$300,000	$2,000,000	$-	$250,000	$3,925,000
24	79TH ST	MIAMI	$200,000	$500,000	$-	$-	$700,000
25	55TH ST	MIAMI	$-	$-	$-	$-	$2,750,000
26	36TH ST	MIAMI	$-	$-	$-	$-	$2,750,000
27	11TH ST	MIAMI	$1,400,000	$1,000,000	$1,250,000	$250,000	$5,275,000
28	GOVERNMENT CENTER	MIAMI	$-	$-	$-	$-	$412,500

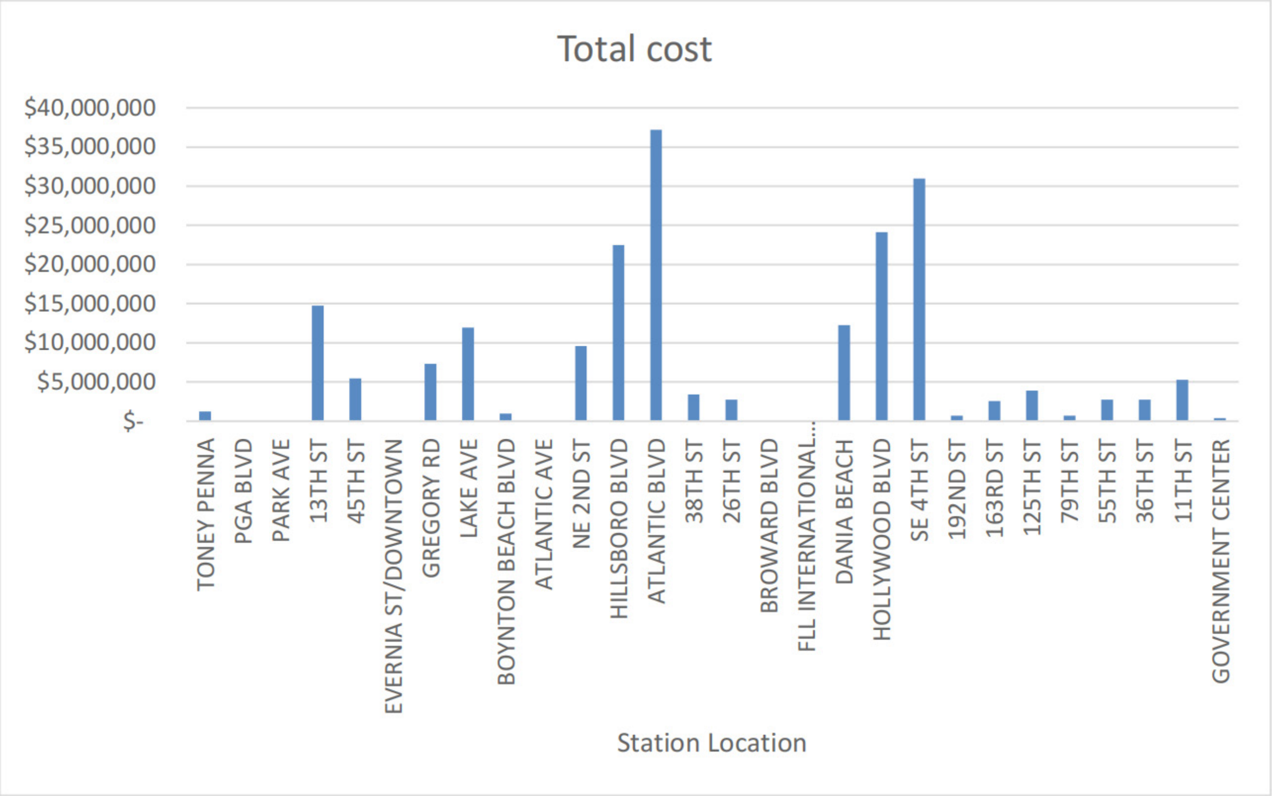

Figure 2. Cost by station.

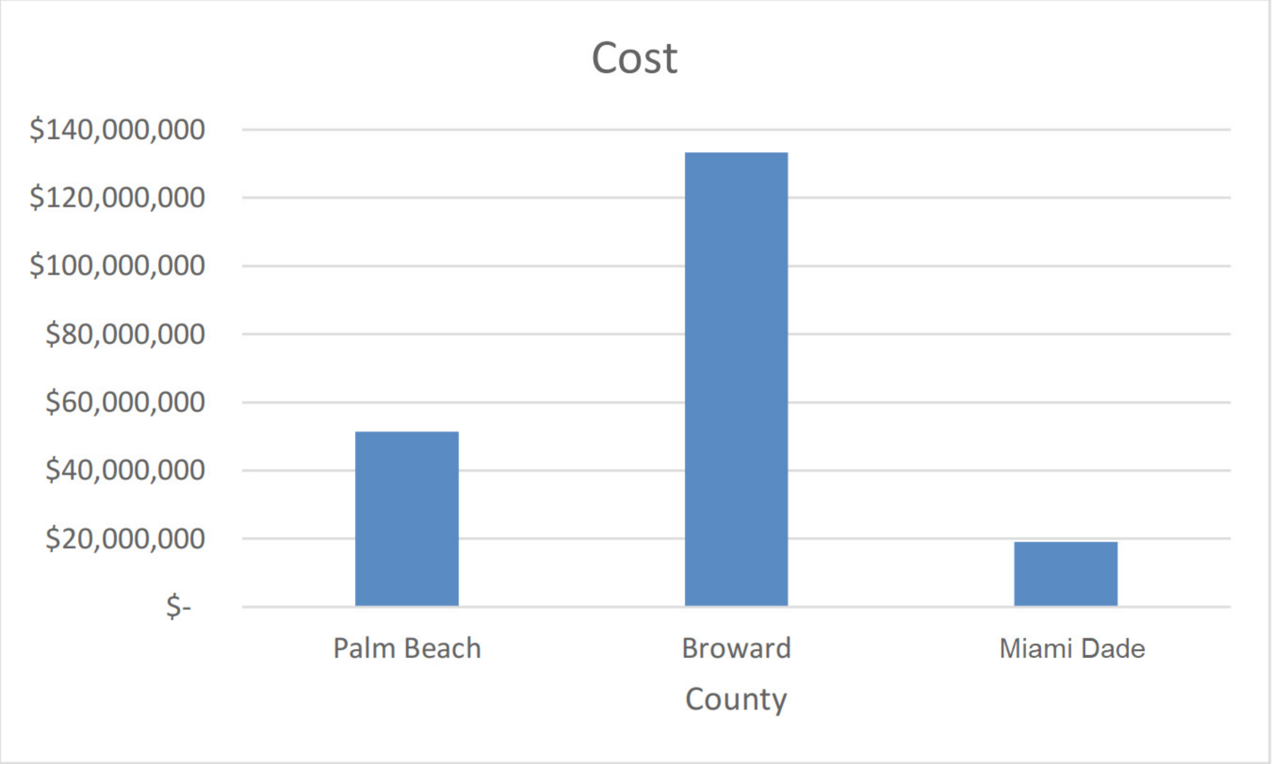

Figure 3. Cost by county.

Table 3. Potential development and limitations

Sta. No.	**1**	**2**	**3**	**4**	**5**	**6**
Station Location	TONEY PENNA	PGA BLVD	PARK AVE	13TH ST	45TH ST	EVERNIA ST/ DOWNTOWN
City	JUPITER	PALM BEACH GARDENS	LAKE PARK	RIVIERA BEACH	WEST PALM BEACH	WEST PALM BEACH
Station Goal	TC	TC	NC	NC	TC	CC
Potential Units For Planning Purposes	6500	6500	4000	4000	6500	12500
Restrictions for WTP, WWTP or Raw Water Capacity				1207		
Raw W (MDG)	24.41	26.92	26.92	9.08	41.2	41.2
Raw Source	Floridan	Surficial Aq	Surficial Aq	Surficial Aq	Surface Water	Surface Water
WTP Cap (MGD)	26	30.5	30.5	17.5	47	47
WTP Demand (MGD)	16.13	18.02	18.02	7.81	29.49	29.49
WWTP Cap (MGD)	11	12	12	70	70	70
WWTP Demand (MGD)	6.5	8	8	41.45	41.45	41.45
Disposal Method	Reuse	Reuse/Inj Well	Reuse/Inj Well	Reuse/Inj Well	Reuse/Inj Well	Reuse/Inj Well
# of Existing Residential Units within Half-Mile of Station (2018)	1474	1660	1066	1168	2178	5111
Potential Units - Water Supply	26220	28183	28183	4022	37082	37082
Net to Add Water Supply	18246	20023	23117	-1146	28404	19471
Potential Units - Treatment	32900	41600	41600	32300	58367	58367
Net to Add Water Treatment	24926	33440	36534	27132	49689	40756
Potential Units - Wastwater Treatment	18000	16000	16000	114200	114200	114200
Net to Add Wastwater Supply	10026	7840	10934	109032	105522	96589
Water Piping	no	no	no	yes	no	no
Sewer Piping/Pumping	no	no	no	yes	no	no
Added Units to Exceed A Parameter				water supply, piping		

Table 3. (Continued)

Sta. No.	**7**	**8**	**9**	**10**	**11**	**12**
Station Location	GREGORY RD	LAKE AVE	BOYNTON BEACH BLVD	ATLANTIC AVE	NE 2ND ST	HILLSBORO BLVD
City	WEST PALM BEACH	LAKE WORTH	Bontyon Beach	DELRAY BEACH	BOCA RATON	DEERFIELD BEACH
Station Goal	NC	TC	TC	TC	TC	TC
Potential Units For Planning Purposes	4000	6500	6500	6500	6500	6500
Restrictions for WTP, WWTP or Raw Water Capacity			0		5200	0
Raw W (MDG)	41.2	41.2	20.86	19.1	51.54	14.74
Raw Source	Surface Water	Surficial Aq	Surficial Aq	Surficial Aq	Biscayne	Biscayne
WTP Cap (MGD)	47	17.4	34	24	70	34.8
WTP Demand (MGD)	29.49	5.31	13.51	16.15	35.02	10.42
WWTP Cap (MGD)	70	70	24	24	17	7
WWTP Demand (MGD)	41.45	41.45	9.5	6.7	14	6.5
Disposal Method	Reuse/Inj Well	Reuse/Inj Well	Reuse/Inj Well	Reuse/Inj Well	Reuse/Inj Well	Outfall/Reuse
# of Existing Residential Units within Half-Mile of Station (2018)	852	3695	2944	2740	3401	2011
Potential Units - Water Supply	37082	113652	23275	9342	52313	13680
Net to Add Water Supply	32230	103457	13831	102	42412	5169
Potential Units - Treatment	58367	40300	68300	26167	116600	81267
Net to Add Water Treatment	53515	30105	58856	16927	106699	72756
Potential Units - Wastwater Treatment	114200	114200	58000	69200	12000	2000
Net to Add Wastwater Supply	109348	104005	48556	59960	2099	-6511
Water Piping	no	yes	no	no	no	no
Sewer Piping/Pumping	no	yes	no	no	no	no
Added Units to Exceed A Parameter		piping				WWTP

Table 3. (Continued)

Sta. No.	**13**	**14**	**15**	**16**	**17**	**18**
Station Location	ATLANTIC BLVD	38TH ST	26TH ST	BROWARD BLVD	FLL INTERNATIONAL AIRPORT	DANIA BEACH
City	POMPANO BEACH	OAKLAND PARK	WILTON MANORS	FT. LAUDERDALE	Broward Co/ Hollywood	DANIA BEACH
Station Goal	TC	TC	TC	CC	P&R	TC
Potential Units For Planning Purposes	6500	6500	6500	12500	0	6500
Restrictions for WTP, WWTP or Raw Water Capacity	0					473
Raw W (MDG)	17.75	61.19	61.19	61.19	61.19	2.58
Raw Source	Biscayne	Biscayne	Biscayne	Biscayne/ Floridan	Biscayne/ Floridan	Biscayne
WTP Cap (MGD)	50	82	82	82	46	5.04
WTP Demand (MGD)	14.56	40.89	40.89	40.89	23.22	2.18
WWTP Cap (MGD)	15.71	55.7	55.7	55.7	3.5	4.15
WWTP Demand (MGD)	16.1	37.5	37.5	37.5	2.5	2.9
Disposal Method	Outfall/Reuse	Inj Well	Inj Well	Inj Well	Inj Well	Outfall
# of Existing Residential Units within Half-Mile of Station (2018)	3682	2272	3978	6136	0	2332
Potential Units - Water Supply	10102	64283	64283	64283	0	1267
Net to Add Water Supply	-80	55511	53805	45647	0	-7565
Potential Units - Treatment	118133	137033	137033	137033	0	9533
Net to Add Water Treatment	107951	128261	126555	118397	0	701
Potential Units - Wastwater Treatment	-1560	72800	72800	72800	0	5000
Net to Add Wastwater Supply	-11742	64028	62322	54164	0	-3832
Water Piping	no	no	no	no	0	no
Sewer Piping/Pumping	no	no	no	no	0	no
Added Units to Exceed A Parameter	WWTP				land space	water supply, WWTP

Table 3. (Continued)

Sta. No.	**19**	**20**	**21**	**22**	**23**	**24**
Station Location	HOLLYWOOD BLVD	SE 4TH ST	192ND ST	163RD ST	125TH ST	79TH ST
City	HOLLYWOOD	HALLANDALE BEACH	AVENTURA	NORTH MIAMI BEACH	NORTH MIAMI	MIAMI
Station Goal	TC	TC	NC	TC	NC	TC
Potential Units For Planning Purposes	6500	6500	4000	6500	4000	6500
Restrictions for WTP, WWTP or Raw Water Capacity	0	0				
Raw W (MDG)	39.38	6.5	386.07	38.38	17.27	386.07
Raw Source	Biscayne/ Floridan	Biscayne	Biscayne	Biscayne	Biscayne	Biscayne
WTP Cap (MGD)	46	10	464	32	16	464
WTP Demand (MGD)	23.22	6.07	338.12	20.55	7.82	338.12
WWTP Cap (MGD)	48.75	9.2	376	376	376	376
WWTP Demand (MGD)	41.5	9.2	195.8	195.8	195.8	195.8
Disposal Method	Outfall	Outfall	Outfall	Outfall	Outfall	Outfall
# of Existing Residential Units within Half-Mile of Station (2018)	5648	2613	1281	1492	3048	3514
Potential Units - Water Supply	51173	1362	151842	56462	29925	151842
Net to Add Water Supply	39025	-7751	146561	48470	22877	141828
Potential Units - Treatment	75933	13100	419600	38167	27267	419600
Net to Add Water Treatment	63785	3987	414319	30175	20219	409586
Potential Units - Wastwater Treatment	29000	0	720800	720800	720800	720800
Net to Add Wastwater Supply	16852	-9113	715519	712808	713752	710786
Water Piping	no	no	no	no	no	no
Sewer Piping/Pumping	no	no	no	no	no	no
Added Units to Exceed A Parameter	potentially SS	Wastewater		potentially SS	potentially SS	

Table 3. (Continued)

Sta. No.	25	26	27	28
Station Location	55TH ST	36TH ST	11TH ST	GOVERNMENT CENTER
City	MIAMI	MIAMI	MIAMI	MIAMI
Station Goal	TC	CC	CC	CC
Potential Units For Planning Purposes	6500	12500	12500	12500
Restrictions for WTP, WWTP or Raw Water Capacity				
Raw W (MDG)	386.07	386.07	386.07	386.07
Raw Source	Biscayne	Biscayne	Biscayne	Biscayne
WTP Cap (MGD)	464	464	464	464
WTP Demand (MGD)	338.12	338.12	338.12	338.12
WWTP Cap (MGD)	376	376	376	376
WWTP Demand (MGD)	195.8	195.8	195.8	195.8
Disposal Method	Outfall	Outfall	Outfall	Outfall
# of Existing Residential Units within Half-Mile of Station (2018)	2429	2336	3299	4902
Potential Units - Water Supply	151842	151842	151842	151842
Net to Add Water Supply	142913	137006	136043	134440
Potential Units - Treatment	419600	419600	419600	419600
Net to Add Water Treatment	410671	404764	403801	402198
Potential Units - Wastwater Treatment	720800	720800	720800	720800
Net to Add Wastwater Supply	711871	705964	705001	703398
Water Piping	no	no	no	no
Sewer Piping/Pumping	no	no	no	no
Added Units to Exceed A Parameter				

capacity is the major limitation to TOD development. Water supply is also correlated, but not nearly as high as wastewater capacity. PCA analysis indicated that 85% of the variability is consumed in the first four factors (see **Figure 4**), which were the current density of the neighborhood, existing units/sewer needs, piping costs and water supply needs. The linear regression modeled confirmed that wastewater capacity is the major limitation to TOD development, followed by water supply and piping (see **Figure 5**).

In performing logistic regression, eliminating co-linearity, the model was able to predict a restriction on services 100% of the time based on:

- population,
- total cost in millions of needs,
- station goal,
- number of existing residential units within a half-mile of the station (in 2018), and
- maximum density scenario within a half-mile of the station.

The major issue affecting the infrastructure is the existing density in the vicinity of the station versus the proposed buildout. Hence, deliberations on the stations' location need to consider the water and sewer infrastructure needs when deciding and prioritizing sites.

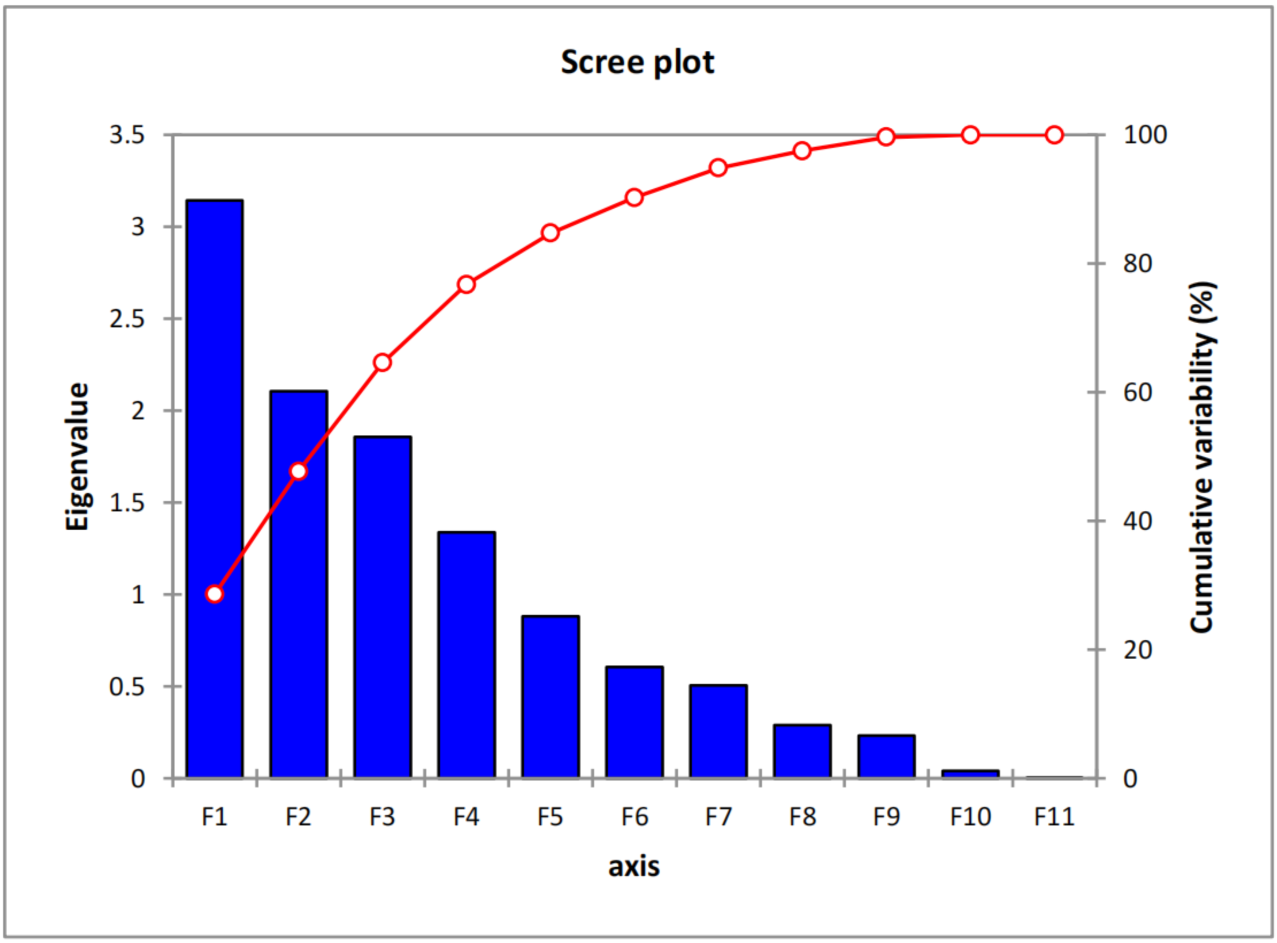

Figure 4. Scree plot showing that 80% of variance is the first four factors.

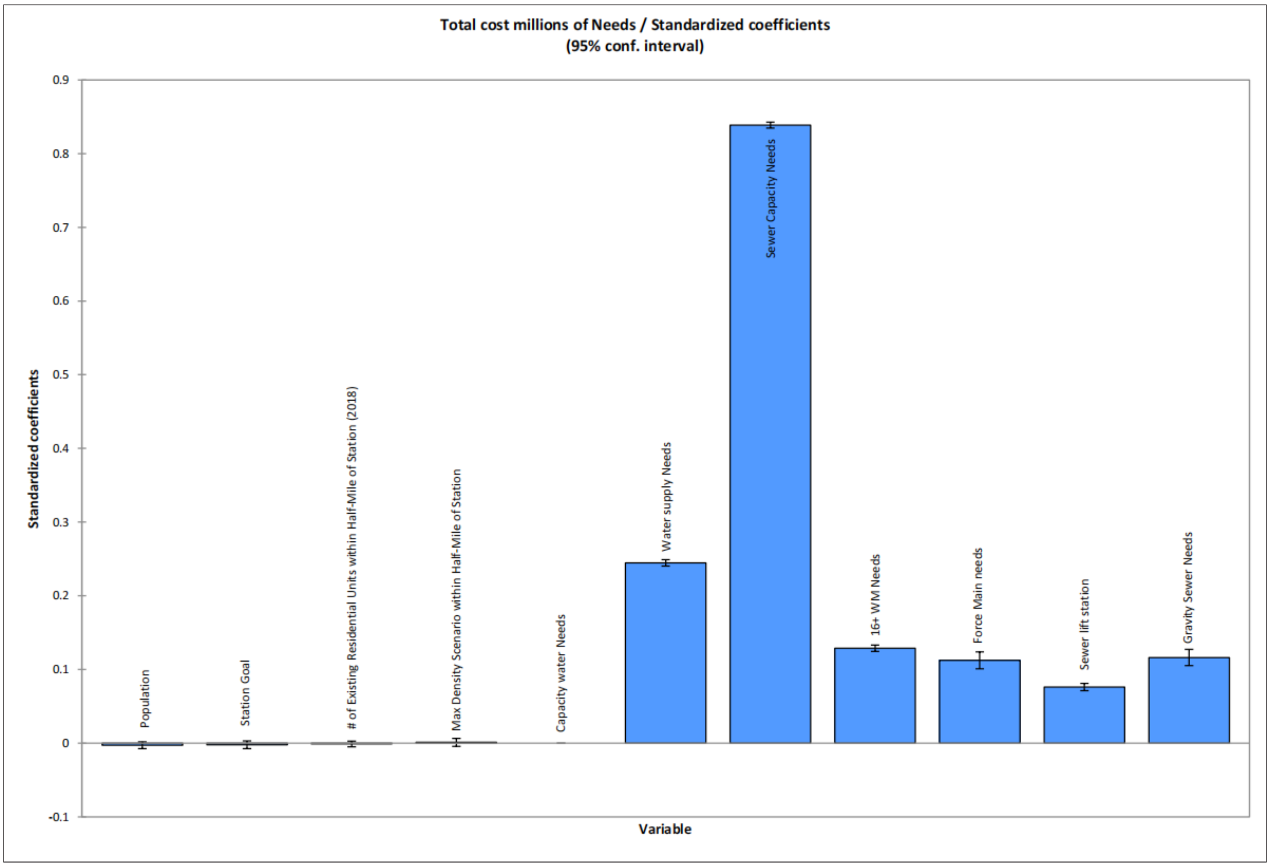

Figure 5. Sewer treatment and water supply as major limitations for TOD zone development.

4.1. Example analysis

Tables and graphs outlining the overall costs and costs by station and county were developed for the region based on the analysis of each node. The following is an example of one such analysis.

4.1.1. Water treatment plant, pumps and capacity

The City of Dania Beach ("City") operates a 5.04 MGD water treatment plant. 3.04 MGD of this capacity is for lime softening. The remaining 2 MGD is for nanofiltration. Disinfection is via chloramination. Raw water comes from the Biscayne aquifer. Capacity is limited to 2.58 MGD, with an application for 2.88 MGD. The City is in the process of developing additional supplies. Water treatment is adequate to supply the needed water. Water supplies are not adequate at this time.

High-service pumps are rated over 12 MGD. A new 20-inch pipeline, with 16/12-inch connections to downtown, and new 12-inch looped pipelines were constructed in anticipation of 4,000 added residential units in 2008, along with a new storage tank; so piping capacity appears adequate for the anticipated growth to 4,000 units. Distribution capacity appears to be adequate.

4.1.2. Wastewater treatment plant, disposal method and capacity

Gravity sewer lines are available throughout the City except Melaleuca Gardens (which is not a potential site for the TOD). 8-inch pipelines exist throughout the City. Major vertical growth may require added sewer line capacity and lift stations. Lift station pump upgrades will be required.

Table 4. Example - Station 18, Dania Beach

City	Raw Water (MDG)	Raw Water Source	Water Treatment Plant Cap (MGD)	Water Treatment Plant Demand (MGD)	Wastewater Treatment Plant Capacity (MGD)	Wastewater Treatment Plant Demand (MGD)	Disposal Method	# of Existing Residential Units within Half-mile of Station (2018)	Max Density Scenario within Half-mile of Station
Dania Beach	2.58	Biscayne	5.04	2.18	3.9*	2.9	Outfall	2,332	10,168

**Part of regional system*

However, the nature of the community may limit growth. The contract with the City of Hollywood includes 4.15 MGD of capacity. Flow capacity is less than this today. Collaboration is needed with the City of Hollywood on the wastewater capacity.

The City of Hollywood treats the wastewater. The City of Hollywood currently uses an ocean outfall for wastewater disposal and two deep-injection wells. The outfall needs to be discontinued by 2025 and a solution has yet to be found. The FDEP and the SFWMD desire to have a 60% reuse goal but this is not achievable. As a result, although added deep wells are in place, there is no other solution.

4.1.3. Additional demands

Additional demands for a TOD zone depend on the type of train station area that is planned and the development anticipated as a result. The largest stations are City Center stations, which include 12,500 units (column 6 of Table 1). Based on such a station, the demands for the TOD of Station 18 site include 3.05 MGD of water supply and treatment and 2.03 MGD of wastewater treatment for a City Center station. Inadequate raw water supply, treated water capacity and wastewater capacity exist for a City Center station (see highlights in Table 3). The Southern Regional Wastewater Treatment Plant in Hollywood, which treats the wastewater, is currently operating at over 80% capacity, and so any station from any large user will be an issue.

However, this station is anticipated to be a Town Center station, which is a smaller station that is more in keeping with what the area can support. If an assumed 5,000 to 8,000 (assume 6,500 for planning) units are anticipated, the demands for this site include 1.25 MGD of water supply and treatment and 0.83 MGD of wastewater treatment (column 2). Inadequate raw water and wastewater capacity exist for a Town Center station.

This station should probably be a Neighborhood Zone station, not a Town Center station, but raw water supply remains an issue. The current utility infrastructure with respect to raw water and wastewater capacity is insufficient for the proposed station, but the piping system poses no restriction.

5. Conclusion

Many communities are attempting to resolve their transportation congestion issues by developing transit-oriented development corridors that link rail, bus, bicycle and pedestrian mobility in one place. One means to do this is to use tax increment financing (TIF) to develop higher-density, mixed-use development near public transit stations. This could also include the use of federal loans from the U.S. Department of Transportation, such as the Transportation Infrastructure Finance and Innovation Act (TIFIA) and the Railroad Rehabilitation and Improvement Financing (RRIF) programs, which allow local infrastructure, including water and wastewater, to be financed. The success of a TOD zone relies on a conducive regulatory and institutional environment, public and private participation and investment, and development incentives to create vibrant, people-oriented communities and mobility options and to support business development. The ability to incorporate affordable and workforce housing in TOD zones increases the potential for meeting the needs of the working community.

In most cases, the focus of TOD developments consists of providing the needed transportation infrastructure and paying those costs back with TIF or other local tax funds. However, few TOD projects consider the costs for water and sewer infrastructure, which can be a major expense in creating TOD zones and may be limiting, as found in this study. Water and sewer infrastructure is buried and is rarely part of the consideration for development until the development is ready to begin. Then, requests for availability are normally submitted to the utility. Unfortunately, just because water and sewer lines are present, that does not mean they will meet future needs. They may be old or undersized (Bloetscher et al., 2014). Areas served with septic tanks are severely limiting. If piping is in place, treatment capacity, along with disposal options, weighs into the problem. Adding capacity, finding new water supplies or addressing the increased need for disposal (reuse, more treatment, etc.) can take three to five years (Bloetscher, 2011; 2019). New water supplies take even longer. As a result, it is important to ensure that the capital needs for utility operation are included when considering a TOD so that plans are not delayed due to the lack of utility infrastructure.

This study focused on determining the water and sewer infrastructure costs for TOD zones along the FEC Railway corridor in southeast Florida. All of the concerns with piping, pumping, treatment capacity and water supplies exist in the corridor. Different station sites have different problems. Larger stations, at points that are currently heavily developed, are more likely to support the TOD than smaller stations. As a result, the finding was that over $400 million is needed to meet those water and sewer needs and that few are currently planned into community capital improvement programs. Those costs represent a total of over $13,000 per residential unit, which is unaccounted for in the pricing. It was noted that the costs vary by site/community and that most of the large communities have sufficient infrastructure to address water sewer needs, but not the smaller ones. Given that these units also need to pay impact fees that are often at least this amount, considerations of solutions for addressing these infrastructure costs at the local level are needed for regional solutions to work.

Author contributions

All three authors were major contributors to writing this paper. Dr. Bloetscher developed the infrastructure costs. Dr. Renne and Ms Hoermann conducted the housing/TOD development analysis. All participated in writing the paper.

References

American Public Transportation Association (APTA) (2019). *The Real Estate Mantra—Locate Near Public Transportation*. https://www.apta.com/wp-content/uploads/The-Real-Estate-Mantra-Locate-Near-Public-Transportation.pdf

Arrington GB and Cervero R (2008). "Effects of TOD on housing, parking, and travel". *Transit Cooperative Research Program (TCRP) Report 128*. Washington, DC, USA: Transportation Research Board. https://doi.org/10.17226/14179

Bloetscher F (2011). *Utility Management for Water and Wastewater Operators*. Denver, CO, USA: America Water Works Association.

_____ (2019). *Public Infrastructure Management: Tracking Assets and Increasing System Resiliency*. Plantation, FL, USA: J Ross Publishing.

Bloetscher F, Sham CH, Danko JJ and Ratick S (2014). "Lessons learned from Aquifer Storage and Recovery (ASR) systems in the United States". *Journal of Water Research*, 6, 1603–1629. https://dx.doi.org/10.4236/jwarp.2014.617146

Burchell RW et al. (2002). "Costs of sprawl—2000". *Transit Cooperative Research Program (TCRP) Report 74*. Washington, DC, USA: Transportation Research Board.

Calthorpe P (1993). *The Next American Metropolis: Ecology, Community, and the American Dream*. New York, NY, USA: Princeton Architectural Press.

Currie G (2006). "Bus transit oriented development—Strengths and challenges relative to rail". *Journal of Public Transportation*, 9(4), 1–21. https://doi.org/10.5038/2375-0901.9.4.1

Environmental Protection Agency (EPA) (2015). *Infrastructure Financing Options for Transit-Oriented Development*. Washington, DC, USA: EPA.

Hamidi S, Ewing R and Renne J (2016). "How affordable is HUD affordable housing?" *Housing Policy Debate*, 26(3), 437–455. https://doi.org/10.1080/10511482.2015.1123753

Levine J, Grengs J and Merlin L (2019). *From Mobility to Accessibility: Transforming Urban Transportation and Land-Use Planning*. Ithaca, NY, USA: Cornell University Press.

Newman P and Kenworthy J (1999). *Sustainability and Cities: Overcoming Automobile Dependence*. Washington, DC, USA: Island Press.

Renne J, Hoermann S, Mayorga E and Jean-Louis L (2019). "Business plan for a South Florida transit-oriented development fund". *Prepared for the South Florida Regional Planning Council and the South Florida Regional Transportation Authority*. Boca Raton, FL, USA: Center for Urban and Environmental Solutions, Florida Atlantic University. https://science.fau.edu/departments/urban-regional-planning/research/cues/research/reports-and-publications-2/pdfs/business-plan-1.pdf

Renne JL, Tolford T, Hamidi S and Ewing R (2016). "The cost and affordability paradox of transit-oriented development: A cost comparison of housing and transportation costs across transit-oriented development, hybrid and transit-adjacent development station typologies". *Housing Policy Debate*, 26(4–5), 819–834. https://doi.org/10.1080/10511482.2016.1193038

Salat S and Ollivier G (2017). *Transforming the Urban Space Through Transit-Oriented Development: The 3V Approach*. Washington, DC, USA: World Bank.

Schlossberg M and Brown N (2004). "Comparing transit-oriented developments based on walkability indicators". *Transportation Research Record: Journal of the Transportation Research Board*, 1887(1), 34–42. https://doi.org/10.3141/1887-05

Suzuki H, Murakami J, Hong Y-H and Tamayose B (2015). *Financing Transit-Oriented Development with Land Values: Adapting Land Value Capture in Developing Countries*. Washington, DC, USA: World Bank. https://doi.org/10.1596/978-1-4648-0149-5

Warren R (2014). *Rail and the City: Shrinking Our Carbon Footprint while Reimagining Urban Space*. Cambridge, MA, USA: MIT Press. https://doi.org/10.7551/mitpress/9711.001.0001