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Technical Memorandum C.2
Demineralization Concentrate Management Plan

Investigation of Demineralization Concentrate Management

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FINAL REPORT

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EXECUTIVE SUMMARY

St. Johns River Water Management District (SJRWMD) has identified brackish groundwater, brackish surface water and seawater as potentially significant alternative sources of supply to meet projected 2020 demands. The use of these mineralized water sources requires management of the concentrate that is a by-product of the demineralization. These technologies are primarily pressure driven membrane processes that include reverse osmosis and nanofiltration. During this process, minerals in the source water, including salt, are removed producing potable water as well as a by-product known as demineralization concentrate.

The relative suitability of various demineralization concentrate management alternatives was evaluated for the 19-county SJRWMD area. From this assessment it was determined that the Florida Department of Environmental Protection (FDEP) regulations, which govern demineralization concentrate, largely determine the viability of a given project. In addition, there is a perception in the municipal demineralization community that current regulations present a challenge that is potentially inconsistent with the characteristics associated with demineralization concentrate. FDEP is actively working with affected parties to evaluate this issue.

Review of existing demineralization concentrate management projects in SJRWMD revealed a history of permitting challenges. These permitting challenges appear to have occurred mainly because existing regulations were not designed to address demineralization concentrate but were designed to deal with domestic and industrial wastewater discharges. Demineralization concentrate has water quality characteristics dissimilar to those commonly associated with domestic and industrial wastewater. Key issues related to demineralization concentrate were identified as part of this Demineralization Concentrate Management Plan (DCMP). These issues and potential solutions are identified below.

- At the present time, the Industrial Waste Disposal Application form is used by FDEP for permitting of demineralization concentrate management alternatives. As a result demineralization concentrate is advertised as an industrial waste discharge rather than a potable water by-product. This type of classification can bring about an inappropriate stigma and negative public perception (EW Consultants and Reiss Environmental 2001). Therefore, there is a need to develop a new and unique application form that is more appropriately suited for demineralization concentrate. FDEP is in the process of rule development mandated by amendments to Section 403.0882, *FS*, which could result in a new application form. This new application form is expected to be inclusive of concentrate from all types of source water and should adequately address this issue.

- In addition to changing the FDEP Industrial Waste Application form, revisions to the Florida UIC Rule (62-528) should be considered to classify demineralization concentrate as a municipal domestic waste rather than industrial waste because it is a potable water by-product. Currently, the UIC rules define municipal injection well as an injection well used to inject fluids from a permitted WWTP. Therefore, consideration should be given to modify this definition of municipal injection well to include certain municipal wastes, such as demineralization concentrate, from WTPs as well. In addition, the rules state that Class I injection wells shall inject fluids through packer and tubing assembly, unless the injection fluid is non corrosive. Therefore, in conjunction with redefining the term municipal injection well, consideration should be given to reclassifying demineralization concentrate as non-corrosive. At a minimum, concentrate of certain acceptable qualities should be classified as non-corrosive. These types of revisions would allow new concentrate injection wells to be constructed to current municipal injection well standards. They would also allow municipalities with existing Class I injection well systems to discharge demineralization concentrate along with treated domestic wastes, without retrofitting existing injection wells with tubing and packer assemblies.

- Another concern with current regulations is the monitoring criteria established for demineralization concentrate discharge projects. A large number of chemical and bacteriological parameters currently required for analysis do not result from the demineralization process. More commonly, a relatively limited list of constituents is likely to occur in demineralization concentrate based on the type of source water, potentially reducing the need for a global list of parameters to be analyzed. Consequently, a standardized list of constituents could be developed by FDEP to allow for the flexibility of determining analytical requirements that are needed based on the proposed source water for each project. This approach would establish regulatory monitoring and compliance criteria that would be more appropriate for demineralization plants. FDEP has indicated that it will consider development of an internal guidance memorandum, which could resolve this concern.

- Demineralization concentrate monitoring and compliance parameters are not always consistent with analytical techniques employed by commercial laboratories. In addition, the regulatory limits for parameters are not always consistent with analytical quantification levels, especially for saline samples. Comparison of water quality parameters with currently available analytical instrumentation and techniques used by commercial, certified laboratories could contribute to resolving this issue. In addition, the concentrations required by water quality standards could be compared to currently achievable detection limits of commercial laboratories. This would ensure that water quality samples can be measured at the concentrations necessary for comparison with regulatory requirements. This review could include consideration of high salinity samples such as demineralization concentrate to ensure that interferences due to high salinity are recognized and quantified.

- The majority of the effluent modeling currently conducted for domestic or other industrial effluents is in the context of stream flow that is unidirectional, and the worst case low flow is the key criterion. In the case of tidal water bodies, tides often reverse flow direction completely and/or result in short term zero flow conditions. The methods for addressing these unique concerns will need to have as much to do with the time step over which worst case is determined as the specific modeling. A reported issue in initiating demineralization projects is uncertainty as to what type and degree of modeling will be necessary for evaluation of surface discharge proposals. Clarity would be gained if FDEP could commit to an applicant that a particular method(s) will be considered acceptable throughout the permitting process. In addition, a shopping list of mixing evaluation methodologies that are appropriate for both tidal and non-tidal receiving waters would provide clarity. Additional consideration should be given to effluent modeling by SJRWMD and FDEP.

- The open ocean classification outlined by the current regulations is another area that limits the use of this demineralization concentrate management alternative. Open ocean waters are defined as all surface waters extending seaward from the most seaward natural 90-foot isobath. This definition and its application to demineralization concentrate appear to be derived from state of

Florida domestic wastewater facility regulations; it was not developed with demineralization concentrate in mind. It may be that the 90-foot isobath is not appropriate for demineralization concentrate discharge. A reasonable mixing zone for dilution purposes is potentially attainable at shallower depths along the coast. The science behind open ocean classifications could be investigated and, if necessary and appropriate, an open ocean classification specific to demineralization concentrate could be developed.

- Many of Florida's coastal waters, including the Indian River Lagoon complex, have experienced substantial declines in salinity due to diversion of stormwater from expanded watersheds due to ditching and from increases in impervious areas associated with development. This outcome has resulted in a decline in seagrass beds due to the freshening of traditionally brackish to saline waters. As such, discharge of demineralization concentrate with a TDS higher than that now present in the waterbody may be a benefit to the natural system. Consideration could be given to using concentrate with its higher salinity, to mitigate the freshening of marine surface waters.

In addition to the issues identified above, studies and research could be conducted to address the following concerns:

- Re-evaluation of toxicity testing with regard to naturally occurring constituents

- Surface water studies to address ion imbalance and toxicity issues relative to suitable/extended mixing zones

- Studies on acute and chronic toxicity as well as radionuclides to better refine the affects from demineralization concentrate

- Studies on deep injection wells to determine actual extent of injection fluid and potential migration pathways within the subsurface

In addition to FDEP regulations, there are a range of factors which determine the feasibility of a demineralization concentrate management strategy. This is due to an unusually wide variability in site-specific factors such as economics, public perception, technical criteria, and environmental considerations for the various demineralization concentrate management strategies.

Primary demineralization concentrate management strategies utilized in Florida which would be applicable to demineralization facilities with capacities on the order of 5 to 50-MGD include subsurface injection and various forms of surface water discharge. In general, the costs for surface water discharge are less than subsurface injection. However, permitting and environmental factors associated with surface water discharge options are generally more significant than that with subsurface injection. Specific conclusions and recommendations are provided below.

CONCLUSIONS

The assessment of demineralization concentrate management alternatives, which is described in this document, considered various factors that affect the relative suitability of a given application. The approach included consideration of the location and characteristics of the alternative source waters including brackish groundwater, brackish surface water and seawater and the characteristics of potential receiving waters. The following conclusions have been drawn from the assessment. Numerical references are not an indication of the relative priority.

1. Sources of brackish groundwater include areas of the Upper Floridan aquifer primarily located east of the St. Johns River. Brackish surface water sources include large portions of the St. Johns River as well as the Intracoastal Waterway. Seawater is available along the 150 miles of coastline in SJRWMD. These alternative sources are available to most municipalities within Priority Water Resource Caution Areas.

2. A wide range of factors must be considered when determining the feasibility of a demineralization concentrate management strategy given large, site-specific variations in economics, public perception, technical criteria, and environmental considerations associated with this water treatment plant by-product. Primary demineralization concentrate management disposal strategies utilized in Florida, which would be applicable to regional-level demineralization facilities within SJRWMD, include subsurface injection and various forms of surface water discharge. In general, the costs for surface water discharge are less than subsurface injection. However, permitting and environmental factors associated with surface water discharge options are generally more significant than with subsurface injection.

3. Through this assessment it was determined that the FDEP regulations which govern demineralization concentrate determine to a large degree the viability of a given project. In addition, there is a perception in the municipal demineralization community that current regulations present a challenge that is potentially inconsistent with the characteristics associated with demineralization concentrate. Presently, FDEP is in the process of rule development mandated by amendments to Section 403.0882, *FS*. It is expected that this rule making process will address many of the perceived inconsistencies in the regulations. The Technical Advisory Committee (TAC) appointed to assist in this process consists of stakeholders in the regulation of demineralization concentrate management. SJRWMD ‘s continued and increased participation in this process can be a positive factor in achieving a satisfactory outcome.

4. The assessment of subsurface injection using Class I wells indicates that the Upper Floridan aquifer has no areas that are suitable for this concentrate management alternative. However, a portion of the Lower Floridan aquifer appears available for consideration. These areas are generally located south of Merritt Island, and are mainly within Indian River and Brevard counties. The absence of significant restrictions on the salinity of the injection fluid render subsurface injection highly suitable for demineralization concentrate from sources of all ranges of salinity, including seawater.

5. It was determined that the permitting of the discharge of demineralization concentrate to inland surface waters (St. Johns River and the Intracoastal Waterway), marine wetlands and coastal ocean waters is dependant upon the concentration and composition of the salinity of the source water. Demineralization of source waters with lower salinity will result in lower salinity concentrate. Low salinity concentrate can be discharged to water bodies with similar or higher salinity ranges. In SJRWMD there are more areas suitable to receive discharge of a low salinity concentrate than there are areas capable of receiving a high salinity concentrate. Therefore, the suitability of discharge is the highest for sources with relatively low salinity. The areas most capable of accommodating a wide range of source water salinity are locations in the St. Johns River near Jacksonville, portions of the Intracoastal Waterway from

Cape Canaveral to Jacksonville, and most coastal ocean areas. However, consideration of the impairment of a water body and the parameters of concern may limit the availability of this discharge option.

6. Based on salinity considerations only, the suitability of discharging demineralization concentrate to inland surface waters, marine wetlands and coastal ocean is greater for a facility using a brackish groundwater source than a brackish surface water source given the larger distribution of lower salinity brackish groundwater in SJRWMD. In addition, size limitation of and environmental protection associated with marine wetlands renders this alternative more suitable for smaller demineralization WTPs, on the order of 10-MGD or less.

7. Discharge of demineralization concentrate from a seawater source to inland surface waters, marine wetlands and coastal ocean is not highly suitable, given the very high salinity of the discharge stream. More suitable approaches include dilution with other lower salinity streams, use of subsurface injection, open ocean discharge, or consideration of lower salinity source water. A demineralization concentrate management strategy defined as less suitable herein may be appropriate due to other unique requirements of a specific demineralization water treatment project.

8. Open ocean discharge (at a depth of 90 feet or greater) readily meets most screening criteria but is greatly limited by the distance from the shoreline and associated ocean pipeline construction costs. The open ocean is 14 to 35 miles offshore in the areas along the SJRWMD coastline.

9. Blending of demineralization concentrate with WWTP effluent will limit the plant capacity, if introduced at the headworks, and also possibly modify the final effluent composition. The result may affect the WWTP's ability to comply with applicable effluent limits. In some cases the effect of blending may actually reduce the environmental impact by diluting the constituents of a wastewater discharge. If the discharge is to brackish or marine waters, the addition of the concentrate will also increase the discharge salinity and improve its ability to disperse in the receiving waters. In the event larger WWTPs exist that are discharging to saline water bodies, a significant

benefit would be realized but is not expected to have wide application for the purposes of regional planning.

10. Blending demineralization concentrate with power plant cooling water may have significant benefit for any proposed facility. There are a total of four power plants with large cooling water flows located within SJRWMD. All four power plants are discharging to an inland surface water. Blending with power plant cooling water will reduce but not eliminate the increase in salinity concentration resulting from a demineralization water treatment plant.

11. All selected alternative water sources and all selected demineralization concentrate management alternatives were considered highly suitable in various locations within SJRWMD. Areas bordering or east of the St. Johns River and in the southern portion of SJRWMD are the most likely locations for future demineralization facilities.

RECOMMENDATIONS

The investigation of demineralization concentrate management revealed a number of recommendations for consideration. These range from additional studies to considerations for future projects and are itemized below. Numerical references are not an indication of the relative priority.

1. The Technical Advisory Committee (TAC) established by FDEP should continue its evaluation of concentrate management issues including but not limited to:
    a. Development of a new and unique application form specific to demineralization concentrate (included in current FDEP demineralization concentrate rule-making initiative discussions)
    b. Appropriateness of making revisions to state of Florida and federal UIC rules for reclassifying demineralization concentrate as a municipal domestic waste as well as non-corrosive (included in current FDEP demineralization concentrate rulemaking initiative discussions)
    c. Development of a standardized list of water quality parameters specific to demineralization concentrate (included in current FDEP demineralization concentrate rule-making initiative discussions)

d. Establishment of a protocol for permit applicants to use to reconcile problems associated with analytical techniques and the characteristics of demineralization concentrate and its receiving waters
e. Development of a list of appropriate modeling procedures for incorporation into the Guide to Wastewater Permitting, Chapter 62-620, F.A.C. (included in current FDEP demineralization concentrate rule-making initiative discussions)
f. Identification of off-shore areas suitable for discharge of demineralization concentrate based on an evaluation of marine characteristics in the Atlantic off-shore of SJRWMD
g. Re-evaluation of toxicity testing with regard to naturally occurring constituents (included in current FDEP demineralization concentrate rule-making initiative discussions)
h. Assessment of ion imbalance and toxicity MSIT protocol issues relative to suitable / extended mixing zones in surface waters

2. A comprehensive site-specific study should be conducted in advance of committing to any potential project. The efforts herein were developed at a macro-level for the region and should serve as broad guidance in the planning effort. In addition, these efforts were directed solely toward demineralization concentrate management. A demineralization concentrate management strategy defined as less suitable herein may be appropriate due to other unique requirements of a specific demineralization water treatment project.

3. Communication between applicants, potentially affected parties, and involved regulatory agencies should be initiated as early as possible.

4. Regional water treatment projects should be considered during the planning process. The many benefits associated with a regional demineralization project include economy of scale for certain demineralization concentrate management alternatives such as open ocean outfall.

5. Water resource studies designed to identify potential benefits of discharge of demineralization concentrate to the salinity

balance in surface waters that are likely candidate receiving waters for demineralization concentrate, should be performed.

6. Additional work to increase the density of Lower Floridan aquifer data observations should be undertaken to help improve the identification of areas suitable for injection of demineralization concentrate.

7. For the purposes of this study, only areas that were expected to meet Class I injection well standards were evaluated. However, along coastal areas of SJRWMD, site-specific water quality and geology may be suitable for a Class V concentrate injection well. It is recommended that projects proposed in coastal areas further evaluate the suitability of Class V injection wells as one potential demineralization concentrate management method.

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ABBREVIATIONS

AC	Acre
DCMP	Demineralization Concentrate Management Plan
DI	Ductile Iron
DO	Dissolved Oxygen
DWSP	District Water Supply Plan
EPA	Environmental Protection Agency
F.A.C.	Florida Administrative Code
FDEP	Florida Department of Environmental Protection
FKAA	Florida Keys Aqueduct Authority
fps	foot per second
FRP	Fiberglass Reinforced Plastic
F.S.	Florida Statutes
GIS	Geographic Information System
IDCMP	Investigation of Demineralization Concentrate Management Project
IWPP	Industrial Waste Pre-treatment Program
MGD	Million Gallon a Day
MFL	Maximum Flow and Level
NGDC	National Geophysical Data Center
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
O&M	Operation and Maintenance
OFW	Outstanding Florida Water
PVC	Polyvinyl Chloride
SJRWMD	St. Johns River Water Management District
TDS	Total Dissolved Solids
UIC	Underground Injection Control
USDW	Underground Source of Drinking Water
USGS	United States Geological Survey
TMDL	Total Maximum Daily Load
WQBEL	Water Quality Based Effluent Limitations
WTP	Water Treatment Plant
WWTP	Wastewater Treatment Plant

INTRODUCTION

St. Johns River Water Management District (SJRWMD), in its District Water Supply Plan (DWSP) (Vergara 2000a), identified limitations in the availability of high quality groundwater and a need for utilization of alternative water supplies to meet future water demands.

In association with the regional water supply planning effort, SJRWMD has established a water resource development program. This program includes projects, based on the provisions of Paragraph 373.0361(2)(b), Florida Statutes (*F.S.*), that would increase the quantity of water available for water supply. The Investigation of Demineralization Concentrate Management Project (IDCMP) represents one of these water resource development projects. This Demineralization Concentration Management Plan (DCMP) represents the key project deliverable.

PROJECT OVERVIEW

SJRWMD has identified brackish groundwater, brackish surface water and seawater as potentially significant alternative sources of supply to meet projected 2020 demands. The use of these mineralized water sources requires management of the concentrate that is a by-product of the demineralization technologies. These technologies are primarily pressure driven membrane processes that include reverse osmosis and nanofiltration. During this process, minerals in the source water, including salt, are removed producing potable water as well as a by-product known as demineralization concentrate. Available management options for the demineralization concentrate include subsurface injection, discharge to surface waters, land spreading, discharge to wastewater treatment facilities, and various forms of reuse, among others.

The history of demineralization projects in SJRWMD and the state of Florida indicate the need for development of acceptable management strategies for demineralization concentrate that can be dependably utilized by public supply utilities and other water users. In particular, the permitting associated with demineralization concentrate has represented a key factor in developing successful demineralization projects. Implementation of demineralization concentrate management options is subject to Florida Department of Environmental Protection (FDEP) regulatory requirements. These regulatory requirements are based on federal regulations administered by the U.S. Environmental Protection Agency (EPA).

The Investigation of Demineralization Concentrate Management Project was designed to assess demineralization concentrate management alternatives on a regional level including consideration of regulatory requirements, technical criteria, and economics. In addition, the IDCMP was designed to identify any required technical studies, data collection, or analysis needed to formulate, implement, evaluate, and monitor the effectiveness of demineralization concentrate management strategies.

The IDCMP included workshops and data collection tasks to support this Demineralization Concentrate Management Plan. The following deliverables were generated in the data collection effort and utilized in the development of the DCMP:

- Demineralization concentrate annotated bibliography;
- Geology of SJRWMD annotated bibliography;
- Technical Memorandum: *Summary of Applicable Rules and Regulations*; and
- Demineralization Concentrate Database / Geographic Information System (GIS) Data Layers: a Microsoft Access database of demineralization concentrate information for all demineralization water treatment plants in the state of Florida with a capacity over 0.1-MGD and an associated GIS map for the plant, source and discharge locations.

These deliverables and the DCMP itself were developed as a cooperative effort with FDEP, public supply utilities, and other affected parties.

Previous deliverables are available as independent documents through the SJRWMD library or the SJRWMD website. This document represents the DCMP itself.

PURPOSES AND SCOPE

This Demineralization Concentrate Management Plan addresses the relative suitability of demineralization concentrate management alternatives in the District's 19-county area. The DCMP integrates existing data to formulate assessments of demineralization concentrate management alternatives presented by geographical location within the boundaries of SJRWMD. In addition, recommendations are provided for future tasks that would enhance planning efforts.

As a regional, planning document, the DCMP provides a comprehensive assessment of demineralization concentrate management options within SJRWMD. Additional data and interpretation are likely necessary to draw final conclusions relative to the feasibility of individual, site-specific situations.

METHODOLOGY

This document represents a Districtwide, and therefore a macro-level, assessment of demineralization concentrate management alternatives. GIS data with associated criteria such as regulatory requirements and technical needs were assessed and utilized to develop this demineralization concentrate management plan.

Conservative screenings based on selected criteria were used to determine the relative suitability of various demineralization concentrate management practices in conjunction with the different source waters within the geographical boundaries of SJRWMD. Areas identified as having highest suitability provide managers and planners with areas meeting the specified criteria, including the ability to meet certain regulatory permitting requirements. Areas not defined as having highest suitability may still be viable locations, as determined through site-specific assessments. In addition, it should be noted that every concentrate management alternative will be subject to a site-specific study during the course of project implementation.

The following sections present the methodology associated with regulatory considerations, potential source waters, potential concentrate management alternatives, and acceptable concentrate management alternatives associated with suitable source waters.

REGULATORY CONSIDERATIONS

Rules and regulations regarding demineralization concentrate management were reviewed and summarized. Difficulties that utilities have experienced statewide were also presented. Requirements associated with current regulations which warrant further review and potential modification were identified based on historical issues within the state.

POTENTIAL SOURCE WATERS

Potential source waters were defined in DWSP and are brackish groundwater, brackish surface water and seawater. DCMP was prepared by utilizing pre-existing source water information and integrating this information into an assessment of relative suitability of various demineralization concentrate management alternatives.

Data for total dissolved solids (TDS) were collected for each type of source water for the entire SJRWMD area. This data, in GIS format, was screened to eliminate all water with TDS less than 500 mg/L. A TDS of less than 500 mg/L represents a fresh or potable water as defined by FDEP. The resulting set of information represented all brackish waters located within the SJRWMD boundaries.

In addition to this water quality-based methodology, the source of the data utilized for each water type is defined in each of the subsections below.

Groundwater

The Upper Floridan aquifer was evaluated as the source of brackish groundwater within SJRWMD. The total dissolved solids concentration coverage in the groundwater was provided by SJRWMD in GIS format.

Surface Water

The St. Johns River and the Intracoastal Waterway were evaluated as the potential sources of brackish surface water within SJRWMD. The TDS concentration coverage in the St. Johns River was generated using data from SJRWMD. The data used to create the map represent twenty years of station monitoring. This coverage was merged with the Intracoastal Waterway salinity coverage provided by EPA. EPA salinity data were converted to TDS. The equations used to convert salinity to TDS are presented in Appendix A.

Seawater

Atlantic Ocean water was considered a potential source water. The TDS of the Atlantic Ocean along the coast of SJRWMD is relatively constant. TDS data were obtained from the National Oceanic and Atmospheric Administration (NOAA).

The criteria and GIS coverages identified above were used to screen and identify waters considered appropriate for utilization as a source of supply to a demineralization facility.

POTENTIAL DEMINERALIZATION CONCENTRATE MANAGEMENT ALTERNATIVES

Potential demineralization concentrate management alternatives were investigated relative to their applicability to SJRWMD. Management alternatives which are currently utilized or could be reasonably utilized within SJRWMD were evaluated in detail using a GIS-based assessment. Emerging alternatives or less feasible alternatives were evaluated qualitatively.

The following demineralization concentrate management alternatives were evaluated using a GIS-based screening process:

- subsurface injection,
- surface water discharge,
- coastal ocean discharge,
- open ocean discharge, and
- marine wetland discharge.

Subsurface injection involves injecting demineralization concentrate below the ground surface into a porous rock formation, typically using a deep well.

Surface water discharge involves introduction of demineralization concentrate into a receiving water body, typically using a submerged outfall structure. Coastal ocean, open ocean, and marine wetlands are all subsets of surface waters and also typically involve the use of outfall structures.

Subsurface Injection

Both the Upper Floridan aquifer and the Lower Floridan aquifer were evaluated relative to subsurface injection. Areas of highest suitability were generated based on the following criteria:

- TDS of greater than 10,000 mg/L,
- transmissivity,
- leakance (confinement) of the aquifer, and
- setback from water supply wells, springs and faults
- permitting history of existing injection wells in SJRWMD

These data were obtained from United States Geological Survey (USGS) and SJRWMD.

Surface Water

The St. Johns River and the Intracoastal Waterway were evaluated as the potential receiving water bodies within SJRWMD. Areas of highest suitability for discharge of demineralization concentrate to surface waters were determined based on the following criteria:

- classification of the water body,
- TDS concentration (relative to demineralization concentrate TDS), and
- location of environmentally sensitive areas.

Surface water classifications were obtained from FDEP. Surface water TDS concentration coverage was obtained from SJRWMD. These data were the same as used in the potential surface water source evaluation. Environmentally sensitive areas include Outstanding Florida Waters (OFWs), parks, and areas with seagrass. These coverages were obtained from FDEP.

Coastal Ocean

Coastal ocean waters are defined as ocean waters within the 90-foot isobath, per FDEP. Areas of highest suitability for discharge of demineralization concentrate management to coastal ocean waters were determined based on the following criteria:

- Within the 90-foot isobath,
- TDS concentration (compared to demineralization concentrate TDS), and
- location of environmentally sensitive areas.

Location of the 90-foot isobath off the coast of SJRWMD was obtained from National Geophysical Data Center (NGDC). TDS concentrations were obtained from NOAA. Environmentally sensitive areas include Outstanding Florida Waters, parks, artificial reefs and areas with seagrass. These coverages were obtained from FDEP.

Open Ocean

Open ocean waters are defined as waters extending seaward from the 90-foot isobath, per FDEP. Areas of highest suitability for discharge of demineralization concentrate to open ocean waters were determined based on the following criteria:

- 90-foot isobath,
- TDS concentration (compared to demineralization concentrate TDS), and
- location of environmentally sensitive areas.

Location of the 90-foot isobath off the coast of SJRWMD was obtained from NGDC. TDS concentrations were obtained from NOAA. Environmentally sensitive areas include artificial reefs. This coverage was obtained from FDEP.

Marine Wetlands

Areas of highest suitability for discharge of demineralization concentrate to marine wetlands were determined based on the following criteria:

- wetland location,
- salinity,
- capacity, and
- location of environmentally sensitive areas.

Wetlands were identified from National Wetland Inventory Maps prepared by the US Fish and Wildlife Service. Salinity information was obtained from EPA. Capacity was determined based on technical design information for similar applications. Coverages of environmentally sensitive areas such as Outstanding Florida Waters, parks and seagrass areas were obtained from FDEP.

The GIS coverages and criteria specified above were utilized to screen and identify the areas within SJRWMD with the highest suitability for utilization of each demineralization concentrate management alternative.

HIGH SUITABILITY DEMINERALIZATION WTP SITES

Coverages representing areas of highest suitability for the three different source waters and for the five different demineralization concentrate management alternatives were combined to determine areas with highest suitability in relation to both a demineralization concentrate management alternative and a source of water. Areas identified as having highest suitability are areas meeting the specified criteria, including the ability to meet certain regulatory permitting requirements. Areas not defined as having highest suitability may still be viable locations, as determined through site-specific assessments.

Source waters and management alternatives were integrated based on a 15-mile proximity criterion. The resulting areas represent potential water treatment plant sites. Within these areas, a water treatment plant could be sited and would require a total pipe length of no more than 15 miles to accommodate both raw water transmission piping and demineralization concentrate transmission piping. This 15-mile criterion was developed based on the economic feasibility of projects and the impact of raw water and demineralization concentrate pipe lengths. This 15-mile threshold is consistent with the threshold utilized in Tampa Bay Water's demineralization investigations, the SJRWMD Seawater Demineralization Siting study and other economic sensitivity evaluations. While project-specific economic factors would define the particular lengths of piping which could be accommodated before making a project unfeasible, this criterion is consistent with other studies and is considered appropriate for this macro-level analysis.

In addition, a TDS criterion was applied to surface water, coastal ocean, open ocean, and wetlands discharges. For these demineralization concentrate management alternatives, regulatory permitting requirements are most readily met when demineralization concentrate TDS is less than the receiving water body. Therefore, an estimate of the expected demineralization concentrate TDS was developed based on source water quality and a typical demineralization plant design for such a source water. Areas in which demineralization concentrate TDS was less than the receiving water body TDS were deemed areas with highest suitability.

For subsurface injection, a demineralization concentrate TDS that is higher than the receiving aquifer TDS is acceptable, both from a technical and regulatory perspective, and therefore this TDS relationship was not used as a screening criterion.

This approach was designed to identify areas of highest suitability in terms of technical criteria, regulatory requirements, and protection of the environment. Situations and locations not identified as highest suitability may still have merit but require more detailed analysis to ensure that project criteria, such as environmental protection or regulatory compliance, can be met. For example, FDEP regulations contain certain relief mechanisms that may support implementation of a project in locations not identified as areas of highest suitability.

REGULATORY CONSIDERATIONS

This DCMP focuses on identification of acceptable management strategies for demineralization concentrate. Understanding the rules and regulations associated with demineralization concentrate management permitting represents a critical starting point for any evaluation.

The existing rules and regulations for demineralization concentrate management are summarized in the following section. In addition, the historical development and application of regulations are examined relative to existing projects. Lastly, the suitability of future desalination projects from a demineralization concentrate management viewpoint is analyzed based on current and proposed regulations.

EXISTING REGULATIONS

The regulations which are applied to demineralization concentrate management are one of the primary considerations associated with the development of demineralization facilities within SJRWMD. A technical memorandum titled *Applicable Rules and Regulations for Concentrate Management* was developed by Reiss Environmental (REI 2002a) addressing this topic. This section provides a summary of these applicable rules and regulations. The full technical memorandum has been provided for reference in Appendix B.

Demineralization concentrate management projects may require permits, approvals or authorization from numerous governmental agencies (Table 1). However, the requirements of the Florida Department of Environmental Protection are the most pertinent to demineralization concentrate management and represent the critical test of the viability of any demineralization concentrate management project. FDEP has not yet developed rules specific to demineralization concentrate. Instead, various sections of Florida Administrative Code (F.A.C.) relate to and are used to regulate various demineralization concentrate management situations (Table 2).

The information presented in this section provides initial guidelines concerning FDEP's permitting requirements and processes that should be expected for areas within SJRWMD. However, site-specific conditions render every concentrate permit effort unique.

Table 1. Summary of agencies potentially requiring permits, approvals, or authorization for demineralization concentrate management projects

Responsible Agency
Federal
EPA Region IV
Army Corps of Engineers
OSHA
United States Geological Survey
United States Fish and Wildlife Service
National Marine Fisheries Service
State
Department of Environmental Protection (Primary Agency)
Water Management Districts
Department of Transportation
Florida Fish and Wildlife Conservation Commission
Local
Health Department
Local Pollution Control
Environmental Resource Management or Natural Resource Management Departments
City/County Building and/or Zoning Departments
CSX Railroad Corporation

Table 2. Applicable Rules and Regulations

Reference	Description	Keyword
State Regulation from Florida Administrative Code:		
62-4	Permits	Surface water discharge, ocean outfall, underground injection control, non-surface water discharge, mixing zones
62-160	Quality Assurance	Sampling, analyses, laboratories, surface water, groundwater, wastewater
62-301	Surface Waters of the State	Surface water, ocean outfall
62-302	Surface Water Quality Standards	Toxicity, OFW
62-330	Environmental Resource Permitting	Dredge and fill, pipelines
62-343	Environmental Resource Permit Procedures	Dredge and fill, pipelines
62-520	Groundwater Classes, Standards, and Exemptions	Groundwater disposal
62-522	Groundwater Permitting and Monitoring Requirements	Groundwater disposal
62-528	Underground Injection Control	Underground injection control wells
62-550	Drinking Water Standards, Monitoring, and Reporting	Land application
62-610	Reuse of Reclaimed Water and Land Application	Reuse, land application
62-620	Wastewater Facility and Activities Permitting	Industrial wastewater, permit applications
62-650	Water Quality Based Effluent Limitations	Surface water discharge
62-660	Industrial Wastewater Facilities	Industrial wastewater, effluent limitations

Underground Injection

FDEP has been authorized to implement EPA's Underground Injection Control (UIC) program. Obtaining an FDEP permit for underground injection of demineralization concentrate begins with the requirements of Chapter 62-528, *F.A.C.*, and identification of the type of well to be constructed. Class I and Class V wells are the two viable candidates for concentrate projects.

Class I wells are wells that inject large volumes of hazardous and non-hazardous wastes into deep, isolated rock formations that are below the lowermost underground source of drinking water. Primary aquifer considerations for a Class I well are:

- Suitable transmissivity,
- Aquifer TDS greater than 10,000 mg/L, and
- Confining zone is present.

Class V wells use injection practices that are not included in the four other classes of wells. Primary aquifer considerations for a Class V well are as follows:

- Suitable transmissivity, and
- Confining zone is present.

If the receiving aquifer has TDS concentrations less than 10,000 mg/L or if the fluid can migrate to an underground source of drinking water (USDW), then the proposed fluid must meet primary drinking water standards and only the ambient groundwater quality for the secondary drinking water parameters (i.e. chloride and TDS). If the aquifer contains TDS greater than 10,000 mg/L and is confined from a USDW or absent of a USDW, then it will not need to meet other groundwater quality standards. Given the elevated levels of TDS and other constituents in many concentrate streams, drinking water standards typically cannot be met. Once the class of well has been selected, FDEP will review information provided by the applicant to support issuance of an Underground Injection Control permit. Following successful review, FDEP will issue a permit to construct the well. Only after successful results are obtained for the newly constructed well is an operating permit issued.

Surface Water Discharge

FDEP defines surface water to be inclusive of inland surface waters, coastal ocean, open ocean and wetlands. FDEP regulations vary to a degree depending on certain factors such as salinity (fresh or marine) and depth of water (coastal ocean versus open ocean). This section provides an overall assessment of surface water regulations, with variations defined in subsequent section.

Discharge of concentrate to a surface water requires issuance of an NPDES permit by FDEP. The permitting process brings together numerous portions of Florida Administrative Code and can be complex.

While each situation is unique and the regulations are complex, every surface water permit application is reviewed for compliance in five main areas:

1. Anti-degradation policy (62-302.300, *F.A.C.)* and Water Quality Based Effluent Limitations (WQBEL) (62-650, *F.A.C.)* (anti-degradation is only applicable to new or increased discharges);
2. Compliance with surface water criteria and mixing zone limitations;
3. Impacts of tidal influence;
4. Toxicity of demineralization concentrate; and
5. Whether the demineralization concentrate contributes to an existing impairment of the surface water / WQBEL

These five main areas are described in more detail within the applicable rules and regulations technical memorandum provided for reference in Appendix B. While some latitude may exist depending upon site-specific conditions, it is important to compare the expected concentrate quality with the water quality standards as soon as possible, especially primary criteria such as TDS. Since TDS is utilized as one of the main primary screening criteria, demineralization concentrate with a TDS less than that of a receiving water body represents a preferred condition which supports the permitting process.

It should be noted that the demineralization concentrate may represent a resource to mitigate some of the freshening of marine environments in Florida, caused by increased discharges of fresh storm waters. However, there are no provisions in the surface water regulations that allow concentrate to be used to mitigate depressed salinity environments.

Coastal Ocean Outfall

Coastal Ocean is defined by FDEP as ocean waters of 90-foot depth or less. Ocean water beyond the 90-foot isobath is defined as Open Ocean. Regulatory requirements for coastal ocean outfall follow those defined previously for surface water discharge, and require issuance of an NPDES permit. As with any surface water discharge, it is important to compare the expected concentrate quality with the water quality standards as soon as possible. While each permit application is evaluated on an individual basis to ensure that FDEP has reasonable assurance that the proposed facility will meet applicable water quality standards, demineralization concentrate with a TDS less than the receiving water body represents a preferred condition for the applicant.

Open Ocean Outfall

Open ocean waters are defined as all surface waters extending seaward from the most seaward natural 90-foot isobath. Discharge of demineralization concentrate to open ocean outfalls also requires an NPDES permit. In many instances, the distances required to reach the 90-foot isobath may render this option less attractive.

As defined in Section 62-4.244, *F.A.C.*, requirements for open ocean discharges are less stringent than those for other surface water bodies. Specific differences are as follows:

1. Dissolved oxygen (DO) requirements are less stringent;
2. Biotoxicity requirements are less stringent: the discharge can be diluted 1/3 its normal concentration for toxicity testing;
3. Water quality standards must be met at the point of 20:1 dilution, not at the point of discharge;
4. If water quality standards are met at the point of 20:1 dilution, a mixing zone is not required;
5. A larger mixing zone is allowed (four times larger than other surface water discharges).

In addition compliance with the anti-degradation policy is more likely. In summary, ocean outfalls are a subcategory of surface water discharge with similar permitting requirements. However, the reduced water quality requirements and the ability to discharge large quantities of demineralization concentrate are such that open ocean discharge may be a reasonable alternative for large municipal demineralization water treatment plant projects.

Marine Wetlands Discharge

Discharge of demineralization concentrate to marine wetlands is considered a surface water discharge and also requires an NPDES permit. FDEP requirements are consistent with those presented for surface water discharges. Therefore, it is important to ensure the expected demineralization concentrate quality meets all water quality screening criteria for marine wetlands to simplify the permitting process.

Other Methods

While a number of lesser-known demineralization concentrate management methods are available, most fall into one of the categories described previously. These lesser-known methods include the following:

- blending with wastewater,
- land spraying and percolation ponds,
- evaporation ponds,
- zero liquid discharge,
- coastal exfiltration galleries and
- bore holes.

Based on the rules and regulations evaluated, these alternative disposal methods may be permitted in Florida, pending compliance with specific criteria. Land spraying or percolation ponds must meet groundwater standards at the edge of the zone of discharge. This can greatly limit these two options since the groundwater standards incorporate drinking water standards such as the requirement that TDS be less than 500 mg/L. Other factors such as costs may also have bearing on the use of these methods. For a more detailed description of the permitting approach associated with these other concentrate management alternatives refer to the applicable rules and regulations technical memorandum provided in Appendix B.

Summary

In summary, permitting of demineralization concentrate for underground injection, surface water discharge, coastal ocean, open ocean outfalls, marine wetlands or other methods involves balancing numerous factors and considerations. A primary consideration of FDEP is the expected demineralization concentrate quality and how it compares with the water quality standards. Therefore, as a starting point for assessing any concentrate management alternative, it is important to know the TDS of the concentrate relative to the receiving water body. This approach would provide a good basis for screening a particular concentrate management alternative to determine the suitability based on a regional scale analysis. Final determination of appropriateness for a permit application is highly dependant on site-specific conditions and interpretation of regulations and compliance with specific criteria.

EXISTING DEMINERALIZATION CONCENTRATE MANAGEMENT PROJECTS

As part of the Demineralization Concentrate Management Project, a statewide survey was conducted of all potable demineralization facilities with a capacity above 0.1-MGD. A total of fifty six plants were identified and are primarily located in coastal regions of the state. Twelve of these demineralization plants are located in SJRWMD and are presented in Table 3.

The twelve demineralization plants in SJRWMD are generally located in coastal areas (Figure1). Figure 1 also shows their concentrate disposal locations.

Management Alternatives

There are four different methods used to dispose of concentrate from the 56 existing demineralization water treatment plants in Florida. These four methods consist of surface water discharge, subsurface injection, sanitary sewer discharge, and land application / percolation ponds. The percentage of each method used for the 56 demineralization plants with a capacity higher than 0.1-MGD is as follows:

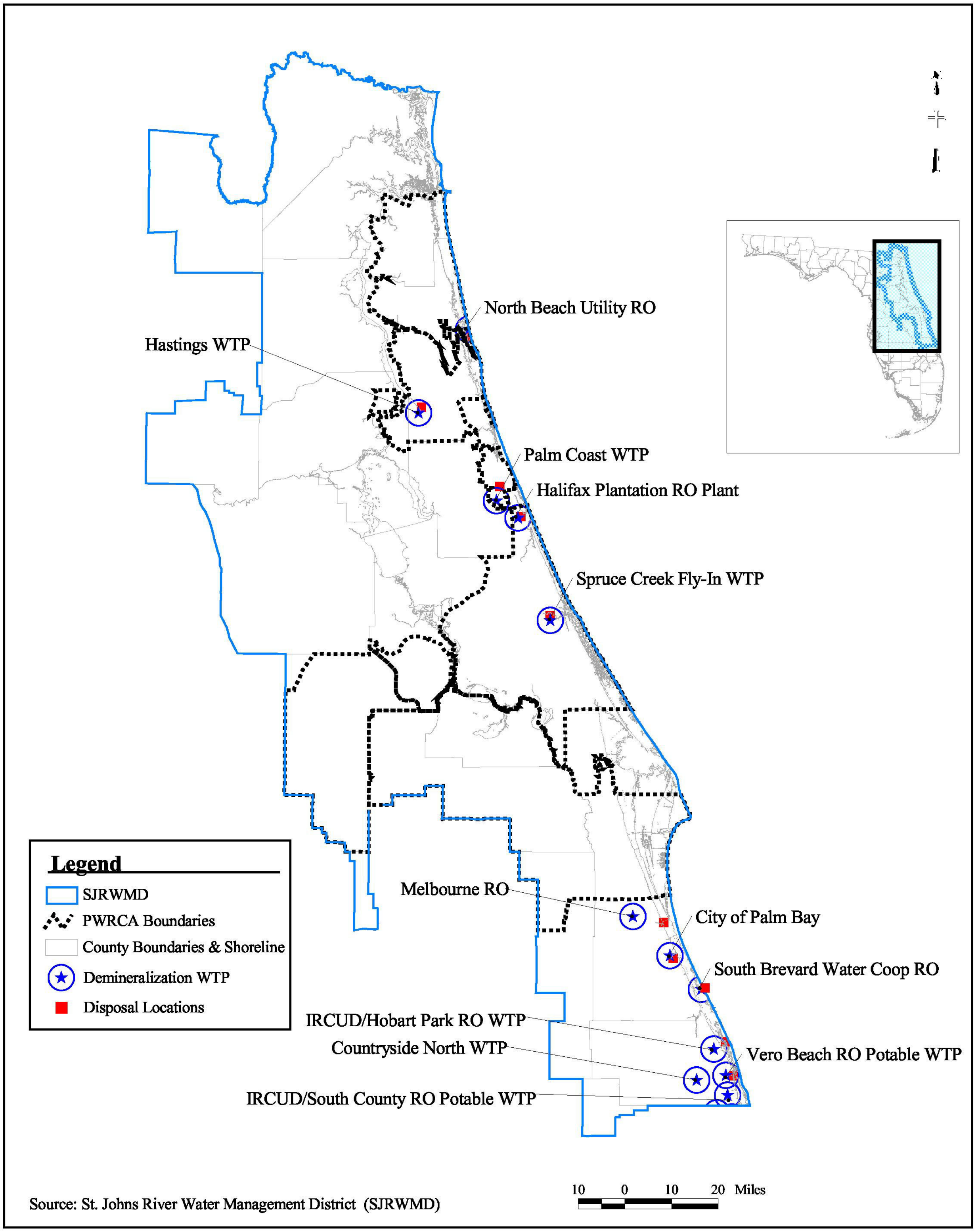

Figure 1. Demineralization WTP's in SJRWMD

- Surface water discharge: 33%
- Subsurface injection: 33%
- Sewer or sewer / reuse: 18%
- Land application: 15%

There are 10 facilities directing their concentrate streams into the sewer system. Seven of them have a capacity of less than 1.5-MGD, representing a concentrate flow of less than 0.375-MGD. Discharging a low concentrate flow into a sewer system is feasible if the WWTP influent flow is large enough to dilute the concentrate and prevent any negative impact to the WWTP microorganisms.

While used in these 10 locations in the state, sewer discharge is not considered a reasonably feasible alternative for water resources planning within SJRWMD, given the effect of demineralization concentrate on fresh water microorganisms in a WWTP and the need for continued compliance with the WWTPs effluent discharge permit conditions.

Table 3. Demineralization WTP in SJRWMD

	WTP	**County**	**Disposal Method**
1.	North Beach Utility	St. Johns	Sewer (Reuse)
2.	Hastings	St. Johns	Surface Water
3.	Palm Coast	Flagler	Surface Water
4.	Halifax Plantation	Volusia	Land Application
5.	Spruce Creek Fly-In	Volusia	Land Application
6.	Melbourne	Brevard	Surface Water
7.	Palm Bay	Brevard	Sewer
8.	South Brevard Water Coop	Brevard	Land application (Drainfield)
9.	IRCUD / Hobart Park	Indian River	Surface Water
10.	IRCUD / South County	Indian River	Surface Water
11.	Countryside North	Indian River	Land Application
12.	Vero Beach	Indian River	Surface Water

In SJRWMD, the 12 demineralization facilities utilize either surface water discharge, land application, or sewer discharge (Table 3). There are six surface water discharge permits, which represents 50% of the total permits in SJRWMD. The other two methods are land application (4 facilities) and discharge to the sewer (2 facilities).

Currently there are no demineralization concentrate injection well systems in operation in SJRWMD, however one construction permit for an injection well for demineralization concentrate was issued for the City of Palm Bay in 2003. It should also be noted that there are 10 permitted domestic waste injection wells in SJRWMD. One potential reason for the lack of demineralization concentrate injection wells within SJRWMD is that 9 out the 12 demineralization plants in SJRMWD have a capacity of less than 2-MGD. This plant capacity was likely too low to justify the cost of constructing a deep well. As a comparison, statewide there are 18 deep injection wells and only four of them are used to dispose of concentrate from a water plant having a capacity of less than 4-MGD.

Variances and Relief Mechanisms

A portion of the 56 demineralization facilities have received variances and/or mixing zones. Out of 56 concentrate disposal permits, four have received variances. Out of the four variances, one is for deep well injection and three are for surface water discharge. The three surface water variances are related to toxicity testing. The only variance in SJRWMD is related to toxicity and was issued for a surface water discharge (Vero Beach RO Potable WTP).

Furthermore, there are 20 demineralization plants in the state using surface water discharge, and 12 of them have been granted a mixing zone. While not a variance, a mixing zone represents a site-specific condition granted by FDEP to allow a zone of dilution to meet certain water quality standards that might not otherwise be met. This requires a detailed assessment of stream or tidal flow and use of a dispersion model(s). As shown by the large number of surface water discharge applications, which require a mixing zone (60%), the use of a mixing zone is an extremely important tool for compliance with regulatory requirements.

The mixing zones granted to 12 of the 20 surface water discharge permits were necessary to meet surface water standards for radionuclides (i.e. gross alpha particles, and combined radium (226 & 228)) as well as for other parameters (Table 4). Additionally, there could be several mixing zones for an individual facility to account for multiple parameters or there could be an individual mixing zone for several parameters. Currently, there are four mixing zones granted within SJRWMD (Hastings WTP, IRCUD/South County RO Potable WTP, Palm Coast WTP, Vero Beach RO Potable WTP) out of the six surface water discharge permits.

As shown in Table 4, radionuclides, fluoride and specific conductance are key parameters to consider in a surface water discharge permitting process. These parameters may not meet surface water standards therefore should be evaluated as early as possible for compatibility with the water quality standards pertinent to the proposed receiving water body.

Table 4. Mixing Zone Parameters

Parameter	Number[1] (Florida)	Number[2] (SJRWMD)
Combined Radium (226 & 228)	11	2
Gross Alpha Particles	8	2
Fluoride	3	--
Specific Conductance	3	2
Iron	2	1
Toxicity	2	1
Dissolved Oxygen	1	--
Ammonia	1	1
Silver	1	1

1 – Out of 20 surface water discharge permits
2 – Out of 6 surface water discharge permits
Note that many facilities have mixing zones for more than one parameter

Historical Changes in Demineralization Concentrate Management Methods

The historic use of various demineralization concentrate management alternatives was evaluated for the state of Florida for the last three decades (Figure 2). As shown, surface water discharge was the method of choice in the 1970s. Issuance of subsurface injection permits has increased each decade: 3 were issued from 1972 to 1982, whereas twelve were issued from 1992 to 2002, ten are for deep well (Floridan aquifer) injection and two are for shallow well (surficial aquifer) injection. Issuance of permits for land application has increased each decade but at a smaller scale than deep well injection: only 4 permits were issued from 1992 to 2002, including one in SJRWMD (Spruce Creek Fly-In WTP).

This shift from surface water to subsurface injection may be due to the stringent water quality parameters and monitoring requirements associated with surface water discharge regulations.

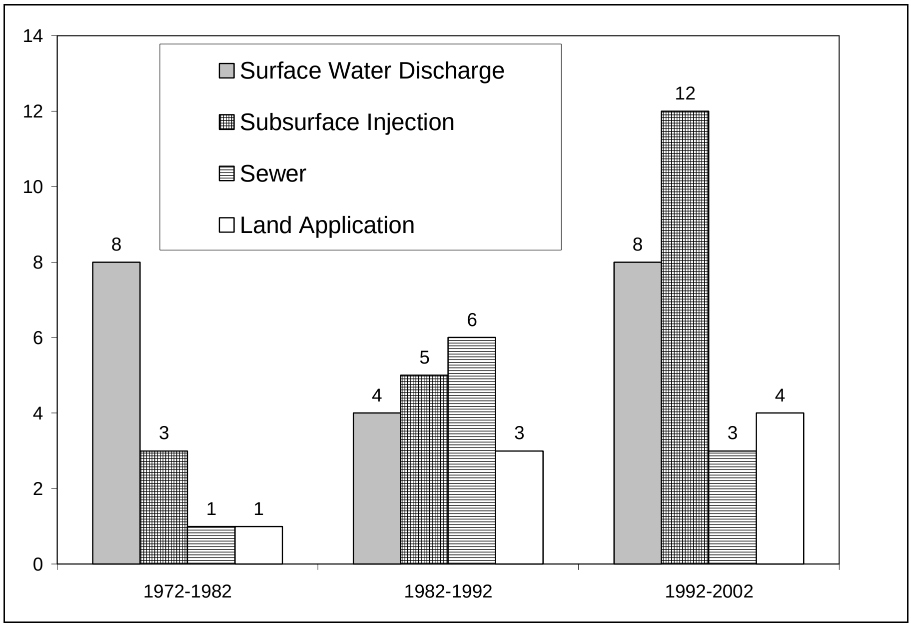

Figure 2. Historical Use of Demineralization Concentrate Disposal Methods

Regulatory Issues for Existing Projects

The increase in utilization of demineralization technology has been driven at least in part by the growing need for higher quality water from alternative water supplies (usually lower quality sources). The type of permitting and regulations that apply to these plants/projects depends on the demineralization concentrate management alterative employed. The UIC program generally covers deep well injection and protection of groundwaters. The NPDES permitting program applies to discharge of demineralization concentrate to all surface waters. Therefore, no matter which one of these permitting programs is applicable to an existing facility, compliance with demineralization concentrate permit requirements is a critical component of operational activities.

Regulatory issues involving existing projects have ranged from inner injection well tubing deterioration to toxicity requirements associated with surface water discharge, according to the recent demineralization plant survey conducted for this project.

To date, the tubing and packer type of Class I injection well has been most commonly used for concentrate injection. This type of deep injection well has several benefits, including, protection of the well casing from injection pressures, isolation of the casing from injection fluid and additional possibilities for monitoring (Mickley 1993).

However, some facilities have experienced deterioration and / or leaks associated with this tubing that have resulted in compliance issues. Currently, there is one facility that has obtained a variance for its deep well due to deterioration of the well's inner tubing.

In addition, retrofitting existing deep wells with tubing and packer systems to meet regulatory requirements can reduce the capacity of the well and will be costly because the system contributes significantly to the capital cost associated with a well. Other alternatives to the packer requirements may be allowed if the alternative method will reliably provide a comparable level of protection to the USDW. EPA has outlined additional performance test and evaluations (shown in Appendix C) that would be necessary to reliably provide this comparable level of protection to USDW and serve as an acceptable alternative to the packer requirement Another major regulatory concern associated with deep well injection is the requirement for containing the injection fluid by ensuring a confining zone is present. The possibilities of leakage through a confining layer or from the well are of concern due to the potential to impact an underground source of drinking water.

In the early 1970's most of the early demineralization plants discharged concentrate directly to brackish surface waters (Mickley 1993). However, as previously mentioned, deep well injection is now the most commonly used method of demineralization concentrate management. This change may be in part a result of the stringent water quality parameters and monitoring requirements associated with current surface water discharge regulations.

Twelve out of the twenty demineralization plants that discharge to surface waters have been granted mixing zones by FDEP. These mixing zones have been established for numerous parameters with the most common being combined radium and gross alpha particles. However, most regulatory compliance issues reported during the demineralization plant survey involved violations associated with mixing zones. There appears to be an intrinsic challenge related to compliance with mixing zone criteria. This supports the consideration of deep well injection for long term compliance. In addition, investigation of the causes associated with mixing zone violations may be worthwhile to determine if changes are necessary in technical, operational or regulatory areas.

A brief summary of utility experiences associated with regulatory issues has been provided in this section with supporting documentation presented in Appendix C. Regulatory issues are presented for three utilities. However, other utilities have also encountered regulatory issues.

Indian River County Utilities currently discharges concentrate into the Indian River Lagoon, at a location that has been designated as an Outstanding Florida Water (OFW). Based on this designation mixing zones are not allowed. The utility has experienced times when the concentrate discharge exceeded water quality standards and failed toxicity requirements, resulting in permit violations. This problem is compounded by the need to increase production thus discharging additional concentrate to meet water demands. As a result, the utility has agreed to cease discharging of concentrate to the Indian River Lagoon. The utility is pursuing the North Relief Canal as a surface water discharge alternative but is concerned over the canal's ability to provide sufficient dilution of concentrate to meet water quality standards (Weinberg 2002b).

The City of Melbourne has a similar problem with its discharge of demineralization concentrate to the Eau Gallie River. In the 1990's FDEP identified a significant number of compliance issues associated with the existing discharge to the Eau Gallie River. These violations/unsatisfactory conditions were primarily related to violation of water quality standards specified in the permit and resulted in issuance of a consent order to cease discharge to the Eau Gallie River. The consent order was issued in conjunction with the issuance of a draft permit for discharge to the Indian River Lagoon. However, public concern regarding water quality impacts to the Indian River Lagoon option resulted in denial of the City's request to discharge to the Lagoon and in development of a new approach, consisting of deep well injection using an existing well. The well was originally intended for discharge of wastewater effluent and was constructed in the 1980s. While construction of the well was approved, integrity issues with the well have prohibited it's use. Due to the integrity issues the city submitted a petition for a minor aquifer exemption (Reiss Environmental, 2002b). Notification was provided by FDEP in November 2002 that the minor aquifer exemption was denied (FDEP 2002b).

Palm Coast WTP also has a long history involving challenges associated with demineralization concentrate management. This facility is discharging to a man-made canal that is heavily influenced by rainfall. Low canal flow during periods of low rainfall has made it difficult to meet dilution requirements. The demineralization plant has had to reduce potable water production to ensure compliance with demineralization concentrate discharge permit requirements. Recently, FDEP Jacksonville District, has granted a mixing zone with an administrative order that requires the plant to monitor water quality in concentrate discharge and receiving waters. This new approach will give the plant two years to evaluate the receiving zone conditions using extensive monitoring and to establish the mixing zone.

In summary, existing regulatory issues include compliance with water quality criteria, toxicity standards, mixing zones, well integrity and suitable confining zones. The cases presented above provide examples of issues which some utilities have faced and are not intended to be inclusive. Surface water discharges appear more likely to have issues with permit requirements than deep well injection. There appears to be an intrinsic challenge associated with surface water discharge permits. This has resulted in a greater level of uncertainty associated with surface water discharges. Given these surface water permit compliance issues, an historical evaluation possibly conducted by FDEP to determine if there are actions which could be taken to minimize the uncertainty associated with surface water discharges and support compliance with FDEP regulations could be a valuable exercise. There may be reasonable changes in technical, operational, or regulatory areas that are justified and are still consistent with the mission of FDEP and the needs of the drinking water community.

Regulatory Issues for Future Projects

The purpose of this section is to assess regulatory issues that are likely to be faced by future municipal demineralization projects. The viability of future demineralization plants will depend upon obtaining the necessary permits for the management of demineralization concentrate component and adhering to the permit requirements. Future demineralization management projects will likely be governed by the same regulations as existing projects; there are no proposed changes to regulations which would fundamentally change permitting requirements. Therefore, regulatory issues for future projects are expected to be similar to those currently being encountered.

The type of permitting and regulations that apply to future projects are related to the UIC program for subsurface injection and protection of groundwaters and to the NPDES program for discharge to surface waters. These permit requirements are not specific to demineralization concentrate and in many cases require policy decisions on the part of

FDEP. In particular the need for reasonable assurance by FDEP that a permit application is consistent with the requirements of Florida Administrative Code allow FDEP personnel to request significant amounts of information as part of the permit application review process. The costs to conduct the studies or to take other actions necessary to obtain this data are difficult to predict given the latitude available to FDEP in requesting information and the site specific nature of any given project. Therefore it is critical to understand the challenges faced by FDEP permitting personnel and to recognize the need to begin pre-application permitting efforts well in advance of any future demineralization water treatment plant project.

As the ocean, St. Johns River and brackish groundwater are developed as potential water supply sources within SJRWMD, the current regulations will likely apply as currently defined. Currently, there is a history of demineralization concentrate deep well permitting but not within the SJRWMD boundary, however there has been some success of permitting domestic waste injection wells in SJRWMD.

Additionally, there is a history of surface water discharge permitting in SJRWMD. However, surface water discharges have been difficult to permit in recent years and this difficulty is expected to continue unless regulations change to a significant degree in the future. Discharge to open ocean and coastal ocean is included in the same NPDES permitting requirements for surface water discharge but is less commonly used as a demineralization concentrate management option. While the requirements for open ocean discharges are less stringent than those for other surface water bodies, the distance required to reach the most seaward natural 90-foot isobath could be too costly to be practical.

In summary, existing regulations will likely apply to future demineralization projects resulting in some of the same issues (e.g. water quality criteria, toxicity, and mixing zones) currently experienced by existing projects. The lack of specific regulations for demineralization concentrate permitting is likely to continue to create an uncertain environment for future projects.

Regulatory Changes

The purpose of this section is to identify potential or perceived issues associated with the current regulations and to recommend actions to address the issues. As the need for alternative water supplies grows and drinking water quality requirements become more stringent, the current trend of developing demineralization plants will increase. This in turn will increase the amount of demineralization concentrate that needs to be managed within permissible regulatory limits.

Based on communication with municipalities, engineers, governmental agencies and other parties associated with demineralization facilities, demineralization concentrate regulatory issues restrict the consideration of demineralization technology for new facilities and could effect the operation of several existing facilities. These reported concerns must be balanced with the mission of FDEP to protect the natural resources of the state of Florida and require a clear elucidation of individual issues to determine merit. Nevertheless, the current regulations are such that municipalities appear to approach demineralization technology much more conservatively than traditional technologies that utilize fresh groundwater as a source. This is in conflict with the interests of SJRWMD and the state of Florida to increase use of alternative water supplies including brackish and saline sources.

A number of specific concerns have been compiled and are presented herein with recommended courses of action.

- At the present time, the Industrial Waste Disposal Application form is used by FDEP for permitting of demineralization concentrate management alternatives. As a result demineralization concentrate is advertised as an industrial waste discharge rather than a potable water by-product. This type of classification can bring about an inappropriate stigma and negative public perception (EW Consultants and Reiss Environmental 2001). Therefore, there is a need to develop a new and unique application form that is more appropriately suited for demineralization concentrate. FDEP is in the process of rule development mandated by amendments to Section 403.0882, *FS*, which could result in a new application form. This new application form is expected to be inclusive of concentrate from all types of source water and should adequately address this issue.

- In addition to changing the FDEP Industrial Waste Application form, revisions to the Florida UIC Rule (62-528) should be considered to classify demineralization concentrate as a municipal domestic waste rather than industrial waste because it is a potable water by-product. Currently, the UIC rules define municipal injection well as an injection well used to inject fluids from a permitted WWTP. Therefore, consideration should be given to modify this definition of municipal injection well to include certain municipal wastes, such as demineralization concentrate, from WTPs as well. In addition, the rules state that Class I injection wells shall inject fluids through packer and tubing assembly, unless the injection fluid is non corrosive. Therefore, in conjunction with redefining the term municipal injection well, consideration should be given to reclassifying demineralization concentrate as non-corrosive. At a minimum, concentrate of certain acceptable qualities should be classified as non-corrosive. These types of revisions would allow new concentrate injection wells to be constructed to current municipal injection well standards. They would also allow municipalities with existing Class I injection well systems to discharge demineralization concentrate along with treated domestic wastes, without retrofitting existing injection wells with tubing and packer assemblies.

- Another concern with current regulations is the monitoring criteria established for demineralization concentrate discharge projects. A large number of chemical and bacteriological parameters currently required for analysis do not result from the demineralization process. More commonly, a relatively limited list of constituents is likely to occur in demineralization concentrate based on the type of source water, potentially reducing the need for a global list of parameters to be analyzed. Consequently, a standardized list of constituents could be developed by FDEP to allow for the flexibility of determining analytical requirements that are needed based on the proposed source water for each project. This approach would establish regulatory monitoring and compliance criteria that would be more appropriate for demineralization plants. FDEP has indicated that it will consider development of an internal guidance memorandum, which could resolve this concern.

- Demineralization concentrate monitoring and compliance parameters are not always consistent with analytical techniques employed by commercial laboratories. In addition, the regulatory limits for parameters are not always consistent with analytical quantification levels, especially for saline samples. Comparison of water quality parameters with currently available analytical instrumentation and techniques used by commercial, certified laboratories could contribute to resolving this issue. In addition, the concentrations required by water quality standards could be compared to currently achievable detection limits of commercial laboratories. This would ensure that water quality samples can be measured at the concentrations necessary for comparison with regulatory requirements. This review could include consideration of high salinity samples such as demineralization concentrate to ensure that interferences due to high salinity are recognized and quantified.

- The majority of the effluent modeling currently conducted for domestic or other industrial effluents is in the context of stream flow that is unidirectional, and the worst case low flow is the key criterion. In the case of tidal water bodies, tides often reverse flow direction completely and / or result in short term zero flow conditions. The methods for addressing these unique concerns will need to have as much to do with the time step over which worst case is determined as the specific modeling. A reported issue in initiating demineralization projects is uncertainty as to what type and degree of modeling will be necessary for evaluation of surface discharge proposals. Clarity would be gained if FDEP could commit to an applicant that a particular method(s) will be considered acceptable throughout the permitting process. In addition, a shopping list of mixing evaluation methodologies that are appropriate for both tidal and non-tidal receiving waters would provide clarity. Additional consideration should be given to effluent modeling by SJRWMD and FDEP.

- The open ocean classification outlined by the current regulations is another area that limits the use of this demineralization concentrate management alternative. Open ocean waters are defined as all surface waters extending seaward from the most seaward natural 90-foot isobath. This definition and its application to demineralization concentrate appear to be derived from state of Florida domestic wastewater facility regulations; it was not developed with demineralization concentrate in mind. It may be that the 90-foot isobath is not appropriate for demineralization concentrate discharge. A reasonable mixing zone for dilution purposes is potentially attainable at shallower depths along the coast. The science behind open ocean classifications could be investigated and, if necessary and appropriate, an open ocean classification specific to demineralization concentrate could be developed.

- Many of Florida’s coastal waters, including the Indian River Lagoon complex, have experienced substantial declines in salinity due to diversion of stormwater from expanded watersheds due to ditching and from increases in impervious areas associated with development. This outcome has resulted in a decline in seagrass beds due to the freshening of traditionally brackish to saline waters. As such, discharge of demineralization concentrate with a TDS higher than that now present in the waterbody may be a benefit to the natural system. Consideration could be given to using concentrate with its higher salinity, to mitigate the freshening of marine surface waters.

In addition to the issues identified above, studies and research could be conducted to address the following concerns:

- Re-evaluation of toxicity testing with regard to naturally occurring constituents
- Surface water studies to address ion imbalance and toxicity issues relative to suitable/extended mixing zones
- Studies on acute and chronic toxicity as well as radionuclides to better refine the affects from demineralization concentrate
- Studies on deep injection wells to determine actual extent of injection fluid and potential migration pathways within the subsurface

In summary, the current regulations which apply to demineralization concentrate management are considered by the municipal demineralization community to be unnecessarily burdensome in certain areas. Evaluation of these issues by regulatory agencies could determine if changes are possible while still protecting the environment and meeting all other regulatory requirements.

POTENTIAL SOURCE WATERS

Potential source waters consisting of brackish surface water, brackish groundwater and seawater were evaluated for the 19-county area. This included collection of data relative to the location, quantity, and quality of each source water. Based on this information, GIS-based coverages of high suitability source waters were developed.

Total dissolved solids concentration was utilized to identify brackish waters within SJRWMD. TDS data, in GIS format, were screened to eliminate all water with TDS less than 500 mg/L. A TDS concentration of less than 500 mg/L represents a fresh or potable water as defined by FDEP. The resulting set of information represented the brackish waters of interest.

Regarding quantity, the amount of potable water necessary to support SJRWMD water supply planning efforts was assessed. Based on previous SJRWMD documents, demand deficits per Work Group Area will vary from 0 to 350-MGD in the year 2020 (Vergara 2000a,c). For example Work Group Area I may have a deficit of 350-MGD in 2020 whereas Work Group Area IV is not projected to have a demand deficit. Local and regional water treatment plants will be needed to meet the significant deficits identified. Therefore, for the purposes of this planning document, four water treatment plant capacities were analyzed as follows: 5, 10, 25, and 50-MGD.

Based on these WTP capacities, the maximum possible source water flow was determined. For a WTP producing 50-MGD and treating a highly saline source water, WTP water recovery could be as low as 50%. Therefore, this plant would require a 100-MGD source water to produce 50-MGD of finished water. This 100-MGD value was utilized to screen source waters to determine their ability to provide this maximum flow.

The assessment of location, quantity and quality of each source water is described in the following sections.

POTENTIAL BRACKISH GROUNDWATER SOURCES

The Upper Floridan aquifer was assessed for its potential as a source of brackish groundwater for future demineralization facilities.

The quantity of brackish groundwater available for withdrawal is dependant upon the hydrogeology of the aquifer. However, given the site-specific nature and interdependency of groundwater withdrawals, a GIS-based, Districtwide coverage of the quantity of available brackish groundwater from the Upper Floridan aquifer does not exist. The ability to withdraw 100-MGD of groundwater, the maximum quantity of source water defined for this project, was not evaluated using GIS. However, sufficient groundwater modeling has been conducted by SJRWMD to confirm the availability of brackish groundwater on the order of 10 to 20-MGD or more within various areas of SJRWMD. These quantities are considered adequate to provide support for the alternative water supply planning effort. Therefore, all brackish water within the Upper Floridan aquifer was considered available for use, pending site-specific hydrogeological modeling.

It should be noted that SJRWMD has conducted assessments of the relative suitability of withdrawal for certain portions of SJRWMD. This work is presented in Figure 3 and is associated with Technical Memorandum D.1.b – *Brackish Groundwater: Source Identification and Assessment* prepared by CH2MHill for SJRWMD, November 1998. It would be of value to expand such an analysis to address all areas of SJRWMD where brackish groundwater is available in the Floridan aquifer and, if possible, to quantify the amount of available brackish water.

Information concerning TDS concentrations in the Upper Floridan aquifer was obtained from SJRWMD. The quality was split into four categories: 500 – 1,000 mg/L, 1000 – 3,000 mg/L and 3,000 – 10,000 mg/L (Figure 4). Based on this figure it should be noted that there are no zones in the Upper Floridan aquifer where TDS is higher than 10,000 mg/L. As described previously, areas with average TDS less than 500 mg/L are considered fresh water and were excluded from this analysis.

As shown in Figure 4, brackish water within the Upper Floridan aquifer is mainly located east of the St. Johns River and in most of the southern portion of SJRWMD. The most saline Upper Floridan groundwater in SJRWMD is primarily located in the Cape Canaveral area.

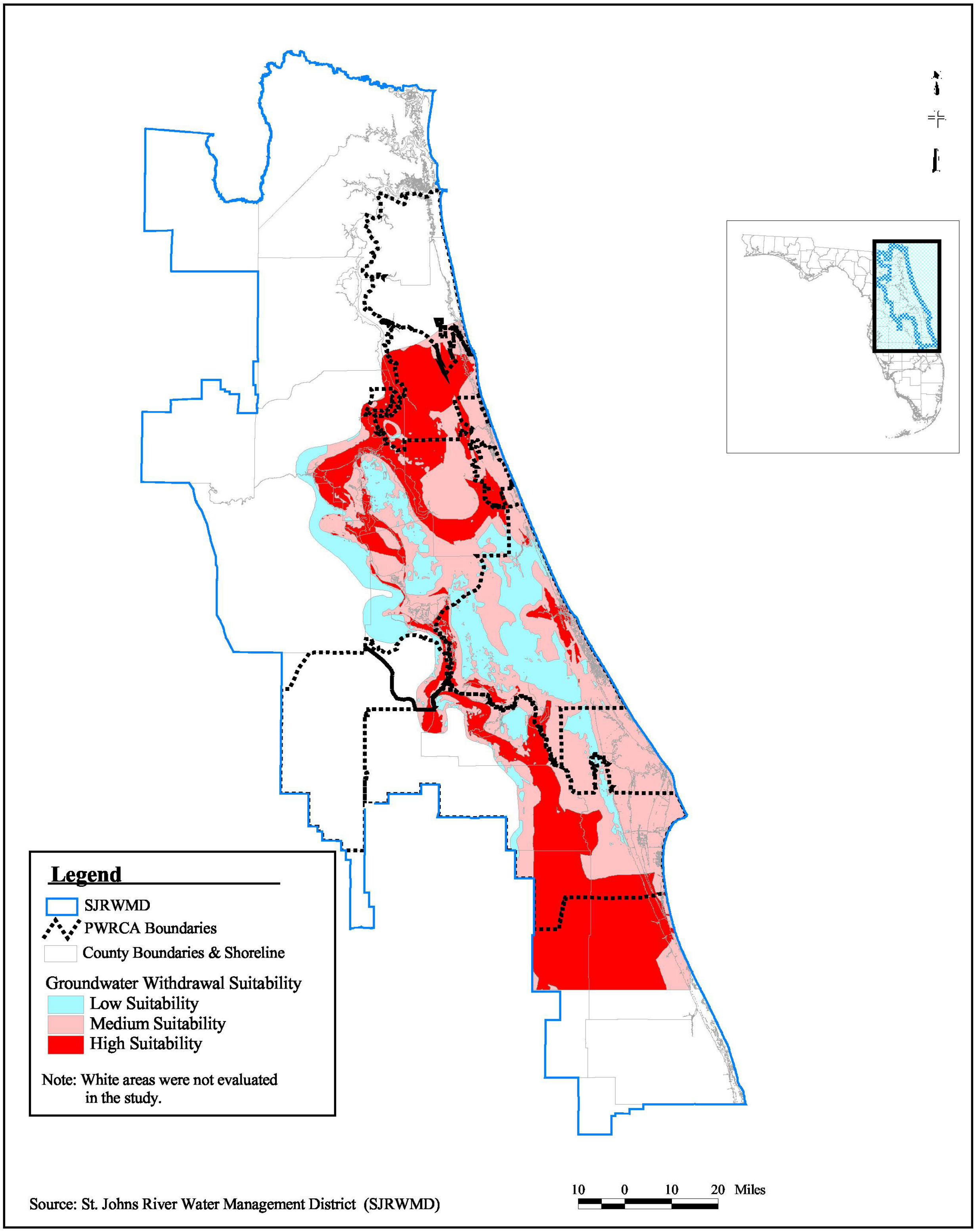

Figure 3. Relative Suitability of Upper Floridan Aquifer Groundwater Withdrawal

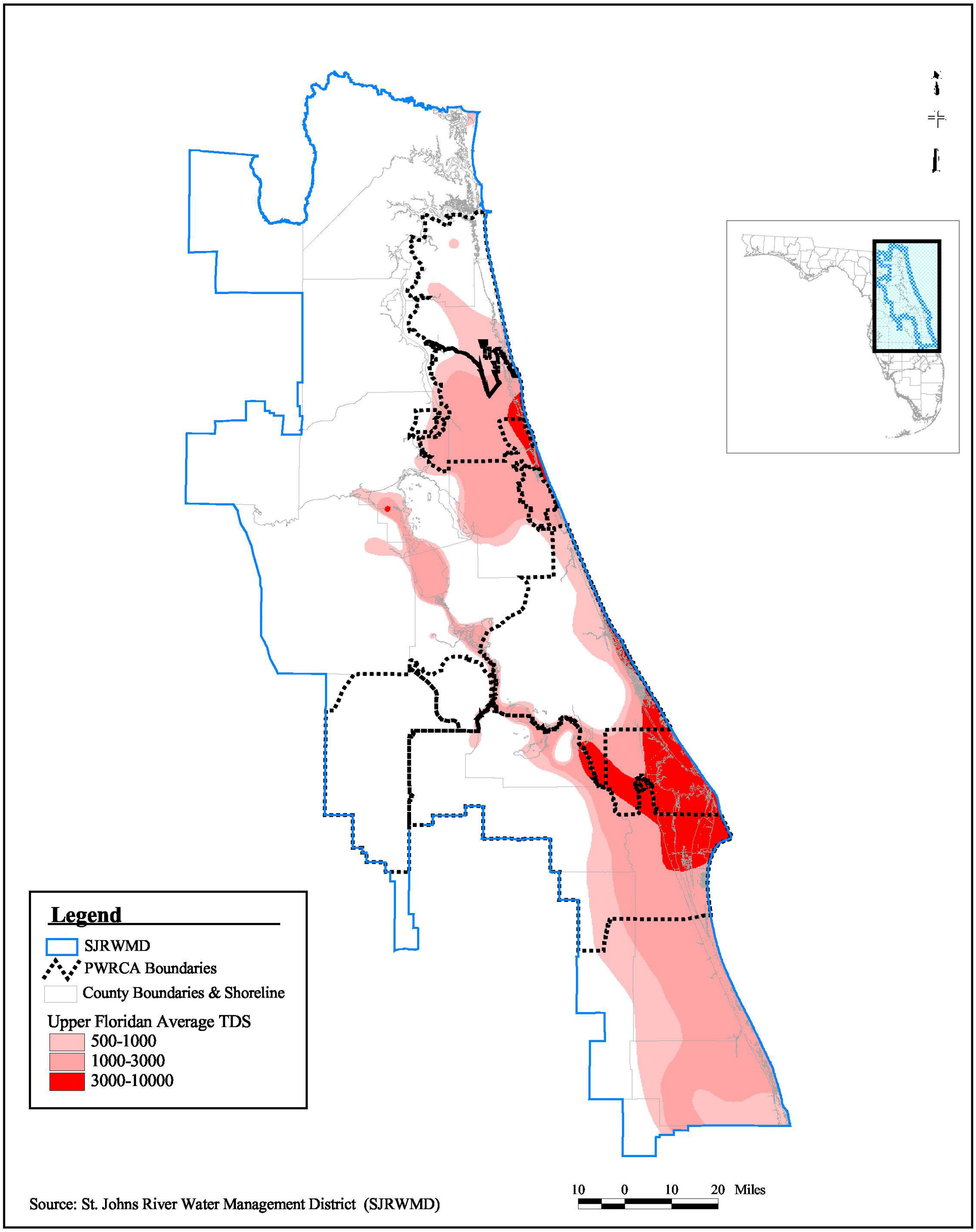

Figure 4. Upper Floridan Aquifer Groundwater Average TDS

The Floridan aquifer is the source water for all twelve demineralization plants in SJRWMD with capacities greater than 0.1-MGD. Ten of these demineralization plants withdraw groundwater having a TDS higher than 500 mg/L.

Out of the 56 desalination WTPs in Florida with capacities greater than 0.1-MGD, 53 facilities are treating groundwater. Of these, TDS data were available for 37 facilities. A total of 27 facilities are treating brackish groundwater with the remaining 10 facilities treating fresh groundwater.

POTENTIAL BRACKISH SURFACE WATER SOURCES

In addition to the potential brackish groundwater sources identified in the previous section, brackish surface water in SJRWMD is another potential source, which would require demineralization. Alternative locations include portions of the St. Johns River, the Intracoastal Waterway and streams, lakes and canals with a TDS concentration above 500 mg/L.

The location, quantity, and quality of brackish surface waters were evaluated. Based on the target WTP capacities of 5, 10, 25, and 50-MGD and the associated need for up to 100-MGD of source water, only the St. Johns River and the Intracoastal Waterway were deemed to have acceptable quantities of water available. The ability for the SJR to provide at least 100-MGD of reliable water supply was defined in previous work by SJRWMD (CH2MHill, 1997, Water Supply Needs and Sources Assessment, Alternative Water Supply Strategies Investigation, Surface Water Availability and Yield Analysis). The ability for the Intracoastal Waterway to provide adequate capacity is due largely to the tidal influence of the ocean on this water body. Other locations may have a flow sufficient to support a smaller facility. Given the focus of this project on demineralization WTPs with capacity ranging from 5 to 50-MGD, these two water bodies were considered appropriate.

It should be noted that there is a need to consider Minimum Flows and Levels (MFLs) for any surface water source that is to be used for public water supply. The MFL evaluation will determine how much water is available for water supply and how much must be reserved for environmental purposes. In addition, any surface water source utilized for public supply may require reclassification as a Class I (Potable Water Supply) by the Environmental Regulation Commission.

Water quality data were collected for the SJR and the Intracoastal Waterway from EPA, USGS and SJRWMD. The most useful water quality data were from the STORET database. Between 10 and 20 years of TDS data were available for nine stations on the St. Johns River and five stations on the Intracoastal Waterway. Additional data from EPA regarding the Intracoastal Waterway were merged to complement the STORET database. An average TDS concentration was calculated and developed in GIS format. The resulting average TDS values in the St. Johns River and the Intracoastal Waterways are outlined on Figure 5.

Out of the 56 desalination WTPs in Florida with capacities greater than 0.1-MGD, only one utilizes brackish surface water (Tampa Bay Desal). The 25-MGD desalination plant in the Tampa area utilizes water from the Middle Hillsborough Bay. This supply has an average TDS concentration of approximately 26,000 mg/L or about 8,000 mg/L less than seawater. TDS concentrate varies from 19,000 mg/L to 34,000 mg/L. Therefore, for a large portion of the year, the facility will treat brackish surface water but has been designed to treat seawater. There is limited experience in treating brackish surface water using demineralization technology in the state of Florida.

POTENTIAL OF SEAWATER

The most available and volumetrically reliable source requiring demineralization is seawater. The seawater demineralization option is available to all water supply utilities, as limited by transmission piping costs. It is expected that coastal waters could become an important supply source in the future within SJRWMD.

The location and quality of the Atlantic Ocean is known, therefore no specific data were collected. TDS of the Atlantic Ocean was obtained from NOAA and is 34,000 mg/L.

SJRWMD has approximately 150 miles of shoreline, all of which potentially could serve as a source for demineralization purposes (Figure 5).

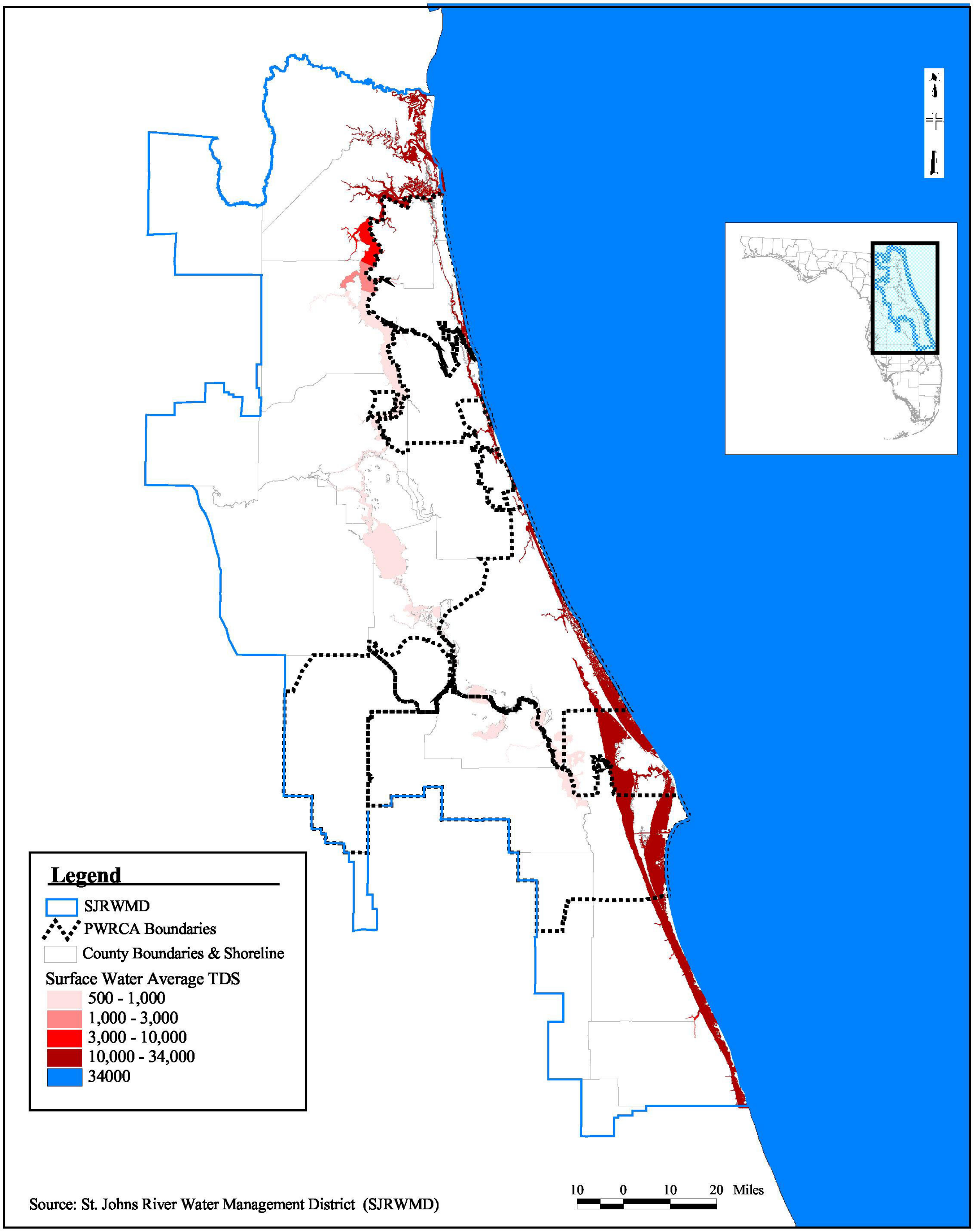

Figure 5. Surface Water and Ocean Average TDS

Of the 56 demineralization WTPs in the state of Florida with capacities greater than 0.1-MGD, three facilities are using ocean water however none are located in SJRWMD. These WTPs are the Tampa Bay Water RO WTP (seawater supply for a portion of the year), Marathon RO WTP, and the Kermit H. Lewin RO Facility (formerly the Stock Island RO WTP). The latter two WTP are owned by the Florida Keys Aqueduct Authority. The experience in treating seawater using large demineralization facilities is relatively new in the state of Florida. The first seawater desalination plant in the United States was built by Water Services of America in 1981, and was owned by the Florida Keys Aqueduct Authority (FKAA). This plant evaporated seawater, but ceased operations after the FKAA built a second pipeline to deliver fresh groundwater to the Florida Keys from the mainland.

Tampa Bay Water is currently investigating a second 25-MGD demineralization plant to be located in Pasco County. In addition, SJRWMD is conducting a seawater siting study *Seawater Demineralization Feasibility Investigation* which will shed more light on this alternative.

SUMMARY

As described in the previous sections, high suitability source waters have been identified for the purposes of this DCMP and include brackish surface water, brackish groundwater, and seawater. Table 5 summarizes the water sources, general geographic location and quantity available. These high suitability source waters were integrated with high suitability demineralization concentrate management alternatives and are presented later in this report.

Table 5. Water Source Summary

Source Water	General Location	Quantity available (MGD)
Brackish Groundwater		
Upper Floridan Aquifer	Areas east of the St. Johns River as well as southern portions of SJRWMD including Indian River and Brevard Counties	Unknown
Brackish Surface Water		
St. Johns River	Cocoa, Brevard County	108*
	Titusville, Brevard County	143*
	Sanford, Seminole County	279*
	DeLand, Volusia County	351*
	Jacksonville, St. Johns County	419*
Intracoastal Waterway	From Nassau County to Indian River County	Unlimited
Seawater		
East coast	From Nassau County to Indian River County	Unlimited

*These values represent the cumulative amount for each individual site and all upstream sites. For example, if a 100 MGD reliable water supply were developed near Titusville, then the maximum reliable yield at Deland (or another downstream site) would be reduced by 100-MGD. (CH2Mhill, 1997, Water Supply Needs and Sources Assessment, Alternative Water Supply Strategies Investigation, Surface Water Availability and Yield Analysis)

POTENTIAL CONCENTRATE MANAGEMENT ALTERNATIVES

Potential demineralization concentrate management alternatives were investigated relative to their applicability to SJRWMD. Management alternatives which are currently utilized or could be reasonably utilized within SJRWMD were evaluated in detail through a GIS-based suitability assessment. Emerging alternatives or less feasible alternatives were assessed qualitatively. The following demineralization concentrate management alternatives were evaluated using a GIS-based screening process:

- subsurface injection,
- surface water discharge,
- coastal ocean discharge,
- open ocean discharge, and
- marine wetland discharge.

Subsurface injection involves injecting demineralization concentrate below the ground surface into a porous rock formation, typically using a deep well.

Surface water discharge involves introduction of demineralization concentrate into a receiving water body, typically using a submerged outfall structure. Coastal ocean, open ocean, and marine wetlands are all subsets of surface waters and also typically involve use of outfall structures.

Additional demineralization concentrate management alternatives include reuse, blending with WWTP influent, land application, concentration and crystallization. These alternatives were less capable of accommodating demineralization concentrate from facilities of the size targeted for this project (5 to 50-MGD). However, these alternatives are discussed qualitatively herein. Additional information regarding various demineralization concentrate management alternatives can be found in Membrane Concentrate Disposal (Mickley, 1993) and other documents identified in the annotated bibliography of demineralization concentrate references developed for this project.

The five selected demineralization concentrate management alternatives were assessed to determine areas within SJRWMD of highest suitability. This GIS-based analysis was conducted independently for each of the five alternatives.

The suitability of a given alternative was evaluated using several criteria including the ability to accommodate a given quantity and quality of demineralization concentrate. Based on the four WTP capacities specified for this project and the range of source water quality available within SJRWMD, demineralization concentrate quality and quantity were defined to support evaluation of the management alternatives, as presented below.

DEMINERALIZATION CONCENTRATE CHARACTERISTICS

To determine relative suitability of demineralization concentrate management alternatives, potential ranges in quality and quantity of demineralization concentrate were estimated. TDS concentration was used as the primary water quality criterion.

The potential ranges in demineralization concentrate TDS concentrations and flow were determined based on the type of demineralization process used to treat the source water, the quality of the source water itself, and the production capacity of the WTP. The demineralization process is a function of the quality of the source water: low pressure reverse osmosis would be used for slightly brackish waters whereas reverse osmosis would be used for highly brackish water and seawater.

Concentrate Quantity

Concentrate quantity is determined based on the capacity of the demineralization WTP and the water recovery. Water recovery represents the ratio of finished water flow to raw water flow and varies with the TDS concentration of the source water. Water recovery typically ranges from 50% to 85%: 50% being used for seawater and 85% for slightly brackish water. Based on the WTP capacities selected for this project (5, 10, 25, and 50-MGD) and the ranges of recovery for various raw water quality, concentrate flows were determined (Table 6). For the purposes of this project, four demineralization concentrate flows were selected that bracket the determined range of flows. Specifically, demineralization concentrate flows of 2, 5, 15, and 30-MGD were selected as the flow criteria to be used in the suitability analysis of the demineralization concentrate management alternatives.

Table 6. Concentrate Flow

WTP Capacities	Source Water TDS	Recovery	Concentrate flow
MGD	mg/L	%	MGD
5	1,000	85	0.9
	3,000	75	1.7
	10,000	65	2.7
	34,000	55	4.1
10	1,000	85	1.8
	3,000	75	3.3
	10,000	65	5.4
	34,000	55	8.2
25	1,000	85	4.4
	3,000	75	8.3
	10,000	65	13.5
	34,000	55	20.5
50	1,000	85	8.8
	3,000	75	16.7
	10,000	65	26.9
	34,000	55	40.9

Concentrate Quality

Concentrate quality is determined based on the source water quality and the design of the demineralization process. The ranges of TDS concentration in the source waters evaluated are 500-1,000, 1,000-3,000, 3,000-10,000 and 10,000-34,000 mg/L. Using appropriate water recovery and salt rejection values (design characteristics of the process), demineralization concentrate TDS concentrations were estimated (Table 7). An appropriate salt passage percentage is a percentage that would result in a finished water TDS between 100 and 500 mg/L.

Table 7. Estimated Concentrate Quality

Source Water TDS	Concentrate TDS*
mg/L	mg/L
500 – 1,000	3,000 – 5,000
1,000 – 3,000	5,000 – 15,000
3,000 – 10,000	15,000 – 30,000
10,000 – 34,000	30,000 – 68,000

* The assumptions for concentrate concentration calculations are as follows:
For source TDS up to 1,000 mg/L, the salt rejection is 75%, and the recovery varies from 75% to 85%
For source TDS from 1,000 up to 3,000 mg/L, the salt rejection is 95%, and the recovery varies from 65% to 75%
For source TDS from 3,000 up to 10,000 mg/L, the salt rejection is 99%, and the recovery varies from 50% to 65%
For source TDS from 10,000 up to 34,000 mg/L, the salt rejection is 99%, and the recovery varies from 40% to 50%

The concentrate concentration is calculated using the equation: $Cc = Cf \times (1 – R \times SP) / (1 – R)$
Where: Cc = concentrate concentration (mg/L)
Cf = feed concentration (mg/L)
R = recovery = ratio permeate/feed flows (expressed as a decimal)
SP = salt passage = 1 – salt rejection (expressed as a decimal)

For the purposes of this project, four demineralization concentrate TDS concentrations were selected to represent the range of water quality presented in Table 7 and to serve as a threshold for assessing suitable demineralization concentrate management alternatives. Specifically, demineralization concentrate TDS concentrations of 5,000, 15,000, 30,000, and 68,000 mg/L were selected as the water quality criteria to be used in the suitability analysis of the demineralization concentrate management alternatives.

The following sections describe the various demineralization concentrate management alternatives and their high suitability areas in SJRWMD.

SUBSURFACE INJECTION

Areas of highest suitability for subsurface injection in the Upper and Lower Floridan aquifers in SJRWMD were determined for four different demineralization concentrate flow rates: 2, 5, 15 and 30-MGD as explained in previous section. Regulatory and technical criteria were considered to evaluate highest suitability areas.

The regulatory requirements vary based on the type of injection well to be permitted. Demineralization concentrate injection wells have been permitted as two types in Florida, Class I and Class V, Group 4. Twenty-one demineralization concentrate injection wells have been or are in the process of being permitted as Class I injection wells, while only two demineralization concentrate injection wells have been permitted as Class V, Group 4 injection wells. The Class V, Group 4 wells are generally in coastal areas where the surficial aquifer is brackish and potential upward migration of the demineralization concentrate would not pose a problem to drinking water supplies.

For the purpose of this regional evaluation, it was assumed that the demineralization concentrate injection wells will be Class I injection wells. Class I standards generally apply except where local geologic and water quality conditions allow for Class V standards, which would require a site-specific investigation.

Based on the four demineralization concentrate flows and use of a Class I well, areas within SJRWMD with highest suitability for subsurface injection were determined as presented below. Additional details regarding this assessment and the associated methodology are presented in Appendix D.

Regulatory Criteria

The regulatory requirements that relate to subsurface injection of concentrate place constraints on the water quality of the injection zone, on the confinement above the injection zone, on the required distance between the injection well and potable water supply wells, and on the distance to potential major Floridan aquifer faults and springs. These regulatory constraints were developed as criteria for determining areas of highest suitability, as described below.

<u>Water Quality</u>

Groundwater with a TDS concentration below 10,000 mg/L is considered by FDEP to be a part of the underground source of drinking water (USDW), and FDEP is responsible for protecting the USDW. Therefore, TDS concentration of the receiving formation must equal or exceed 10,000 mg/L for a Class I injection well. Injected fluids must also not migrate into the USDW. Areas where the top of the Upper or Lower Floridan aquifers are below the base of the USDW were identified as having acceptable water quality for injection. Note that demineralization concentrate of all TDS concentration ranges, from 5,000 mg/L to 68,000 mg/L, are considered suitable given that this is not typically a restriction associated with subsurface injection permitting.
Figure 6 shows areas with TDS concentration higher than 10,000 mg/L in the Lower Floridan aquifers. Potential areas in the Lower Floridan

aquifer include areas east of the St. Johns River from Flagler County to Indian River County. However, there are no areas in the Upper Floridan aquifer that have a TDS higher than 10,000 mg/L. Given the absence of water with a TDS concentration greater than 10,000 mg/L in the Upper Floridan aquifer, this aquifer was not considered to be of highest suitability for the purposes of this project. No further analysis was performed for the Upper Floridan aquifer, though it is understood that site-specific investigations could find certain, limited areas to be viable for subsurface injection.

The remaining regulatory criteria, confinement and feature setbacks, were developed relative to the Lower Floridan aquifer and analyzed within the areas with a TDS concentration greater than 10,000 mg/L.

<u>Confinement</u>

Class I injection wells must have at least one confining zone above the injection zone. This confining zone must be of sufficient areal extent, thickness, lithologic and hydraulic characteristics to prevent fluid migration into underground sources of drinking water. No minimum quantitative guidelines are given for these parameters, and the evaluation of these characteristics is made by the FDEP based upon the reasonable assurance provided by the applicant. This reasonable assurance may be provided in the form of geophysical logging, flow logging, coring results, or video logging. Confinement was assessed by evaluating leakance and thickness of the middle confining unit for the Lower Florida aquifer. As a measure of confinement, the travel time through this confining unit was considered (the equation used to determine the travel time is presented in Appendix D).

In addition to travel time, empirical criteria was used to demonstrate appropriate confinement within the Lower Floridan aquifer based on the presence of permitted Class I injection wells. In fact, there are 10 Class I domestic waste injection wells in SJRWMD. A permitted well would have previously presented data that shows the well would meet the necessary regulatory criteria for confinement. Though the regulatory criteria for permitting domestic waste and demineralized concentrate injection wells are slightly different, the presence of either type of injection well was used to indicate that adequate confinement exists within the Lower Floridan aquifer.

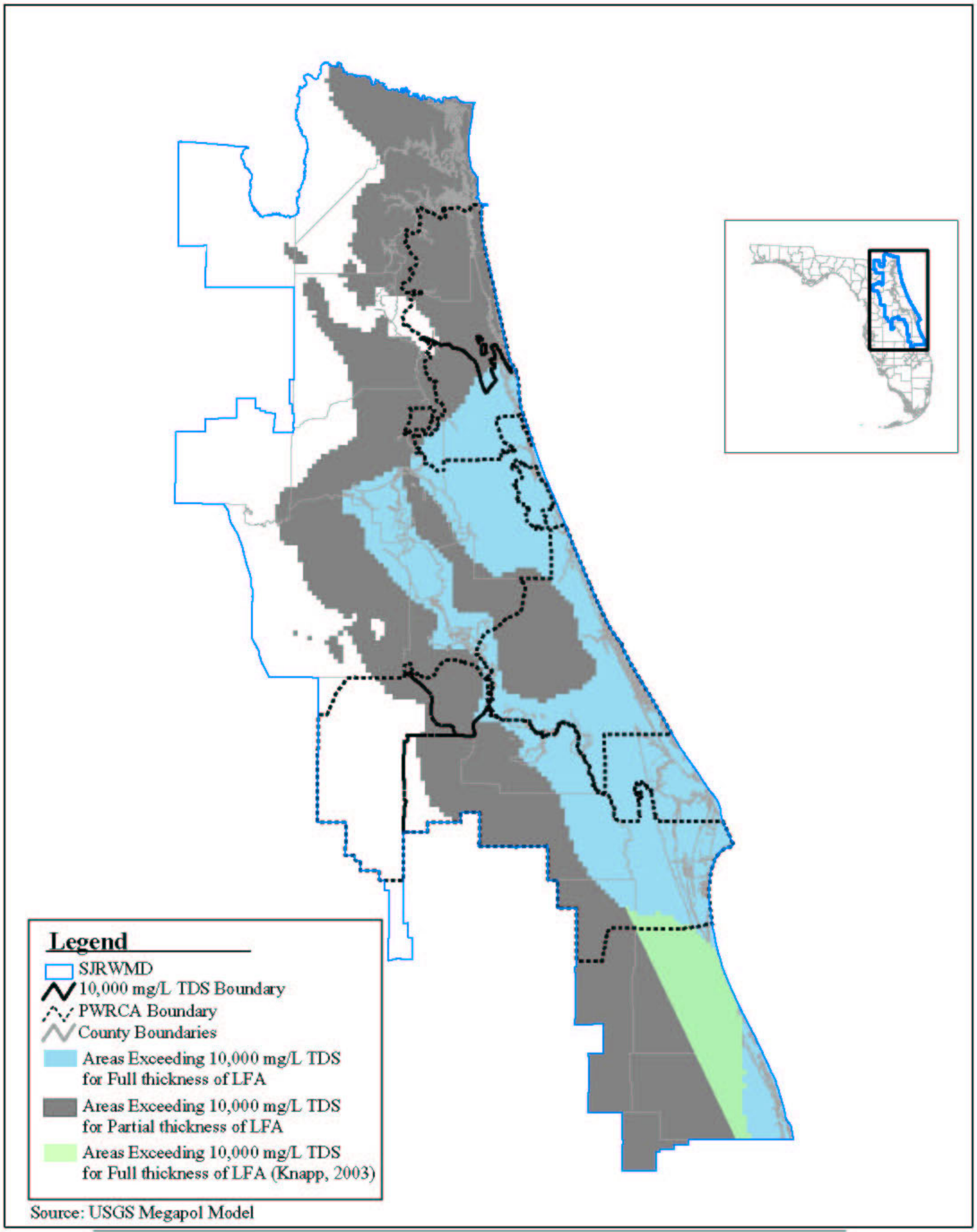

Figure 6. Areas Exceeding 10,000 mg/L TDS in Lower Floridan Aquifer, Revised

The travel time through the confining unit was used to determine if there was sufficient thickness and/or a low enough leakance to provide sufficient confinement for concentrate injection (Figure 7). Though the existing UIC rules require no migration of the injected fluid, existing permitting experience has indicated that this criterion is somewhat subjective. The time calculated for travel of injected concentrate through the middle semi-confining unit ranged from approximately 0 to 100 years. Based on the FDEP rules which call for no migration of the injected fluid, it was determined that the middle semi-confining unit is not likely to be an acceptable confining unit for concentrate injection within SJRWMD. However, the travel time calculations do not account for the potential existence of low permeability confining units within the Lower Floridan aquifer.

Furthermore, other confining units within the Lower Floridan aquifer have been identified in previous studies (Duncan et al., 1994). Several injection wells have previously been permitted in Indian River and Brevard counties utilizing these other confining units to prevent fluid migration (also shown on Figure 7). Even though these areas do not meet the middle semi-confining unit confinement criteria, sufficient confinement within the Lower Floridan aquifer to prevent upward migration has been empirically demonstrated. Since these confining units within the Lower Floridan aquifer have been identified in permitted injection wells south of Merritt Island, the areas south of Merritt Island were considered the area of potential highest suitability for concentrate injection.

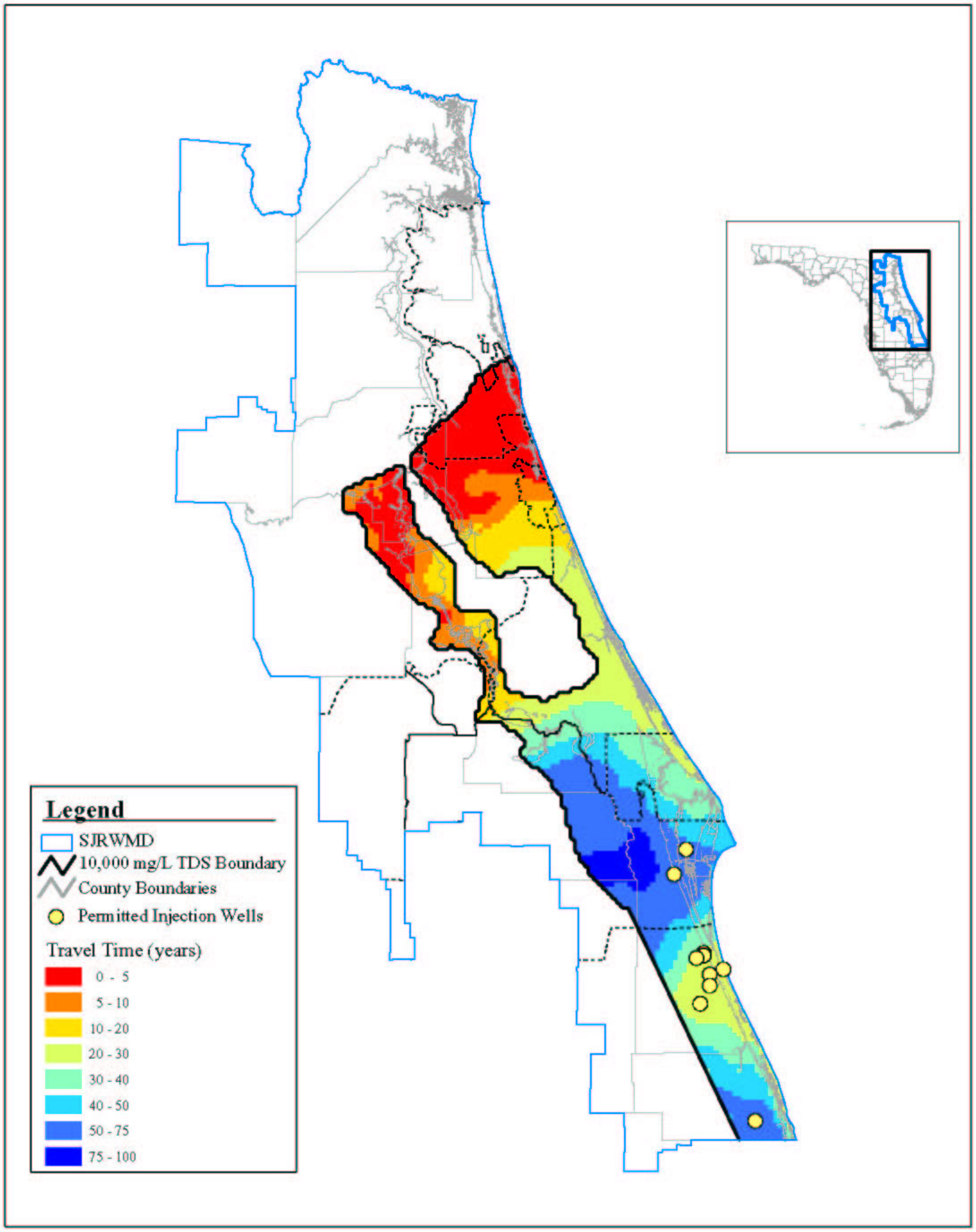

Figure 7. Calculated Travel Time through the Middle Semi-Confining Unit

Feature setbacks

Injection wells must be located in geologically stable areas that are free of transmissive fractures or faults through which injected fluids could travel to drinking water sources. Water supply wells and other artificial pathways can provide a connection between the injection zone and drinking water sources.

Therefore, setback distances were determined for potable water supply wells, faults, and springs. The minimum FDEP regulatory required setback from a potable water supply well is 500 ft. Injection wells located within one mile of a potable water supply well require additional review by FDEP. Suitable areas identified in this study will be at least one mile away from public supply wells so that they would lie outside of the FDEP-required area of review.

No rules require an injection well to maintain a specific minimum separation from a spring or fault. However, locating a well too closely to either a spring or fault may cause migration of injected water into a USDW. Springs are aquifer discharge features that may draw injected water towards them. Faults also can be discharging features where overlying confinement may be breached. For the purpose of this study, a radial travel distance of one mile was used to identify acceptable injection well locations.

Figures 8, 9 and 10 present the locations of wells, springs and faults within the Lower Floridan aquifer areas with a TDS concentration greater than 10,000 mg/L and a setbacks of one-mile. It should be noted that the faults are located along the St. Johns River and the coastal area in the southeast portion of SJRWMD.

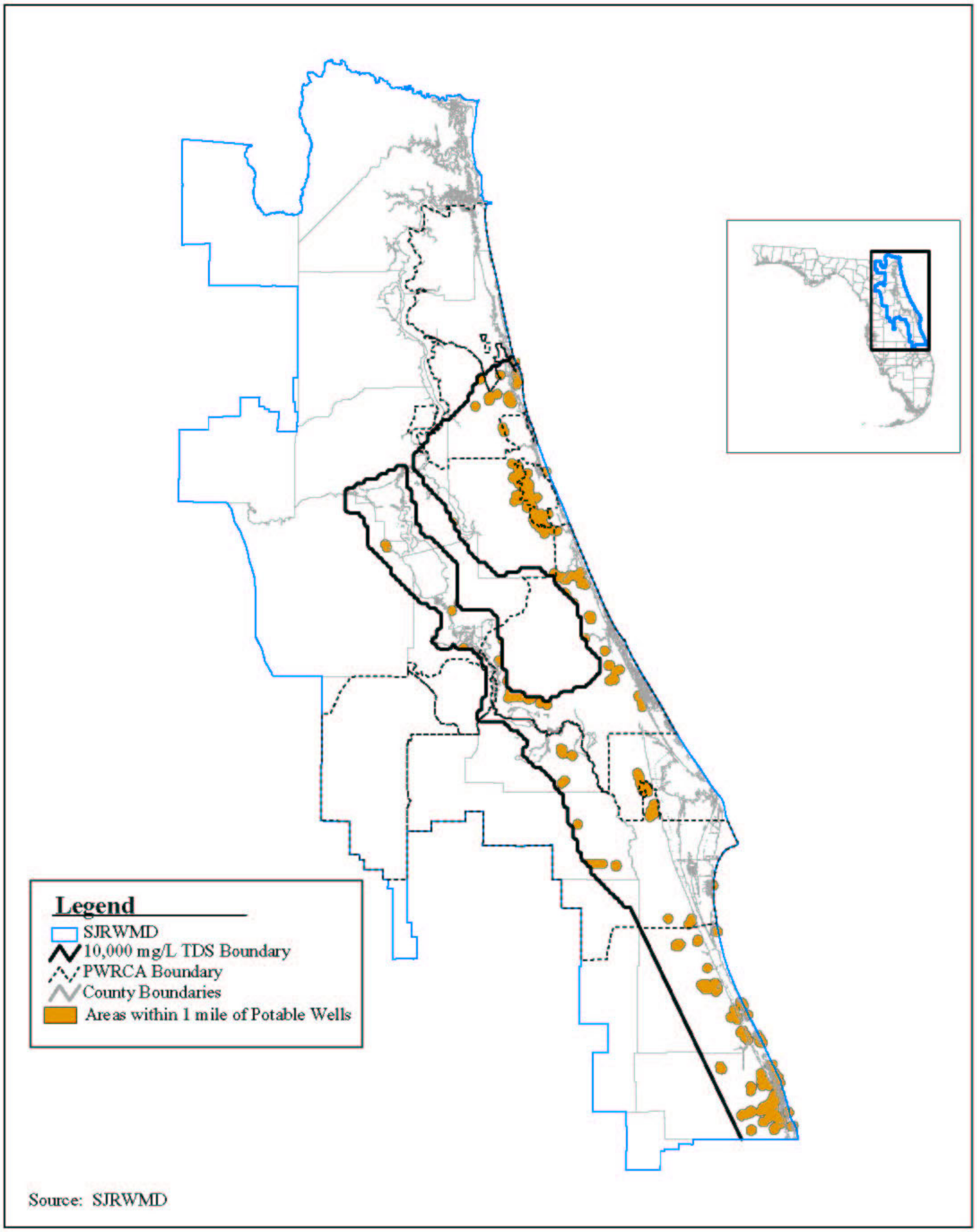

Figure 8. Setback Areas for Public Supply Wells

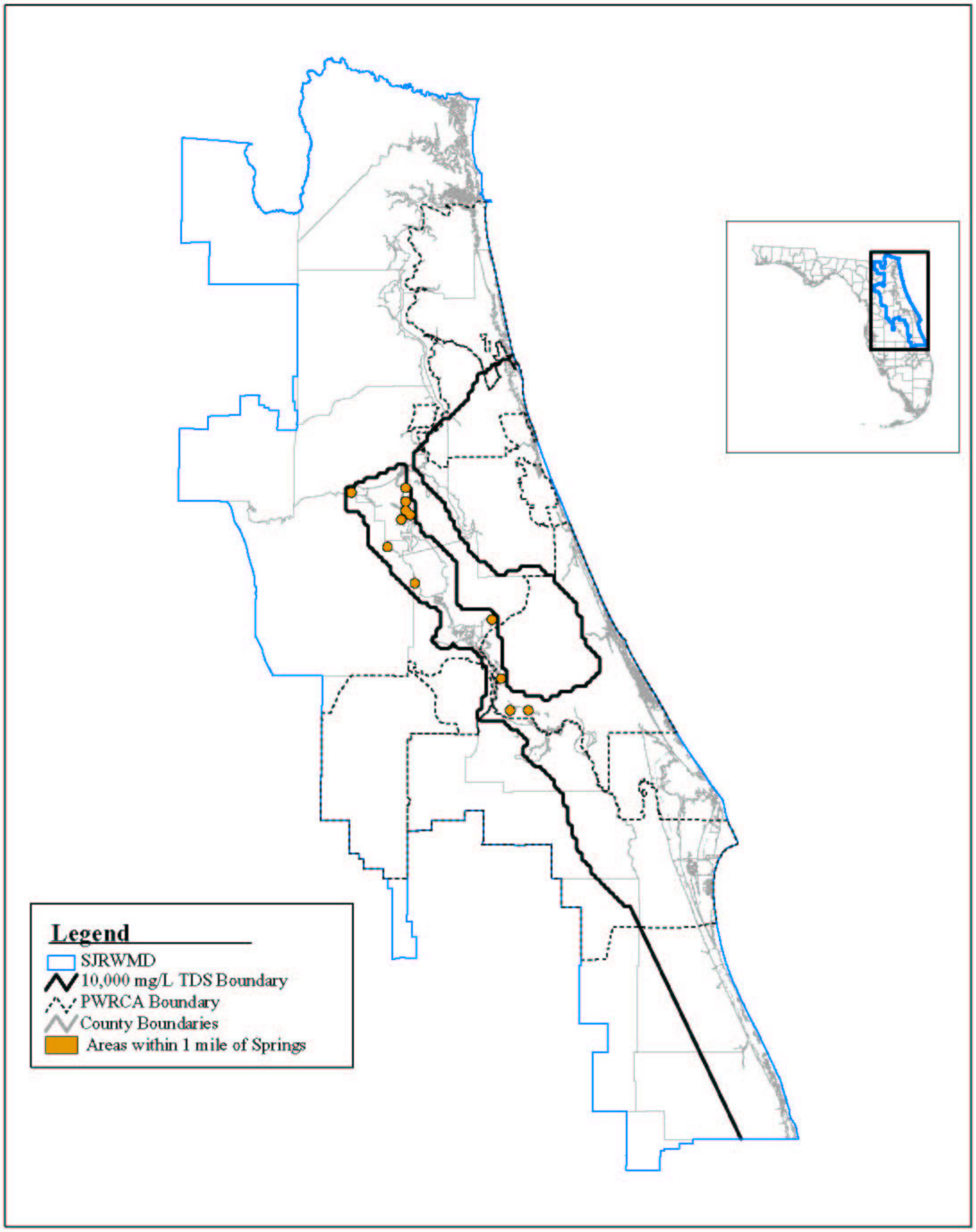

Figure 9. Setback Areas for Springs

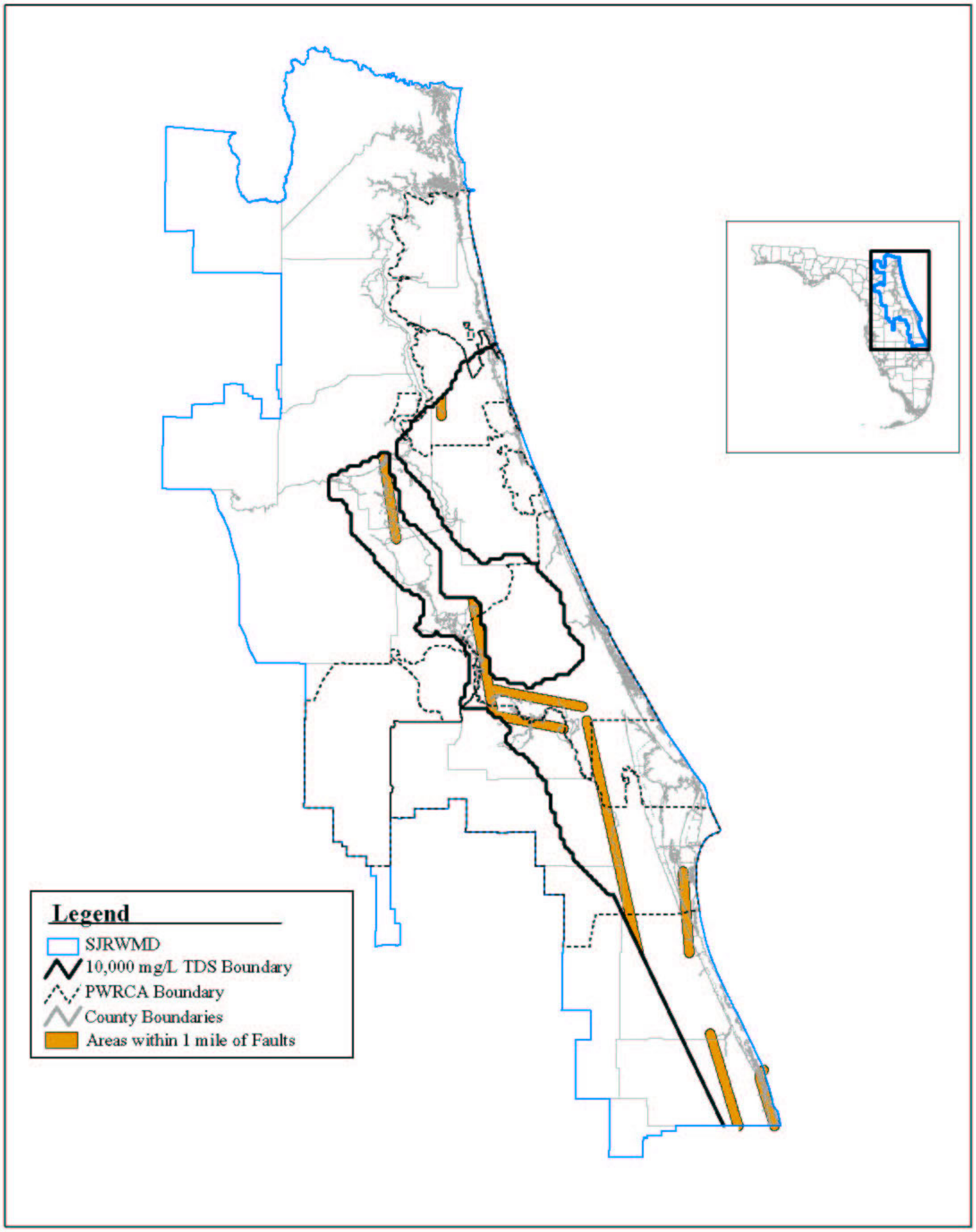

Figure 10. Setback Areas for Faults

Technical Criteria

Transmissivity and Injection pressure

Injection into a confined aquifer such as the Lower Floridan aquifer system causes an increase of the aquifer's potentiometric surface (mounding). Additional information regarding this section and subsequent sections are presented in Appendix D. The transmissivity of the receiving formation is the primary parameter used to determine the magnitude and extent of mounding that will occur at the injection well. Lower transmissivity formations generally have slower lateral movement of water which causes a greater increase in the potentiometric surface. A minimum acceptable transmissivity was determined for the receiving aquifer at each design flowrate (Table 8). These values represented the lowest transmissivity at which mounding of the potentiometric surface stays below a maximum design injection pressure of 40 pounds per square inch (psi). The minimum transmissivity in the Lower Floridan aquifer is 95,000 ft2/day in the analyzed area, which meets the minimum transmissivity requirements at each injection rate. Therefore transmissivity is not considered a limiting factor for subsurface injection into the Lower Floridan aquifer for this screening-level assessment.

Table 8. Minimum Acceptable Transmissivity values

Injection Rate (MGD)	Minimum Transmissivity (ft^2/day)
2	4,750
5	12,500
15	25,000
30	42,500

Maximum well depth

Injection wells in Florida are regularly constructed to depths up to 3,500 feet below land surface (bls). In SJRWMD, the bottom of the Lower Floridan aquifer is approximately 3,200 feet bls in the extreme southern and northeastern parts of SJRWMD (Toth, 2003). Therefore, constructing a demineralization concentrate injection well within SJRWMD should not be limited by aquifer depth.

Suitability Areas

All criteria described previously were integrated using GIS to identify areas of highest suitability for demineralization concentrate injection in the Lower Floridan aquifer for four different injection rates. The algorithm used to select these areas is detailed in Appendix D and is summarized as follows:

- For each scenario, areas where TDS concentrations were greater than 10,000 mg/L were identified and all other analyses were confined to these areas.
- Lower Floridan aquifer transmissivities were compared to the calculated acceptable values. The transmissivities within the entire area with TDS concentrations greater than 10,000 mg/L were acceptable.
- The Lower Floridan aquifer middle semi-confining unit travel times were compared to the FDEP regulatory criteria. It was determined that the middle semi-confining unit did not meet the travel time criteria.
- The location of permitted injection wells was evaluated to determine areas where other confining units within the Lower Floridan aquifer had been identified. The area with permitted wells within Indian River and Brevard counties was considered the area of highest potential suitability.
- Areas within the setback distance from public-supply wells, springs and faults were excluded from the area of highest potential suitability to further define the highest suitability areas.

The sites meriting further consideration for demineralization concentrate injection into the Lower Floridan aquifer are shown in Figure 11 . These identified areas should be considered as areas where further site-specific investigations of the feasibility of concentrate injection should begin. Thus, for the purposes of regional-level planning, demineralization concentrate flow is not considered to have a significant impact in determining areas of highest suitability. Generally, the areas south of Merrit Island meet all of the criteria. These areas mainly lie within Indian River and Brevard counties.

While this analysis has identified areas within SJRWMD deemed to be highly suitable, the relative risk associated with a subsurface injection project should be understood. The FDEP permitting process is two-fold, with a construction permit issued followed by an operating permit. The operating permit is only issued following construction of the well and demonstration that the well meets FDEP requirements including the absence of fluid movement. Therefore, an operating permit for deep well injection of demineralization concentrate is assured only following expenditure of funds for both feasibility analysis and construction of the well. This cost can be on the order of $3M to $15M. By comparison, obtaining an operating permit for a surface water discharge involves feasibility analyses only. While this may require such activities as dispersion modeling, water quality sampling, and pilot testing, costs to conduct such analyses are expected to be on the order of $0.5M to $2M.

Therefore, the high capital cost for construction of a deep well should be considered given the potential risk of not obtaining an operating permit. The City of Melbourne constructed the D.B. Lee well but has not been able to use the well due to confinement issues. This risk and initial outlay of capital funds should be balanced with other concentrate management options that require less initial costs to determine permit feasibility.

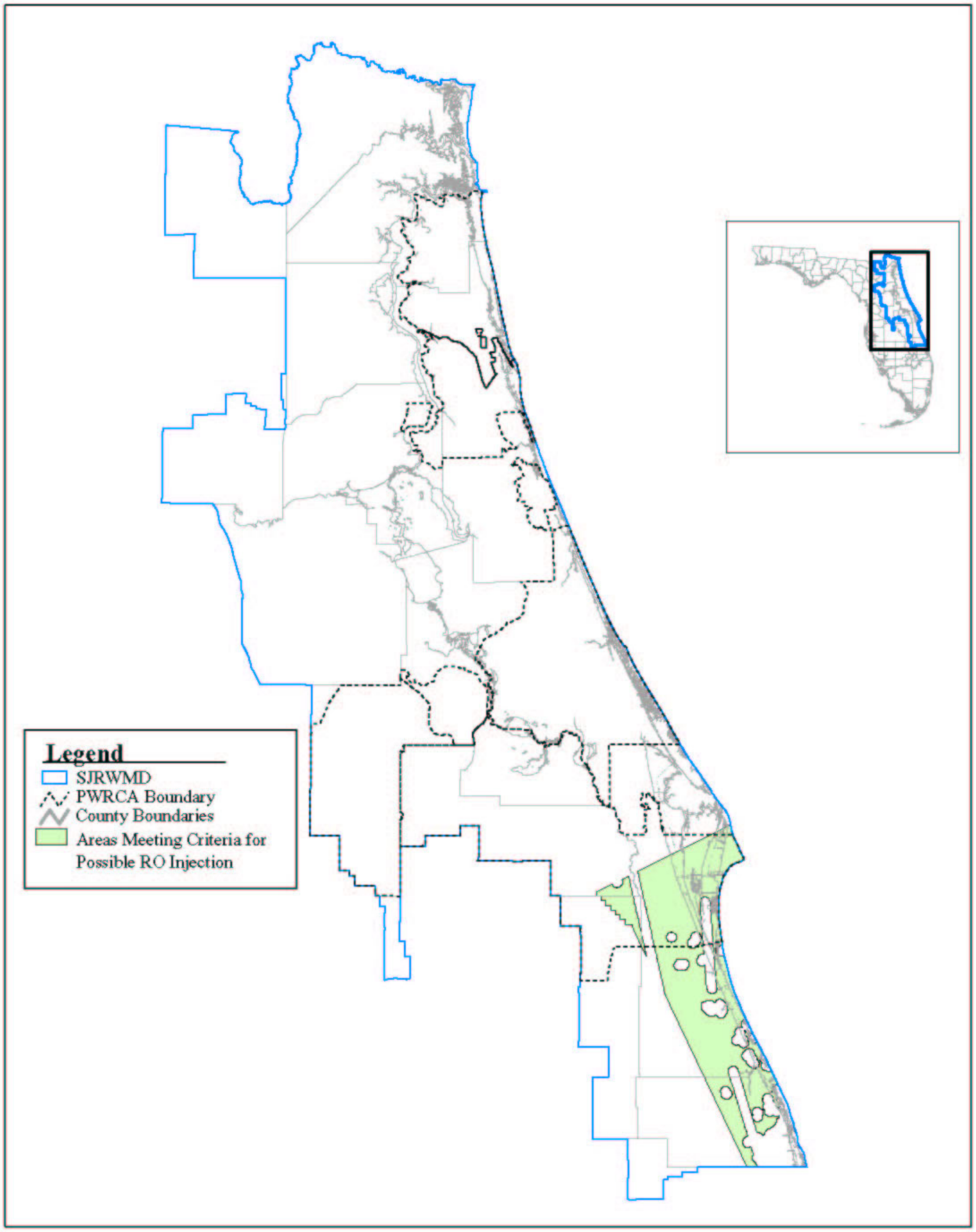

Figure 11. Highest Suitability Areas Meeting Regulatory and Technical Criteria for Potential Lower Floridan Aquifer Injection for all Flow Rates

SURFACE WATER DISCHARGE

The relative suitability of surface water discharge was evaluated through a quantitative assessment utilizing specific screening criteria. These criteria included the following:

- capacity of the water body,
- classification of the water body,
- TDS concentration,
- location of environmentally sensitive areas, and
- potential for blending with WWTP and power plant discharges.

Potential receiving water bodies include portions of the St. Johns River, the Intracoastal Waterway and streams, lakes and canals.

Surface Water Capacity

SJRWMD water supply planning has identified a need for up to 350-MGD of alternative water supplies. The water treatment plant capacities evaluated in this study ranges from 5 to 50-MGD, with resulting demineralization concentrate flows on the order of 2 to 30-MGD. Surface water bodies that have sufficient stream flow or tidal influence to accommodate these demineralization concentrate flows are the St. Johns River and the Intracoastal Waterway. St. Johns River has positive flow in the reaches of the river considered herein. The Intracoastal Waterway is tidally influenced and has positive dilution. For the purpose of this evaluation minimum flow considerations are considered met for these water bodies. Establishments of minimum flows and levels in the future may change the estimates of water availability from these surface water systems, but these changes will likely not be significant.

Other water bodies such as streams, lakes and canals may have a sufficient flow to support smaller facilities or may be deemed acceptable through a site-specific study. However, given the focus of this project on demineralization WTPs with capacity ranging from 5 to 50-MGD, only the SJR and the Intracoastal Waterway were considered to be appropriate.

Surface Water Classification

Discharge to surface waters is regulated based on the classification of the receiving water body. The definition for each classification of surface waters is provided in Chapter 62-302,*F.A.C.*, as follows:

Class I:	Potable Water Supplies
Class II:	Shellfish Propagation or Harvesting
Class III:	Recreation, Propagation and Maintenance of a Healthy, Well-Balanced Population of Fish and Wildlife
Class IV:	Agricultural Water Supplies
Class V:	Navigation, Utility and Industrial Use

In addition to the classifications above, a water body may be designated as an Outstanding Florida Water (OFW). An OFW is designated by the Environmental Regulation Commission as worthy of special protection because of its natural attributes.

Furthermore, impaired waters are waters in the state of Florida that do not currently meet the designated use for the classification. Total maximum daily loads (TMDL) will be established for the impaired waters and no additional loading will be permitted. Almost the entire Intracoastal Waterway and the St. Johns River are listed as impaired waters forwith regards to nutrients. However, nutrients were not considered a limiting factor in this study and further consideration should be given on a site-specific basis. Therefore, impaired waters were still considered suitable areas for demineralization concentrate discharge.

There are two categories under Class II and III: fresh water and marine surface waters. The water quality criteria for the different classes of water are described in Section 62-302.530, *F.A.C.*

Based on surface water discharge regulations and permitting history, only Class II and III surface waters are considered to be of highest suitability for this demineralization concentrate management assessment (Figure 12). In addition, due to greater regulatory restrictions, OFWs and state parks are not considered to be of highest suitability for concentrate discharge (Figure 13). Therefore, only Class II and III surface waters without OFWs and parks were determined to be the highest suitability water bodies for surface water discharge (Figure 14).

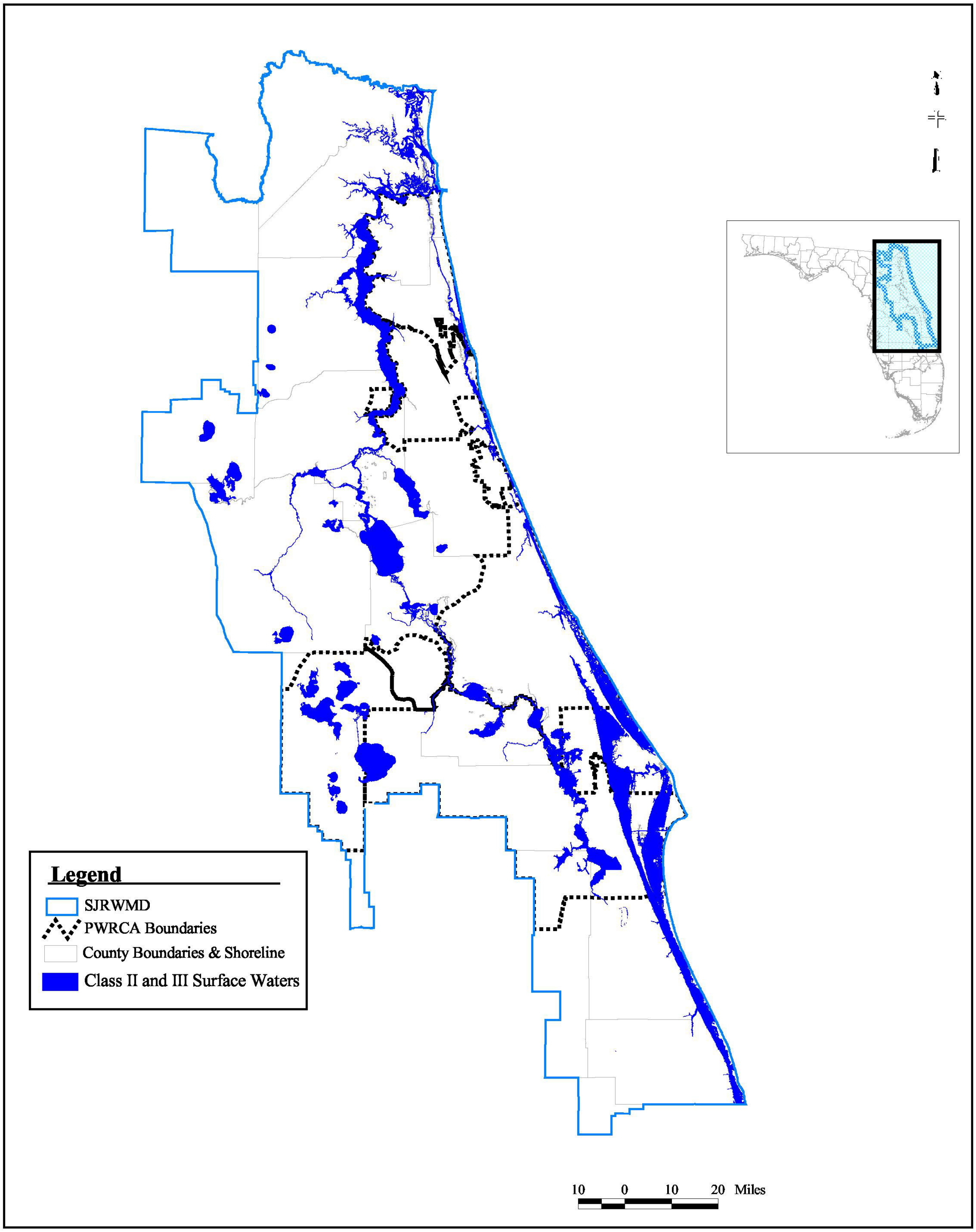

Figure 12. Class II and III Surface Waters

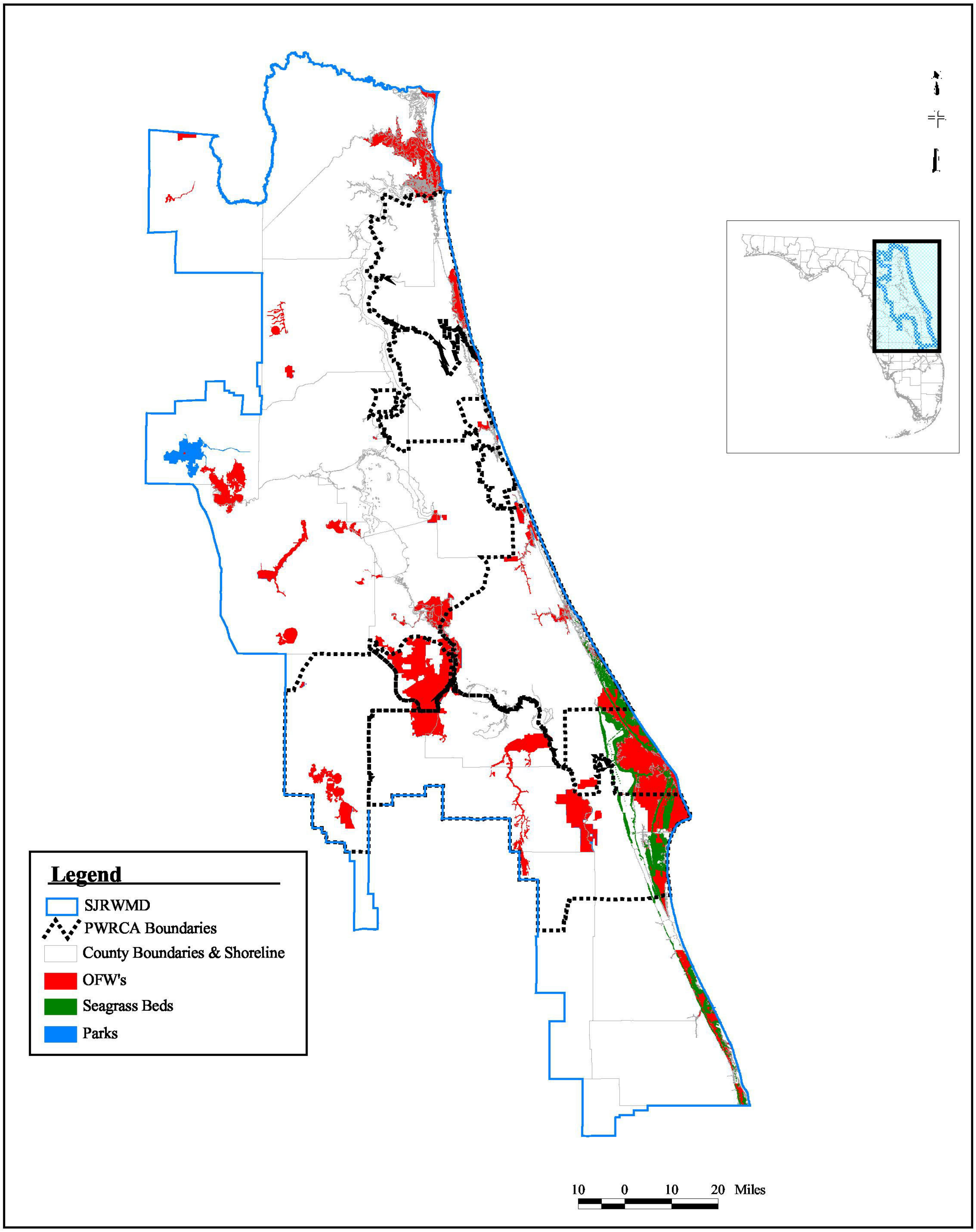

Figure 13. Seagrass, Parks and Outstanding Florida Waters (OFW)

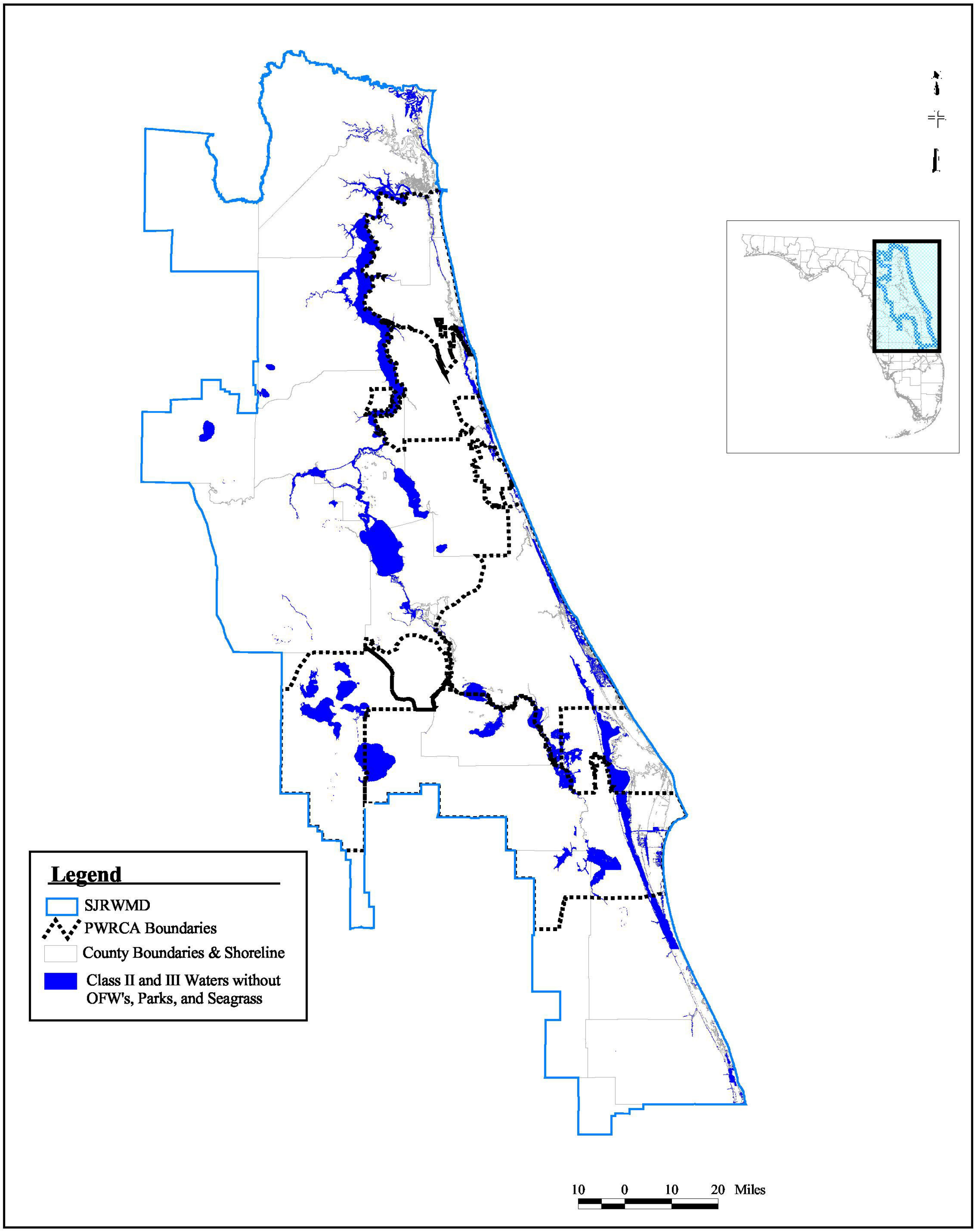

Figure 14. Class II and III Waters without OFW's, Parks, and Seagrass

Currently, FDEP is proposing to reclassify certain surface waters from Class III (recreation) to Class II (shellfish propagation or harvesting) based on shellfish harvesting areas designated by the Department of Agriculture and Consumer Services (FDEP, 2002c). This proposed reclassification could potentially change Class III surface waters in the Intracoastal Waterway to Class II waters for shellfish harvesting. However, this reclassification would not impact the results presented in this DCMP, since Class II waters are considered suitable areas for concentrate discharge based on the specific screening criteria presented herein as well as the regulatory guidelines in affect at the time this report was developed.

Environmentally Sensitive Areas

Seagrass is the environmentally sensitive criterion assessed for surface water discharge. Seagrass is mostly located on the coast in Cape Canaveral and south of the Cape (Figure 13). Surface waters with seagrass bed were considered not suitable for surface water discharge.

The St. Johns River and almost the entire Intracoastal Waterway are listed as impaired waters with regards to nutrients. While nutrient loading is not expected to increase in the demineralization concentrate, there potentially could be source waters with high nutrients levels that may result in high nutrient concentrations in the demineralization concentrate. Therefore, the specific screening criteria utilized herein was developed on a macro-level for the region and further consideration may need to be given to nutrient loading on a site-specific basis.

Surface Water Salinity

Salinity, as measured by TDS concentration, was considered the most pertinent water quality screening parameter for this macro-level analysis. If the TDS concentration of the demineralization concentrate is less than the average TDS concentration of the receiving water body, the permitting process would be facilitated compared to a situation where the demineralization concentrate TDS concentration is higher than the average TDS concentration of the receiving water body.

In addition, note that mixing zones or other procedures may still be required during high flow, low TDS conditions in a surface water body since demineralization concentrate TDS concentration could exceed the receiving water body TDS concentration at this point. However, comparing demineralization concentrate TDS concentration to average receiving water TDS concentration is an appropriate screening tool to support relative suitability assessments.

It should be noted that demineralization concentrate could be beneficial if discharged to depressed salinity areas such as portions of the Indian River Lagoon. However, current regulations orient discharge of concentrate to water bodies with higher TDS concentrations than are in the demineralization concentrate. Therefore the potential benefit of using concentrate to mitigate freshening of marine environments is generally not realized.

The TDS coverage for surface water presented in the Potential Source Waters section of the DCMP was used for this evaluation. The data represent average TDS collected by SJRWMD over 20 years, when available. As previously defined in the Demineralization Concentrate Characteristics section, concentrate TDS concentration ranges of 3,000 – 5,000 mg/L, 5,000 – 15,000 mg/L, 15,000 – 30,000 mg/L and 30,000 – 68,000 mg/L were estimated for the source waters present within SJRWMD. From these ranges, four conservative demineralization concentrate TDS concentrations of 5,000, 15,000, 30,000, and 68,000 mg/L were selected as the water quality criteria to be used in the suitability analysis.

The evaluation compared demineralization concentrate TDS concentrations to the average TDS concentration of the receiving water to determine highest suitability waters. For example, demineralization concentrate with a TDS concentration of 15,000 mg/L could be discharged in surface water having an average TDS concentration higher than 15,000 mg/L. Areas within the St. Johns River and Intracoastal Waterway with TDS corresponding to the demineralization concentrate TDS requirement of at least 5,000 mg/L are shown in Figure 15.

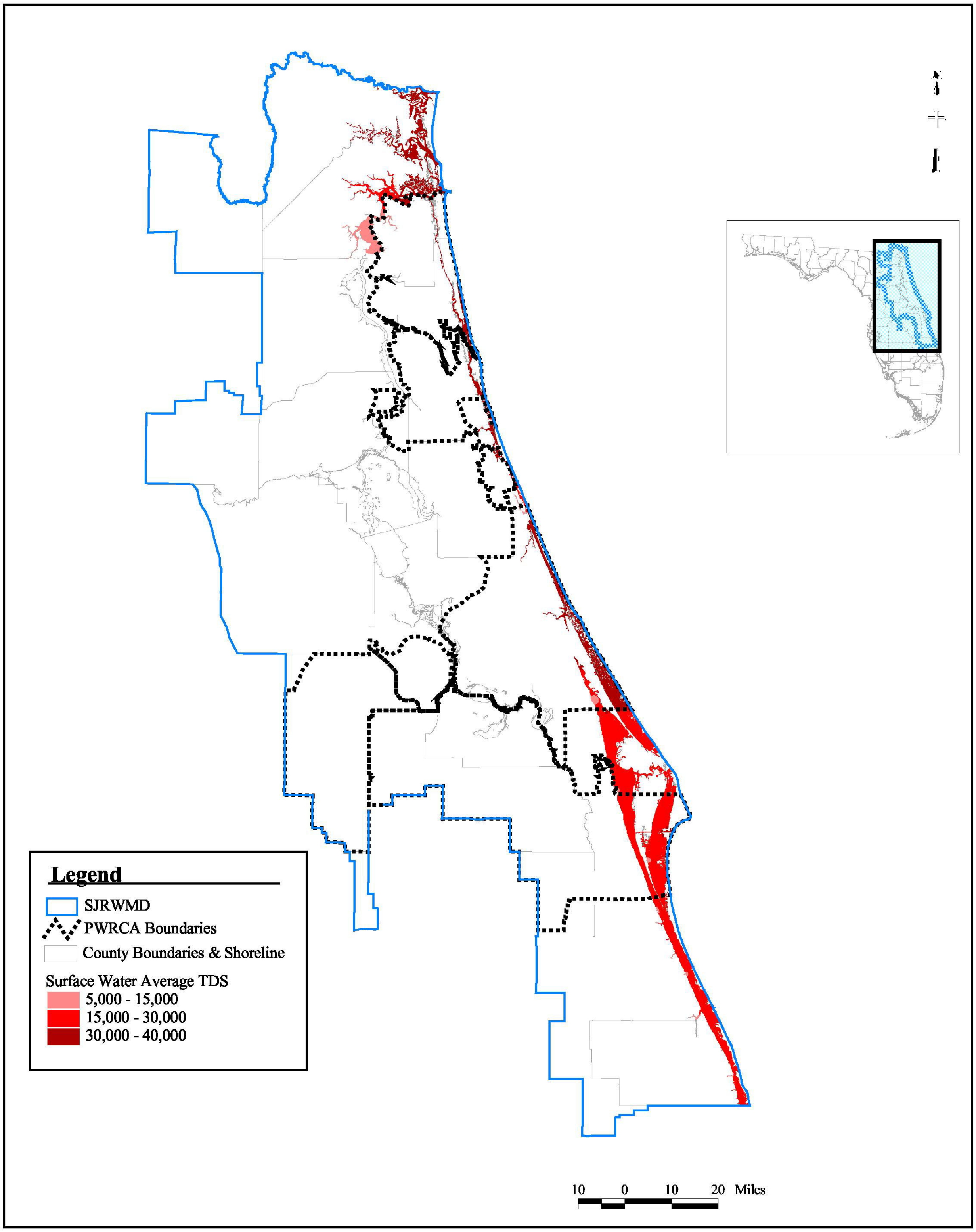

Figure 15. Highest Suitability Surface Water with Average TDS Greater than 5,000 mg/L

Fluoride

While TDS concentration was the water quality screening criterion used in this study, other parameters such as fluoride and radionuclides may limit the suitability of surface water discharge. For example, 11 of the 56 demineralization WTPs in Florida have a mixing zone for combined radium (226 and 228) and 3 for fluoride based on the state-wide survey conducted for this project. Therefore, some areas deemed high suitability based on the TDS criterion used herein could potentially have difficulty meeting standards for other constituents. Based on the review of mixing zones associated with existing demineralization concentrate permits (presented previously), radionuclides and fluoride are most commonly a concern. These parameters should be evaluated as early as possible in any site-specific feasibility assessment of demineralization concentrate management involving a surface water discharge to ensure the appropriate measures are taken to meet regulatory conditions. As an example, fluoride was investigated further in this subsection in an effort to provide some additional insight to the importance of evaluating fluoride as early as possible in any site-specific feasibility assessment. This analysis evaluates fluoride from a groundwater source using a surface water discharge for managing demineralization concentrate. However, this same methodology would apply when using surface water as a source.

Fluoride in groundwater in SJRWMD is derived primary from two sources (Maddox, 1992): 1) weathering of naturally occurring fluorapatite minerals and 2) mixing of recent and relic seawater with fresh groundwater.

Most of the fluoride in groundwater in SJRWMD is derived from the weathering of fluorapatite minerals in the Hawthorn Group sediments. In central SJRWMD, the thickness of the Hawthorn Group is generally less than 100 feet. Therefore, water recharging the Floridan aquifer in these areas has relatively short residence times as it moves downward through fluorapatite rich sediments overlying the Floridan aquifer. Fluoride concentrations in the Floridan aquifer water in these areas are, therefore, relatively low.

Higher fluoride concentrations are found in the coastal seawater transition zones and in Floridan aquifer discharge areas where fresh groundwater mixes with recent and relic seawater, which have relatively high fluoride concentrations.

As water in the Floridan aquifer moves along flow paths from recharge to discharge areas, longer residence times allow more opportunity for the chemical composition of the water to be altered and for chemical reactions between the water and aquifer materials to reach equilibrium. These groundwater fluoride concentrations in the Upper Floridan aquifer from wells in SJRWMD are presented in Figure 16 and a percent distribution is shown in Table 9. The fluoride concentration is less than 0.25 mg/L in more than half the samples taken from the wells.

Table 9. Groundwater Fluoride Concentration Distribution.

Concentration	Percentage*
mg/L	%
0 - 0.125	25
0.125 - 0.25	35
0.25 – 0.5	22
0.5 – 1	16
1 – 1.75	2
> 1.75	0

* Percentage based on number of wells with specified fluoride concentration

Once fluoride concentration in a source water is known, then a determination of the fluoride concentration in demineralization concentrate can be made based on the type of demineralization plant and associated plant recovery. As a result of this evaluation process, fluoride concentration in the demineralization concentrate could be as high as 11 mg/L if the fluoride concentration from the source water is approximately 1.75 mg/L using high rejection membranes with 85% recovery as shown in Table 10. This resulting fluoride concentrate concentration was then compared to fluoride surface water standards (62-302 *F.A.C.*) for various surface water classifications. Only Class II and III surface water are considered in this DCMP (as explained previously). The associated fluoride standards are 0.5, 5 and 10 mg/L for Class II, marine Class III, and fresh Class III surface waters, respectively. It should be noted that fluoride is one of very few parameters that has a higher standard (less restrictive) in fresh Class III surface water than in marine Class III surface water. In a situation where fluoride concentrations are higher than the surface water standard a mixing zone would have to be granted to meet the fluoride regulatory standards.

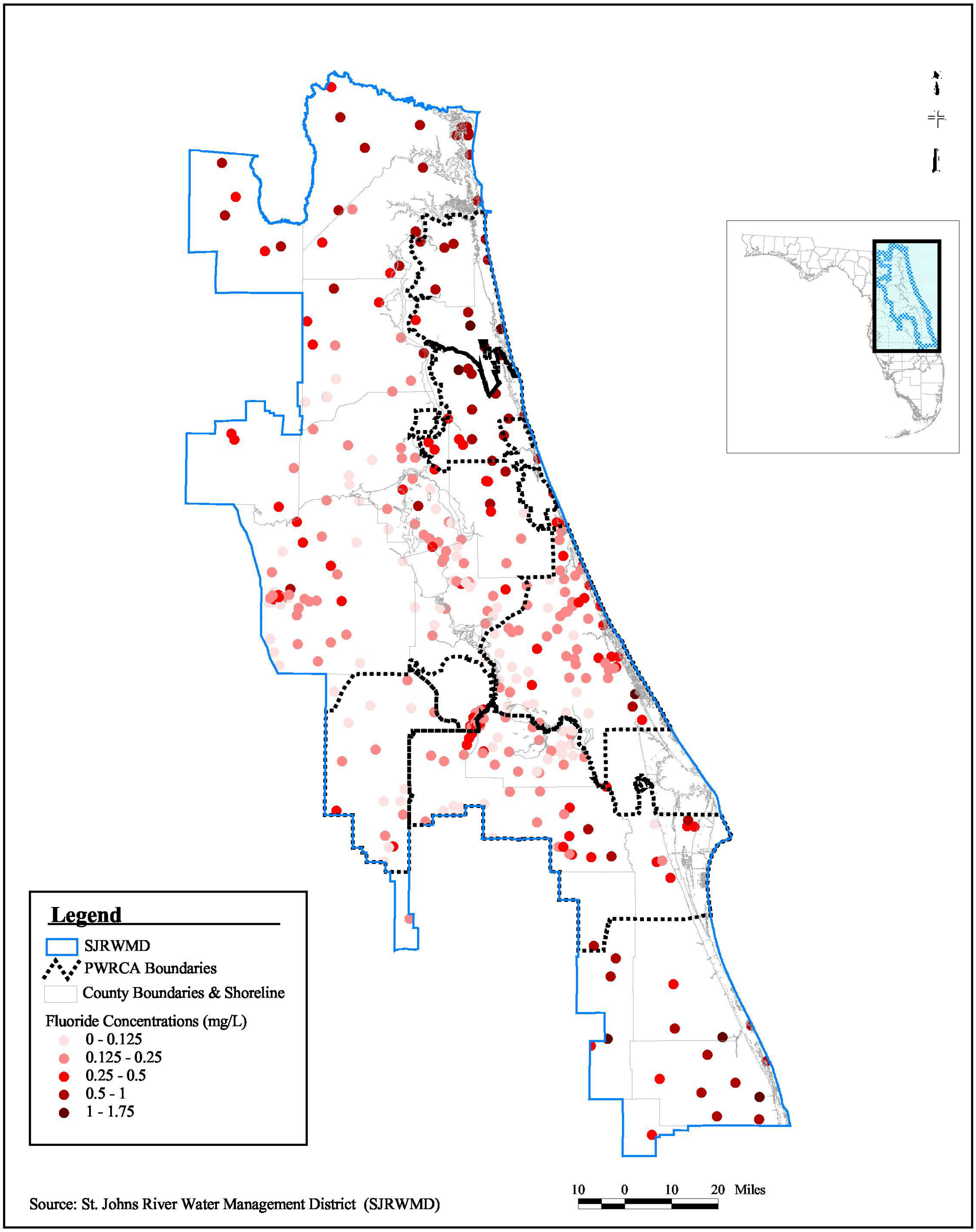

Figure 16. Flouride Concentration in the Upper Floridan Aquifer

The various fluoride raw water concentrations shown in Figure 16 were used to develop fluoride concentrate concentration based on the type of demineralization process as well as anticipated recovery, and are presented in Table 10. For each scenario where a mixing zone would be required to meet surface water standards, a dilution factor was calculated assuming that the fluoride concentration in the receiving water body is 0.5 mg/L.

A brief discussion regarding each surface water classification comparison outlined in the table is provided in the following paragraphs beginning with Class II surface water. As shown in the table discharging demineralization concentrate into a Class II surface water using brackish or moderately brackish source water with a concentration of fluoride higher than 0.25 mg/L would require a mixing zone, since the fluoride concentration in the concentrate would be higher than the 1.5 mg/L standard. As a result, discharge into Class II surface waters would require dilution factors from 2 to 10 in the mixing zone. A dilution factor of 10 would not be practical within the limits of a mixing zone due to area limitations. A mixing zone would also be required for a seawater treatment plant using a water source with a fluoride concentration higher than 0.8 mg/L, since dilution is required to meet regulatory conditions. It should be noted that a mixing zone shall not include a nursery area of indigenous aquatic life or any area approved by the Department of Environmental Protection for shellfish harvesting (62-4.244(1)e, *F.A.C.*). Currently, these areas are legally designated as Class II waters. However, not all Class II waters are shellfish harvesting or propagation areas.

In the situation where the potential receiving water is a Class III marine surface water, demineralization concentrate discharge would not require a mixing zone for fluoride if the moderately brackish water source has a fluoride concentration less than 0.5 mg/L. However, for a demineralization treatment plant using brackish or seawater as a source, the fluoride concentration could be as high as 1 mg/L and still meet the fluoride standard of Class III marine surface water without the need of a mixing zone as result of the lower recoveries associated with these membrane treatment processes.

Table 10. Comparison of Concentrate Fluoride Concentration to Fluoride Surface Water Standards resulting in the associated Dilution Factor Requirements*

Fluoride Source Water Concentration	Fluoride Concentrate Concentration	Class II		Class III		Class III	
		SW Standard	Dilution Factor	Marine water SW Standard	Dilution Factor	Fresh water SW Standard	Dilution Factor
mg/L	mg/L	mg/L		mg/L		mg/L	
Moderately brackish water demineralization WTP (85% Recovery, 90% Rejection)							
0.125	0.8	1.5	No MZ req'd	5.0	No MZ req'd	10.0	No MZ req'd
0.25	1.5	1.5	1.0	5.0	No MZ req'd	10.0	No MZ req'd
0.50	3.1	1.5	2.6	5.0	No MZ req'd	10.0	No MZ req'd
1.00	6.1	1.5	5.6	5.0	1.2	10.0	No MZ req'd
1.75	10.7	1.5	10.2	5.0	2.3	10.0	1.1
Brackish water demineralization WTP (75% Recovery, 95% Rejection)							
0.125	0.5	1.5	No MZ req'd	5.0	No MZ req'd	10.0	No MZ req'd
0.25	1.0	1.5	No MZ req'd	5.0	No MZ req'd	10.0	No MZ req'd
0.50	1.9	1.5	1.4	5.0	No MZ req'd	10.0	No MZ req'd
1.00	3.9	1.5	3.4	5.0	No MZ req'd	10.0	No MZ req'd
1.75	6.7	1.5	6.2	5.0	1.4	10.0	No MZ req'd
Seawater WTP (50% Recovery, 99% Rejection)**							
0.125	0.2	1.5	No MZ req'd	5.0	No MZ req'd	10.0	No MZ req'd
0.25	0.5	1.5	No MZ req'd	5.0	No MZ req'd	10.0	No MZ req'd
0.50	1.0	1.5	No MZ req'd	5.0	No MZ req'd	10.0	No MZ req'd
1.00	2.0	1.5	1.5	5.0	No MZ req'd	10.0	No MZ req'd
1.75	3.5	1.5	3.0	5.0	No MZ req'd	10.0	No MZ req'd

* Dilution factor calculated assuming that receiving water has a fluoride concentration of 0.5 mg/L
** This is not applicable to groundwater source water, but only for seawater and highly brackish surface waters
MZ: Mixing Zone

Even though a mixing zone is not required for discharge into Class III fresh surface water for a majority of cases shown in Table 10, discharge of demineralization concentrate into a Class III fresh surface water is very unlikely due to other surface water standards (such as TDS) and the anti-degradation policy. In order to meet the TDS surface water standard, significant dilution through a mixing zone would be required that might not be practical due to size limitations associated with the mixing zone.

In summary, the highest suitability areas for demineralization concentrate discharge are into a Class III marine surface water. Discharge would not be significantly restricted due to the presence of fluoride as long as the fluoride concentration in the source water does not exceed 0.8 mg/L. This represents 94% of the samples taken from the wells in SJRWMD. However, the highest suitability areas for demineralization concentrate discharge into a Class III fresh surface water and Class II surface waters could potentially have difficulties meeting fluoride surface water standards due to size limitations for mixing zones or other regulatory standards (i.e. anti-degradation policy). Therefore, this analysis demonstrated that while some areas are deemed high suitability based on the TDS criterion, there is a potential to have difficulty meeting standards for other constituents (such as fluoride or radionuclides) enhancing the importance of evaluating fluoride as early as possible in any site-specific feasibility assessment.

Co-location with Wastewater Treatment Plants or Power Plants

In order to meet the TDS criteria (demineralization concentrate TDS lower than surface water TDS), dilution with wastewater treatment plant effluent or power plant cooling water can be valuable in certain instances. Blending demineralization concentrate with WWTP effluent is feasible if there is a large amount of effluent compared to the demineralization concentrate volume. Assuming that the WWTP effluent has a TDS concentration of 250 mg/L, approximately 36-MGD of WWTP effluent would be required to blend with 2-MGD of demineralization concentrate with a TDS concentration of 5,000 mg/L to achieve a TDS concentration of 500 mg/L (the water standard that many WWTPs must achieve) in the blended stream. The largest WWTP in SJRWMD has a capacity of 36-MGD. Therefore the WWTPs in SJRWMD are not of adequate size to support blending of concentrate with WWTP effluent to meet water standards in the blended stream for the purposes of this relative suitability comparison.

Blending could be feasible for WWTPs having different TDS requirements such as facilities discharging effluent to the Intracoastal Waterway. However, if the WWTP discharging to the Intracoastal Waterways has low flows due to their reuse program, then there once again would not be adequate volume for blending.

Blending demineralization concentrate with power plant cooling water has certain advantages such as a shared discharge outfall, existing infrastructure at the power plant, and a dilution effect from the cooling water. A total of four power plants in SJRWMD have once-through cooling and all have receiving water body/cooling water TDS concentrations on the order of 25,000 mg/L (Table 11).

For demineralization concentrate streams with a TDS concentration less than 25,000 mg/L, these power plants would not dilute the TDS. For demineralization concentrate with a TDS concentration higher than 25,000 mg/L, the resulting blend would still exceed 25,000 mg/L and would therefore not be consistent with the high suitability target (demineralization concentrate TDS less than receiving water body TDS).

Table 11. Power Plants with Once-Through Cooling Water

Power Plant Name/Location	Cooling Water TDS	Cooling Water Flow
	mg/L	MGD
Cape Canaveral/Titusville	≈ 25,000	500
Indian River/Titusville	≈ 25,000	310
Northside/Jacksonville	≈ 25,000	806
Vero Beach Municipal/Vero Beach	≈ 25,000	160

While power plants can provide a significant benefit through the presence of an existing outfall, existing power grid, existing discharge permits, and many other factors, these are specific to individual situations and evaluations. For this macro-level analysis and using the high suitability water quality target (demineralization concentrate TDS less than receiving water body TDS) these four power plants do not increase the opportunity to reduce concentrate TDS to less than that of the receiving water body.

For example, while the Tampa Bay Water desalination project benefited from dilution of demineralization concentrate by the power plant cooling water, the fact that the resulting blend was 1.5% higher in TDS concentration than the receiving water body, as well as other issues, was such that it was necessary to mount a very large research and modeling effort, utilizing Universities and national experts, to provide reasonable assurance to FDEP regarding the proposed discharge. Therefore, for the purposes of this study, the TDS criterion is considered a key measure of suitability. Power plants are able to minimize the difference in TDS concentration between a demineralization concentrate stream and the receiving water body but are not able to eliminate an increase in TDS concentration. However, SJRWMD is conducting the Seawater Demineralization Siting Study which will focus more site-specific attention on the factors, including the benefits, associated with power plants.

Power plants using once-through cooling water and wastewater treatment plants are shown in Figure 17.

Suitability Areas

Criteria defined above were integrated in a GIS format to generate a coverage of high suitability areas for surface water discharge in SJRWMD. Figure 18 shows that the St. Johns River in the Jacksonville area and large portions of the Intracoastal Waterway are highly suitable for demineralization concentrate having TDS concentration up to approximately 30,000 mg/L. This corresponds to sources with TDS concentration up to 10,000 mg/L. Demineralization concentrate having TDS concentration higher than 34,000 mg/L cannot be discharged into surface water unless a mixing zone can be granted for TDS and any other parameters that exceed surface water standards.

This analysis shows that limited portions of the St. Johns River and large portions of the Intracoastal Waterway are high suitability areas for surface water discharge of demineralization concentrate, based on the criteria utilized herein. Most of the St. Johns River is defined as less suitable for the purposes of this project. However, areas of the St. Johns River which were not considered high suitability solely due to low TDS concentration (i.e. are not designated an OFW, park, or other highly restricted classification) may still be worthy of site-specific consideration.

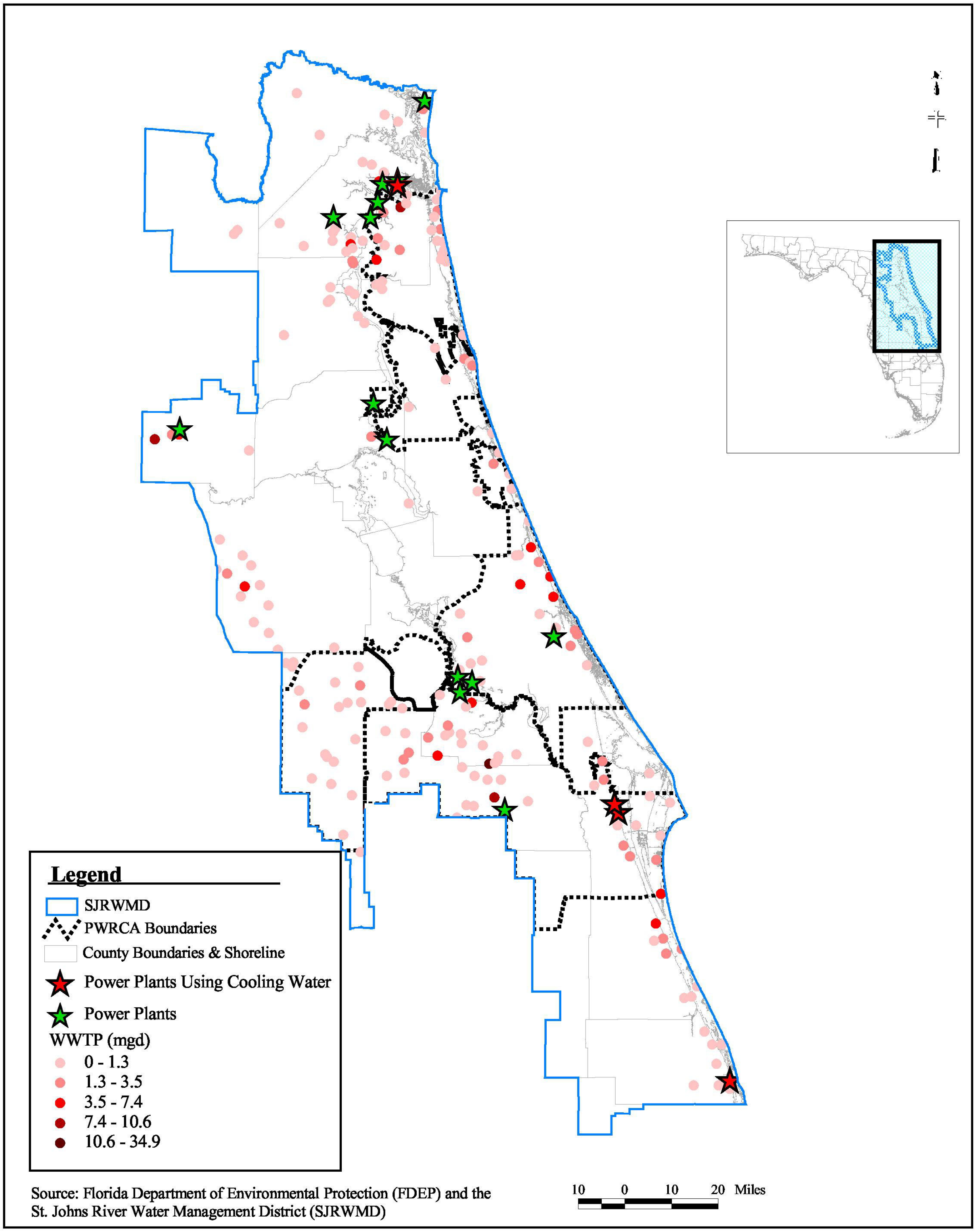

Figure 17. Wastewater Treatment Plants and Power Plants

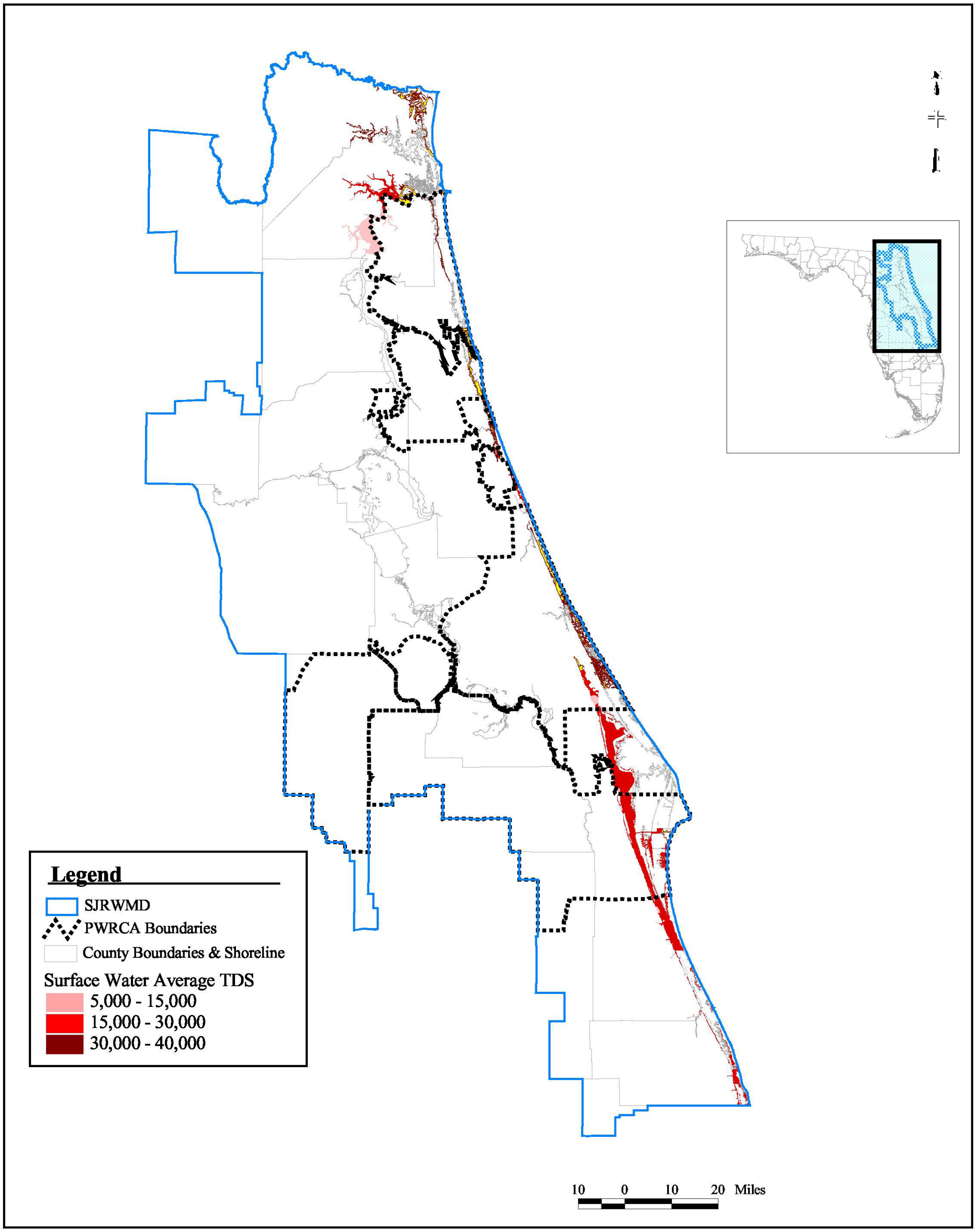

Figure 18. Surface Water Discharge Suitability Areas

Given that the S. Johns River ultimately discharges to the ocean, these areas may possibly meet regulatory requirements if innovative approaches are utilized. This could include use of large quantities of dilution water or limiting the TDS concentration of the demineralization concentrate (e.g. use of a selective ion membrane or reduced water recovery). Conversely, areas defined as highly suitable areas may be considered not suitable under site-specific conditions. As presented previously, a mixing zone cannot be permitted in shellfish harvesting or propagation areas. Also, site specific conditions where source waters with high nutrients levels potentially result in high nutrient concentrations in the demineralization concentrate would be deemed less suitable, due to possibly contributing to further impairment of already impaired water.

COASTAL OCEAN OUTFALL

The relative suitability of the coastal ocean along the boundary of SJRWMD to accommodate demineralization concentrate was assessed. The coastal ocean is defined as seawater between the shoreline and the 90 foot isobath (Figure 19). Coastal ocean is evaluated separate from open ocean (beyond the 90 foot isobath) because water quality criteria for discharge are different for coastal ocean versus open ocean.

Areas of highest suitability for discharge of demineralization concentrate management to coastal ocean waters were determined based on the following criteria:

- capacity,
- location of environmentally sensitive areas, and
- co-siting with WWTP and power plant discharges.

Coastal Ocean Capacity

The water treatment plant capacities evaluated in this study ranges from 5 to 50-MGD, with resulting demineralization concentrate flows on the order of 2 to 30-MGD. All coastal ocean areas in SJRWMD have sufficient tidal influence to accommodate these demineralization concentrate flows. Therefore minimum flow considerations are considered met for this water body.

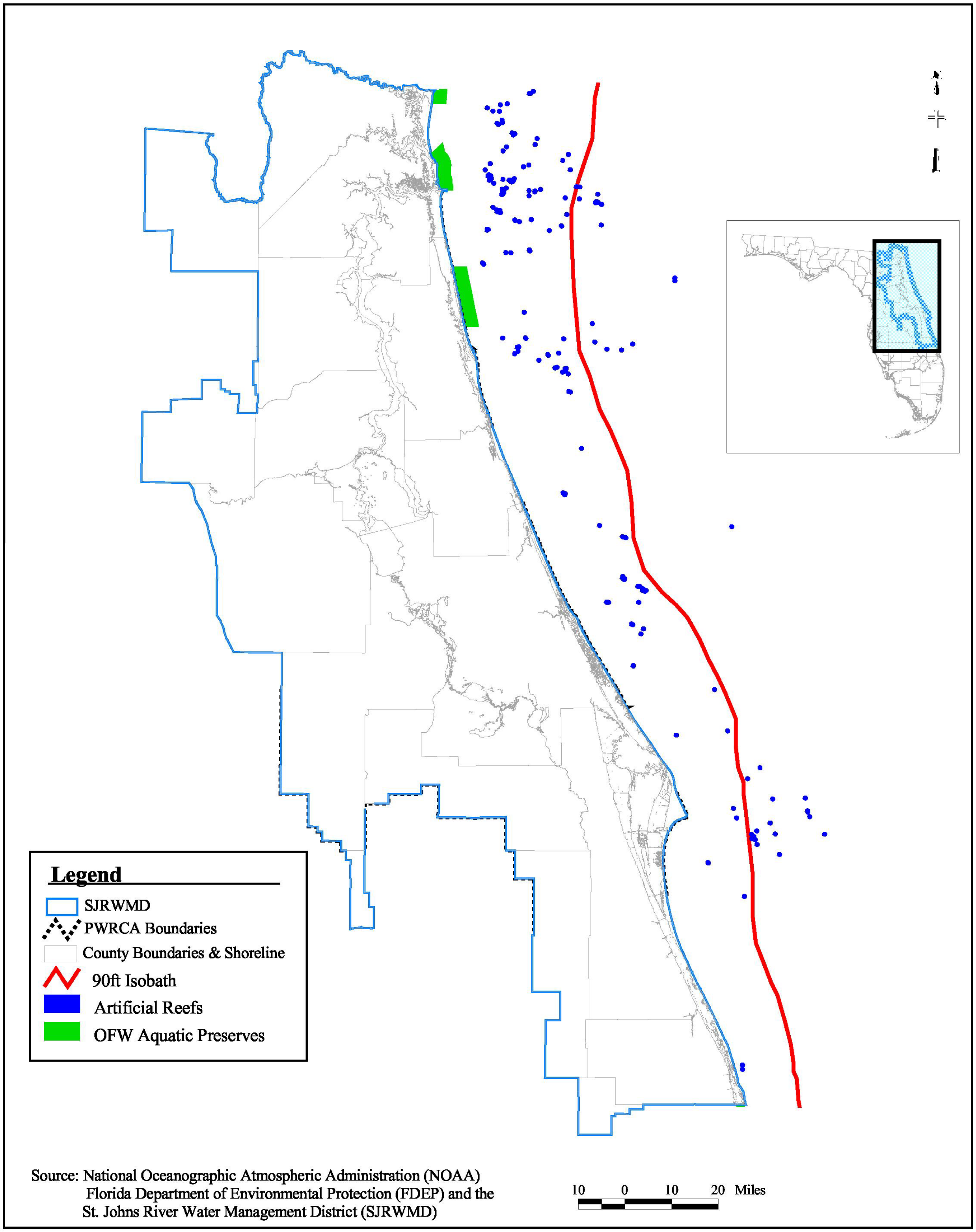

Figure 19 Ocean 90 ft Isobath, Ocean OFW's and Artificial Reefs

Environmentally Sensitive Areas

Outstanding Florida Waters designation, seagrass and artificial reefs were the sensitive environmental criteria assessed for coastal ocean discharge. It was determined that seagrass is not present in the ocean along the SJRWMD shoreline since the conditions on the coast are not optimal for seagrass development. Sand, strong stream current, and depth along the coast are adverse conditions for seagrass development. It was also determined that there were no coral reefs along the coast (NOAA, 2002). Ocean Outstanding Florida Waters are primarily located in the northern portion of SJRWMD in the Jacksonville area. Artificial reefs are present all along the SJRWMD shoreline and may be considered nursery areas or otherwise provide habitat for aquatic species. Figure 19 presents the OFWs and the artificial reefs with a buffer of ½ mile within the coastal ocean.

Co-siting with Wastewater Treatment Plants and Power Plants

There are no power plants or wastewater treatment plants in SJRWMD that discharge their cooling waters or effluent in the coastal ocean. Therefore, no analysis of co-siting a demineralization plant with a power plant or wastewater treatment plant was performed.

Suitability Areas

Based on the screening criteria used herein, Figure 20 shows areas in the coastal ocean that are highly suitable for demineralization concentrate having TDS concentration up to approximately 34,000 mg/L. Demineralization concentrate having TDS concentration higher than 34,000 mg/L cannot be discharged into the coastal ocean unless a mixing zone can be granted for TDS and any other parameters that exceed surface water standards.

This analysis shows that most of the coastal ocean in SJRWMD is highly suitable for demineralization concentrate management, based on the screening criteria utilized.

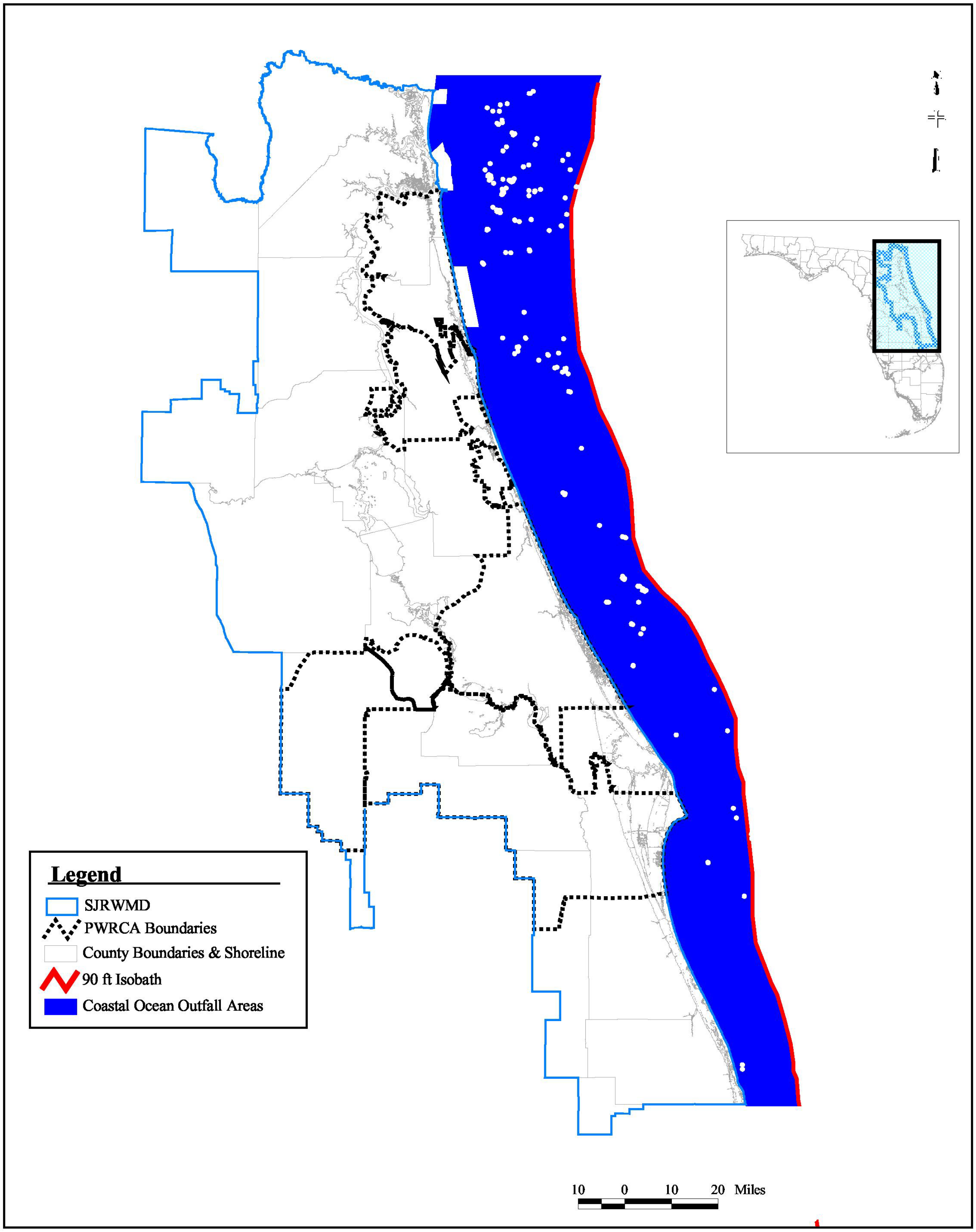

Figure 20. Coastal Ocean Outfall Suitability Areas

OPEN OCEAN OUTFALL

The relative suitability of open ocean adjacent SJRWMD to accommodate demineralization concentrate was assessed. Open ocean waters are defined as all surface waters extending seaward from the most seaward natural 90-foot (15-fathom) isobath.

The distinction between open ocean and coastal ocean is of importance since the concentrate discharge regulations differ for open ocean and coastal ocean. Coastal ocean discharge generally follows surface water regulations whereas open ocean discharge follows less restrictive regulations (See Rules and Regulations Summary, Appendix B). Specific differences comparing open to coastal ocean are as follows:

1. Compliance with the anti-degradation policy is more likely;
2. Dissolved oxygen requirements are less stringent;
3. Biotoxicity requirements are less stringent: the discharge can be diluted 1/3 its normal concentration for toxicity testing;
4. Water quality standards must be met at the point of 20:1 dilution, not at the point of discharge;
5. If water quality standards are met at the point of 20:1 dilution, a mixing zone is not required;
6. A larger mixing zone is allowed (four times larger than other surface water discharges).

Areas of highest suitability for discharge of demineralization concentrate management to open ocean waters were determined based on the following criteria:

- capacity, and
- location of environmentally sensitive areas.

Distance Between Shoreline and the 90 Foot Isobath

The distance for an open ocean outfall is defined as the distance from the shoreline to the 90 foot isobath. The 90 foot isobath along Florida's east coast is presented in Figure 19. The 90 foot isobath along the St. Johns River Water Management District is approximately 14 to 35 miles away from the coast line. The longest distance between the coastline and the 90 foot isobath is on the northern end of SJRWMD along Nassau and Duval counties. The shortest distance between the coastline and the 90 foot isobath is located in the southern end of SJRWMD along Indian River and Brevard counties. The issue of distance was not used as a screening tool at this point in the evaluation but is a critical economic issue addressed later in this report in the integration of source waters and demineralization concentrate management options.

In Florida there are six open ocean outfalls, all in Dade, Broward, and Palm Beach counties, disposing of more than 400-MGD of wastewater effluent. There are no open ocean outfalls within SJRWMD.

Open Ocean Capacity

The water treatment plant capacities evaluated in this study range from 5 to 50-MGD, with resulting demineralization concentrate flows on the order of 2 to 30-MGD. All open ocean areas along SJRWMD have sufficient volume to accommodate these demineralization concentrate flows. Therefore minimum flow considerations are considered met for this water body.

Environmentally Sensitive Areas

No parks or seagrass are present in the open ocean. Only a few artificial reefs can be found beyond the 90 foot isobath. Artificial reefs coverage is presented in Figure 19. It should be noted that there are several ledges in the 90’ isobath area that are key fishing grounds in the Atlantic Ocean.

Suitability Areas

The high suitability areas for open ocean discharge are presented in Figure 21. All points along the 90-foot isobath are potential locations for concentrate discharge. Of the criteria identified for this discharge alternative, only distance to the 90 foot isobath restricts the use of open ocean. Open ocean discharge regulations might be less stringent than the other surface water discharge alternatives, however, non concentrate specific regulations such as ocean pipeline permitting may make open ocean discharge more problematic. Economic considerations for open ocean discharge are presented later in the document.

This analysis shows that most of the open ocean is suitable for demineralization concentrate management, pending screening of the economics associated with the distance to reach the open ocean.

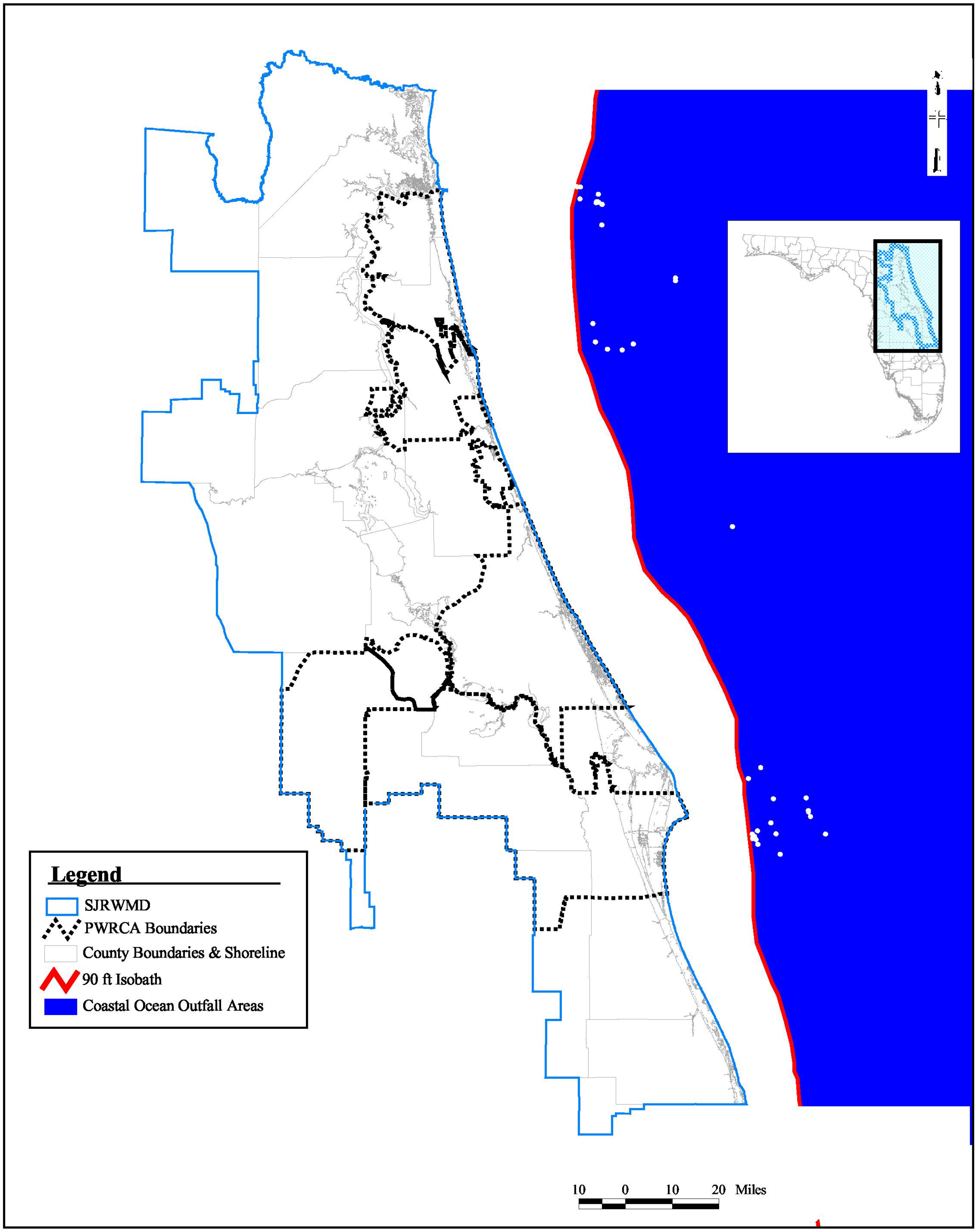

Figure 21. Open Ocean Outfall Suitability Areas

Marine Wetland Discharge

The relative suitability of marine wetlands in SJRWMD to accommodate demineralization concentrate discharge was assessed. Wetlands within SJRWMD were identified from National Wetland Inventory Maps prepared by the US Fish and Wildlife Service. Marine wetlands by their nature occur in association with saline groundwater areas. As such, there are no significant restrictions that would be expected regarding groundwater compatibility. In addition, marine wetlands are subject to the same water quality requirements as surface water discharge. Criteria used in this evaluation were as follows:

- classification,
- location of environmentally sensitive areas,
- salinity, and
- capacity.

Classification

With regard to marine wetlands, classification is related to sovereign submerged lands, mean high water, and other site specific factors. However, a general assumption can be made that the FDEP classification will be consistent with the classification of the adjoining surface water. Therefore, only wetlands adjoining Class III surface waters were identified as suitable areas for demineralization concentrate disposal. In addition, Class III wetlands designated as Outstanding Florida Waters were excluded due to the greater restrictions associated with OFWs.

Environmentally Sensitive Areas

Marine wetlands include a variety of resources that must be considered in determining their compatibility with demineralization concentrate discharge. First, wetland systems are considered to have high resource value, and thus any proposed discharge would be subject to increased scrutiny. Additionally, there are restrictions associated with national parks as well as aquatic preserves and other designated areas. These areas are subject to significant protective restrictions that render their adjacent wetlands impractical as potential receiving water bodies for demineralization concentrate. Lastly, wetlands may be considered aquatic nursery areas, within which mixing zones are not allowed, and thus opportunity for demineralization concentrate discharge would be reduced. All marine wetlands within parks and aquatic preserves were removed from the wetland coverage with the resulting suitable areas shown in Figure 22.

Marine Wetland Salinity

The potential for marine wetlands to receive demineralization concentrate is in part governed by the salinity ranges of the concentrate and the wetlands. For the tidally influenced wetlands evaluated herein, TDS concentration is estimated to be equal to 34,000 mg/L. Only discharge of demineralization concentrate with a TDS concentration less than 34,000 mg/L was considered highly suitable.

Capacity

In order to identify marine wetlands of sufficient size, a relationship of demineralization concentrate discharge flow to wetland capacity was developed. A concentrate flow range from 2 to 30-MGD was defined for this project. Marine wetlands are typically tide driven, and experience twice daily tidal flood that can reasonably be assumed to have an average depth of 0.5 feet. Each acre (AC) of typical marine wetland can accommodate dilution of approximately 160,000 gallons per day of concentrate discharge. This capacity is subject to site specific modifications with regard to hydraulic capacity but does provide a reasonable planning-level value for identifying potential marine wetland receiving water bodies for demineralization concentrate.

Based on this criterion of 160,000 gpd of discharge per acre of wetland, the size of wetland necessary to accommodate each demineralization concentrate flow is presented in Table 12.

Table 12. Wetland Area Requirement

Concentrate Flow (MGD)	Wetland Area (Ac)
2	13
5	31
15	94
30	188

Each wetland was individually considered to assess what demineralization concentrate flow it can accept. The assessment was based on the area, the shape, and the continuity of the wetland. This information was integrated with the other criteria herein to support the suitability assessment presented below.

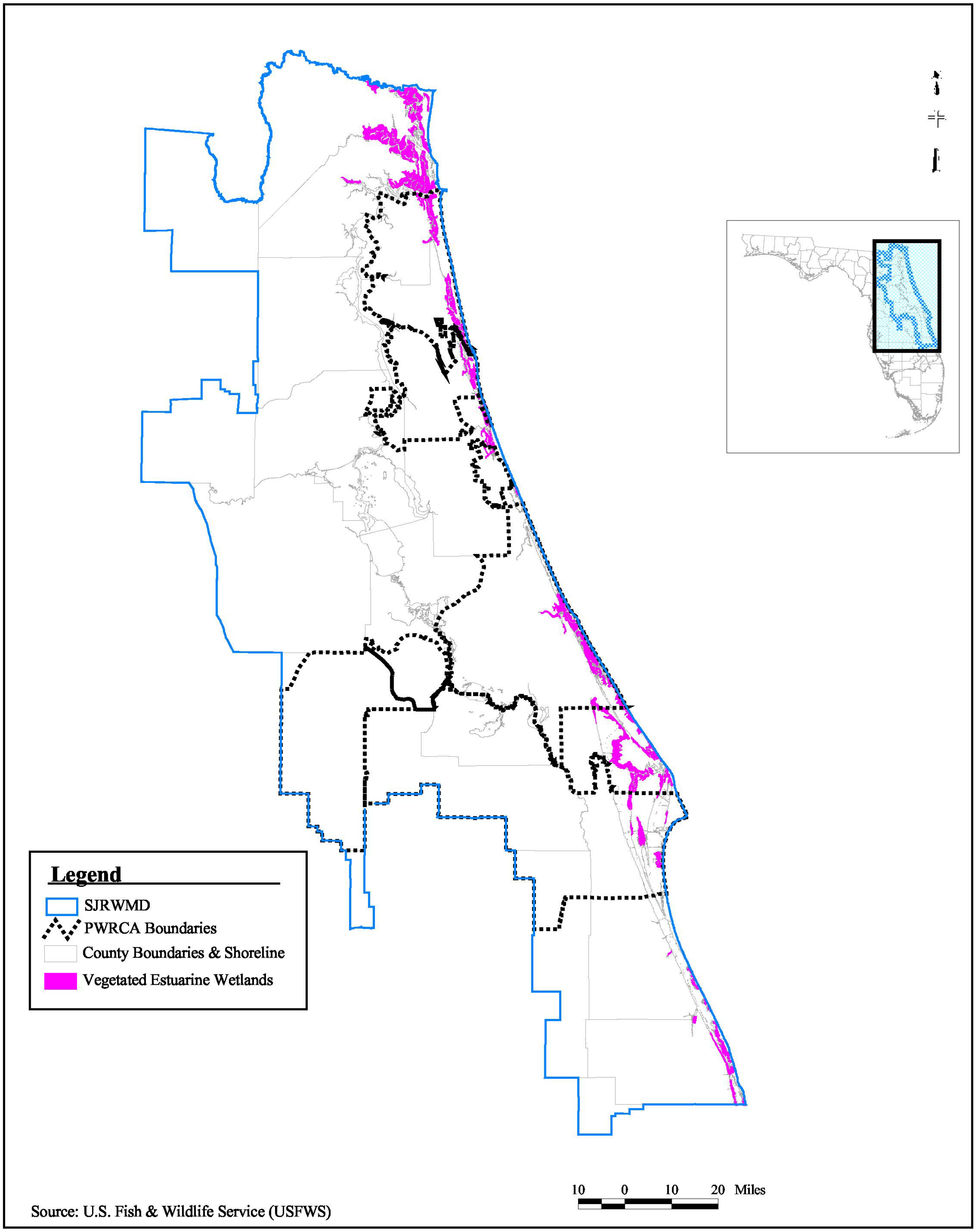

Figure 22. Vegetated Estuarine Wetlands

Creation of new marine wetlands was also considered, to supplement the areas identified above. However, at least 13 acres of wetlands are required for 2-MGD of demineralization concentrate discharge. The vast majority of the available property for wetland creation (i.e. uplands) is significantly more expensive in coastal locations and often has significant ecological value in its existing state. In addition, the ability to meet groundwater standards is unlikely given the existing groundwater TDS in upland areas should be less than the 34,000 mg/L for tidally influenced areas assessed herein. Creation of a marine wetland that can be used as a receiving water body for demineralization concentrate discharge is not considered to be a highly suitable alternative.

Availability of a Fresher Water Source for Blending

An available technique for achieving part or all of the necessary dilution to make a demineralization concentrate discharge meet state water quality standards is through dilution with other flows. The typical sources of such flows include discharges from domestic wastewater treatment plants as well as cooling water discharges. As with evaluation of potential capacity for dilution as well as dilution demand, the total flows of each need to be compared in order to determine the potential for providing needed dilution. In the case of marine wetland receiving waters, the added flow volume of dilution flows increases the size of wetland necessary in order to accommodate the discharge. Further, the nutrient issues that may be associated with a domestic wastewater discharge and/or the elevated temperature concerns of a cooling water flow can reduce the compatibility of a discharge with the nature of wetlands.

Suitability Areas

The high suitability areas for wetland discharge are presented in Figure 23. The areas are only wetlands with adequate capacity that are not OFWs, not within parks, without seagrass beds and not connected to Class I and II surface waters. The results show that there are several suitable areas along the coast and in the Jacksonville area. Note that there are no wetlands that can be used to discharge 15 or 30-MGD of demineralization concentrate in SJRWMD because of their limited size or because of the protection associated with them.

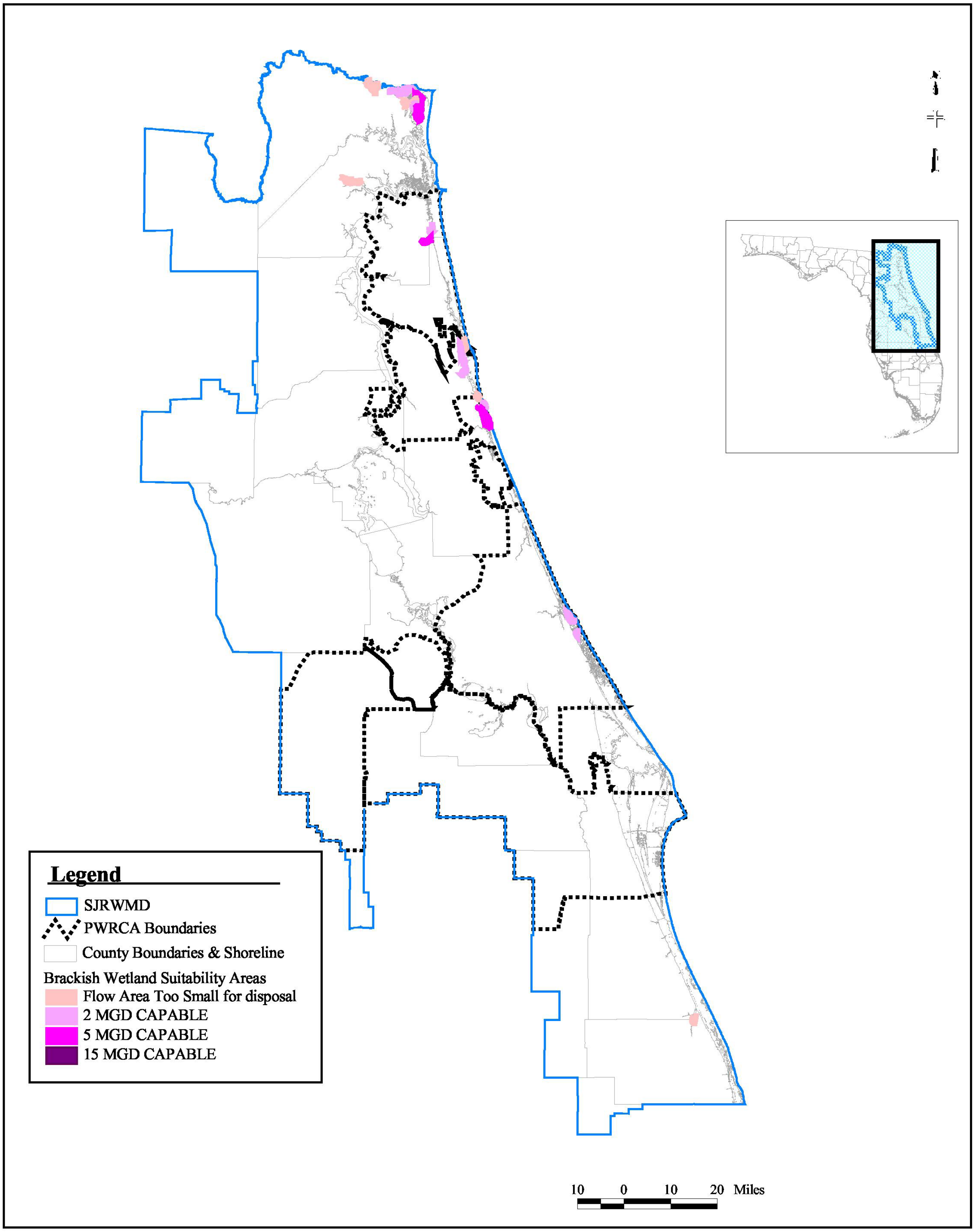

Figure 23. Brackish Wetland Discharge Suitability Areas

Other Concentrate Management Options

Other options and technologies to use or dispose of demineralization concentrate from around the country are listed and briefly described. They were not analyzed using GIS methods as they are emerging technologies, are not being used in the state of Florida, or for other reasons as explained in each option.

Reuse

Demineralization concentrate can be blended with domestic effluent and the blended stream could be used as reclaimed water for irrigation of public access, golf courses, roadway median, commercial areas, and residential areas. This option is only valid if there is enough available domestic effluent to blend with to meet reuse requirements. FDEP regulations typically require that discharges onto land, such as golf courses and roadway medians, meet drinking water standards at the boundary of the zone of discharge. The drinking water standard for TDS concentration is 500 mg/L. This standard is such that it is difficult to blend large quantities of demineralization concentrate with domestic effluent while ensuring compliance with the standard. Demineralization concentrate reuse has been addressed in detail in an FDEP Program Guidance Memo DOM-00-04 – Blending of Concentrate with Reclaimed Water.

The option of reuse was not analyzed using GIS methods because it is typically applicable to small concentrate flows blended with large reclaimed water flows in order to meet public access reuse requirements or through a more detailed evaluation to determine if a high TDS blended stream would not impact the areas irrigated.

Influent to WWTP

One option to dispose of demineralization concentrate is to send concentrate to a sanitary sewer or to the headworks of a WWTP. Demineralization concentrate has to meet the water quality standards defined in the local Industrial Waste Pre-Treatment Program (IWPP), and therefore it may on occasion require pretreatment. More importantly, the salinity of demineralization concentrate can negatively impact the WWTP microorganisms. The quantity of demineralization concentrate must be limited to ensure an appropriate environment is maintained for biological WWTPs, and therefore it's quantity does not typically exceed 10 percent of the influent flow. In addition, discharge to a sanitary sewer or to the headworks of a

WWTP encumbers wastewater system capacity, thus representing a capital and operational cost to the wastewater utility. Lastly, WWTP effluent discharge permit requirements must still be met. Depending upon the ultimate discharge method / location for the WWTP effluent, compliance with permit requirements may not be possible with introduction of demineralization concentrate or may greatly limit the quantity of demineralization concentrate that can be accepted.

Discharge of demineralization concentrate to sanitary sewers and to the headworks of WWTPs has occurred in previous projects and is expected to remain an option. However, these facilities are of small capacity. For the purposes of regional planning and for demineralization WTPs with capacities of 5 to 50-MGD, discharge of demineralization concentrate to a WWTP is not considered a highly suitable option.

Land Application

The land application methods include spray irrigation and rapid infiltration systems (percolation ponds or infiltration trenches).

Spray irrigation

Concentrate can be applied to cropland or vegetation by sprinkling or by land application techniques. However, the vegetation has to be tolerant of high salinity. The following criteria will have to be assessed for concentrate disposal by spray irrigation: site selection, pre-application treatment, ambient groundwater quality, hydraulic loading rates, land requirements, vegetation selection, distribution techniques, and surface runoff control.

Rapid infiltration and infiltration percolation

Infiltration percolation allows the applied concentrate to percolate through permeable soils and then reach the groundwater system. The percolation ponds usually have sideliners to prevent horizontal movement of the concentrate. This option requires very permeable soil (sand and loamy sand) and a water table a few feet below the bottom of the pond in order to have an unsaturated zone for concentrate to percolate.

Land application is considered appropriate only for small water treatment systems given the large land area that would be required. In addition, concentrate applied through land application techniques needs to meet groundwater standards at the boundary of the zone of discharge (such as a TDS concentration of 500 mg/L). Land application was not considered to be of highest suitability to meet the needs of this regional planning effort.

Brine Concentrator Evaporator

A brine concentrator reduces the volume of concentrate by evaporation. While the volume of demineralization concentrate is reduced, there is a proportionate increase in the concentration of the stream (i.e. no mass of dissolved solids is removed, only water).

Concentrators are typically used for small volume industrial applications including power plant cooling water blow down waste. The advantage of the evaporator is that water recovery can reach 95%, compared to 50-85% in typical demineralization facilities. However, brine concentrators are typically thermal systems requiring very large amounts of energy, with associated power costs. Capital costs are high, with an estimate of $15M for a brine concentrator sized to treat 2-MGD of demineralization concentrate (Mickley, 1993). In addition, since this process only reduces the volume of the demineralization concentrate stream; the same mass of dissolved solids remains and must be addressed using some subsequent disposal or management method.

There has been an increase in interest in brine concentrators for municipal demineralization WTPs in arid states in the southwest US. For many of these arid areas, there are no acceptable surface waters or suitable deep well aquifers. Therefore piping and transmission of demineralization to coastal areas for discharge is the most likely option. Reduction in volume of demineralization concentrate, for the purpose of reducing transmission costs, may justify the cost of concentrating the discharge stream. However, for the purposes of this study and given the options available in SJRWMD, brine concentrators are not considered highly suitable or applicable.

Crystallization (Zero Liquid Discharge)

Crystallization can be used downstream of a brine concentrator evaporator to achieve zero liquid discharge of demineralization concentrate. Crystallization is also used in small volume industrial applications. The capital cost of a crystallizer is estimated to be $5M to treat 100,000 gpd of demineralization concentrate from an evaporator (Mickley, 1993). Again, thermal techniques are used, with associated high power costs. The resulting solid material may be eligible for disposal in a landfill. Because of its prohibitive cost, crystallizers were not considered to be highly suitable for use in SJRWMD.

Sodium Hypochlorite Generation

Brine could be used to generate sodium hypochlorite (bleach), which is widely used for disinfection of water, wastewater effluent and reclaimed water in the US. At this time this option is not commercially feasible. This option is at a research and development phase to study the feasibility of using demineralization concentrate as a brine solution for on-site sodium hypochlorite generation. Demineralization concentrate can contain high calcium and bromide concentrations which can lead to scaling of the generation equipment and formation of sodium bromate, an undesirable by-product. This emerging beneficial use for demineralization concentrate was not considered highly suitable for regional planning purposes at this time.

Solar Ponds

Solar concentrators consist of a pond containing demineralization concentrate. Solar energy is captured in the pond and utilized to generate electricity. Research is on-going at the Center for Environmental Resource Management at the University of Texas at El Paso for this emerging technology. In addition to being in the research and development phase, this technology does not appear to be feasible at this time in Florida due to technical limitations. For example, demineralization concentrate is not removed from the pond, therefore very large ponds would be required to allow long-term operation of a large (5 - 50-MGD) WTP as defined in this project. In addition, the heavy rainfall in Florida would consume additional capacity in the pond. While the solar energy captured and utilized from the pond could be used for evaporation of some of the water in the pond, it is not currently commercially viable and is not considered highly suitable for the purposes of this project.

POTENTIAL DESIGN CONSIDERATIONS ACCORDING TO LOCATION AND VOLUME REQUIREMENTS

Design considerations were developed for subsurface injection and for surface water disposal. The latter includes surface water, wetland, coastal ocean and open ocean discharge because they are considered surface waters by FDEP and have similar design considerations.

Subsurface Injection

Several generalizations were used to develop the conceptual injection well design. The well was designed as a Class I industrial waste injection well. The injection well will be constructed with a final steel casing extending the entire depth of the well. Fiberglass-reinforced plastic (FRP) was selected for the inner injection tubing for its corrosion-resistant properties and proven use in similar environments. The tubing will extend from land surface to the bottom of the final steel casing. The desired concentrate flows and a maximum allowable injection velocity of 10 feet per second (fps) were used to determine the well diameters.

In addition to the well, several appurtenances are required. The annular space in the well will be filled with pressurized fresh water. This water will be maintained at a constant pressure by hydropneumatic tanks, and the pressure in the annular space will be monitored to ensure the mechanical and operational integrity of the well. A significant change in the annular fluid pressure often indicates a leak in the tubing or final casing.

The wellhead will require both pressure release and vacuum release valves. Meters and instrumentation are also necessary to continuously measure annular pressure, injection pressure, and injection flowrate.

Monitor wells are required at each injection well to allow monitoring of the injection zone and of the base of the USDW. The depth of the monitor wells can be determined on a site-specific basis, but has also been generalized for the purpose of developing conceptual cost estimates.

The design of the injection wells may and likely will vary from that provided here based on site-specific geology. The following is a typical design for a Lower Floridan aquifer injection well, which was used to estimate potential construction costs. The depth and number of intermediate casings will be dependent on the field geology.

<u>Lower Floridan Aquifer Injection Well Construction</u>

Generalized procedures for the construction of a Lower Floridan aquifer injection well are presented. However, actual construction methods will vary based on site-specific data. In areas where data do not exist or are inconsistent, an exploratory well is normally drilled. In this case, the construction procedures would be based on the data obtained from this exploratory well.

The sizes of the required boreholes and casings are dependent on the injection flowrate because FDEP has a 10 fps limit on the downhole velocity of injected concentrate. The proposed casing diameters presented in Table 13 are commercially-available sizes that meet the FDEP's velocity limit. Conceptual schematics of the wells for which construction was described below are presented in Appendix D.

First, a steel pit casing of the selected diameter will be installed by vibration or rotary drilling to a site-specific depth (typically less than 100 feet) to provide stability for the drill rig. Then, an 8 to 12-inch pilot hole will be drilled to the approximate top of the Floridan aquifer system using the mud rotary method. Geophysical logging (natural gamma ray, caliper, long and short normal with spontaneous potential, temperature, and fluid resistivity logs) will then be performed on the pilot hole. The pilot hole will be reamed to allow installation of the appropriate steel surface casing with minimum 0.375-inch wall thickness.

Table 13. Injection Well Casing Size Based On Flowrate

Design Flow (MGD)	Pit Casing (in)	Surface Casing (in)	Intermediate Casing (in)	Final Casing (in)	Injection Tubing (in)
2	40	32	24	12	8
5	48	40	32	20	14

An 8 to 12-inch pilot hole will be drilled to the approximate base of the USDW using the reverse-air circulation drilling method. A geophysical logging suite will be performed on this pilot hole and includes:

- long and short normal electrical resistivity,
- spontaneous potential,
- fluid resistance, both static and pumping,
- temperature, both static and pumping,
- natural gamma ray,
- flowmeter, both static and pumping,
- caliper,
- dual induction log,
- borehole compensated acoustic log with variable density display,
- video survey, and

- borehole televiewer.

The geophysical logging will be used to determine the elevation of the base of the USDW. If it is found that the pilot hole was drilled below the base of the USDW, the pilot hole can be back-plugged to the top of the Lower Floridan aquifer. The pilot hole will be reamed to allow installation and cementing of an intermediate casing to the base of the USDW.

An 8 to 12- inch pilot hole will be drilled to the approximate top of the injection zone using the reverse-air circulation drilling method. The same geophysical logging suite previously performed will be performed on the pilot hole. The pilot hole will be reamed to allow installation and cementing of a final casing to the top of the injection zone. This final casing will be ASTM A53B or API 5L steel casing with a minimum wall thickness of 0.5 inches.

A borehole of the appropriate diameter will be drilled through the injection zone using the reverse-air circulation drilling method. The same geophysical logging suite previously performed will be performed on the pilot hole. This geophysical logging will be performed to determine the depth at which the design injection flowrate can be achieved. The depth of this open hole section, therefore, will be field-determined.

Injection tubing will be installed from land surface to the top of the injection zone with packers installed at the top and bottom, and grouted at the bottom of the tubing to allow the annular fluid between the tubing and final casing to be pressurized. After installation of the injection tubing, a video survey of the completed well will be performed and an injection test will be conducted at the design flow rate. Pressure and vacuum release valves, a hydropneumatic tank to hold pressure in the annular space, and a pump with pump housing to provide the injection pressure will be installed.

<u>Monitor Well Construction</u>

To meet the permitting requirements for injection well operation, monitoring of the groundwater adjacent to the injection well will be required. FDEP regulations require installation of a monitoring well within 150 feet of the injection well for the purpose of monitoring above the injection zone and the base of the USDW. Above the injection zone is monitored to assess the effectiveness of the confining unit. The base of the USDW is monitored to assure that there is no upward movement of injected concentrate. Upward migration of the injected concentrate through the confining unit would be in violation of FDEP rules.

In order to provide for monitoring of the injection zone and base of the USDW, one 6-inch diameter inner casing / 14-inch diameter outer casing dual zone monitor well will be constructed within 150 feet of the injection well. However, it is likely that for the multi-well injection well systems, more than one dual-zone monitor well will be required by FDEP.

Surface Water Discharge

The design considerations described in this section are valid for surface water discharge, wetland discharge and coastal / open ocean discharge because they all require the same infrastructure: post-treatment, transportation using pipeline, and outfall structure in the receiving water body. These three components are described in terms of design in the next three sections.

<u>Post-treatment</u>

Post-treatment is an important aspect of concentrate management and may be necessary in order to meet receiving water standards and to protect the flora and fauna of the receiving water bodies. Post-treatment could include:

- Aeration to raise the dissolved oxygen concentration to meet the DO requirements of the receiving water body
- Aeration to remove gases that could lead to corrosion
- pH adjustment to protect flora and fauna of the receiving water body and / or to control corrosion
- Chlorination to prevent bacterial growth in the pipeline

Aeration is the most common post-treatment process. Aeration is accomplished by injection of compressed air into the concentrate pipeline prior to an in-line mixer. The power requirement of the compressor is a function of the amount of oxygen to be injected and the concentrate flowrate. If necessary, removal of gases is accomplished through degasification towers. Adjustment of pH is typically accomplished by injection of soda ash to raise the pH. In most cases the feed water of the demineralization facility is treated to lower the pH to 5.0 - 6.5 standard units before membrane treatment. The resulting concentrate would have a pH slightly higher than the feed water, between 5.5 and 7.0 standard units. Therefore the pH may need to be increased before discharging the demineralization concentrate to a receiving water body.

Transportation

Transportation of the concentrate from the demineralization plant to the discharge location includes two components: pumping station and pipeline.

In many cases, a pumping station is not necessary because the concentrate is under pressure. The residual pressure is typically sufficient to overcome the friction losses in the pipe and any elevation differences. In case a pumping station is required, the horse power of the pumps will be a function of concentrate residual pressure, friction losses (function of the pipe length) and elevation difference between the demineralization facility and the discharge location.

The pipeline size is a function of the volume of concentrate to be discharged and the distance between the facility and the discharge location. Table 14 presents the impact of pipeline length on head loss. A typical fluid velocity would range from 2 to 5 fps. Velocities higher than 5 fps could result in high friction losses, especially for a long pipeline. Typical materials of concentrate pipelines are polyvinyl chloride (PVC), ductile iron (DI) and steel reinforced concrete. All of these materials are resistant to corrosion.

Table 14. Friction Losses (ft) as function of pipe length and pipe size

Flow	Pipe Size	Pipe Length		
MGD	in	5 miles	10 miles	15 miles
2	12	108	216	324
5	16	145	290	435
15	30	52	104	156
30	36	77	154	231

Outfall structure

Outfalls consist of a single outlet or diffuser. Diffusers can come in various configurations. Typically a diffuser consists of a series of ports on the side or on the top of a pipe over a determined length of pipeline. The size of the diffuser is based on the fluid velocity and head loss. The material of the outfall pipe is usually reinforced concrete, ductile iron or cast iron. These materials as well as the joints must be corrosion resistant (AWWARF).

There are special requirements for ocean outfalls. The diffuser should be placed perpendicular to the prevailing ocean current. In case there is no prevailing ocean current, a Y- or V- shaped diffuser is common. The design of the diffuser is based on an hydraulic analysis (AWWARF).

The following is a list of design information required by FDEP, obtained from the Guide to Permitting Wastewater Facilities or Activities under Chapter 62-620, *F.AC.* Section II for surface water, coastal/open ocean discharge:

Design information for outfalls discharging to surface waters

- *Discussion of the antidegradation requirements of Rule 62-4.242, F.A.C.*
- *Discussion of the receiving water body classification and corresponding water quality standards*
- *Discussion of any considerations to be given to the receiving water body or contiguous waters such as any designated Outstanding Florida Waters or Outstanding National Resource Waters described in Chapter 62-302, F.A.C.*
- *Discussion of the applicable water quality based effluent limitations as determined in accordance with Chapter 62-650, F.A.C.*

Design information for outfalls discharging to coastal or open ocean waters

- *Bottom profiles of the route selected for the outfall and typical cross sections for outfall segments, joints, and diffuser, if applicable*
- *Description of all materials to be used and an outline of construction procedures as well as design considerations in Rule 62-600.510(6) F.A.C.*
- *Description of structural protection for the outfall*
- *Discussion of the disinfection process to be used and operating criteria proposed to ensure that microbiological requirements will be met*

These design considerations provide guidelines for planning purposes. Additional design details associated with demineralization concentrate management alternatives would be developed during the course of detailed design and permitting.

ECONOMIC CONSIDERATIONS

The cost of demineralization concentrate management can vary greatly with the method selected. Costs can be developed by identifying factors that will have a direct impact on the total capital and operating cost for a concentrate disposal system. The following is a list of the major factors that can impact cost:

- Distance from plant facility to discharge point
- Quantity of concentrate discharge
- Method of disposal
- Permitting requirements
- Monitoring requirements

It was assumed that a discharge pumping station is not necessary because the concentrate is under pressure (100 to 800 psi). In most cases the residual pressures will be high enough to overcome pipe friction losses and elevation differences.

Monitoring costs vary greatly depending on the permit requirements. The concentrate discharge permit would determine what parameters to monitor, the number of sample points, and the frequency of monitoring, which cannot be predicted until permit issuance. In addition, water quality monitoring costs are not expected to represent a large portion of total costs. For this reason, monitoring costs were not developed in this study.

Non-construction costs include engineering design, permitting and construction services. However, permitting cost could vary greatly depending on the specific conditions of a demineralization facility project. Costs do not include water quality tests, toxicity tests and negotiations or justifications with FDEP or other agencies involved in the permitting process.

It should be noted that these costs are planning-level estimates and are based on not site-specific engineering. If a site is selected for further study, the level of engineering accuracy will be better defined and the accuracy of this estimate can be improved.

The construction and O&M costs for the five concentrate management options are presented in the following tables.

Subsurface Injection

Subsurface injection costs are presented in Table 15 for the four demineralization concentrate flows of interest (2, 5, 15, and 30-MGD). These costs include the injection wells as well as the monitor wells and the wellheads. A 2 and 5-MGD injection well system only vary in cost by approximately 13 percent. This is because the 5-MGD well has only slightly larger casings than the 2-MGD well. However, as more injection wells are required, the costs increase significantly.

Assumptions for cost estimates:

- The injection well costs for the 2 and 5-MGD injection well systems were based on the cost of one well only. However, an alternative concentrate disposal method will be required for periodic maintenance and mechanical integrity testing of the injection well. Costs for this backup disposal were not calculated.
- For the 2 and 5-MGD injection well systems, one monitor well was estimated. For the 15-MGD system, two monitor wells were estimated, and for the 30-MGD system, three monitor wells were estimated.
- The cost of the injection well and monitor well wellheads does not include injection pumps, pipelines, or electrical costs.
- A total of three 5-MGD injection wells were assumed for a 15-MGD concentrate flow.
- A total of six 5-MGD injection wells were assumed for a 30-MGD concentrate flow.
- Non-construction costs and O&M costs are based on the number of wells and not on the construction cost. Non-construction cost was assumed to be approximately 45% at the low flow case down to 16% for the high flow.
- Land costs assumed that 2 acres of land are required for 2 and 5-MGD injection capacity (1 well), 10 acres for 15-MGD injection capacity (3 wells) and 20 acres for 30-MGD (6 wells) injection capacity.

Surface Water and Wetland Discharge Costs

Costs for surface water and wetland discharge would be the same in terms of construction. The costs are presented in Table 16. Depending on the length of the pipe (5, 10, or 15 miles) different pipe sizes were selected to take into account the increase of friction losses with length. This aspect is presented in the design consideration chapter. Costs increase with size and length of the pipe. Assumptions for cost estimates are as follows:

- Conventional installation of water main includes 1 jack & bore per 5 miles and one valve per mile. These costs do not include any directional drilling that may be required. For example, directional drilling could be used when crossing the Indian River as a means for protecting the seagrass beds. In addition, directional drilling could also be a cost effective approach to installing a pipeline on the bottom of the river and mitigating the seagrass bed.
- Non-construction costs include design, permitting, construction services and contingency. Non-construction costs were assumed to be 45, 40, 35 and 30% for 2, 5, 15 and 30-MGD, respectively. Whereas for surface water discharge, they were assumed to be 55, 50, 45 and 40% for open ocean discharge.
- Land costs assumed that land requirement for suburban easement are 25% of the total route length (75% of the total route length was assumed to use existing right-of-way). The required area of easement per linear foot of pipe and easement costs (land and acquisition) were based on Law Engineering Special Publication (1997) and multiplied by 1.2 to take into account the inflation from 1996 to 2002.
- O&M cost estimates are only for the aeration system. O&M costs for pipeline were assumed to be negligible.
- The annual cost was based on a life service of 50 years for the pipeline, and life service of 30 years for structure and an interest rate of 7%.
- The costs for water line and aeration were based on Law Engineering Special Publication (1997) and multiplied by 1.2 to take into account the inflation from 1996 to 2002.

Open Ocean Discharge Costs

Costs for open ocean discharge are presented in Table 17. The costs of pipeline construction in the ocean are approximately 5 times the cost of conventional pipeline construction. Costs for a 5-mile or 10-mile route are presented for coastal ocean discharge as explained in the next section. Costs for open ocean are associated with the 15-mile route since the 90 foot isobath is at least 14 miles off the shoreline. There are no land costs associated with discharge into the ocean that is within US waters. A permit from FDEP (under the Submerged Land Management Chapter) would be necessary to obtain an easement in the ocean bottom in order to install a pipeline.

In 2000 a study for Texas Water Development Board showed that the construction cost for a 42-inch pipeline for concentrate disposal using a 10 mile ocean outfall would cost approximately $50 million.

Coastal Ocean Discharge Costs

The costs associated with coastal ocean discharge are a combination of surface water discharge costs and open ocean discharge costs depending on where the concentrate discharge point is relative to the coast line and the plant. For example: for 10 miles of pipeline constructed inland, refer to surface water costs, and for 5 miles of pipeline installed in the bottom of the ocean, refer to open ocean costs.

Economic Summary

The open ocean demineralization concentrate management option is the most expensive option, the subsurface injection is the second most expensive disposal method. Surface water and marine wetland disposal are the least costly methods. However, a site-specific study is necessary to obtain a more accurate cost estimate for each option, and the ranking of the different options based on cost may be changed due to some conditions specific to a project.

Table 15. Subsurface injection cost estimates

Concentrate Discharge Capacity	Construction Costs: Injection Well	Monitor Well	Wellhead	Non-construction Cost	Land Acquisition Cost[1]	Total Cost	O&M Cost	Equivalent Annual Cost
MGD	$	$	$	$	$	$	$/year	$/year
2	1,600,000	600,000	100,000	1,000,000	40,000	3,340,000	50,000	280,000
5	1,900,000	600,000	100,000	1,000,000	40,000	3,640,000	50,000	310,000
15	5,100,000	1,200,000	300,000	1,500,000	200,000	8,300,000	100,000	730,000
30	9,900,000	1,800,000	600,000	2,000,000	400,000	14,700,000	150,000	1,330,000

(1) Law Engineering (1997).

Table 16. Preliminary Construction Costs for Surface Water and Wetland Discharge

Concentrate Discharge Capacity	ADF	Pipe Diameter	Installation Distance	Construction Costs: Pipe Install(1)	Construction Costs: Outfall Structure	Construction Costs: Treatment Aeration(1)	Non-construction Cost	Land Acquisition Cost(1)	Total Cost	O&M Cost	Equivalent Annual Cost
MGD	MGD	inch	miles	$	$	$	$	$	$	$/year	$/year
2	1.3	12	5	1,060,000	300,000	180,000	700,000	270,000	2,510,000	10,000	190,000
5	3.3	16	5	1,460,000	400,000	340,000	880,000	270,000	3,340,000	10,000	260,000
15	10.0	30	5	3,040,000	700,000	680,000	1,550,000	350,000	6,310,000	20,000	480,000
30	20.0	36	5	3,750,000	1,000,000	960,000	1,720,000	350,000	7,780,000	30,000	610,000
2	1.3	16	10	2,910,000	300,000	180,000	1,530,000	530,000	5,450,000	10,000	400,000
5	3.3	20	10	3,860,000	400,000	340,000	1,840,000	530,000	6,970,000	10,000	520,000
15	10.0	30	10	6,080,000	700,000	680,000	2,610,000	700,000	10,760,000	20,000	800,000
30	20.0	42	10	8,820,000	1,000,000	960,000	3,240,000	870,000	14,890,000	30,000	1,120,000
2	1.3	16	15	4,360,000	300,000	180,000	2,180,000	790,000	7,810,000	10,000	570,000
5	3.3	20	15	5,790,000	400,000	340,000	2,610,000	790,000	9,920,000	10,000	730,000
15	10.0	30	15	9,110,000	700,000	680,000	3,670,000	1,050,000	15,200,000	20,000	1,120,000
30	20.0	42	15	13,230,000	1,000,000	960,000	4,560,000	1,310,000	21,060,000	30,000	1,560,000

ADF: Average Daily Flow
(1) Law Engineering (1997).

Table 17. Preliminary Construction Costs for Open Ocean Discharge

Concentrate Discharge Capacity	ADF	Pipe Diameter	Installation Distance	Construction Costs: Pipe Install[1]	Construction Costs: Outfall Structure	Construction Costs: Treatment Aeration[1]	Non-construction Cost	Total Cost	O&M Cost	Equivalent Annual Cost
MGD	MGD	inch	miles	$	$	$	$	$	$/year	$/year
2	1.3	12	5	7,920,000	1,000,000	180,000	5,010,000	14,110,000	10,000	1,030,000
5	3.3	16	5	8,880,000	1,200,000	340,000	5,210,000	15,620,000	10,000	1,140,000
15	10.0	30	5	12,680,000	1,500,000	680,000	6,680,000	21,530,000	20,000	1,580,000
30	20.0	36	5	15,210,000	1,850,000	960,000	7,210,000	25,230,000	30,000	1,870,000
2	1.3	16	10	17,750,000	1,000,000	180,000	10,410,000	29,340,000	10,000	2,120,000
5	3.3	20	10	19,650,000	1,200,000	340,000	10,590,000	31,770,000	10,000	2,300,000
15	10.0	30	10	25,350,000	1,500,000	680,000	12,390,000	39,910,000	20,000	2,900,000
30	20.0	42	10	34,540,000	1,850,000	960,000	14,940,000	52,290,000	30,000	3,810,000
2	1.3	16	15	26,620,000	1,000,000	180,000	15,290,000	43,090,000	10,000	3,100,000
5	3.3	24	15	29,470,000	1,200,000	340,000	15,510,000	46,520,000	10,000	3,360,000
15	10.0	36	15	38,020,000	1,500,000	680,000	18,090,000	58,280,000	20,000	4,220,000
30	20.0	42	15	51,800,000	1,850,000	960,000	21,850,000	76,460,000	30,000	5,540,000

ADF: Average Daily Flow
(1) Law Engineering (1997).

SUMMARY

In summary, there are numerous options to manage demineralization concentrate. The alternatives evaluated in the GIS-based screening process represent the most pertinent to SJRWMD and the state of Florida at this time. These alternatives have been screened for relative suitability based on macro-level screening criteria. In addition, the relative economics associated with each alternative are of particular importance and have been presented.

As identified herein, there is a secondary set of options to manage demineralization concentrate such as brine concentrators and generation of sodium hypochlorite. While these were not deemed of highest suitability, it is important that research continue in methods to manage demineralization concentrate and, in particular, methods that involve a beneficial use.

One alternative is to utilize demineralization concentrate to offset the decreased salinity of marine environments resulting from increased, fresh stormwater runoff associated with development and reductions in pervious areas.

It is recommended that the state of Florida conduct a comprehensive salinity balance assessment, similar to states in the southwest US, to ensure that the effect of mankind on the natural salinity balance in Florida's environment is minimized.

Of most importance to this regional planning effort, the information generated in this section was integrated with known source waters within the SJRWMD boundary to determine potential WTP sites with both an available water source and a highly suitable demineralization concentrate management alternative, as presented in subsequent sections.

HIGH SUITABILITY DEMINERALIZATION WTP SITES

Areas of highest suitability to site a demineralization water treatment plant were developed based on the results of the screenings of source waters and demineralization concentrate management alternatives presented previously. This information was integrated using GIS analysis to develop graphical representations of areas of suitability, based on the criteria identified herein, for the 19-county SJRWMD area.

Source waters and management alternatives were integrated based on a 15-mile proximity criterion. The resulting areas represent potential water treatment plant sites. Within these areas, a water treatment plant could be sited and would require a total pipe length of no more than 15 miles to accommodate both raw water transmission piping and demineralization concentrate transmission piping.

This 15-mile criterion was developed based on the economic feasibility of projects and the impact of raw water and demineralization concentrate pipe lengths. This 15 mile threshold is consistent with the threshold utilized in Tampa Bay Water's demineralization investigations, the SJRWMD Seawater Demineralization Siting study and other economic sensitivity evaluations. While project-specific economic factors would define the particular lengths of piping which may be required before making a project unfeasible, this criterion is consistent with other studies and is considered appropriate for this macro-level analysis.

In addition, each demineralization concentrate management alternative was assessed based on flows of 2, 5, 15 and 30-MGD, corresponding to the range of flows expected from demineralization WTPs with capacities of 5, 15, 25, and 50-MGD.

A generalization of the algorithm to develop the potential demineralization WTP sites is as follows:

- Source water within 15 miles of the receiving water body that meets regulatory, technical and environmental criteria.

All GIS algorithms are presented in Appendix E.

The areas not shown as high suitability areas do not meet criteria defined in this study. However, an area that is not designated as a high suitability area may still result in the siting of a demineralization facility, if demineralization concentrate management is addressed through permitting relief mechanisms or for other extenuating reasons.

The following sections are organized by demineralization concentrate management alternative. Each alternative is assessed for the three different water sources.

SUBSURFACE INJECTION

The following subsections present areas of high suitability for locating demineralization facilities that utilize one of the three alternative source waters and subsurface injection of demineralization concentrate. This analysis was conducted for the Lower Floridan aquifer since this was deemed the most suitable for subsurface injection.

Note that determination of high suitability areas for subsurface injection is independent of the quality of the concentrate. As explained in the previous chapter, suitability depends on the hydrogeology of the subsurface and concentrate flow. Therefore, individual maps representing various source water TDS concentrations are not necessary or pertinent to subsurface injection.

In addition, it was previously determined that varying demineralization concentrate flows between 2, 5, 15 and 30-MGD had no impact on the areas deemed to be highly suitable for subsurface injection. Therefore, the results presented in the following subsections are applicable for flows between 2 and 30-MGD.

Groundwater Source

High suitability areas for siting of a demineralization WTP that uses a brackish groundwater source and subsurface injection of demineralization concentrate were determined using the 15 mile proximity criterion. Figure 24 presents the high suitability areas for any injection rate from 2 to 30-MGD. These areas are located south of Merritt Island, and are areas mainly within the Indian River and Brevard counties .

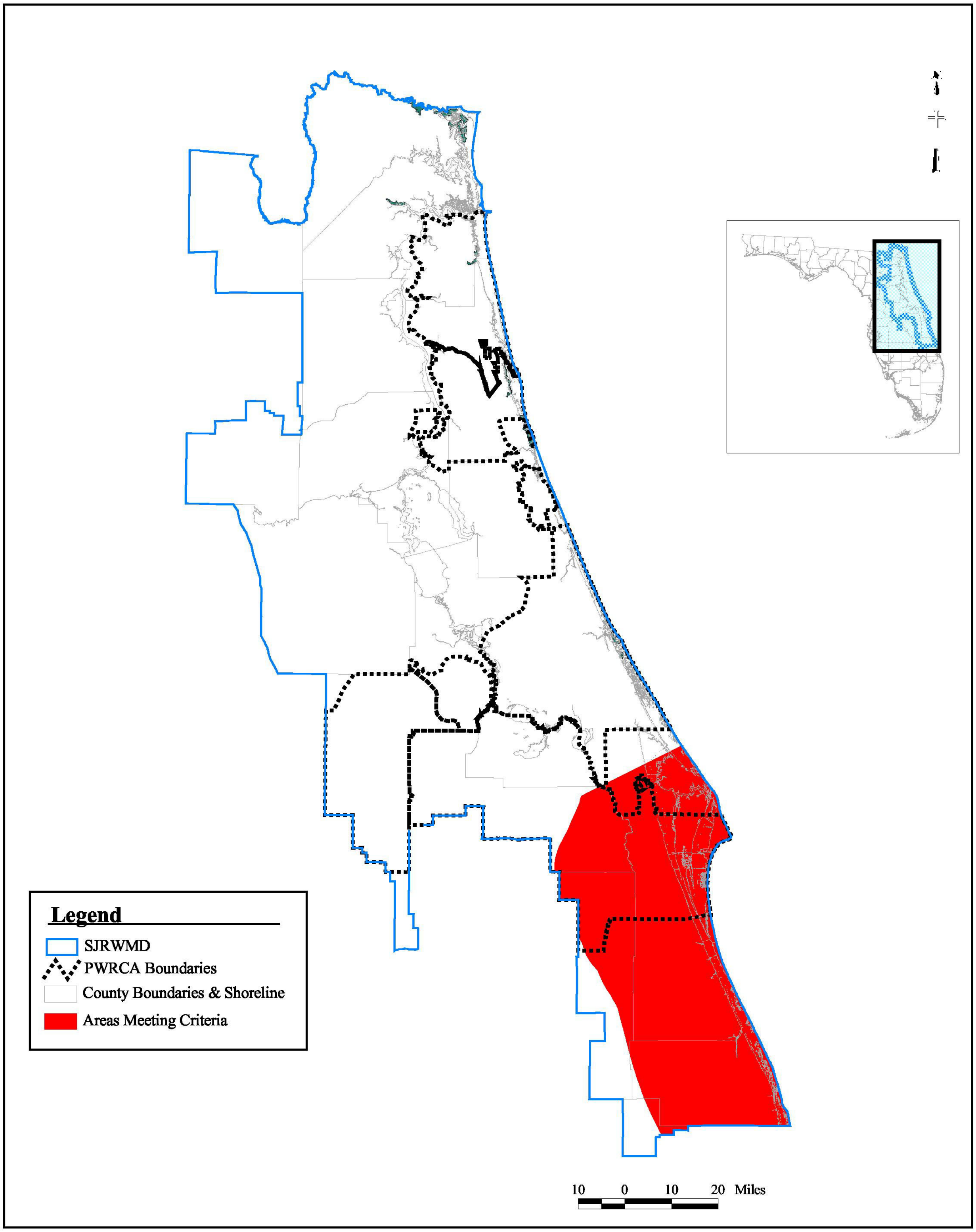

Figure 24. Subsurface Injection in Conjunction with Groundwater Source

Surface Water Source

High suitability areas for siting of a demineralization WTP that uses a brackish surface water source and subsurface injection of demineralization concentrate were determined using the 15 mile proximity criterion. Figure 25 presents the high suitability areas for any injection rate from 2 to 30-MGD. These areas are also located south of Merritt Island, and are mainly within the Indian River and Brevard counties.

Seawater Source

High suitability areas for siting of a demineralization WTP that uses seawater as a source and subsurface injection of demineralization concentrate were determined using the 15-mile-proximity criterion. Figure 26 resents the high suitability areas for any injection rate from 2 to 30-MGD. These areas consist of a strip of land 15 miles deep along the shoreline from Merritt Island to the southern end of SJRWMD.

The areas where a demineralization plant cannot be located are areas where the TDS concentration in the Lower Floridan aquifer is less than 10,000 mg/L and empirical criteria was not available to demonstrate appropriate confinement within the Lower Floridan aquifer based on the presence of previously permitted injection wells. These areas are located in the northern part of SJRWMD from Merrit Island and west of the St. Johns River.

SURFACE WATER DISCHARGE

The following subsections present areas of high suitability for locating a demineralization facility that is utilizing each of the three alternative source waters and surface water discharge of demineralization concentrate. For this project, the available surface waters were deemed to be the St. Johns River and the Intracoastal Waterway.

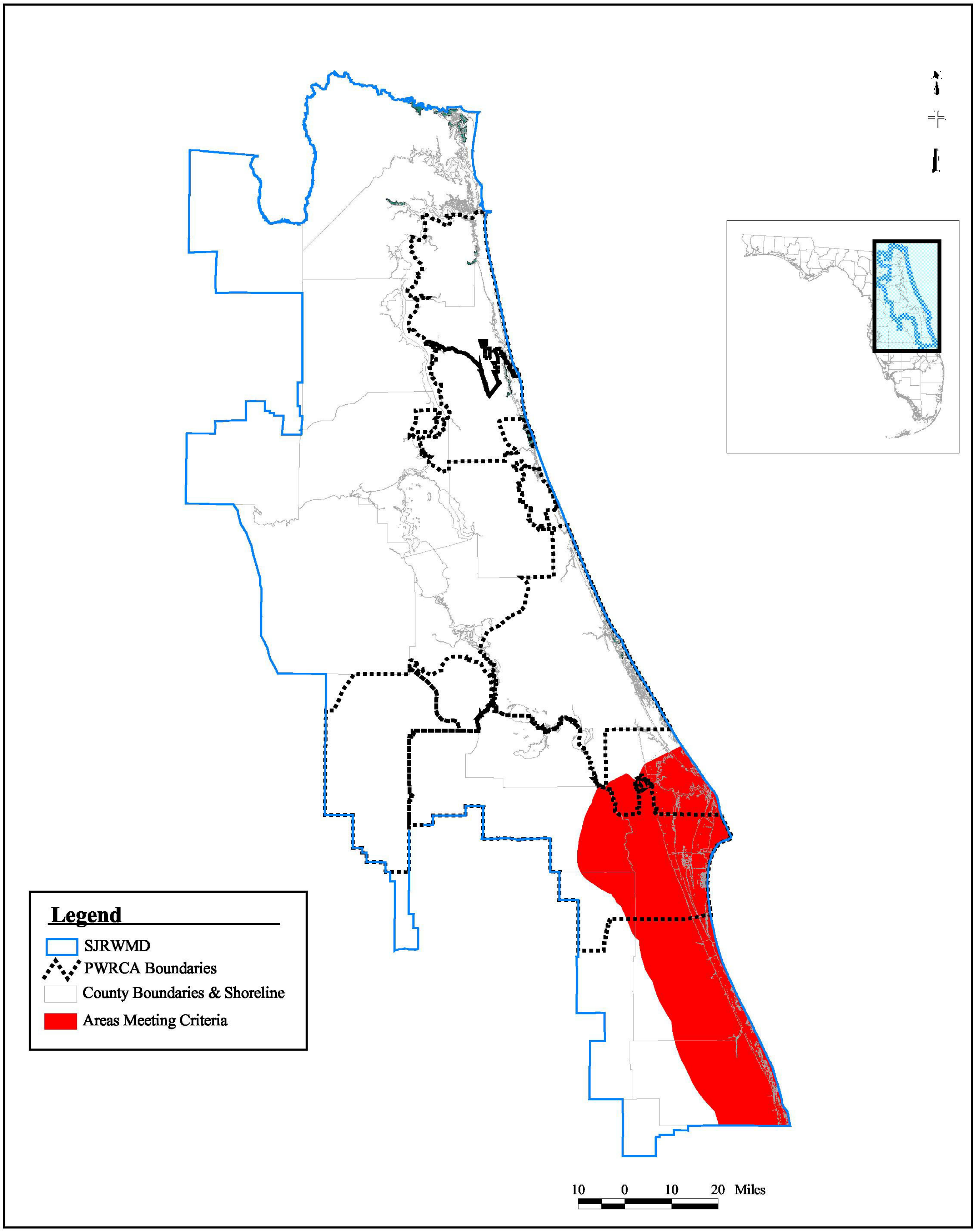

Figure 25. Subsurface Injection in Conjunction with Surface Water Source

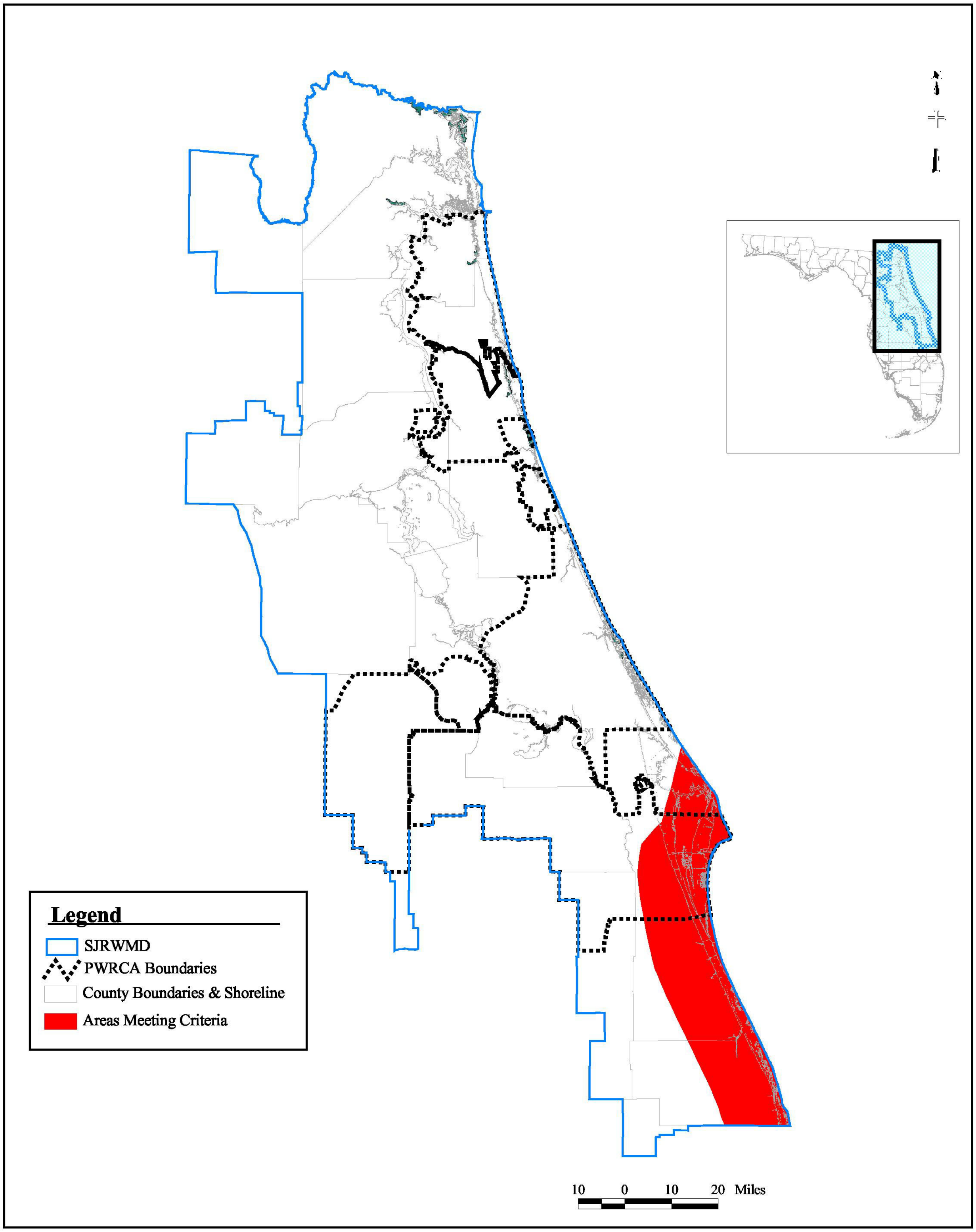

Figure 26. Subsurface Injection in Conjunction with Seawater

Note that selection of high suitability areas for surface water discharge is dependent on water quality of the demineralization concentrate. The water quality of demineralization concentrate is dependent upon source water quality. As described previously, the four source water TDS ranges (500 – 1,000, 1,000 – 3,000, 3,000 – 10,000, and 10,000 – 34,000) where converted to expected demineralization concentrate TDS concentrations. From these ranges, values of 5,000, 15,000, 30,000, and 68,000 mg/L were selected as conservative water quality criteria for comparison to receiving water body TDS concentrations.

As would be expected, there is no surface water body identified as highest suitability for receipt of demineralization concentrate from a source with TDS concentrations between 10,000 and 34,000 mg/L. This type of source water would result in demineralization concentrate TDS of up to 68,000 mg/L. This is well above the maximum surface water TDS concentration of 34,000 mg/L, therefore does not meet the high suitability criteria for TDS. As a result, dilution with power plant cooling water and wastewater effluent was also considered. Neither alternative was deemed highly suitable. A more detailed discussion is presented at the end of this surface water section, because this issue is common to all three source waters.

It was determined previously that the surface waters in SJRWMD have adequate base flows to accommodate introduction of demineralization concentrate flows of 2 to 30-MGD. Therefore the results presented in the following subsections are applicable for demineralization concentrate flows between 2 and 30-MGD.

Groundwater Source

High suitability areas for siting of a demineralization WTP that uses a brackish groundwater source and surface water discharge of demineralization concentrate are presented for each of the four ranges of source water TDS in Figures 27 to 29. The high suitability areas are located mainly on the coast, where available brackish surface waters for concentrate discharge are within 15 miles of brackish groundwater sources. The high suitability areas become smaller as the source water TDS and demineralization concentrate TDS increases. Note that there are no areas identified for receipt of concentrate associated with a brackish groundwater with TDS concentration between 10,000 and 30,000 mg/L.

Surface Water Source

High suitability areas for siting of a demineralization WTP that uses a brackish surface water source and surface water discharge of demineralization concentrate are presented for each of the four ranges of source water TDS in Figures 30 to 32. The high suitability areas are located in the Jacksonville area and the Cape Canaveral area, where available brackish surface waters for concentrate discharge are within reasonable distance of less brackish surface water sources. Note that there are no areas identified for receipt of demineralization concentrate associated with a brackish surface water with TDS concentration between 10,000 and 30,000 mg/L.

Seawater source

Seawater demineralization will produce a demineralization concentrate with a TDS concentration on the order of 68,000 mg/L. This is greater than the maximum TDS concentration in the St. Johns River or the Intracoastal Waterway which reaches 34,000 mg/L. Therefore, no areas along the St. Johns River or the Intracoastal Waterway meet the high suitability criteria defined for this project for receipt of demineralization concentrate from a seawater source. Dilution with other streams can provide benefit to certain projects as discussed in the next section.

Dilution Options

Dilution options include blending with WWTP effluent and with power plant cooling water. Based on the available data for WWTPs within SJRWMD, there are no WWTPs with enough effluent flow to blend with demineralization concentrate and meet the blended TDS standard of 500 mg/L for effluent discharge to waters of the state. However, in the event a WWTP discharges to a saline portion of the St. Johns River or the Intracoastal Waterway, the benefit of the facility might render that location highly desirable.

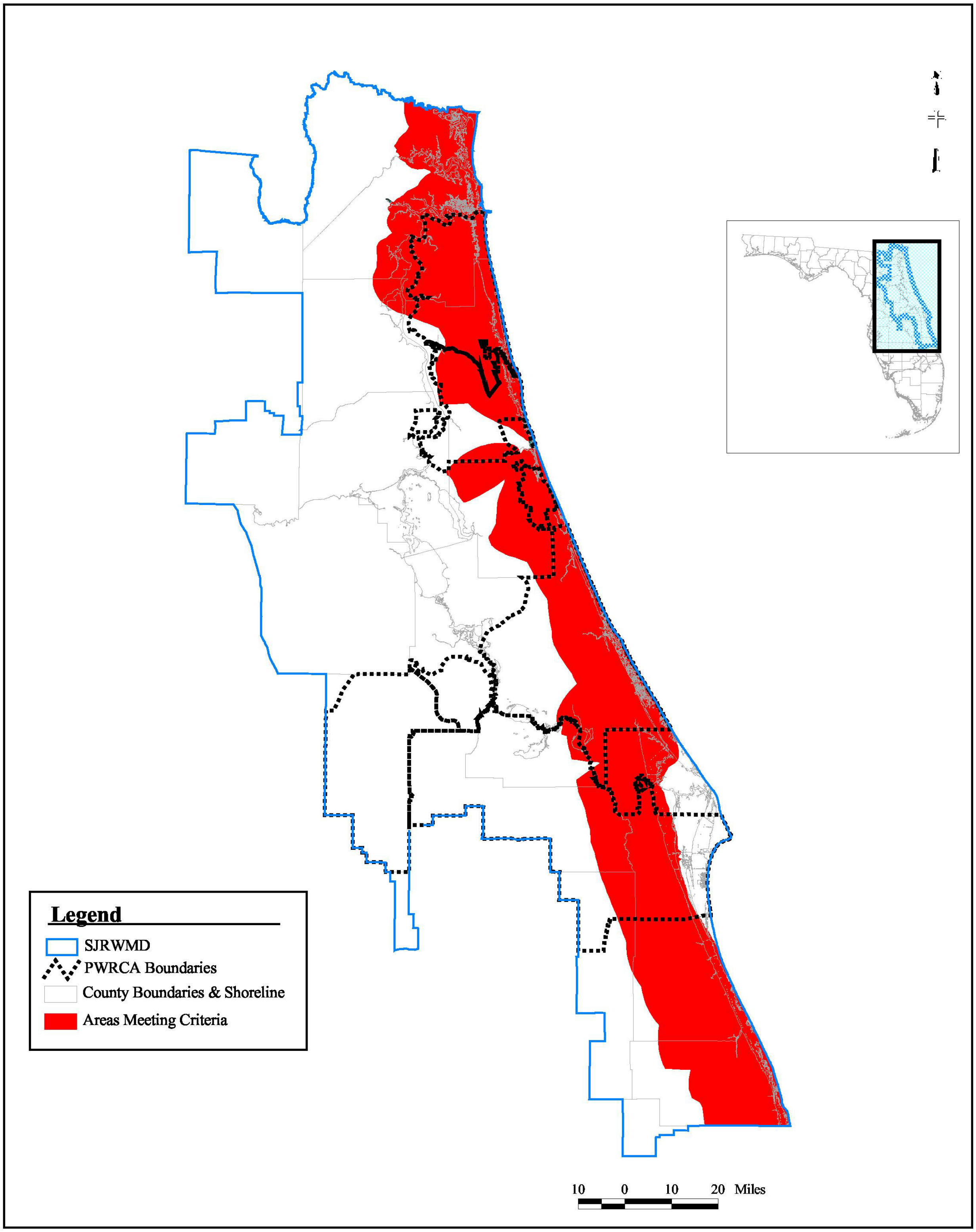

Figure 27. Surface Water Discharge in Conjunction with Groundwater Source (500-1,000 mg/L)

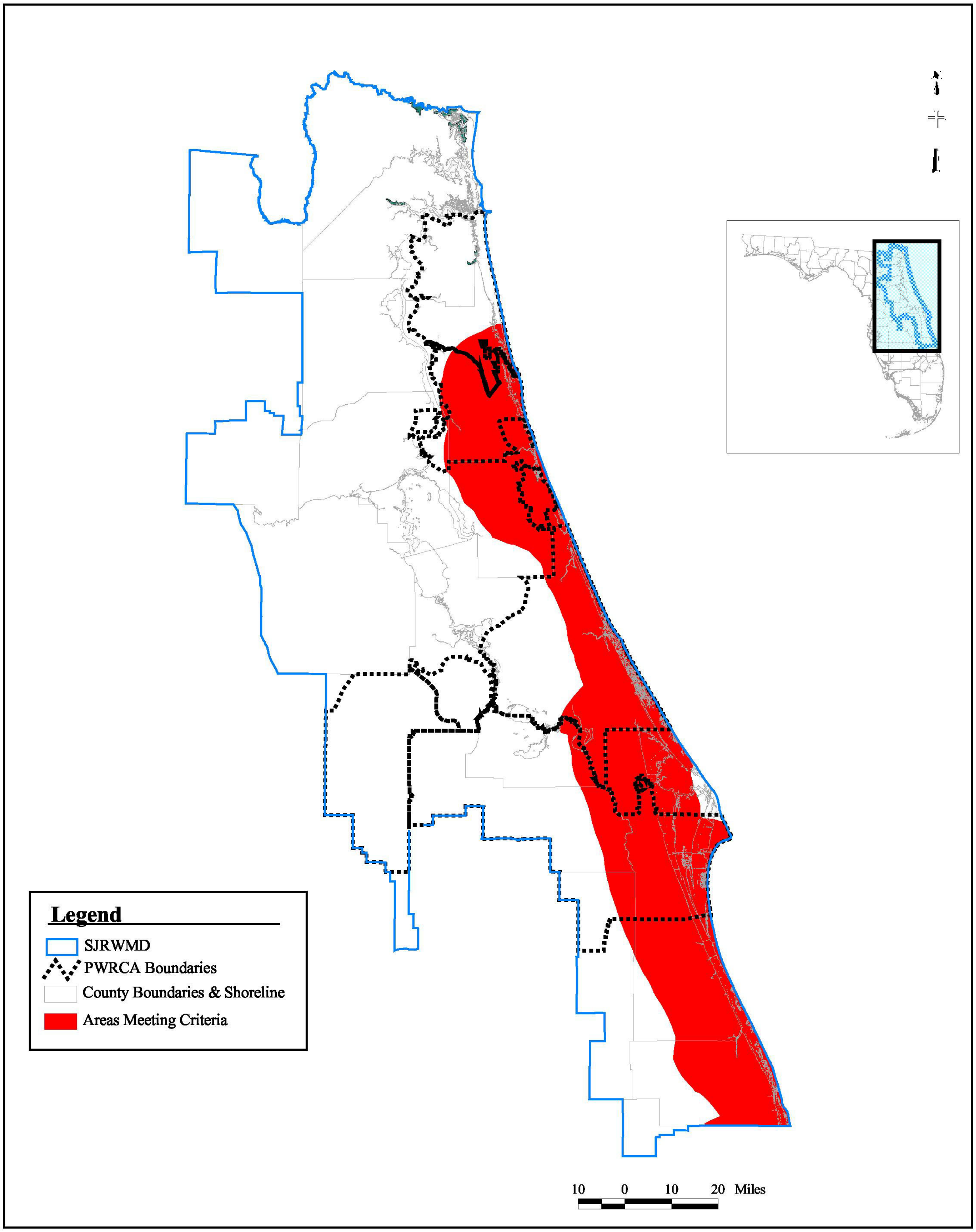

Figure 28. Surface Water Discharge in Conjunction with Groundwater Source (1,000-3,000 mg/L)

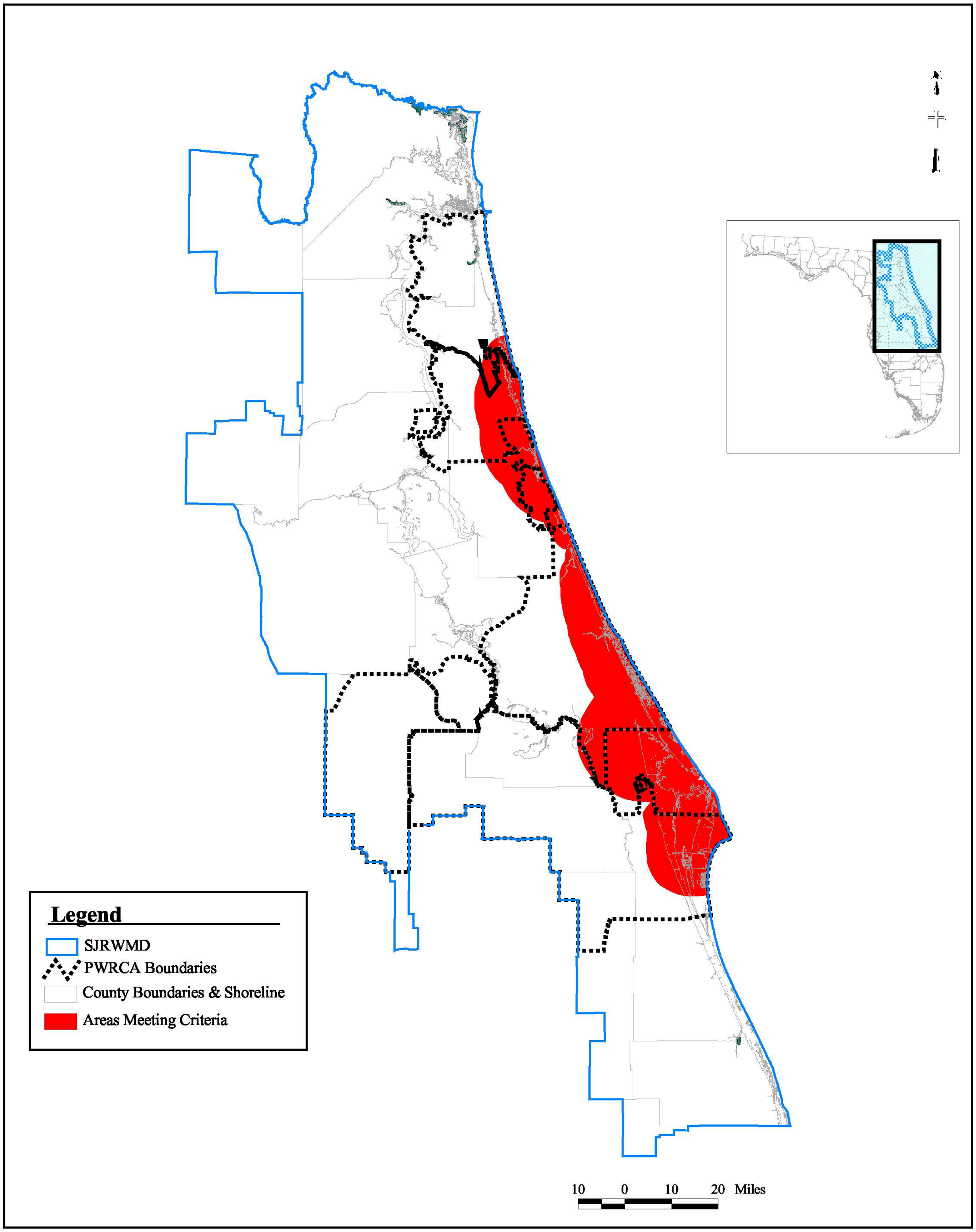

Figure 29. Surface Water Discharge in Conjunction with Groundwater Source (3,000-10,000 mg/L)

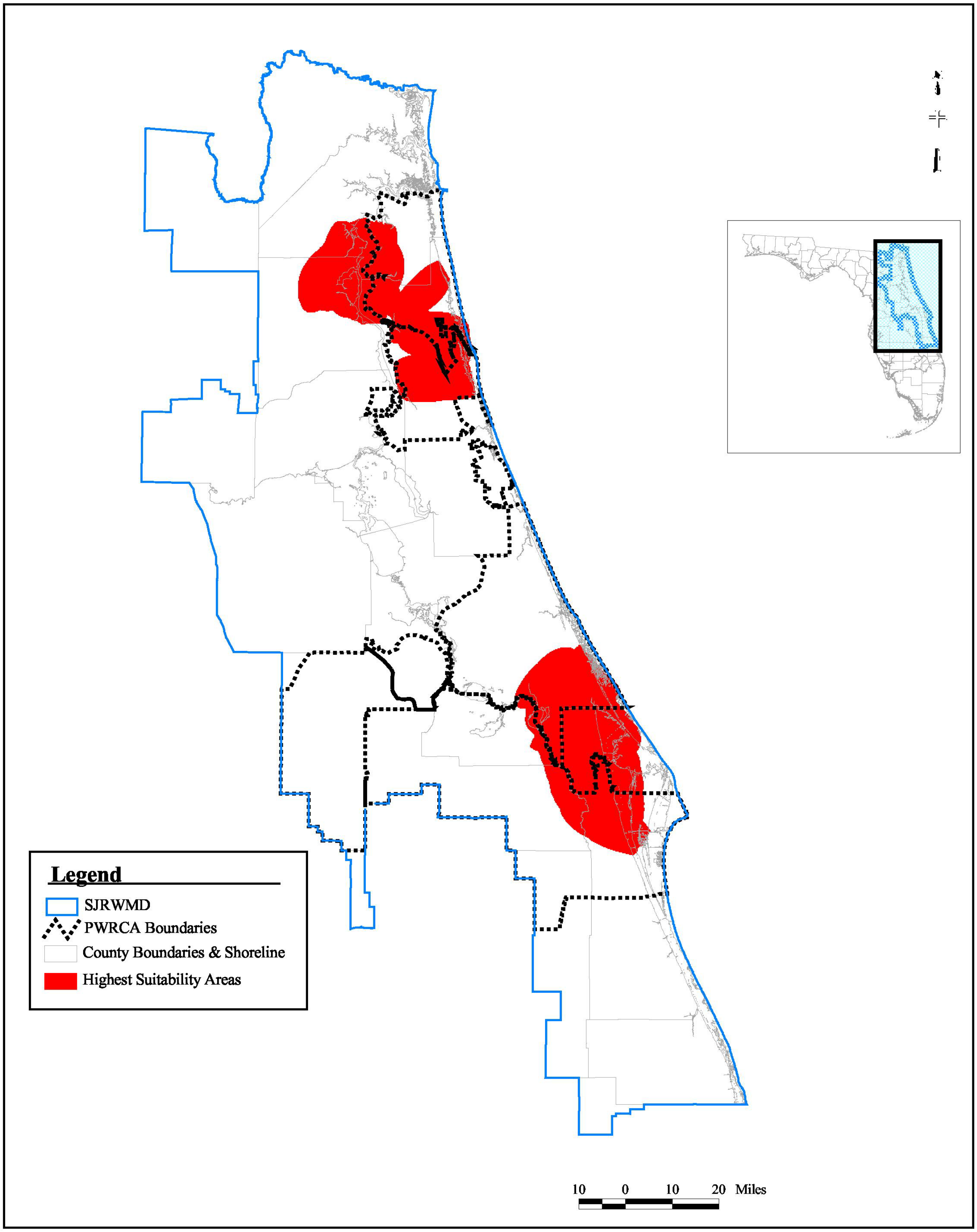

Figure 30. Surface Water Discharge in Conjunction with Surface Water Source (500 - 1,000 mg/L)

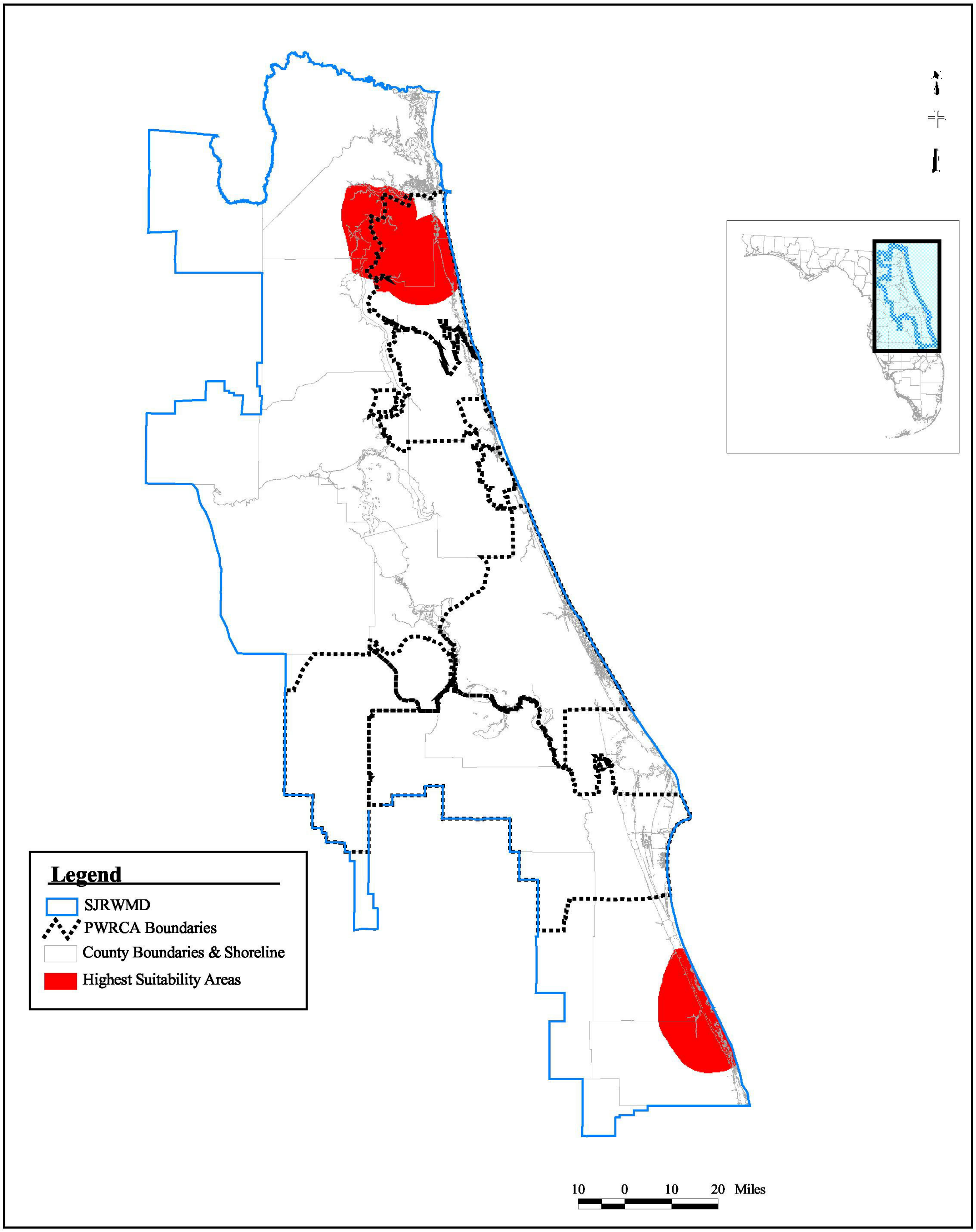

Figure 31. Surface Water Discharge in Conjunction with Surface Water Source (1,000 - 3,000 mg/L)

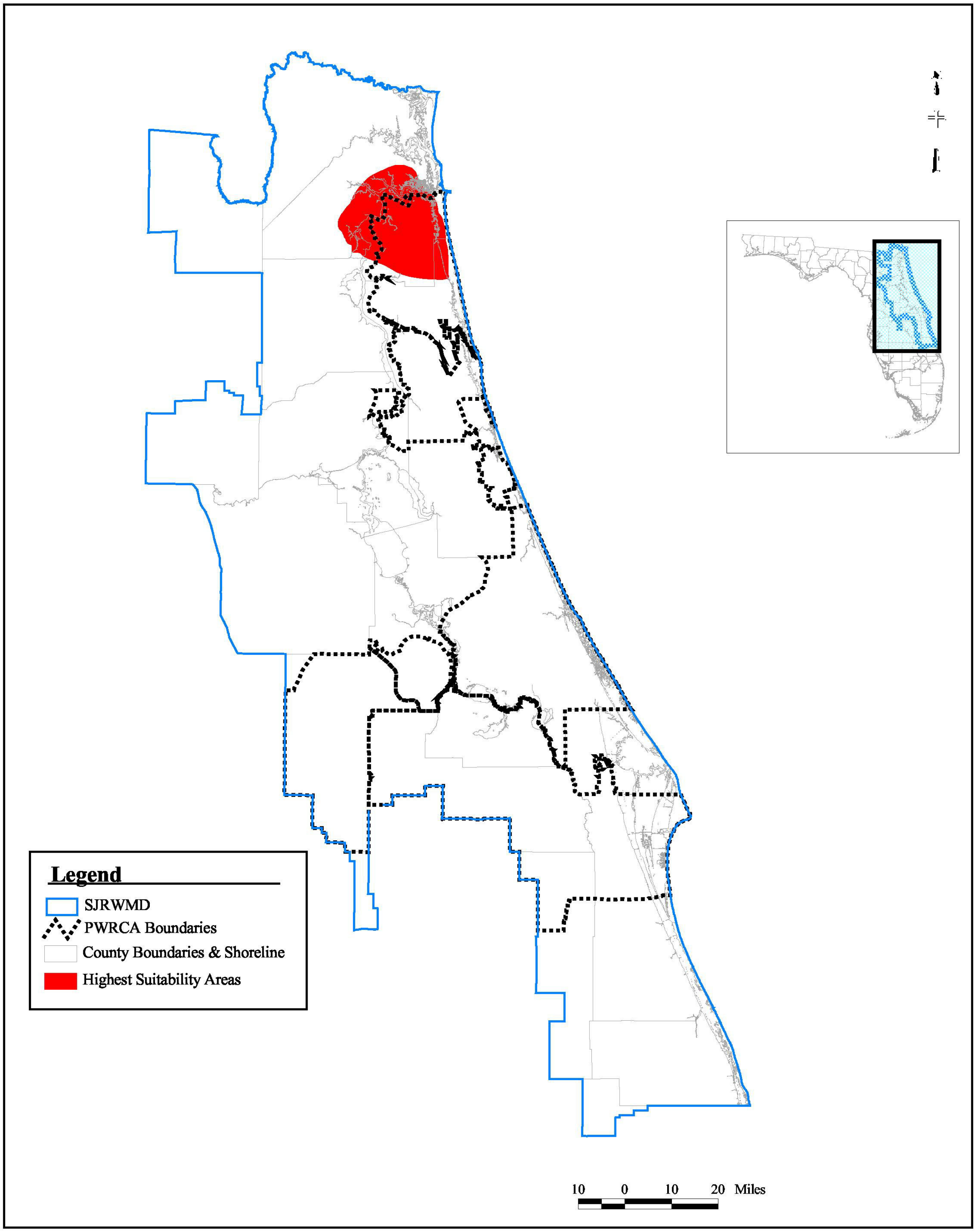

Figure 32. Surface Water Discharge in Conjunction with Surface Water Source (3,000 - 10,000 mg/L)

Blending demineralization concentrate with power plant cooling water can also minimize the impact of high TDS concentrations. For this reason, all existing power plants within SJRWMD were investigated to determine the presence of a once-through cooling water system and the flows utilized. A total of four facilities were identified and all discharge to the Intracoastal Waterway, therefore all four fall under this surface water section of DCMP. Cooling water TDS concentration for all four of these facilities averages approximately 25,000 mg/L.

An analysis was conducted to determine the ability for these four power plant facilities to dilute 68,000 mg/L demineralization concentrate (i.e. from a seawater source). Results are presented in Table 18. As shown, a net increase in the TDS of a blended water stream would occur in all cases and would range from 0.4 to 27 percent.

Table 18. TDS Increase by Dilution with Seawater

Power Plant	Vero Beach Municipal	Indian River	Cape Canaveral	Northside
Cooling Water TDS (mg/L)	25,000	25,000	25,000	25,000
Cooling Water Flow (MGD)	160	310	500	806
Concentrate TDS (mg/L)	68,000	68,000	68,000	68,000
Concentrate Flow (MGD)	2	2	2	2
Blend TDS	25,531	25,276	25,171	25,106
TDS Increase	2.12%	1.10%	0.69%	0.43%
Concentrate Flow (MGD)	5	5	5	5
Blend TDS	26,303	25,683	25,426	25,265
TDS Increase	5.21%	2.73%	1.70%	1.06%
Concentrate Flow (MGD)	15	15	15	15
Blend TDS	28,686	26,985	26,252	25,786
TDS Increase	14.74%	7.94%	5.01%	3.14%
Concentrate Flow (MGD)	30	30	30	30
Blend TDS	31,789	28,794	27,434	26,543
TDS Increase	27.16%	15.18%	9.74%	6.17%

A TDS increase of only 0.5 percent in the receiving water due to blending with high TDS content concentrate is low, however, the demineralization concentrate permitting history associated with the

25-MGD Tampa Bay Water demineralization facility clearly shows that obtaining approval for any increase in TDS concentration can be very time consuming, and costly and may not be assured. For this reason, increases in TDS are not deemed highly suitable for this project but may be an unavoidable condition in certain future projects within SJRWMD. Those projects should be balanced and compared with the alternate approaches defined herein which do not result in an increase in TDS.

The lowest suitability areas for locating a demineralization plant with a surface water discharge in SJRWMD are areas where only OFWs would be available for surface water discharge. These waters could technically be available for surface water discharge but the concentrate quality would have to meet all surface water standards and meet background water quality of the surface water without any exceptions. Compliance with this criterion would most likely be improbable, without any relief mechanisms from the surface water discharge regulations.

Lastly, it should be noted that the TDS criterion (TDS of concentrate less than TDS of receiving water body) was selected because it represents a condition that supports issuance of a permit and minimizes public concerns regarding the environment. However, note that fresh storm water runoff to marine environments has increased over time as a result of development and can depress the natural salinity of a marine environment. Therefore, demineralization concentrate could represent a resource to mitigate some of the freshening of marine environments in Florida. However, regulations are such that concentrate generally must be fresher than the receiving water body, therefore this opportunity to mitigate depressed salinity from fresh storm water runoff is not realized.

COASTAL OCEAN DISCHARGE

The following subsections present areas of highest suitability for locating a demineralization facility for each of the three alternative source waters and coastal ocean discharge of demineralization concentrate. For this project, the available coastal waters were deemed to be seaward of SJRWMD's Atlantic coastline up to the 90-foot isobath.

For each source water quality, suitability areas were determined using the 15-mile criterion and the criteria for coastal ocean discharge described in the previous sections.

As with the inland surface waters, selection of high suitability areas for coastal ocean discharge is dependent on the water quality of the demineralization concentrate. Given that coastal ocean TDS concentration does not vary significantly and is on the order of 34,000 mg/L, a single threshold was established consisting of demineralization concentrate less than 34,000 mg/L. This is consistent with the TDS criterion (demineralization concentrate TDS less than receiving water body).

For demineralization concentrate with TDS concentration greater than 34,000 mg/L, the coastal ocean was not identified as highest suitability. This corresponds to source waters with TDS concentration between 10,000 and 34,000 mg/L. Dilution with power plant cooling water and wastewater effluent is not an option since there are no facilities discharging to the coastal ocean.

As a result, the following sections present areas of highest suitability which correspond to source waters with TDS concentration less than 10,000 mg/L.

The coastal ocean was determined to have adequate base flow and volume to accommodate introduction of demineralization concentrate flows of 2 to 30-MGD. Therefore, the results presented in the following subsections are applicable for demineralization concentrate flows between 2 and 30-MGD.

Groundwater Source

High suitability areas for siting of a demineralization WTP that uses a brackish groundwater source and coastal discharge of demineralization concentrate are presented in Figure 33. This includes all Upper Floridan brackish groundwater with TDS concentration between 500 and 10,000 mg/L. In this scenario, locating a demineralization plant within 15 miles of the shoreline is feasible in most coastal areas. However, areas could be limited near Cape Canaveral due to the presence of seagrass beds in the Intracoastal Waterway that would have to be crossed for piping from the plant to the ocean.

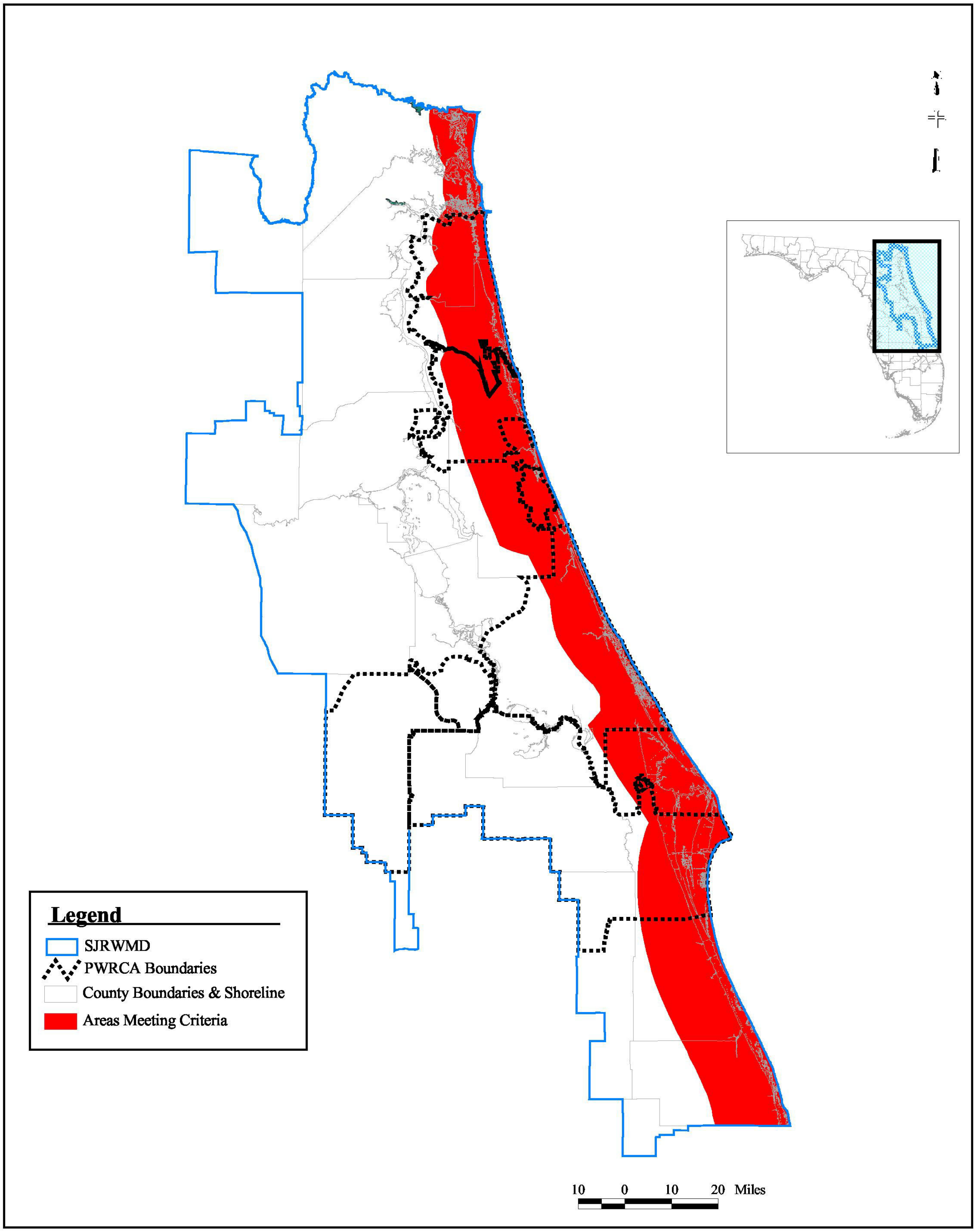

Figure 33. Coastal Ocean Discharge in Conjunction with Groundwater Source

Surface Water Source

High suitability areas for coastal ocean discharge using surface water with TDS concentration up to 10,000 mg/L as a source are presented in Figure 34. In this scenario, locating a demineralization plant within 15 miles of the shoreline is feasible only in the Jacksonville area and the south end of SJRWMD. In these areas there are portions of the St. Johns River or Intracoastal Waterway with an average TDS concentration of less than 10,000 mg/L that are within 15 miles of the coastal ocean (with average TDS concentration of 34,000 mg/L).

Seawater Source

Seawater demineralization will produce a concentrate TDS concentration of 68,000 mg/L, higher than that of the coastal ocean, and therefore it does not meet the TDS criterion for being discharged to coastal ocean. Certainly there are seawater demineralization facilities in existence world-wide which discharge to coastal ocean. Similar facilities may, in fact, be built within SJRWMD. This decision would occur through weighing all factors associated with selection of a project, including but not limited to the issue of demineralization concentrate management. It is possible that the issue of discharging a high TDS demineralization concentrate to lower TDS coastal ocean is outweighed by other advantages associated with such a demineralization facility. However for the purposes of DCMP, there are alternate approaches for management of demineralization concentrate from a seawater source which will more readily meet the selected screening level criteria (such as subsurface injection or discharge to inland surface waters following dilution with cooling water from one of the four power plants). These should be given consideration due to their higher suitability.

The lowest suitability areas for coastal ocean discharge are inland areas. Discharge to the coastal ocean is technically feasible, however, the cost associated with piping from inland areas to the ocean might be too prohibitive to be considered as a high feasibility option.

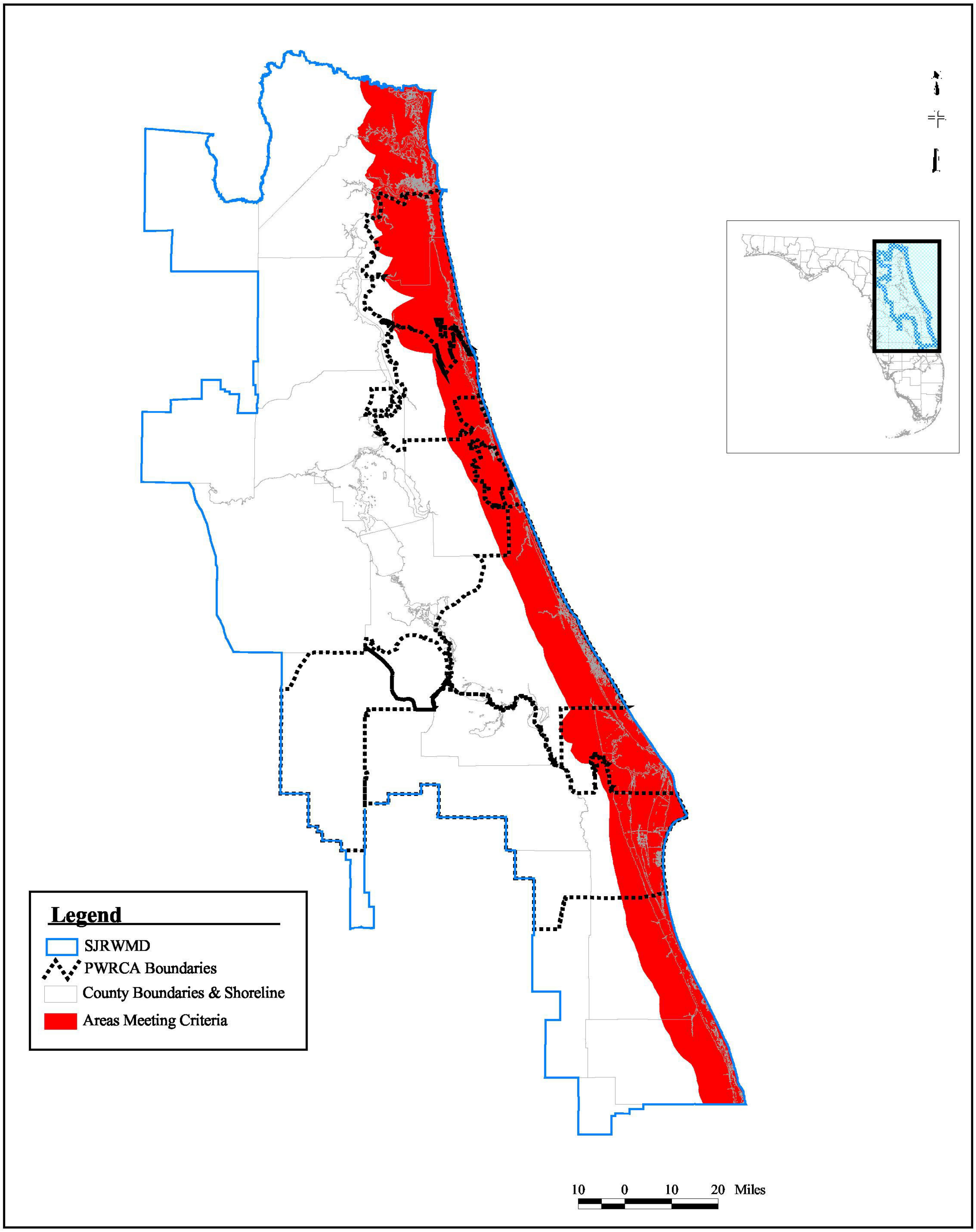

Figure 34. Coastal Ocean Discharge in Conjunction with Surface Water Source

OPEN OCEAN DISCHARGE

The following subsections present areas of highest suitability for locating a demineralization facility for each of the three alternative source waters and open ocean discharge of demineralization concentrate. Open waters are those seaward of the 90-foot isobath.

For each source water quality, high suitability areas were determined using the 15-mile criterion and the criteria for open ocean discharge described in the previous sections.

Unlike inland surface waters and coastal ocean waters, the TDS of demineralization concentrate is not used as a screening criterion given the 20 to 1 dilution allowed by FDEP regulations for open ocean discharge. Therefore, all source waters with TDS concentration greater than 500 mg/L were considered highly suitable, in terms of TDS.

The open ocean was determined to have adequate base flow and volume to accommodate introduction of demineralization concentrate flows of 2 to 30-MGD. Therefore, the results presented in the following subsections are applicable for demineralization concentrate flows between 2 and 30-MGD.

Groundwater Source

High suitability areas for siting of a demineralization WTP that uses a brackish groundwater source with a TDS concentration greater than 500 mg/L and open ocean discharge of demineralization concentrate are presented in Figure 35. This represents areas where sites are within 15 miles of the 90’ isobath. The suitability areas are located in the southern end of SJRWMD and in the Cape Canaveral area.

Surface Water Source

The areas where sites are within 15 miles of the 90-foot isobath using any surface water with TDS concentration higher than 500 mg/L are presented in Figure 36. Suitable areas for locating a demineralization plant within 15 miles of the 90 foot isobath are in the southern end of SJRWMD. The Intracoastal Waterway in the Cape Canaveral area is a potential surface water source, which was not deemed highly suitable due to its OFW classification and/or the presence of seagrass or other environmentally sensitive conditions.

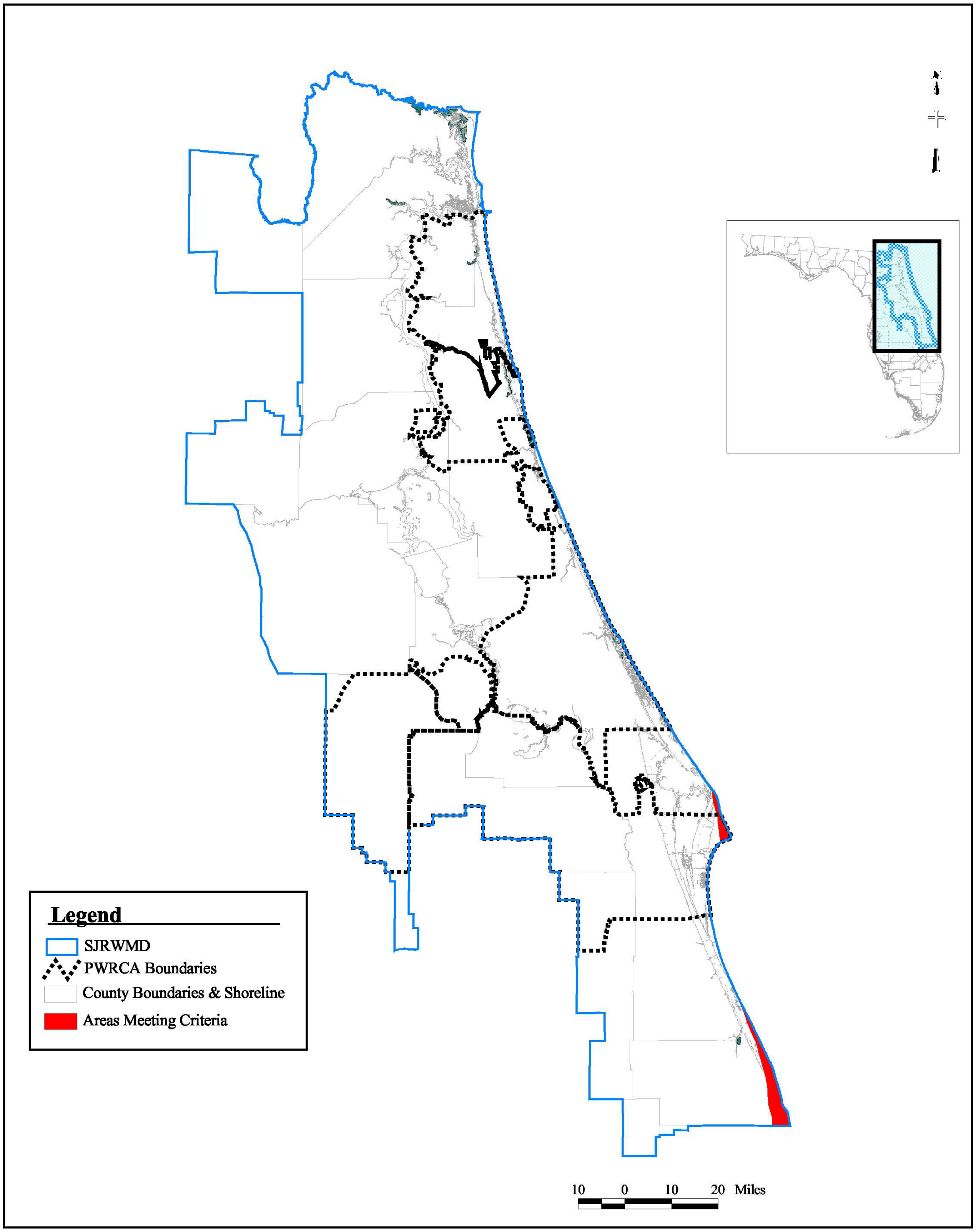

Figure 35. Open Ocean Discharge in Conjunction with Groundwater Source

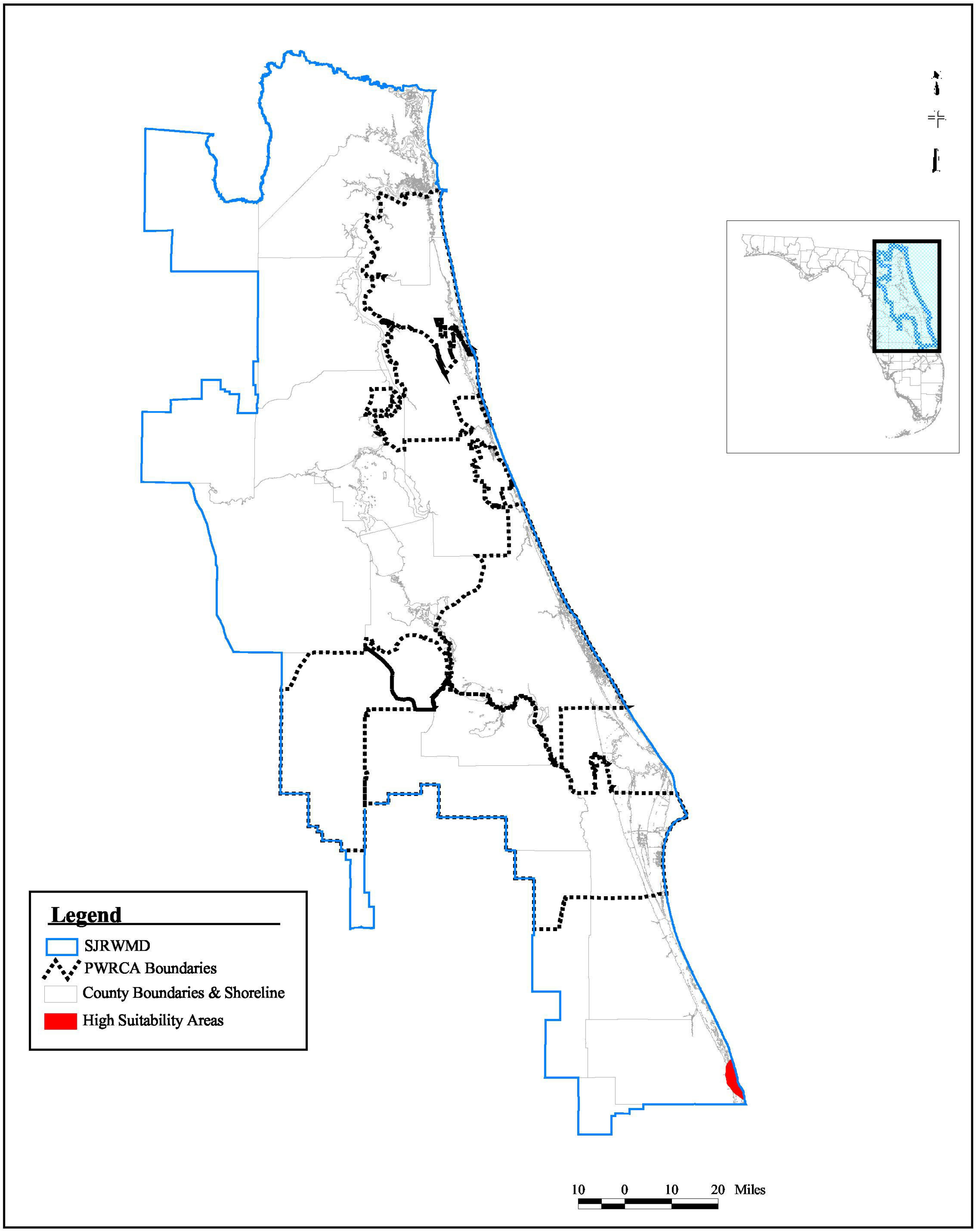

Figure 36. Open Ocean Discharge in Conjunction with Surface Water Source

Seawater Source

The areas where sites are within 15 miles of the 90-foot isobath using seawater as a source are presented in Figure 37. The high suitability areas are located in the southern end of SJRWMD and in the Cape Canaveral area.

A 15-mile criterion was used throughout this study. However, all areas along the 90 foot isobath are available for consideration. The specific distance which a given project can accommodate while still remaining economically feasible may vary. In general, the ability to utilize open ocean appears to be limited in SJRWMD given the distance between the 90-foot isobath and the shoreline. However, as presented previously, the 90-foot isobath definition for open ocean was apparently developed by FDEP for WWTP effluent and is associated with concerns over nutrient loading.

Consideration could be given to an isobath (depth) criterion that more accurately reflects the constituents associated with demineralization concentrate. Generally nutrient loading associated with demineralization concentrate is much lower than WWTP effluent. Without the appropriate research, it is not known if this investigation would increase or decrease the depth requirement for discharge of demineralization concentrate. Regardless, such an effort would have more scientific justification than utilization of the current open ocean isobath definition developed for WWTP effluent.

The lowest suitability areas for open ocean discharge are inland areas and coastal areas north of Cape Canaveral. Discharge to open ocean is technically feasible, however, the cost associated with piping from inland areas to the open ocean may be prohibitive for many projects.

MARINE WETLAND DISCHARGE

The following subsections present areas of highest suitability for locating a demineralization facility for each of the three alternative source waters and marine wetland discharge of demineralization concentrate. For different source water quality, suitability areas were determined using the 15-mile criterion and the criteria for marine wetland discharge described in the previous chapter.

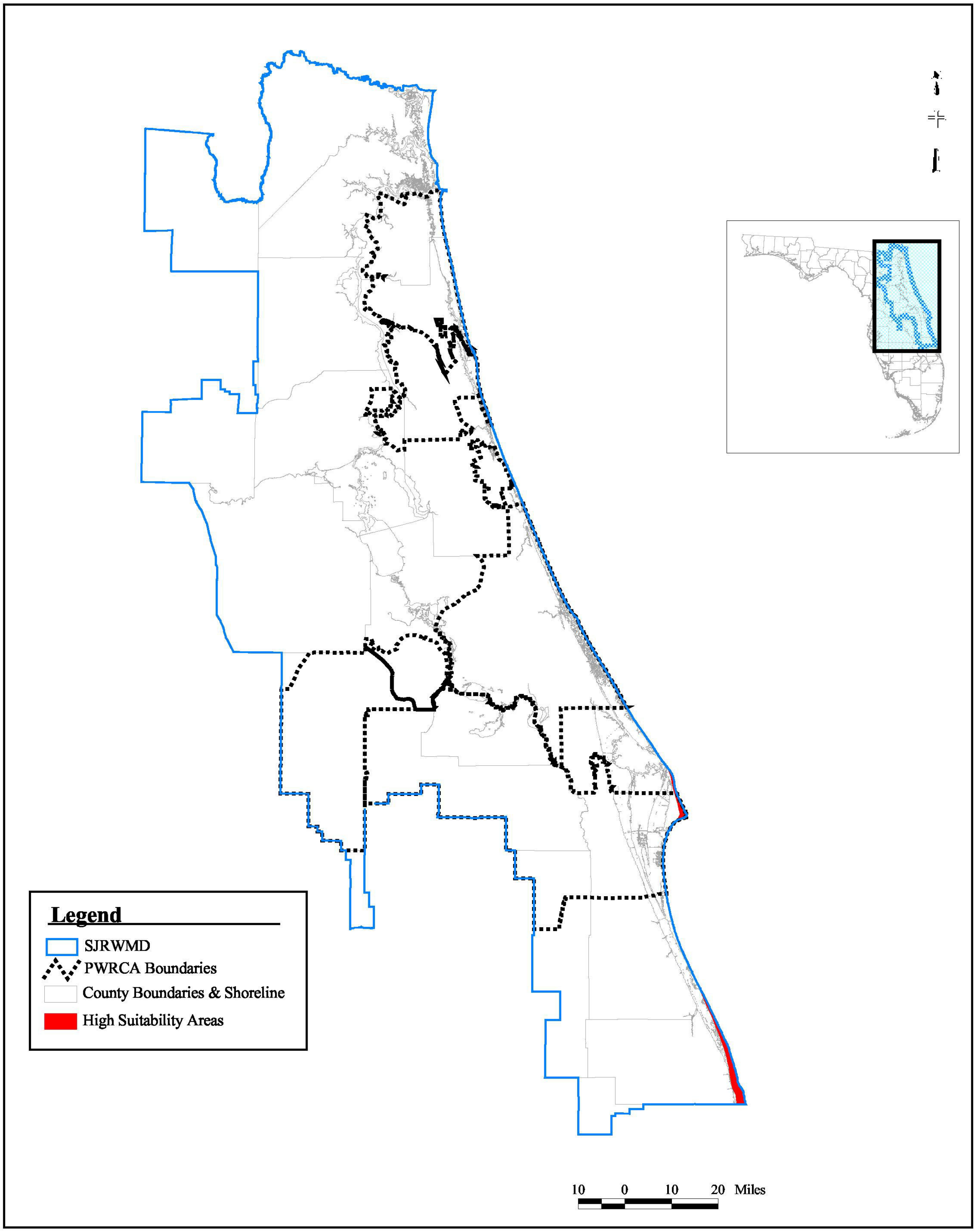

Figure 37. Open Ocean Discharge in Conjunction with Seawater Source

As with the inland surface waters and coastal ocean, selection of high suitability areas for marine wetland discharge is dependent on the water quality of the demineralization concentrate. Given that marine wetland TDS concentration does not vary significantly and is on the order of 34,000 mg/L, a single threshold was established consisting of demineralization concentrate less than 34,000 mg/L. This is consistent with the TDS criterion (demineralization concentrate TDS concentration less than receiving water body).

For demineralization concentrate with TDS concentration greater than 34,000 mg/L, marine wetlands were not identified as highest suitability. This corresponds to source waters with TDS concentration between 10,000 and 34,000 mg/L. Dilution with power plant cooling water and wastewater effluent is not an option since there are no known facilities discharging to a marine wetland.

As a result, the following sections present areas of highest suitability which correspond to source waters with TDS concentration less than 10,000 mg/L.

In addition, the suitability of a marine wetland to receive concentrate discharge is highly dependent upon its hydraulic capacity. As defined previously, wetland capacities were estimated based on technical and regulatory criteria. These capacities were compared to the desired demineralization concentrate flows of 2, 5, 15, and 30-MGD.

Groundwater Source

The high suitability areas for marine wetlands discharge in conjunction with the first three ranges of source water TDS concentration are presented in Figures 38 and 39 for 2 and 5-MGD concentrate flows. There are no wetlands having enough capacity to receive 15 or 30-MGD concentrate flows. The high suitability areas are located on the coast, where available marine wetlands for concentrate discharge are within reasonable distance of brackish groundwater sources. The suitability areas become smaller as the concentrate TDS increases.

Surface Water Source

The high suitability areas for marine wetland discharge in conjunction with inland surface water sources (St. Johns River and Intracoastal Waterway) having a TDS concentration up to 10,000 mg/L are presented in Figures 40 and 41 for 2 and 5-MGD concentrate flows. The high suitability areas are located in the Jacksonville area and Cape

Canaveral area, where brackish surface water and the estuarine wetlands are within the 15-mile-proximity criterion.

Seawater Source

Seawater demineralization will produce a concentrate TDS concentration of approximately 68,000 mg/L, higher than that of marine wetlands, and therefore does not meet the TDS criterion to be discharged to marine wetlands.

SUMMARY

High suitability areas for locating a demineralization plant were determined for each demineralization concentrate management alternative in conjunction with three different source waters. These high suitability areas vary with the demineralization concentrate management alternative and the water source. The high suitability areas are the result of macro-level screening for the entire 19-county SJRWMD area. These results provide guidance to planners and managers regarding the relative suitability of siting a demineralization WTP in terms of availability of an alternative source water and a high suitability demineralization concentrate management alternative.

Note that TDS concentration was used as the water quality screening criterion throughout this study. However, other parameters such as radionuclides and fluorides could also limit the suitability of discharge to a receiving water body. Therefore, analysis of compliance with all water quality standards is recommended as early as possible in the feasibility stage of a project. Particular emphasis should be placed on TDS, radionuclides and fluoride given that these are the parameters which have most commonly required a mixing zone.

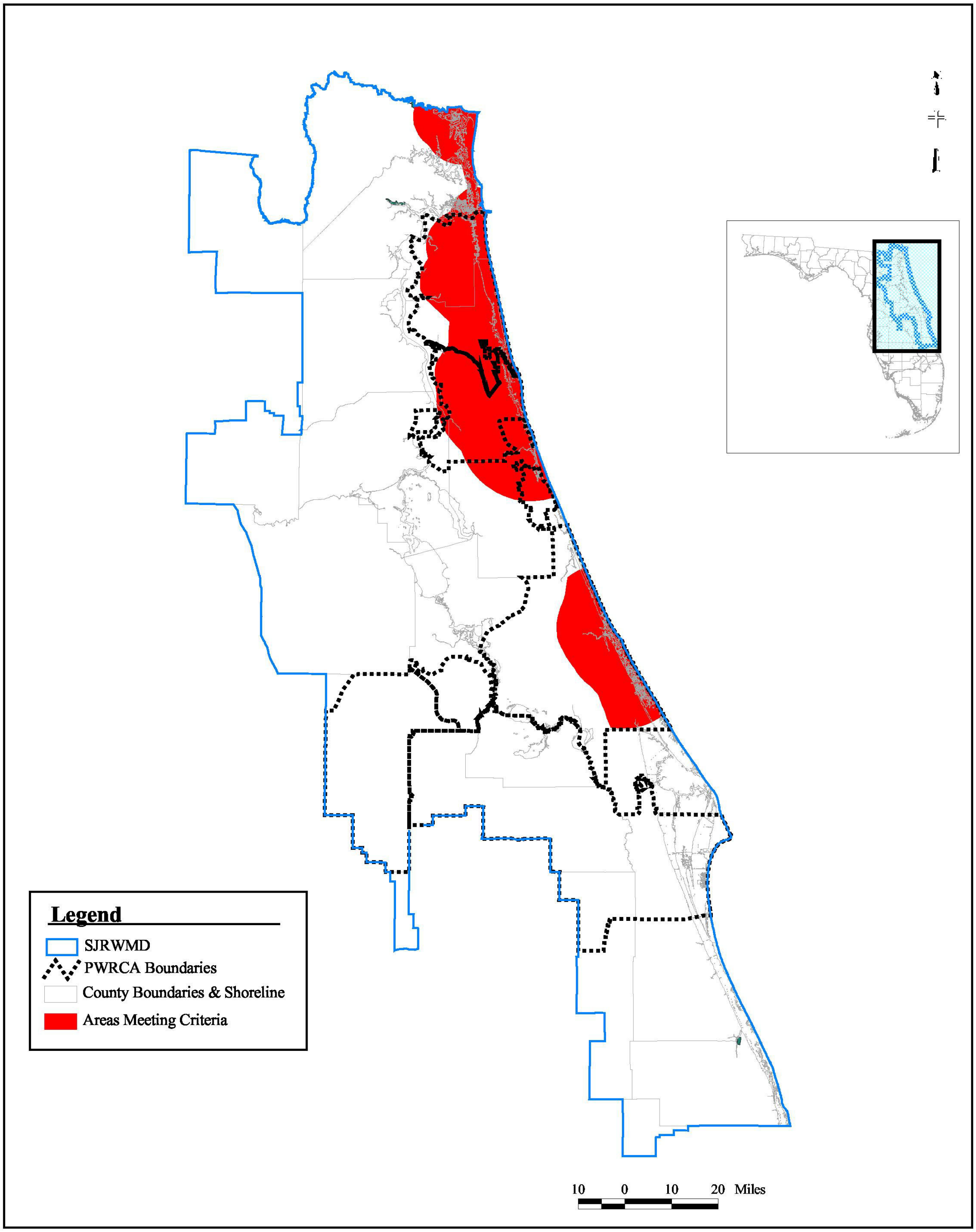

Figure 38. Wetland Discharge in Conjunction with Groundwater Source for a Concentrate Flow of 2 MGD

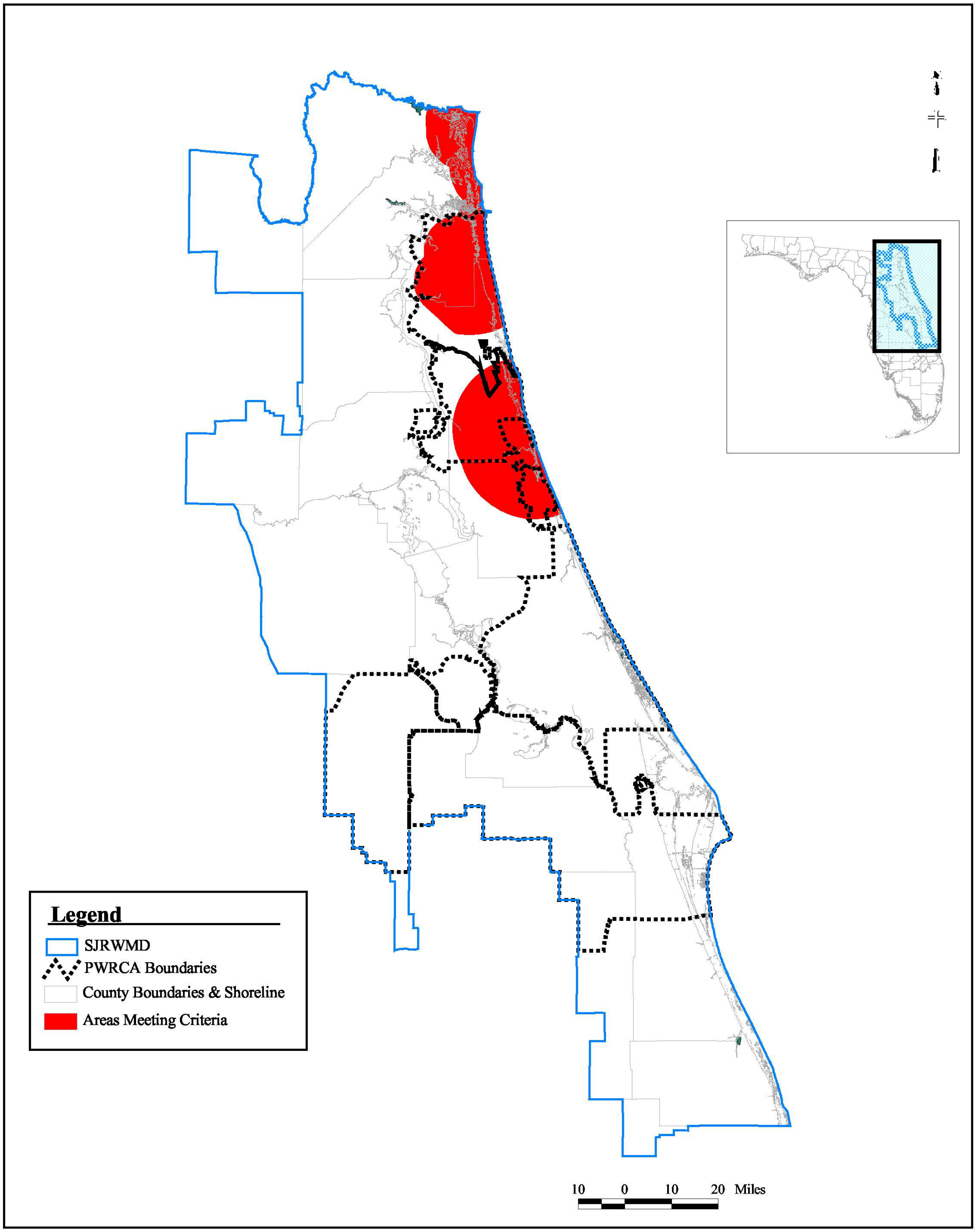

Figure 39. Wetland Discharge in Conjunction with Groundwater Source for a Concentrate Flow of 5 MGD

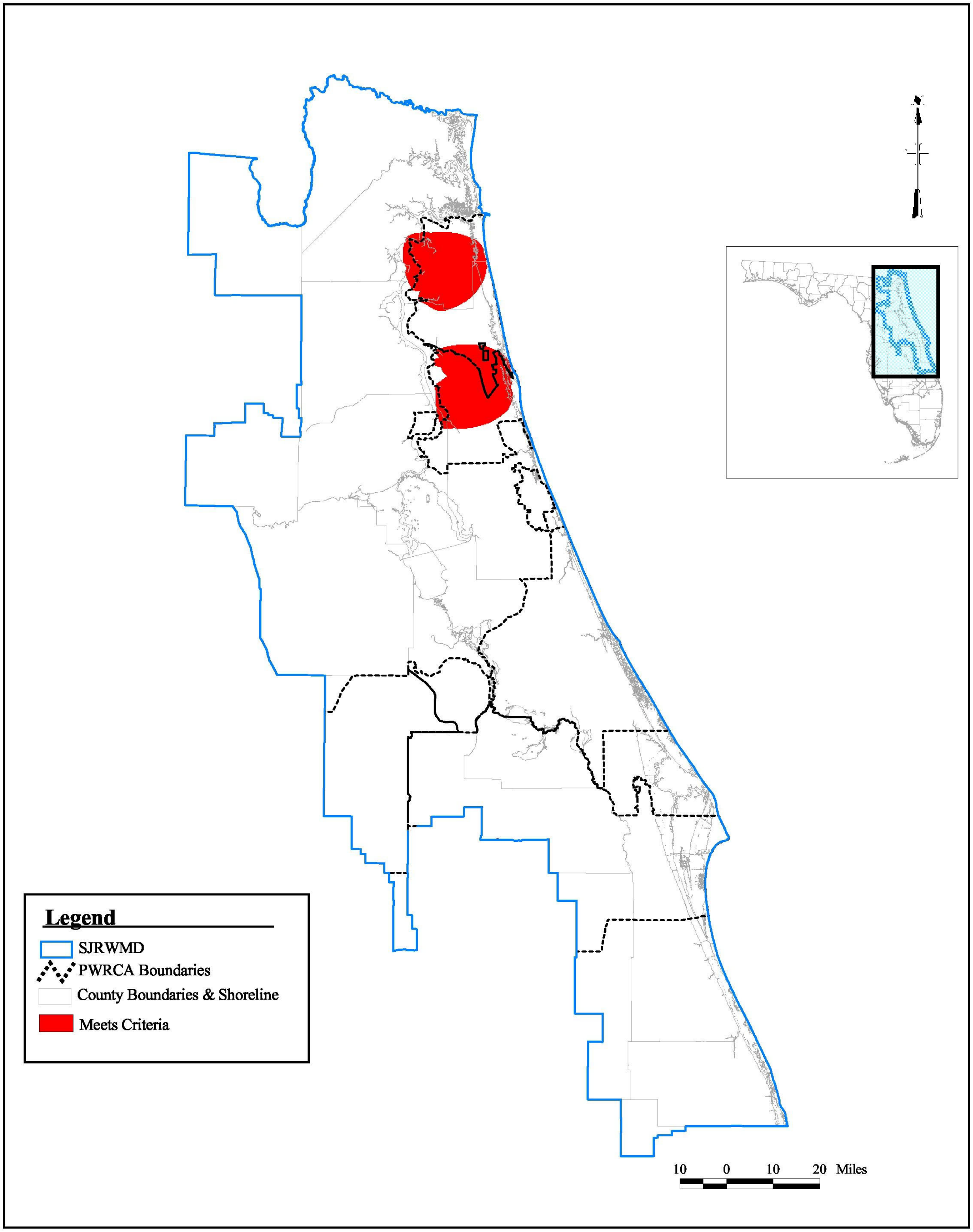

Figure 40. Wetland Discharge in Conjunction with Surface Water Source for a Concentrate Flow of 2 MGD

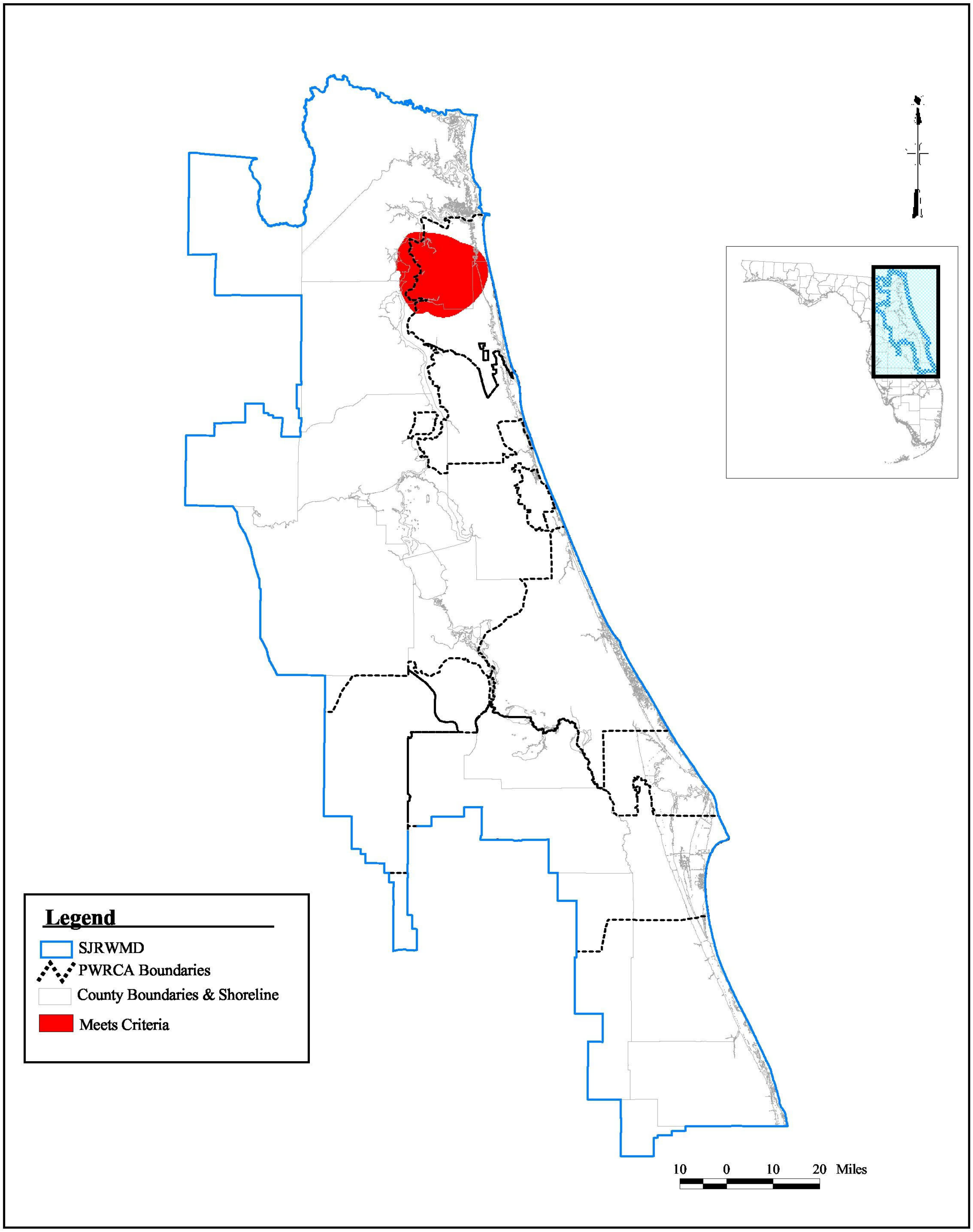

Figure 41. Wetland Discharge in Conjunction with Surface Water Source for a Concentrate Flow of 5 MGD

A risk management plan is of value when considering concentrate discharge permitting. In most cases a large investment is required to determine the feasibility of concentrate management, and in some cases the utility may not succeed in obtaining an operating permit. For example, planners and managers have to consider the risk associated with the cost of deep well construction and not obtaining a deep well operating permit versus investing the environmental aspects for surface water discharge. Construction of a deep well has much higher costs than the expense associated with an environmental study for surface water discharge.

As described previously, the only discharge options considered to be highly suitable for demineralization concentrate with a TDS of over 34,000 mg/L are subsurface injection and discharge to the open ocean. Subsurface injection is not restricted by TDS considerations and open ocean discharge permits are granted a 20 to 1 dilution ratio. However, it is important to note that other options, such as coastal ocean discharge or surface water discharge have been used in the past and may be selected for a given project following a risk versus cost assessment.

For example, the Tampa desalination project will utilize a coastal ocean discharge, not open ocean discharge. This is despite the fact that the dilution of the demineralization concentrate with power plant cooling water still results in a discharge water with a TDS approximately 1.5% higher than the receiving water body. The decision to pursue a permit for this demineralization concentrate discharge method was made, in part, because of the high costs to pipe the demineralization concentrate to the open ocean (additional concerns included disturbing grass beds along the open ocean pipe route). This was balanced with the potential of not receiving a discharge permit due to more stringent water quality regulations for a coastal ocean discharge.

Therefore, it is expected that projects using seawater or other high TDS (> 10,000 mg/L) sources will include an evaluation of the higher costs of open ocean discharge or subsurface injection versus the risk of pursuing a surface water or coastal ocean discharge permit, which may have less likelihood of meeting water quality-based permitting requirements. With the costs to pursue a permit application as high as $2M or more, a substantial difference in costs must exist (>$2M) between demineralization concentrate management options which do not have restrictive TDS criteria (subsurface injection and open ocean discharge) and other more restrictive alternatives before the risk of pursuing these alternatives makes economic sense.

In summary, all concentrate management alternatives considered in conjunction with the three alternative water sources were considered highly suitable in various locations within SJRWMD for discharging demineralization concentrate. Figure 42 presents the combined highest suitability areas for all demineralization concentrate management alternatives and alternative water supplies. This coverage shows that there is at least one specific combination of source water and demineralization concentrate management alternative for approximately 50% of the SJRWMD boundary. These areas are mainly located on the East coast and southern portion of SJRWMD.

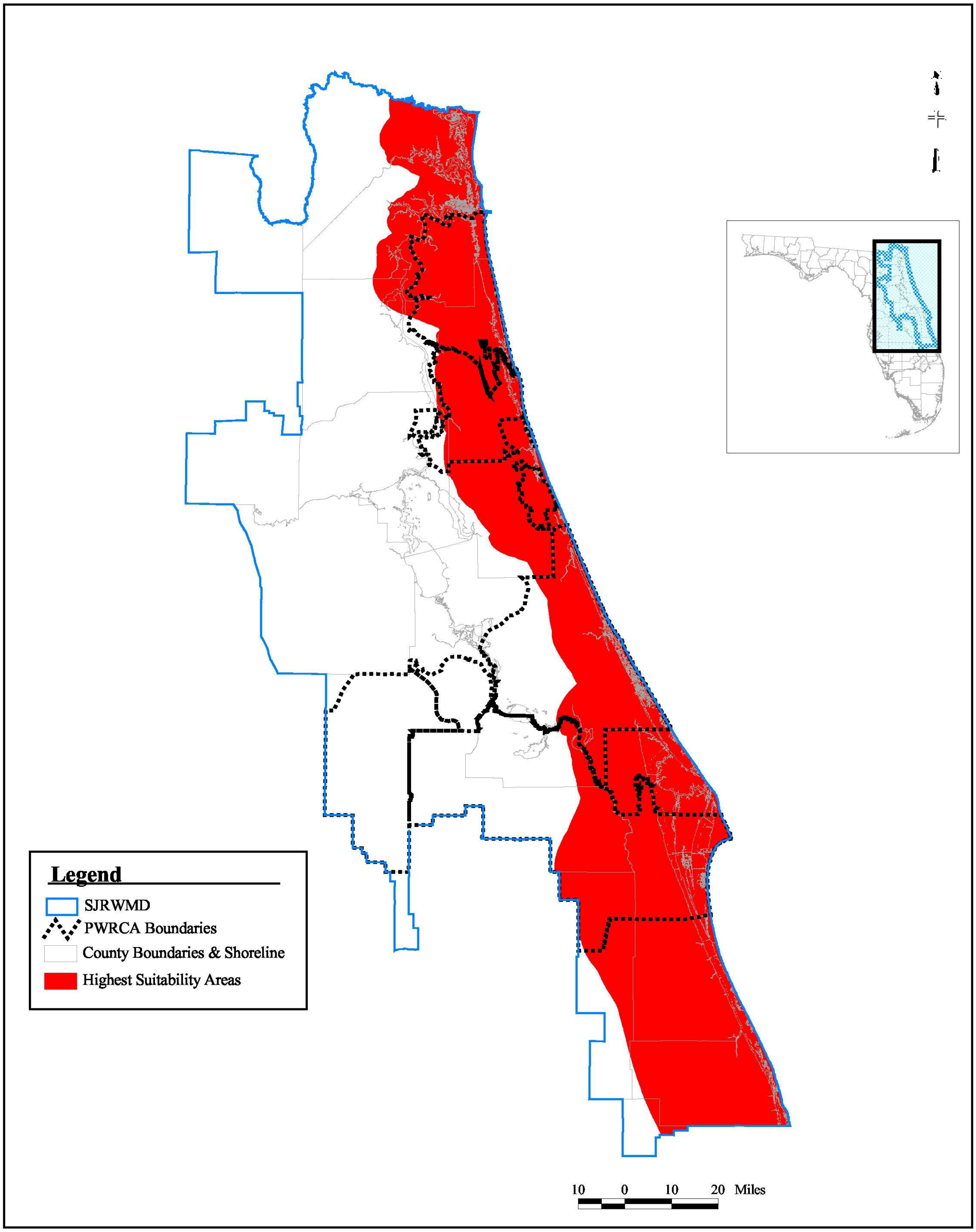

Figure 42. Highest Suitability Areas for Demineralization Concentrate Management Alternatives in Conjunction with Source Waters

CONCLUSIONS

The assessment of demineralization concentrate management alternatives, which is described in this document, considered various factors that affect the relative suitability of a given application. The approach included consideration of the location and characteristics of the alternative source waters including brackish groundwater, brackish surface water and seawater and the characteristics of potential receiving waters. The following conclusions have been drawn from the assessment. Numerical references are not an indication of the relative priority.

1. Sources of brackish groundwater include areas of the Upper Floridan aquifer primarily located east of the St. Johns River. Brackish surface water sources include large portions of the St. Johns River as well as the Intracoastal Waterway. Seawater is available along the 150 miles of coastline in SJRWMD. These alternative sources are available to most municipalities within Priority Water Resource Caution Areas.

2. A wide range of factors must be considered when determining the feasibility of a demineralization concentrate management strategy given large, site-specific variations in economics, public perception, technical criteria, and environmental considerations associated with this water treatment plant by-product. Primary demineralization concentrate management disposal strategies utilized in Florida, which would be applicable to regional-level demineralization facilities within SJRWMD, include subsurface injection and various forms of surface water discharge. In general, the costs for surface water discharge are less than subsurface injection. However, permitting and environmental factors associated with surface water discharge options are generally more significant than with subsurface injection.

3. Through this assessment it was determined that the FDEP regulations which govern demineralization concentrate determine to a large degree the viability of a given project. In addition, there is a perception in the municipal demineralization community that current regulations present a challenge that is potentially inconsistent with the characteristics associated with demineralization concentrate. Presently, FDEP is in the process of rule development mandated by amendments to Section 403.0882, *FS*. It is expected that this rule making

process will address many of the perceived inconsistencies in the regulations. The Technical Advisory Committee (TAC) appointed to assist in this process consists of stakeholders in the regulation of demineralization concentrate management. SJRWMD ‘s continued and increased participation in this process can be a positive factor in achieving a satisfactory outcome.

4. The assessment of subsurface injection using Class I wells indicates that the Upper Floridan aquifer has no areas that are suitable for this concentrate management alternative. However, a portion of the Lower Floridan aquifer appears available for consideration. These areas are generally located south of Merritt Island, and are mainly within Indian River and Brevard counties. The absence of significant restrictions on the salinity of the injection fluid render subsurface injection highly suitable for demineralization concentrate from sources of all ranges of salinity, including seawater.

5. It was determined that the permitting of the discharge of demineralization concentrate to inland surface waters (St. Johns River and the Intracoastal Waterway), marine wetlands and coastal ocean waters is dependant upon the concentration and composition of the salinity of the source water. Demineralization of source waters with lower salinity will result in lower salinity concentrate. Low salinity concentrate can be discharged to water bodies with similar or higher salinity ranges. In SJRWMD there are more areas suitable to receive discharge of a low salinity concentrate than there are areas capable of receiving a high salinity concentrate. Therefore, the suitability of discharge is the highest for sources with relatively low salinity. The areas most capable of accommodating a wide range of source water salinity are locations in the St. Johns River near Jacksonville, portions of the Intracoastal Waterway from Cape Canaveral to Jacksonville, and most coastal ocean areas. However, consideration of the impairment of a water body and the parameters of concern may limit the availability of this discharge option.

6. Based on salinity considerations only, the suitability of discharging demineralization concentrate to inland surface waters, marine wetlands and coastal ocean is greater for a facility using a brackish groundwater source than a brackish surface water source given the larger distribution of lower

salinity brackish groundwater in SJRWMD. In addition, size limitation of and environmental protection associated with marine wetlands renders this alternative more suitable for smaller demineralization WTPs, on the order of 10-MGD or less.

7. Discharge of demineralization concentrate from a seawater source to inland surface waters, marine wetlands and coastal ocean is not highly suitable, given the very high salinity of the discharge stream. More suitable approaches include dilution with other lower salinity streams, use of subsurface injection, open ocean discharge, or consideration of lower salinity source water. A demineralization concentrate management strategy defined as less suitable herein may be appropriate due to other unique requirements of a specific demineralization water treatment project.

8. Open ocean discharge (at a depth of 90 feet or greater) readily meets most screening criteria but is greatly limited by the distance from the shoreline and associated ocean pipeline construction costs. The open ocean is 14 to 35 miles offshore in the areas along the SJRWMD coastline.

9. Blending of demineralization concentrate with WWTP effluent will limit the plant capacity, if introduced at the headworks, and also possibly modify the final effluent composition. The result may affect the WWTP's ability to comply with applicable effluent limits. In some cases the effect of blending may actually reduce the environmental impact by diluting the constituents of a wastewater discharge. If the discharge is to brackish or marine waters, the addition of the concentrate will also increase the discharge salinity and improve its ability to disperse in the receiving waters. In the event larger WWTPs exist that are discharging to saline water bodies, a significant benefit would be realized but is not expected to have wide application for the purposes of regional planning.

10. Blending demineralization concentrate with power plant cooling water may have significant benefit for any proposed facility. There are a total of four power plants with large cooling water flows located within SJRWMD. All four power plants are discharging to an inland surface water. Blending with power plant cooling water will reduce but not eliminate the increase in salinity concentration resulting from a demineralization water treatment plant.

11. All selected alternative water sources and all selected demineralization concentrate management alternatives were considered highly suitable in various locations within SJRWMD. Areas bordering or east of the St. Johns River and in the southern portion of SJRWMD are the most likely locations for future demineralization facilities.

RECOMMENDATIONS

The investigation of demineralization concentrate management revealed a number of recommendations for consideration. These range from additional studies to considerations for future projects and are itemized below. Numerical references are not an indication of the relative priority.

1. The Technical Advisory Committee (TAC) established by FDEP should continue its evaluation of concentrate management issues including but not limited to:
    a. Development of a new and unique application form specific to demineralization concentrate (included in current FDEP demineralization concentrate rule-making initiative discussions)
    b. Appropriateness of making revisions to state of Florida and federal UIC rules for reclassifying demineralization concentrate as a municipal domestic waste as well as non-corrosive (included in current FDEP demineralization concentrate rulemaking initiative discussions)
    c. Development of a standardized list of water quality parameters specific to demineralization concentrate (included in current FDEP demineralization concentrate rule-making initiative discussions)
    d. Establishment of a protocol for permit applicants to use to reconcile problems associated with analytical techniques and the characteristics of demineralization concentrate and its receiving waters
    e. Development of a list of appropriate modeling procedures for incorporation into the Guide to Wastewater Permitting, Chapter 62-620, F.A.C. (included in current FDEP demineralization concentrate rule-making initiative discussions)
    f. Identification of off-shore areas suitable for discharge of demineralization concentrate based on an evaluation of marine characteristics in the Atlantic off-shore of SJRWMD
    g. Re-evaluation of toxicity testing with regard to naturally occurring constituents (included in current FDEP demineralization concentrate rule-making initiative discussions)

h. Assessment of ion imbalance and toxicity MSIT protocol issues relative to suitable / extended mixing zones in surface waters

2. A comprehensive site-specific study should be conducted in advance of committing to any potential project. The efforts herein were developed at a macro-level for the region and should serve as broad guidance in the planning effort. In addition, these efforts were directed solely toward demineralization concentrate management. A demineralization concentrate management strategy defined as less suitable herein may be appropriate due to other unique requirements of a specific demineralization water treatment project.

3. Communication between applicants, potentially affected parties, and involved regulatory agencies should be initiated as early as possible.

4. Regional water treatment projects should be considered during the planning process. The many benefits associated with a regional demineralization project include economy of scale for certain demineralization concentrate management alternatives such as open ocean outfall.

5. Water resource studies designed to identify potential benefits of discharge of demineralization concentrate to the salinity balance in surface waters that are likely candidate receiving waters for demineralization concentrate, should be performed.

6. Additional work to increase the density of Lower Floridan aquifer data observations should be undertaken to help improve the identification of areas suitable for injection of demineralization concentrate.

7. For the purposes of this study, only areas that were expected to meet Class I injection well standards were evaluated. However, along coastal areas of SJRWMD, site-specific water quality and geology may be suitable for a Class V concentrate injection well. It is recommended that projects proposed in coastal areas further evaluate the suitability of Class V injection wells as one potential demineralization concentrate management method.

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APPENDIX A

SALINITY TO TDS CONVERSION EQUATIONS

SALINITY TO TDS CONVERSION EQUATIONS

Salinity was converted to conductivity using equation developed by an international commission in 1902 (cited by Sverdrup, Johnson, and Fleming 1942, 1951 as referenced in Pyatt 1959, 38) using these equations:

salinity = cond. x 0.5625	for c < 16 mmhos/cm
salinity = (cond. - 16.0) x 0.6923 + 9.0	for 16 < c < 42
salinity = (cond. - 42.0) x 0.72222 + 27.0	for c > 42

Then the conductivity was converted to TDS using the following equation:

TDS = 0.64 x conductivity (in umho/cm)

In summary the TDS was computed using the following equations:

TDS = 1137.8 salinity	salinity < 9 ppt
TDS = 924.45 x (salinity + 2.0768)	9 ppt < salinity < 27 ppt
TDS = 886.15 x (salinity + 3.33324)	salinity > 27 ppt

APPENDIX B

SUMMARY OF APPLICABLE RULES AND REGULATIONS

Technical Memorandum B.5
Applicable Rules and Regulations for Concentrate Management

Task B.5
Applicable Rules and Regulations

Investigation of Demineralization Concentrate Management

by

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Palatka, Florida

November 2001

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INTRODUCTION

PROJECT OVERVIEW

The St. Johns River Water Management District (SJRWMD) water supply plan, titled District Water-Supply Plan, outlines water-supply options to meet projected water needs through the year 2020. Currently, the Floridan Aquifer provides most of the region's existing water needs for public supply. The high quality, economical and reliable characteristics of this groundwater source has made it the water supply of choice. However, the Floridan Aquifer cannot provide all future water supply needs in the region without damaging wetlands, reducing spring flows and increasing the likelihood of saltwater intrusion. Therefore, the SJRWMD investigated the feasibility of alternative water supply strategies and identified brackish groundwater, brackish surface water, and seawater as potential sources of supply to meet future demands. These alternative water sources will require treatment using demineralization technologies. These technologies are primarily pressure driven membrane processes that include reverse osmosis or nanofiltration. During this process, minerals in the source water, including salt, are removed producing potable water as well as a byproduct known as demineralization concentrate.

Developing acceptable management strategies for demineralization concentrate has lead to implementation of this project, Investigation of Demineralization Concentrate Management (the Project). A primary component of the Project will be the development of a Demineralization Concentrate Management Plan. The Plan will outline environmentally acceptable options for addressing concentrate. Currently, some available concentrate management options include deep well injection, land spreading, discharge to surface waters, discharge to domestic wastewater treatment facilities, and various forms of reuse (including blending with reclaimed water). This project is part of SJRWMD's water supply plan implementation to meet future water supply needs. Prior to development of the Plan or implementation of the concentrate management alternatives mentioned, it is important to have an understanding of applicable rules and regulations governing concentrate management.

PURPOSE AND SCOPE

The purpose of this Technical Memorandum (TM) is to identify and summarize relevant demineralization concentrate management rules and regulations. The contents of this TM will be used to support the Project and the Demineralization Concentrate Management Plan. Addressing this topic is very important since demineralization concentrate management and the associated regulations are primary considerations associated with the development of demineralization facilities within the SJRWMD.

Applicable rules and regulations have been collected, reviewed and summarized as they relate to demineralization concentrate management. In addition, recommendations have been provided regarding potential actions to support an environmentally sound, logical, and clear regulatory process.

The information presented herein does not represent a legal or binding interpretation of Florida laws and statutes. Legal counsel is the responsibility of the user.

METHODOLOGY

This TM was prepared by identifying agencies that have a direct or indirect impact on permitting of demineralization concentrate management, followed by the collecting and summarizing of specific rules and regulations. Information was obtained through a literature search and by contacting regulatory agency officials, other experts in the field, and utilities currently using demineralization processes.

REGULATORY AGENCIES

Demineralization concentrate management projects require permits, approvals, or authorizations from a number of governmental agencies. The need for interaction with these agencies may not be self evident when considering a demineralization project and associated concentrate management strategy. In considering the issues related to demineralization concentrate management, there are a number of agencies that would be considered "secondary" as their review is related to ancillary facilities for concentrate disposal, such as pipelines and outfall structures. **Clearly, the Florida Department of Environmental Regulation is the primary agency responsible for the review and issuance of permits for demineralization concentrate disposal.**

This section defines Agencies that may have review and approval requirements for any portion of a demineralization concentrate management project. Agencies responsible for approval of components of a demineralization facility other than concentrate are also referenced if the Agency's authority or the language of its governing regulations is broad enough to allow expansion of the review process into the area of demineralization concentrate management.

Agencies are summarized in Table 1 below, followed by brief descriptions of each organization and its potential role in approval of a demineralization concentrate management project. The order in which these agencies are listed below does not represent their relative level of importance, nor does it represent functional hierarchy related to a demineralization concentrate management project.

Table 1. Summary of agencies potentially requiring permits, approvals, or authorization for demineralization concentrate management projects

Responsible Agency
Federal
EPA Region IV
Army Corps of Engineers
OSHA
United States Geological Survey
United States Fish and Wildlife Service
National Marine Fisheries Service
State
Department of Environmental Protection (Primary Agency)
Water Management Districts
Department of Transportation
Florida Fish and Wildlife Conservation Commission
Local
Health Department
Local Pollution Control
Environmental Resource Management or Natural Resource Management Departments
City/County Building and/or Zoning Departments
CSX Railroad Corporation

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY (USEPA)

The United States Environmental Protection Agency mission is to protect human health and to safeguard the natural environment (air, water, and land) upon which life depends. The USEPA is structured into 10 regions with Region 4 responsible for Alabama, Florida, Georgia, Kentucky, Mississippi, North Carolina, South Carolina and Tennessee. Region 4 location is as follows:

United States Environmental Protection Agency
Region 4
Atlanta Federal Center
61 Forsyth Street, SW
Atlanta, GA 30303-3104
Telephone: (404) 562-9900 or (800) 241-1754
www.epa.gov

The USEPA has given full delegation to the Florida Department of Environmental Protection (FDEP) for the regulation of underground injection and surface water discharge permitting of demineralization concentrate and the associated management issues. However, the USEPA does participate in the review of demineralization concentrate management permits and related topics concerning demineralization concentrate subject matter in cooperation with the FDEP. A USEPA member sits on the Technical Advisory Committees for proposed underground injection control projects. Although the EPA's permitting authority is delegated to the FDEP, their oversight and technical input are important factors in FDEP consideration of permitting for demineralization concentrate disposal.

UNITED STATES ARMY CORPS OF ENGINEERS

The United States Army Corps of Engineers (USACE) is made up of civilian and military men and women, which include a diverse workforce of biologists, engineers, geologists, hydrologists, natural resource managers and other professionals. The USACE mission is to provide quality, responsive engineering services to the nation including: Planning, designing, building and operating water resources and other civil works projects (Navigation, Flood Control, Environmental Protection, Disaster Response, etc.); Designing and managing the construction of military facilities for the Army and Air Force. (Military Construction); and Providing design and construction management support for other Defense and federal agencies. (Interagency and International Services).

USACE involvement in a desalination project and concentrate disposal would revolve around construction in navigable waterways of the United States for example construction of ocean outfall, intracoastal waterway pipe crossing that require dredge and fill permitting procedures, wetland modifications, also construction, operation, or abandonment of facilities on land under federal jurisdiction, or actions requiring major federal action.

USACE District office location is as follows:
400 W. Bay Street or P.O. Box 4970
Jacksonville, FL 32202
Telephone: (904) 232-2568 or (800) 291-9405
www.usace.army.mil

OSHA

OSHA was created under the Occupational Health and Safety Act to monitor health and safety in the work environment and to prevent work-related injuries, illnesses and death. This agency may play a role in any construction aspects related to a demineralization project especially concerning any trenching and confined spaces issues encountered during the construction phase.

OSHA's Region 4 office location is as follows:
St 61 Forsyth Street, SW
Atlanta, Georgia 30303
Telephone: (404) 562-2300
www.osha.gov

UNITED STATES GEOLOGICAL SURVEY (USGS)

The United States Geological Survey (USGS) serves the Nation by providing reliable scientific information to describe and understand the Earth; minimize loss of life and property from natural disasters; manage water, biological, energy, and mineral resources; and enhance and protect our quality of life. USGS would play a role in concentrate discharge related to a demineralization project when the discharge concerns underground injection. The USGS is part of a Technical Advisory Committee that is established by the FDEP to evaluate the permitting of underground injection control projects.

USGS Florida office location is as follows:
United State Geological Survey
227 N. Bronough St., Suite 3015
Tallahassee, FL 32301
Telephone: (850) 942-9500
www.usgs.gov

UNITED STATES FISH AND WILDLIFE SERVICE (USFWS)

The United States Fish and Wildlife Service (USFWS) serves the Nation by working with others, to conserve, protect, and enhance fish and wildlife and their habitats for the continuing benefit of the American people. The Service's major responsibilities involve managing migratory birds, endangered species, certain marine mammals, and freshwater and anadromous fish, conserving wetlands and restoring nationally significant fisheries. In addition, USFWS enforces Federal wildlife protection laws, such as the Endangered Species Act (ESA).

This law allows the listing of species as either “endangered” or “threatened”. A species classified as endangered means it is in danger of extinction throughout all or a significant portion of its range. A threatened classification means a species is likely to become endangered within the foreseeable future. All species of plants and animals (i.e. plants, mammals, birds, fish, reptiles, and clams/mussels), except pest insects, are eligible for listing as endangered or threatened. Therefore, the purpose of the ESA is to conserve “the ecosystem upon which endangered and threatened species depend” and to conserve and recover these listed species.

USFWS and National Marine Fisheries Service share the responsibility for administration of the ESA. The USFWS primary responsibility is for terrestrial and freshwater species, while the NMFS responsibilities are mainly for marine species such as salmon and whales. Therefore, the USFWS could become involved if the proposed demineralization project could potentially impact listed species such as marine mammals (i.e. manatees) or other fish and/or wildlife habitats.

USFWS Southeast Regional office location is as follows:
United State Fish and Wildlife Service
1875 Century Blvd., Suite 400
Atlanta, GA 30345
Telephone: (404) 679-4000
www.fws.gov

NATIONAL MARINE FISHERIES SERVICE (NMFS)

The mission of National Marine Fisheries Service (NMFS) is stewardship of the Nation's living marine resources. Through conservation and wise use, these resources and their habitat are managed by NMFS to benefit the Nation without jeopardizing options for the future. In addition, NMFS share the responsibility with USFWS for administration of the Endangered Species Act. The agency could become involved in a similar role as USFWS, if the proposed demineralization project could potentially impact marine resources such as fish and / or marine habitats.

NMFS Southeast Regional office location is as follows:
National Marine Fisheries Service (NMFS) -Southeast Regional Office
9721 Executive Center Drive North
St. Petersburg, FL 33702
Telephone: (727) 570-5301
www.nmfs.noaa.gov

FLORIDA DEPARTMENT OF ENVIRONMENTAL PROTECTION (FDEP)

The Florida Department of Environmental Protection is the state agency whose mission is to “protect, conserve, and manage Florida’s environment and natural resources”. The FDEP accomplishes this mission through an established regulatory program of permitting, compliance and enforcement actions for activities that could have a negative impact on public health and the natural environment. The FDEP is also responsible for purchase and conservation of environmentally significant lands, management of the state park system, and outreach and environmental education. The FDEP also provides water quality data on many surface waters throughout the state and coordinates the monitoring activities associated with ambient sampling with other agencies. **The FDEP has received federal delegation of the underground injection control (UIC) and surface water discharge (NPDES) permitting programs.**

The State of Florida is divided into six regulatory Districts including Northwest District, Northeast District, Southwest District, Central District, South District and Southeast District. Headquarters of the FDEP are located in Tallahassee. The Central District and Northeast District cover the area that is within the St. Johns River Water Management District. These FDEP District office locations are as follows:

Northeast District
7825 Baymeadows Way,
Suite 200B
Jacksonville, Florida 32256-7590
(904) 448-4300 / sc 880-4300 x201
Fax (904) 448-4366 /
scfax 880-4366
www.dep.state.fl.us

Central District
3319 Maguire Boulevard,
Suite 232
Orlando, Florida 32803-3767
(407) 894-7555 / sc 325-2290
Fax (407) 897-2966 /
scfax 342-2966

ST. JOHNS RIVER WATER MANAGEMENT DISTRICT (SJRWMD)

The St. Johns River Water Management District is one of five water management Districts in the state of Florida dedicated to the preservation and management of Florida's precious water resources. Duties of the SJRWMD include:

- Issuing permits for various water use activities and/or activities that have the potential to adversely impact ground or surface water resources and adjacent lands
- Buying land to preserve or restore vital wetlands and water resources
- Conducting research about the quality and quantity of ground and surface water resources
- Mapping ground and surface water resources
- Conducting outreach and public education programs

SJRWMD is responsible for issuing many types of permits, however some of the most common are consumptive use permit (CUP) and environmental resource permit (ERP). These source water permits include evaluation of environmental impacts and public water supply, which could include evaluation of impacts from the concentrate management component of a demineralization project. In addition, artificial recharge permitting could become an issue relating to injection wells associated with demineralization projects, if the water is not being beneficially used or the injection could adversely affect existing beneficial uses of water. Artificial recharge is addressed under the Districts 40C-5 permitting program.

The SJRWMD's location is as follows:
St. Johns River Water Management District
P.O. Box 1429
Palatka, Florida 32178-1429
Telephone: (386) 329-4500
www.sjrwmd.com or sjr.state.fl.us

FLORIDA DEPARTMENT OF TRANSPORTATION (FDOT)

The Florida Department of Transportation's (FDOT) responsibilities impact nearly every facet of transportation - from highways to railways - airports to seaports. FDOT's mission is to provide a safe transportation system that ensures the mobility of people and goods, enhances economic prosperity and preserves the quality of our environment and communities. Therefore, FDOT involvement with a demineralization project would be associated with transportation of any oversized structures or pipes on State or Federal roadways during construction phase, and/or any construction that takes place in State or Federal road right-of-way would require utilization permits. Multiple permits could be required for various activities proposed in FDOT right-of-way.

The FDOT's location is as follows:
Florida Department of Transportation
605 Suwannee Street
Tallahassee, Florida 32399-0450
Telephone: (850) 414-4100
www.dot.state.fl.us

FLORIDA FISH AND WILDLIFE CONSERVATION COMMISSION

The Florida Fish and Wildlife Conservation Commission (FFWCC) responsibility is to manage fish and wildlife resources for their long-term well being and the benefit of people. The agency could become involved if the proposed demineralization project could potentially impact listed species such as manatees or other fish and/or wildlife habitats. In addition, this agency is provided the opportunity to comment on proposed FDEP NPDES permits.

The FFWCC's location is as follows:
Florida Fish and Wildlife Conservation Commission
Northeast Region
1239 S.W. 10th Street
Ocala, Florida 34474-2797
Telephone: (352) 732-1225
www.floridaconservation.org

OTHERS

The remaining agencies that could be involved in concentrate discharge from a demineralization project include local city and county government agencies. Depending on the location and extent of the project, it could involve many different departments from the local county and/or city. Some of these departments include Building and Zoning, Health Department, Local Drainage, and Environmental Resources Management or Natural Resource Management Departments. These departments' involvement is associated with permits for construction, changes in zoning, public health and welfare, easement acquisitions, issues concerning right-of-ways as well as to restore, enhance, conserve and manage the air, water and land resources in the local area. In addition, CSX Railroad Corporation which is responsible for operating the rail network in the eastern United States, could require permits for any pipelines associated with a demineralization project when these pipelines cross over/under properties and/or tracks related to the rail network.

The degree of involvement and compliance requirements from the agencies will differ depending on the City and/or County, however their involvement has to be addressed because depending on the situations or different circumstances such as location, source regime, discharge regime, capacity, etc. could lead to methods requiring additional time, effort, policy decisions and/or compliance requirements affecting the demineralization project. No contact information is provided since it will be based on location.

SUMMARY

As defined above, a large number of agencies could directly or indirectly affect permitting of demineralization concentrate management. **However, the requirements of the United States**

Environmental Protection Agency and the Florida Department of Environmental Protection are the most pertinent to demineralization concentrate management and represent the critical test of the viability of any demineralization concentrate management project. Given that FDEP has primacy, the role of USEPA is secondary and consists of review and comment on FDEP draft NPDES permits and associated information about the project. However, EPA can object to an FDEP issued permit, which emphasizes the importance of both agencies in demineralization projects. Given that the focus of this Technical Memorandum is demineralization concentrate regulations, the following Rules and Regulations section specifically delineates the FDEP regulations that affect demineralization concentrate management.

APPLICABLE RULES AND REGULATIONS

The FDEP regulates demineralization concentrate management based on Florida Statutes and the associated Florida Administrative Code. In general, Florida Statutes are an edited compilation of general laws of the state and Florida Administrative Code is a compilation of the rules and regulations of state agencies that have been filed with the Department of State pursuant to the provisions of Florida Statutes. The Federal Acts that contributed to the development of these regulations were researched and are presented herein. In addition, the sections of Florida Administrative Code that govern demineralization concentrate management have been identified and summarized.

REGULATORY DEVELOPMENT

The regulations that govern demineralization concentrate in the State of Florida have evolved with the increase in numbers of demineralization plants within the State, the availability of more detailed information on concentrate characteristics, and the promulgation of new Federal regulations. Florida regulations have incorporated the Federal requirements and, in some cases, have developed more stringent requirements consistent with the unique characteristics of Florida's natural environment.

Federal Acts that impact demineralization concentrate management include the Clean Water Act (CWA), the Safe Drinking Water Act (SDWA), and the Resource Conservation and Recovery Act (RCRA). The role of each Federal Act is described below.

The Federal Water Pollution Control Act, enacted in 1972, was amended in 1977 with the Clean Water Act (CWA). This Act addresses the discharge of pollutants to surface water of the United States. The CWA established a National Pollutant Discharge Elimination System (NPDES) under which the administrator of the USEPA may issue permits for discharge of pollutants from a point source into waters of the United States that meet applicable CWA requirements. These requirements include effluent limitations, waste load allocations, monitoring and entry provisions, toxic and pretreatment effluent standards, and guidelines for ocean discharge criteria, among others. The CWA directly affects discharge of demineralization concentrate to surface waters and municipal wastewater treatment plants that subsequently discharge to surface waters, via the NPDES permitting process. However, there is no known, specific reference to demineralization concentrate in the CWA.

The Safe Drinking Water Act (SDWA), enacted initially in 1974, contains provisions for the protection of groundwater. Subtitle C is designed to prevent endangerment of underground drinking water sources. It contains the Underground Injection Control (UIC) program provisions and the sole source aquifer provision, which are the only provisions of the SDWA specifically addressing groundwater protection. The UIC program directs the USEPA to establish minimum requirements for state regulation of injection of liquids into wells. This program directly affects deep well injection of concentrate, via the UIC permitting process.

The Resource Conservation and Recovery Act (RCRA), enacted in 1970, provided legislation for solid waste management that includes guidelines and standards for solid waste storage, treatment and disposal of hazardous and non-hazardous wastes. RCRA requirements would apply to the disposal of solid or crystallized concentrate in landfills. There is no known specific reference to demineralization concentrate in the RCRA.

In summary, the Clean Water Act and the Safe Drinking Water Act provide the primary basis for Federal criteria that apply to the most common demineralization concentrate management methods (underground injection control alternatives and the various surface water discharge options). The Resource Conservation and Recovery Act provides criteria related to disposal of materials to landfills and would encompass solidified demineralization concentrate.

Under federal regulations, demineralization concentrate is a category of industrial wastewater. The State of Florida has enacted legislation and is developing regulations specific to demineralization concentrate. State law classifies concentrate as a drinking water treatment by-product, which is permitted as an industrial wastewater through the Industrial Wastewater Permitting Section of FDEP.

CURRENT REGULATIONS

Current FDEP regulations that affect demineralization concentrate permitting are listed in Table 2 and summarized below. The table includes regulations that directly affect the disposal of concentrate such as the State Water Quality Criteria in 62-302 as well as regulations that may have secondary or indirect effects on a concentrate disposal option such as ERP review in section 62-330. These sections from Chapter 62 of the Florida Administrative Code (FAC) include all known references to demineralization concentrate as well as the sections generally used by FDEP as part of concentrate permitting efforts.

The purpose of this information is to provide a reference point for rapid identification of pertinent sections of Florida Administrative Code. However, permitting of concentrate management alternatives is site-specific and complex. As with most regulations, a step-wise checklist of permit feasibility cannot be gleaned from the regulations due to the numerous factors that are considered in permitting of discharges to the environment. Therefore more detailed comparison of regulations with project-specific factors is necessary on a case-by-case basis to more accurately determine viable options for concentrate management.

Table 2. Applicable rules and regulations.

Reference	Description	Keyword
State Regulation from Florida Administrative Code (FAC):		
62-4	Permits	Surface water discharge, ocean outfall, underground injection control, non-surface water discharge, mixing zones
62-160	Quality Assurance	Sampling, analyses, laboratories, surface water, ground water, wastewater
62-301	Surface Waters of the State	Surface water, ocean outfall
62-302	Surface Water Quality Standards	Toxicity, OFW
62-330	Environmental Resource Permitting	Dredge and fill, pipelines
62-343	Environmental Resource Permit Procedures	Dredge and fill, pipelines
62-520	Ground Water Classes, Standards, and Exemptions	Ground water disposal
62-522	Ground Water Permitting and Monitoring Requirements	Ground water disposal
62-528	Underground Injection Control	Underground injection control wells
62-550	Drinking Water Standards, Monitoring, and Reporting	Land application
62-610	Reuse of Reclaimed Water and Land Application	Reuse, land application
62-620	Wastewater Facility and Activities Permitting	Industrial wastewater, permit applications
62-650	Water Quality Based Effluent Limitations	Surface water discharge
62-660	Industrial Wastewater Facilities	Industrial wastewater, effluent limitations

62-4: Permits

Chapter 62-4, F.A.C. outlines procedures for obtaining permits of all types from the FDEP. This regulation contains Part 1 – General, Part 2 –Specific Permits; Requirements, and Part 3 – Procedures for General Permits.

Part 1 - General identifies procedures and fees associated with permits and includes 62-4.001, F.A.C. through 62-4.160. F.A.C. The majority of this information consists of administrative procedures and fees related to permit issuance, renewal, transfer, and revocation.

Part 2 – Specific Permits; Requirements includes Rule 62-4.200, F.A.C. through Rule 62-4.250, F.A.C. and specifies criteria that are important for determining the viability of a concentrate management project that involves a discharge to surface waters. Sections of particular interest are described below.

Rule 62-4.242, F.A.C. – Antidegradation Permitting Requirements; Outstanding Florida Waters; Outstanding National Resource Waters; Equitable Abatement. This regulation includes criteria to balance the value of a project with the associated impacts to surface waters to determine if issuance of the permit is clearly in the public interest. In addition, the regulation requires confirmation that no other viable alternative exists in lieu of the proposed surface water discharge. Specific water quality criteria are not presented but are contained in other, referenced regulations. This regulation is a critical test of the viability of a surface water discharge option for concentrate disposal and can be a primary permitting focus point. Anti-degradation requirements are applicable to new and / or expanding surface discharge projects.

Rule 62-4.244, F.A.C. – Mixing Zones: Surface Waters. Requirements for mixing zones, including dilution ratios, water quality requirements, and toxicity requirements are identified. This section is critical to many demineralization concentrate management projects discharging to surface waters including open ocean waters in those situations where the demineralization concentrate does not meet water quality criteria established for the classification of the water body.

Rule 62-4.246, F.A.C. – Sampling, Testing Methods, and Method Detection Limits for Water Pollution Sources. A portion of this section addresses method detection limits (MDLs) and practical quantification limits (PQLs). It is possible that FDEP would deem the PQL of a parameter(s) to be the necessary and acceptable effluent limit for issuance of a permit. It is important to ensure that laboratories conducting analyses for a permit, in addition to being certified, are able to meet the MDLs and PQLs established through this regulation.

62-160: Quality Assurance

Chapter 62-160 applies to all programs, projects, studies or other activities that involve the measurement, use or submission of environmental data or reports to FDEP. The section address Quality Assurance plans, laboratory and field procedures, record keeping requirements, sampling and analytical requirements for FDEP programs, which would govern monitoring procedures for demineralization concentrate projects.

62-301: Surface Waters of the State

This Chapter defines the landward demarcation of surface waters of the State. This connection point to Surface Waters of the State is where the state’s jurisdiction and thus application of rules and water quality standards begin. This demarcation is also used for permitting of pipelines and other physical improvements that may be associated with construction of a demineralization concentrate outfall.

62-302: Surface Water Quality Standards

Chapter 62-302 defines many water quality-related factors and requirements important to demineralization concentrate permitting efforts. This information is material to most permitting efforts and includes such data as the state water quality standards for each classification of surface water, thermal surface water criteria, and special protection requirements for Outstanding Florida Waters and Outstanding National Resource Waters.

62-302.400: Classification of Surface Waters, Usage, Reclassification, Classified Waters

This subsection classifies waters of the state according to their designated use or uses as follows:

CLASS I	Potable Water Supplies
CLASS II	Shellfish Propagation or Harvesting
CLASS III	Recreation, Propagation and Maintenance of a Healthy, Well-Balanced Population of Fish and Wildlife
CLASS IV	Agricultural Water Supplies
CLASS V	Navigation, Utility and Industrial use

Water quality classifications are ordered in the degree of protection required with Class I generally having the most stringent water quality criteria and Class V the least. The classification of any water considered for concentrate disposal is critical in determining the viability of the project. Most surface waters in the State are Class I, II, or III waters. Class IV waters are described in 62-302.400(12) as wholly artificial canals or ditches contained on agricultural lands behind a control structure which is part of a water control system that is connected to the works of a water management district and which is permitted by such water management district. There are currently no Class V waters remaining in the State of Florida.

62-302.530: Table: Surface Water Quality Criteria

This section includes water quality criteria for different classes of water, including a differentiation between fresh and marine waters. For tidally influenced waters, requirements may include dual limits to encompass both fresh and marine conditions. Over 70 water quality parameters are listed and represent a significant body of data required for approval of any surface water discharge of demineralization concentrate. Surface water discharges must meet all of the water quality criteria established for the classification of waters or be granted a mixing zone or other administrative relief by the FDEP. Revisions to the water quality criteria are considered by the FDEP every three years (triennial review). FDEP is currently working on revision to the water quality criteria including revisions to the antidegradation permitting requirements, and risk based assessment of numeric criteria that were established based on human health.

62-302.700: Special Protection, Outstanding Florida Waters, Outstanding National Resource Waters

This Section lists water bodies designated by the Environmental Regulation Commission (the Commission) as Outstanding Florida Waters (OFWs) or Outstanding National Resource Waters (ONRWs). These waters are designated as worthy of special protection because of their natural attributes. In addition, the Outstanding National Resource Waters are designated as such exceptional recreational and ecological significance that water quality should be maintained and protected under all circumstances. Discharge of demineralization concentrate to OFWs and ONRWs is extremely limited in scope and will not be acceptable in most instances. Discharges to OFWs may not degrade the natural background water quality established at the time that they were classified as an OFW.

62-330: Environmental Resource Permitting

This Chapter authorizes the FDEP to adopt by reference certain Environmental Resource Permit Rules of the Water Management Districts to be used in conjunction with certain regulations, thus giving the FDEP independent authority to regulate surface water management systems including activities in, on or over wetlands or other surface waters. The Environmental Resource Permitting process applies to concentrate discharge permitting in relation to construction of pipelines and outfalls within waters of the state.

62-340: Delineation of the Landward Extent of Wetlands and Surface Waters

This Chapter defines the landward demarcation of wetlands and surface waters of the State. This connection point to Surface Waters of the State is where the state’s jurisdiction and thus application of rules and water quality standards begin. In addition, this information is used for permitting of pipelines and other physical improvements that may be associated with construction of a demineralization concentrate outfall.

62-341: Noticed General Environmental Resource Permits

General Environmental Resource Permits are defined in this Chapter for a broad range of activities, primarily related to construction, installation or maintenance of various types of infrastructure. While over 25 permits are included in this Chapter, examples that may be pertinent to concentrate management projects include construction or installation of riprap, fences, pipelines, and subaqueous utility crossings.

62-343: Environmental Resource Permit Procedures

This Chapter provides the procedural requirements for processing environmental resource permits and for obtaining formal determinations of the landward extent of wetlands and surface waters. This connection point to Surface Waters of the State is where the state’s jurisdiction and thus application of rules and water quality standards begin. In addition, this information is used for permitting of pipelines and other physical improvements that may be associated with construction of a demineralization concentrate outfall.

62-520: Groundwater classes, Standards, and Exemptions

Groundwater classes are defined in this Chapter as shown in Table 3 below. Groundwater classifications are ordered in the degree of protection required with Class G-I generally having the most stringent water quality criteria and Class G-IV the least. Among other requirements, discharges into Class G-I and G-II groundwaters must meet the primary and secondary drinking water standards for public water systems. This standard is difficult to meet for virtually any concentrate stream. Typically underground injection of demineralization concentrate occurs in Class G-IV groundwater aquifers.

Finally, Chapter 62-520 F.A.C. defines exemptions for installations discharging into groundwater and exemptions from secondary drinking water standards in Class G-II groundwater.

The standards and requirements in this section relate to percolation ponds, deep well injection, land spraying, reuse and any other concentrate management alternative that could result in migration of concentrate into Underground Sources of Drinking Water (USDWs).

Table 3. Definition of groundwater classes

Class F-I	Potable water use, groundwater in a single source aquifer described in Rule 62-520.460, F.A.C. which has a total dissolved solids content of less than 3,000 mg/L and was specifically reclassified as Class F-I by the Commission
Class G-I	Potable water use, ground water in single source aquifers which has a total dissolved solids content of less than 3,000 mg/L
Class G-II	Potable water use, ground water in aquifers which has a total dissolved solids content of less than 10,000 mg/L, unless otherwise classified by the Commission
Class G-III	Non-potable water use, ground water in unconfined aquifers which has a total dissolved solids content of 10,000 mg/L or greater; or which has total dissolved solids of 3,000-10,000 mg/L and either has been reclassified by the Commission as having no reasonable potential as future source of drinking water, or has been designated by the Department as an exempted aquifer pursuant to Rule 62-28.130(3), F.A.C.
Class G-IV	Non-potable water use, ground water in confined aquifers which has a total dissolved solids content of 10,000 mg/L or greater

62-522: Groundwater Permitting and Monitoring Requirements

Permitting and monitoring requirements for discharge to groundwater are defined including general provisions, dimensions of zones of discharge, permit renewal and modification procedures, exemptions, and monitoring requirements. These criteria are applicable to percolation ponds, deep well injection, land spraying, reuse and any other concentrate management alternative that could result in migration of demineralization concentrate into groundwater.

Per 62-522.300.5, F.A.C., concentrate from potable water demineralization plants are exempt from obtaining a zone of discharge in order to discharge to ground water, provided the applicant demonstrates that the receiving unconfined aquifer exhibits a natural background total dissolved solids concentration exceeding 1,500 mg/L. Such installations cannot cause violation of primary or secondary drinking water standards at any private or public water supply well outside of the installation's property boundary.

62-528: Underground Injection Control (UIC)

Chapter 62-528 F.A.C. is the primary regulation governing underground injection of demineralization concentrate. The UIC regulations protect the groundwater sources of drinking water within the State and prevents the degradation of aquifer water quality adjacent to the injection zone that could potentially be used for other purposes. This Chapter governs the construction and operation of injection wells in such a manner that the injection fluid remains in the determined injection zone, and is not allowed to interchange between aquifers.

The Chapter includes eight sections defined as follows:

Part I (general information)
Part II – Criteria and Standards for Class I and Class III Wells
Part III – Class I Well and Class III Well Permitting
Part IV – Criteria and Standards for Class IV Wells
Part V – Criteria and Standards for Class V Wells
Part VI – Class V Well Permitting
Part VII – Specific Permits; Requirements
Part VIII – General Permits

General descriptions of each class of well are as follows:

Class I: Class I wells are technologically sophisticated wells that inject large volumes of hazardous and non-hazardous wastes, including municipal wastewater, into deep, isolated rock formations that are below the lowermost underground source of drinking water (USDW).

Class II: Class II wells inject fluids associated with oil and natural gas production. Most of the injected fluid is brine that is produced when oil and gas are extracted from the earth.

Class III: Class III wells inject super-hot steam, water, or other fluids into mineral formations, which is then pumped to the surface and extracted.

Class IV: Class IV wells inject hazardous or radioactive wastes into or above underground sources of drinking water. These wells are banned under the Underground Injection Control Program because they directly threaten the quality of underground sources of drinking water.

Class V: Class V wells use injection practices that are not included in the other classes. Some Class V wells are technologically advanced wastewater disposal systems used by the desalination industry for disposal of concentrate.

Under current regulations, concentrate from desalination plants may only be injected via a Class I or V well. Underground injection regulations are organized almost entirely in this single Chapter (62-528, F.A.C.) and facilitate a clear understanding of the potential acceptability of subsurface injection of concentrate. Sections of Chapter 62-528 that are pertinent to Class I and V wells are described below.

Part I (Sections 62-528.100-360) provide general provisions, permit processing information, public notification requirements, and other general information necessary for all classes of wells.

Parts II and III provide information on Class I and Class III wells. Class I wells require injection into an aquifer with a total dissolved solids (TDS) concentration of greater than 10,000 mg/L, acceptable transmissivity, and a secure confining unit. Concentrate injection wells are most commonly Class I. Tubing and packer are required. In addition, an emergency disposal option is required for up to 3 days of flow. Specific requirements are contained in Sections 62-528.400-460.

Part V – Criteria and Standards for Class V Wells (Sections 62-528.600-625) and Part VI – Class V Well Permitting (Sections 62-528.630-645) address Class V wells specifically and include general criteria, exploratory well and testing permitting information, well construction standards, operating and monitoring requirements and other relevant information. Class V wells apply to aquifers with a TDS of less than 10,000 mg/L therefore may not be applicable for direct concentrate discharge.

Section 62-528.600 defines Groups of Class V wells based on usage, to facilitate the determination of permitting, operating, or monitoring requirements for these wells. A total of eight Groups are defined in Section 62-528.300(1)(e). Demineralization concentrate falls under Group 4, Type d:

"Non-hazardous industrial and commercial disposal wells, which include laundry waste wells, dry wells, injection wells associated with aquifer remediation projects, desalination process concentrate wells, and nuclear disposal wells used to inject radioactive wastes, provided the concentrations of the waste do not exceed drinking water standards contained in Chapter 62-550, F.A.C."

To obtain a permit for a Class V demineralization concentrate well, an exploratory well is required to determine the feasibility of the underground injection at the proposed site. Section 62-528.603 defines exploratory well construction and testing requirements.

Section 62-528.605 defines construction standards for Class V wells. Both exploratory and operational Class V concentrate wells are required to have tubing and packer, among other requirements.

Section 62-528.610 characterizes operational requirements for Class V wells, including the need for pretreatment of fluids as necessary for the fluid to comply with applicable water quality standards. Typical pretreatment of concentrate includes-dilution with fresh water and/or mixing with treated reclaimed water.

Sections 62-528.615-625 provide Class V requirements for monitoring, reporting, and plugging and abandonment.

In Part VI, 62-528.630-645, specific permitting requirements are defined. A Class V concentrate well involves a multi-phased approval process. A permit application must be submitted for construction of an exploratory well. Following collection and submission of data from the exploratory well, approval must be granted for construction of the full-scale well. Following collection and submission of data from the full-scale well, approval must be granted for operation of the well. A necessary and critical measure of the viability of a Class V well is the adequacy and preservation of the integrity of the confining beds between aquifers. These criteria are outlined in Part VI.

62-550: Drinking Water Standards, Monitoring, and Reporting

The drinking water standards and associated requirements are defined in this Chapter. This information is relevant to concentrate management for those alternatives that require compliance with drinking water standards. Chloride can be one of the most critical parameters and it is a violation of Secondary Standards when it increases above a maximum contaminant level of 250 mg/L. The regulations in this Chapter include restrictions on discharge or migration of concentrate to certain classes of groundwater, such as Class G-I and G-II. These concerns would apply to land spraying, percolation ponds and potentially other alternatives. Demineralization concentrate generally will not comply with drinking water standards. Therefore options that require compliance with drinking water standards are not typically viable. However, exceptions for up to three parameters may be granted under the UIC rules. This opens up the opportunity for dilution and mixing of demineralization concentrate with treated domestic effluent and for combined disposal.

62-600: Domestic Wastewater Facilities

The requirements for domestic wastewater facilities are defined in this Chapter, including the characteristics of the influent water necessary to meet the domestic wastewater classification (62-600.200(25), F.A.C.). The maximum amount of demineralization concentrate that can be discharged to a domestic wastewater facility is dependent upon the resulting changes to influent quality and the ability to meet the classification requirements. In addition, each FDEP office, depending on the type of industrial waste, may require pretreatment of the waste consistent with Chapter 62-625 prior to mixing. Therefore, at this time the demineralization concentrate must be mixed with the raw wastewater and receive complete treatment with the domestic wastewater.

62-610: Reuse and Reclaimed Water and Land Application

This Chapter addresses all forms of domestic wastewater reuse, reclaimed water and land application. It only applies to demineralization concentrate when it is blended with domestic reclaimed water Sections include the following:

Part I – General
Part II – Slow-Rate Land Application Systems; Restricted Public Access
Part III – Slow-rate Land Application Systems; Public Access Areas, Residential Irrigation, and Edible Crops
Part IV – Rapid-Rate Land Application Systems (Rapid Infiltration Basins and Absorption Fields)
Part V – Ground Water Recharge and Indirect Potable Reuse
Part VI – Overland Flow Systems
Part VII – Industrial Uses of Reclaimed Water
Part VIII – Permitting
Part IX – Forms and Instructions

Parts II and III address slow-rate land application system such as spray irrigation. Part IV identifies rules and regulations associated with rapid-rate land application systems such as rapid infiltration basins and percolation ponds. These sections provide pertinent information regarding the requirements for such disposal methods. While the FDEP office governing the SJRWMD service area has granted permits for concentrate mixing with reclaimed domestic wastewater and disposal via rapid infiltration basins and percolation ponds, this practice is limited.

Parts V, VI and VII are generally not applicable to demineralization concentrate management.

Part VIII – Permitting provides detailed information related to issuance of domestic wastewater reuse permits. Of most importance is subsection 62-610.865 – Blending of Demineralization Concentrate with Reclaimed Water. Per this regulation, all land application and reuse projects must be designed to meet the groundwater standards at the edge of a zone of discharge. These standards, for the most part, are the primary and secondary drinking water standards. Given the high concentration of inorganic constituents in concentrate and the relatively limited opportunity for dilution, the reclaimed water blend normally must come close to meeting the ground water standard as it is applied to the land. This puts practical limits on using large quantities of demineralization concentrate in a blending operation with reclaimed water.

62-620: Wastewater Facility and Activities Permitting

This Chapter addresses permitting requirements for any wastewater facility or activity that will reasonably be expected to be a source of pollution. This includes domestic and industrial facilities and is the *key* Chapter associated with demineralization concentrate permitting. Permit applications necessary for a demineralization concentrate project are identified in 62-620.910. This Chapter will likely undergo amendment in pending rule-making efforts, described in the Proposed and Pending Regulations section of this document.

62-650: Water Quality Based Effluent Limitations

This Chapter contains the procedures for establishing Water Quality Based Effluent Limitations (WQBEL) and apply to all surface water discharges. The intent of the regulation is to ensure that no wastes are discharged to any waters of the state without first being given the level of treatment necessary to protect the designated uses of the water. Criteria are provided to establish discharge water quality requirements based on one of the following:

1. Technology Based Effluent Limit;
2. Level 1 WQBEL; or
3. Level 2 WQBEL.

Criteria for each method of establishing an effluent limit are provided. Technology Based Effluent Limits do not preclude compliance with surface water quality criteria. Level 1 WQBELs are based on the availability of sufficient data to determine that the current quality of the receiving water body meets standards and will continue to do so with the introduction of the concentrate. Level 2 WQBELs involve an assessment of the assimilative capacity of a water body and setting WQBELs by simulating and predicting water quality impacts.

62-660: Industrial Wastewater Facilities

This Chapter contains the procedures for permitting an industrial wastewater facility. This includes definitions for industrial wastewater and effluent limitations, both applicable to demineralization concentrate. In addition, there are specific definitions for exemptions that may apply to certain demineralization concentrate projects or situations.

Proposed and Pending Regulations

Pursuant to Senate Bill 536, signed in June 2001, Section 403.0882 Florida Statutes (F.S.) was amended. The amended statute states that the Legislature finds and declares that it is in the public interest to conserve and protect water resources, provide adequate water supplies and provide for natural systems, and promote brackish water demineralization as an alternative to withdrawals of freshwater groundwater and surface water. This is to be accomplished by removing institutional barriers to demineralization, and through research to advance water and wastewater byproduct treatment technology, sound waste byproduct disposal methods, and regional solutions to water resource issues.

Key changes to Section 403.0882, F.S. include:

1. The FDEP is to develop rules that will address demineralization concentrate regulatory issues including:
    a. Permit application forms for demineralization concentrate disposal;
    b. Specific options and requirements for demineralization concentrate disposal;
    c. Specific requirements and accepted methods for evaluating mixing of effluent in receiving waters; and
    d. Specific toxicity provisions.
2. For surface water discharges, failure of whole effluent toxicity tests predominately due to the presence of constituents to be specifically identified in the regulations as naturally occurring in the source water may not be the basis for denial of a permit, provided that the volume of water necessary to achieve water quality standards is available within a distance less than or equal to two times the natural water depth at the point of discharge under all flow conditions;
3. Specific permitting requirements for Small Water Utility businesses (i.e. those discharging <50,000 gallons per day); and
4. Specific permitting requirements for discharge of demineralization concentrate to Outstanding Florida Waters.

SB536 will result in revised regulations that should provide a clearer permitting process for demineralization concentrate management and discharge. Therefore the information presented herein regarding the permitting process will require revision following development of the new rules.

In addition, and not directly associated with legislation or rulemaking for demineralization concentrate discharge, FDEP is considering changes to the surface water quality standards, antidegradation permitting requirements, identification of impaired waters, and potential reclassification of certain waters. These changes could ultimately impact discharges of all types including demineralization concentrate.

OVERVIEW OF PERMITTING PROCESS

Developing a viable demineralization water treatment plant in Florida is contingent upon obtaining necessary permits for the demineralization concentrate management component of the project. As described previously, the Florida Department of Environmental Protection represents the primary and most important agency associated with concentrate management. Demineralization concentrate is regulated by FDEP through issuance of the appropriate permit for any of the management alternatives proposed. Various components of Florida Administrative Code are integrated into FDEP's evaluation of the permit application.

Given the varying requirements depending upon application, this Section defines the primary steps associated with a demineralization concentrate management permitting effort, as determined by the management approach.

The following demineralization concentrate management options are addressed:

1. Underground injection;
2. Surface water discharge;
3. Ocean outfalls;
4. Blending with wastewater effluent;
5. Brackish wetlands discharge
6. Other methods

The information presented herein is representative of a typical application and provides an initial guide as to FDEPs permitting requirements and processes that should be expected. However, site-specific conditions render every concentrate permit effort unique. In addition, agencies other than FDEP may become the critical factor in determining the acceptability of a project, such as projects that would impact endangered or threatened species.

The regulations contained within Florida Administrative Code are not specific to concentrate and in many cases require policy decisions on the part of FDEP for interpretation of a permit application and issuance of a permit. Therefore it is critical to understand the challenges faced by FDEP Industrial Wastewater permitting personnel and the need to begin pre-application permitting efforts well in advance of any demineralization water treatment plant project.

In addition, the lack of a specific regulation for concentrate permitting creates an uncertain environment for the municipal water treatment community. The amendments to Section 403.0882, F.S. pursuant to Senate Bill 536 will result in development of concentrate-specific regulations and is intended to provide a consistent approach for FDEP permitting personnel to follow. Therefore future permitting efforts may differ from those presented below.

UNDERGROUND INJECTION

Obtaining an FDEP permit for underground injection of demineralization concentrate begins with the requirements of Chapter 62-528, FAC and identification of the type of well to be constructed. Class I and Class V wells are the two viable candidates for concentrate projects.

Primary aquifer considerations for a Class I well are:

- Suitable transmissivity,
- Aquifer TDS greater than 10,000 mg/L, and
- Confining zone is present.

If the fluid is non hazardous, as is typical for demineralization concentrate streams and suitable geology exists, then the demineralization concentrate will not need to meet other water quality standards and the project has reasonably high probability of being permitted. Class I wells are most common.

Aquifer considerations for a Class V well are as follows:

- Suitable transmissivity, and
- Confining zone is present.

If the aquifer TDS is less than 10,000 mg/L or if the fluid can migrate to an underground source of drinking water (USDW), then fluid must meet drinking water standards. If the aquifer TDS is greater than 10,000 mg/L and confined from a USDW or absent of a USDW, then it will not need to meet other groundwater quality standards. Given the elevated levels of TDS and other constituents in many concentrate streams, drinking water standards typically cannot be met.

However, certain projects, such as softening applications or treatment of fresh or slightly brackish water, may be eligible for a Class V well permit. In addition, FDEP has the authority to issue an exemption for parameters that exceed drinking water standards. An exemption will only be granted if exceeding secondary standards and the state primary standard for sodium. An exemption is renewable with the permit and requires a fee that is currently $6,000 per parameter. At least one reverse osmosis WTP operates a Class V concentrate well, with a TDS less than 10,000 mg/L and exemptions for certain secondary standards.

Once the Class of well has been selected, FDEP will review information provided by the applicant to determine the steps that will be required for issuance of an Underground Injection Control (UIC) permit. If insufficient information is available on the hydrogeologic environment, then FDEP may require an exploratory well, in which case a three-phased permit process would result:

1. Approval for construction of the exploratory well. This well will be used to obtain additional subsurface information and may eventually be used as a monitoring well.
2. Approval for construction of the full-scale well. If the information from the exploratory well is acceptable, the permit for construction of the full-scale well may be issued. Information gained following construction of the full-scale well must be submitted as part of an Engineering Report and will be used to evaluate issuance of an operating permit; and
3. Approval of an operating permit. Only following receipt of acceptable information from both the exploratory well and the full-scale well will an operating permit be issued.

Of great importance is the potential for FDEP to deny further and subsequent approvals at any point in the process described above. Therefore a municipality may invest funds in an exploratory well and possibly a full-scale well, to find that FDEP will not issue the operating permit due to concerns over transmissivity, confining layers or other issues. The large capital expenditure (typically over $2M) and the uncertainty and financial risk associated with deep well injection are such that careful consideration should be given before a decision is made. Collection of detailed hydrogeologic information as well as preliminary meetings with FDEP is recommended.

One specific area of interest to FDEP is the solubility level of the various constituents concentrated by the desalination process. The main concern is with the potential for precipitation when some parameters at near supersaturated levels in the concentrate mix with the same parameters at nearly saturated levels in the native waters of the receiving formation. This potential for the creation of precipitates of various concentrated salts inside the well would endanger the permeability of the receiving aquifer. The FDEP often requires bench studies of solubility and precipitate formation in mixed media with similar hydrologic characteristics as the receiving aquifer.

Once an underground injection well has been approved, the mechanical integrity of the well must be demonstrated every five years. A minimum of two monitoring wells will need to be constructed to provide monthly monitoring of the injection well. In addition, an emergency disposal alternative is required and will need to accommodate at least 3 days of flow. In some cases, the redundancy requirements for the continued operation of potable water treatment facilities can lead to the requirement for two separate injection wells. Any additional permits associated with this alternative disposal method must also be procured. This duplicate permitting effort may also be a critical factor in determining viability of underground injection alternatives.

Finally, the construction of Class I or Class V wells must follow design standards outlined by FDEP, which include tubing and packer construction, testing during drilling and construction, and testing upon completion of well. Due to high construction costs, with drilling and construction costs on the order of $2-5M per well, underground injection is most applicable for larger water treatment plants.

In summary, a feasibility study is recommended prior to pursuing underground injection. Also, FDEP is required under their primacy agreement with USEPA to form a Technical Advisory Committee (TAC). This TAC brings into the permit process the opinions of diverse agencies including USEPA, USGS, SJRWMD, local county Health Department, and local county environmental regulatory agency, in addition to the local office of FDEP and the FDEP UIC Tallahassee office.

SURFACE WATER DISCHARGE

Discharge of concentrate to a surface water requires an NPDES permit. The permitting process brings together numerous portions of Florida Administrative Code and can be complex. Surface water discharges are more likely to result in the need for discretionary decisions by FDEP permitting staff when compared to other alternatives such as underground injection.

The first and foremost factor associated with a surface water discharge is the classification of the receiving water. The definition for each Class is presented below.

CLASS I	Potable Water Supplies
CLASS II	Shellfish Propagation or Harvesting
CLASS III	Recreation, Propagation and Maintenance of a Healthy, Well-Balanced Population of Fish and Wildlife
CLASS IV	Agricultural Water Supplies
CLASS V	Navigation, Utility and Industrial use

While each situation is unique and the regulations are complex, every surface water permit application is reviewed for compliance in four main areas:

1. Anti-degradation policy and WQBEL (anti-degradation is only applicable to new or increased discharges);
2. Compliance with surface water criteria and mixing zone limitations;
3. Impacts of tidal influence; and
4. Toxicity of demineralization concentrate and,
5. Whether the demineralization concentrate contributes to an existing impairment of the surface water / WQBEL

The anti-degradation policy is defined in 62-302.300, F.A.C. and requires abatement of water pollution and conservation and protection of Florida's natural resources and scenic beauty. The anti-degradation policy was adopted by the Commission in 1989. In addition to requiring compliance with water quality standards that were originally developed and adopted in 1979, the policy requires that any degradation of existing background quality be found to be clearly in the public interest. Revisions to the water quality standards are considered every three years (triennial review) in accordance with the Clean Water Act. The water quality criteria are listed in 62-302.500-530, F.A.C.

FDEPs application of the anti-degradation policy includes a variety of intentionally subjective criteria that are applied uniquely to each specific permit scenario. There is a "weighing" of various public interest criteria including economic and social concerns against the potential for degradation of the state's valuable water resources. An excerpt from 62-302.300, F.A.C. best explains the purpose behind the flexibility:

62-302.300.10.b.1 – The Department’s rules that were adopted on March 1, 1979, regarding water quality standards are based upon the best scientific knowledge related to the protection of the various designated uses of waters of the State.

62-302.300.10.b.2 – The mixing zone, zone of discharge, site specific alternative criteria, exemption, and equitable allocation provisions are designed to provide an opportunity for the future consideration of factors relating to localized situations which could not adequately be addressed in this proceeding, including economic and social consequences, attainability, irretrievable conditions, natural background, and detectability.

62-302.300.10.d – Without the moderating provisions described in b.2 above, the Commission would not have adopted the revisions described in b.1 above nor determined that they are attainable as generally applicable water quality standards.

While some latitude may exist depending upon site-specific conditions, it is important to compare the expected concentrate quality with the water quality standards as soon as possible. Projects that meet all water quality criteria although rare, greatly simplify the permitting process.

In addition, the anti-degradation policy requires that the Department consider and balance four factors, paraphrased below (see 62-4.242, F.A.C.):

1. Whether the proposed project is important to and is beneficial to the public health, safety, or welfare;
2. Whether the proposed discharge will adversely effect conservation of fish and wildlife, including endangered or threatened species, or their habitats;
3. Whether the proposed discharge will adversely affect the fishing or water-based recreational values or marine productivity in the vicinity of the proposed discharge; and
4. Whether the proposed discharge is consistent with any applicable Surface Water Improvement and Management Plan that has been adopted by a Water Management District and approved by the Department.

Each permit application is evaluated on individual basis to ensure that the Department has reasonable assurance that the proposed facility will meet applicable water quality standards. Staff members and the Department must make discretionary decisions, balancing these factors, with each surface water permit application. Since the majority of membrane concentrate discharges are related to public water supply facilities, they are considered to be beneficial to the public health, safety, and welfare in most cases but not all cases. However, the economic analysis requirements may often point to other alternatives for disposal (i.e. underground injection control) that, although more costly, can be implemented and avoid any degradation of surface waters.

Mixing zones may be granted for dilution of concentrate, if no pre-dilution takes place at the treatment facility. The applicant must demonstrate a current and continuing need for the mixing zone. Mixing zones are commonly needed for concentrate projects due to exceedance of water quality criteria such as radionuclides and acute or chronic toxicity. Criteria for mixing zones are complex and are dependent upon the type of receiving water body. Three categories of water bodies are defined and addressed differently:

1. Canals, rivers, streams, and other similar water bodies;
2. Lakes, estuaries, bays, lagoons, bayous, sounds, and coastal waters; and
3. Open ocean waters.

Open ocean waters are defined as all surface waters extending seaward from the most seaward natural 90-foot (15-fathom) isobath.

For additional information on mixing zones, 62-4.244, F.A.C. should be referenced. In addition, the recent (June 2001) passage of Senate Bill 536 allows for approval of mixing zones for toxicity due to ionic imbalance in Outstanding Florida Waters, if certain criteria are met. This expands the Classes of surface waters eligible for consideration.

Tidal influences are addressed via identification of the chloride concentrations of the water body and flow patterns. Predominately fresh waters are defined as waters in which the chloride concentration at the surface is less than 1,500 mg/L. Marine waters are those with chloride concentrations greater than 1,500 mg/L. In tidally influenced water bodies, FDEP may require dual limits, addressing both fresh and marine waters. In addition, tidally influenced water bodies pose difficult flow modeling challenges since there is reduced flow during tide reversal and, at least for a short period of time, concentrate is accumulating at the discharge location. Identification of the range of chloride concentrations for the receiving water body should be conducted as soon as possible to determine if tidal influence will be an issue in the permitting process as well as whether the receiving waters will be considered predominantly marine.

Biotoxicity requirements are identified in 62-302, F.A.C. – Surface Water Quality Standards for acute and chronic toxicity. For discharge of concentrate to marine waters, FDEP typically requires assessment of the mortality rates for the mysid shrimp and silverside minnow. Certified laboratories are available in Florida and are familiar with FDEPs testing procedure requirements.

In many cases, demineralization concentrate has been found to fail biotoxicity tests due to naturally occurring constituents such as calcium, potassium, and sodium. In many cases, the relative ratio of these constituents is different than that of the proposed receiving water body, even though the concentration of total dissolved solids may be equal. This difference in the ratio of constituents has been found to cause mortality in test organisms that can be corrected by adjustment of the ratio of these ions, such as naturally occurs in free flowing surface water bodies via dilution effects. Due to the source of and solution to this toxicity, Senate Bill 536 has dictated that failure of toxicity tests due to naturally occurring constituents cannot be the cause for rejection of a permit application. Therefore demineralization concentrate streams that fail biotoxicity tests should be evaluated to determine if naturally occurring constituents are the cause. In 1995, FDEP published a methodology for testing membrane demineralization concentrate to determine whether and to what degree observed toxicity is the result of naturally occurring constituents.

In summary, permitting of concentrate discharge to surface waters involves balancing numerous factors and considerations. The viability of a permit application is highly dependant on site-specific conditions and interpretation of regulations.

OCEAN OUTFALLS

Discharge of demineralization concentrate to the open ocean falls under the NPDES permitting requirements presented herein for surface water discharge. This section should be referenced for basic requirements of ocean discharge. Note that ‘open ocean waters’ are defined as all surface waters extending seaward from the most seaward natural 90-foot (15-fathom) isobath. In many instances, ocean discharges may not meet this criteria thus would fall under the criteria for coastal waters, also addressed in the surface water discharge section herein.

As defined in 62-4.244, requirements for ocean discharges are less stringent than that for other surface water bodies. Specific differences are as follows:

1. Compliance with the anti-degradation policy is more likely;
2. Dissolved oxygen requirements are less stringent;
3. Biotoxicity requirements are less stringent: the discharge can be diluted 1/3 its normal concentration for toxicity testing;
4. Water quality standards must be met at the point of 20:1 dilution, not at the point of discharge;
5. If water quality standards are met at the point of 20:1 dilution, a mixing zone exemption is not required;
6. A larger mixing zone is allowed (four times larger than other surface water discharges).

Regulations require the use of a diffuser system that results in at least a 20:1 dilution before the effluent reaches the surface. In addition, the relative density of demineralization concentrate should be considered (for example, in ocean waters, brackish demineralization concentrate will be less dense and seawater demineralization concentrate would be more dense) and appropriate diffuser and outfall structures constructed.

While FDEP requirements may be less stringent, additional Agencies may become involved in an ocean outfall project. These may include the Coast Guard (navigable waterways), the Army Corp of Engineers (navigable waterways), Florida Fish and Wildlife Conservation Commission (well being of fish and wildlife resources), and local coastal and ocean protection agencies.

In summary, ocean outfalls are a subcategory of surface water discharge with similar permitting requirements. However, the reduced water quality requirements and the ability to discharge large quantities of water treatment plant concentrate are such that ocean discharge may be a reasonable alternative for large municipal demineralization water treatment plant projects.

BRACKISH WETLANDS DISCHARGE

Discharge of demineralization concentrate to brackish wetlands is considered a surface water discharge and requires an NPDES permit. FDEP requirements are consistent with those presented for surface water discharges.

BLENDING WITH WASTEWATER

The permitting process associated with blending of demineralization concentrate with wastewater is application-specific. Primary methods for combining demineralization concentrate and wastewater are listed below, following by a description of the permitting approach.

1. Discharge to sewerage system or at the headworks of a WWTP; or
2. Blending with wastewater effluent for
    a. Discharge to a surface water;
    b. Subsurface injection; or
    c. Reuse

Concentrate may be discharged into the sewerage system or conveyed to the headworks of a domestic wastewater treatment facility. This method is commonly used by small demineralization facilities due to the low capital costs involved. The maximum amount of industrial waste including demineralization concentrate a domestic WWTP may receive is limited by the domestic wastewater facility capacity to accept the discharge as well as meet the appropriate effluent regulations. Depending on the type of industrial waste, pretreatment may be required prior to mixing. The utility selects the pretreatment, in accordance with the approved pretreatment program for the utility.

Additional considerations include confirmation that the introduction of the concentrate will not affect the treatment process and that the wastewater effluent discharge permit requirements will not be impacted. If introduction of concentrate into the sewerage system does not increase the total influent flow of industrial waste above 10%, no separate permitting requirements are expected from FDEP.

Permitting requirements for blending of concentrate with treated wastewater effluent are dependant upon the fate of the combined stream. Typical management methods include surface water discharge, deep well injection, and reuse.

Discharge of blended water to a surface water must comply with NPDES permitting requirements, as described previously herein. In the event the concentrate is introduced to a wastewater effluent with an existing NPDES permit, a new or updated permit application will be required to confirm compliance with surface water discharge requirements.

Underground injection of blended water must comply with UIC permitting requirements. Given the differing requirements for concentrate and wastewater effluent, permit modification or construction of a different Class of well may be required. It is also possible that improvements will likely be required of an existing and permitted Class I well if it is to receive a blend of reclaimed water and desalination concentrate and the ratio of concentrate to reclaimed water exceeds 10%. The improvements required will likely include a need for tubing and packer as well as fluid filled annulus and hydropneumatic fluid level control of the annular fluid.

Reuse of blended concentrate / wastewater effluent is approached cautiously by FDEP due to concerns over violation of water quality standards and impact to the environment. The applicant must submit an engineering report addressing an array of issues. Major points that should be addressed in the engineering report include:

1. Compliance with ground water quality criteria at the edge of the zone of discharge. For the most part, water quality criteria are the primary and secondary drinking water standards. The high concentration of inorganic ions in demineralization concentrate limits the ability to meet such standards. In addition, rainfall exceeds evapotranspiration by less than 10 inches per year over much of Florida. Therefore, rainfall at the land application sites provides a limited dilution before the edge of the zone of discharge. Detailed water balances will be required in the report and possibly monitoring wells to confirm compliance.

2. Impact of sodium on percolation rates. The sodium adsorption ratio (SAR) and other factors should be evaluated to determine if an adverse impact to percolation rate would occur. FDEP generally views an SAR of less than 15 to be acceptable.
3. Vegetation concerns. Vegetative concerns may result from salinity, boron, selenium, beryllium, and other specific constituents. The report must provide reasonable assurances that the blend will not harm vegetation or crops grown on the land application site(s).
4. Operating protocol. Given the interruptible nature of a reuse supply, the report must include an operating protocol for the disinfection process (for the wastewater) and for the blending operation.
5. Monitoring requirements must be addressed and must include multiple locations (individual supplies, blend, and groundwater).

Concentrate / wastewater reuse projects will be required to have a minimum of 3-days of demineralization concentrate and reclaimed water storage. Storage for extended wet weather conditions must be evaluated as part of any project involving slow rate irrigation. Finally, an annual summary must be prepared and submitted to FDEP for review. Concentrate reuse has been addressed in detail via 62-610.865, F.A.C. and Program Guidance Memo DOM-00-04 – Blending of Concentrate with Reclaimed Water.

OTHER METHODS

While a number of lesser-known demineralization concentrate management methods are available, most fall into one of the categories described previously. These lesser-known methods and the permitting approach are defined as follows:

1. Land Spraying and Percolation Ponds. Demineralization concentrate addressed via land spraying or percolation ponds must meet groundwater standards at edge of zone of discharge. Given the issues of percolation rates and land area required, these methods are typically not used for large-scale facilities.

   Nevertheless, permits can be issued and have similar requirements as those described previously for reuse of blended concentrate and wastewater effluent. Primary concerns that must be addressed by the applicant include impact of sodium on percolation rates, protection of vegetation and crops, operational and monitoring procedures, concentrate storage, and the ability to meet drinking water standards at the edge of the zone of discharge. This latter requirement can be the most difficult to meet.

2. Evaporation Ponds. The use of evaporation ponds for management of concentrate is typically restricted to small-scale water systems in areas with a warm, dry climate, high evaporation rates, level terrain, and low land costs. As a result, most applications are in the Western United States. However, a survey of Florida demineralization WTPs indicates at least one concentrate evaporation pond is operating in the state.

   Permitting of an evaporation pond requires an impervious liner and development of monitoring wells. While evaporation ponds are typically designed to accommodate concentrate for the projected life of the demineralization facility, precipitation of salts is expected and must be incorporated into the depth requirements of the pond. These precipitated salts or the liquid brine may ultimately have concentrations of constituents at levels that result in a hazardous waste classification. Therefore the ultimate fate of the concentrated salts and the future regulatory implications should be considered for any evaporation pond project.

3. Zero Discharge. Zero discharge systems have been designed for concentrate from industrial applications. The most cost effective method involves increasing the TDS of the stream via use of a concentrator evaporator, followed by solidification via a crystalizer. The resulting wet cake can readily be transported for disposal in a landfill. Both a concentrator evaporator and crystalizer are thermal processes and require a source of steam or electrical power for heating. Amortized capital costs (excluding operation and maintenance costs) for a zero discharge system are typically over $12 per 1,000 gallons of potable water produced (Mickley et al.). Therefore zero discharge applications have been limited to select industrial applications.

   Permitting of a zero discharge system would be limited to the RCRA requirements for landfill disposal. Considerations include the ability of the material to pass a toxicity characteristic leaching procedure (TCLP) test and confirmation that the cake does not contain levels of constituents that result in a hazardous waste classification.

4. Coastal Exfiltration Galleries – Surface water discharges include coastal exfiltration galleries given their direct connection to coastal and ocean waters. Based on input from FDEP, standard NPDES permitting requirements would apply as described herein. However, it is also possible that the FDEP Underground Injection Control group would become involved to confirm that the design and location of the galleries were such that they did not fall under UIC domain.

5. Bore Holes. A bore hole represents a Class V UIC system under the Safe Drinking Water Act. Requirements for Class V systems were defined in the Deep Well Injection section herein.

In summary, the alternative disposal methods described can all be permitted in Florida, pending compliance with specific criteria. Other factors such as costs may have more bearing on the use of these methods.

SUMMARY AND CONCLUSIONS

The rules and regulations governing the management of demineralization concentrate in Florida are primarily associated with the Florida Department of Environmental Protection, with additional requirements from a broad base of local, state, and federal agencies. While FDEP must grant approval for any and all concentrate projects, the involvement of other agencies may be dependant upon project-specific factors such as the selected concentrate management alternative or the location of the project.

The complexity of FDEPs regulations are such that the acceptability of a demineralization concentrate management alternative to FDEP is difficult to determine prior to detailed development of the permit application. In addition, the specifics of individual demineralization water treatment projects render each concentrate permitting effort unique.

The amendments to Section 403.0882 F.S. pursuant to passage of Senate Bill 536 will result in rule making by FDEP that will, at a minimum, result in permit applications specific to demineralization concentrate and clarification of options and requirements for demineralization concentrate disposal. Therefore the permitting approach defined in this document will change following this rule making. However, the federal industrial wastewater requirements that form the base of FDEPs regulations have not changed. Therefore technical criteria may remain as stringent but the level of effort to determine permit viability and the intentions of FDEP should be reduced. This summary of rules and regulations should be updated following completion of the rule making pursuant to Senate Bill 536.

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APPENDIX C

CORRESPONDENCE

1903-3.1.6
File: INDIAN RIVER COUNTY

NATURAL RESOURCE MANAGEMENT, WETLAND, AND ENVIRONMENTAL PERMITTING SERVICES

EW CONSULTANTS, INC.

RECEIVED
AUG 29 2002
BY:

MEMORANDUM

TO: Barbara Vergara

FROM: Ed Weinberg EW   EWC PROJECT NO.: 1125.00

DATE: August 27, 2002

RE: Indian River County Utilities Demineralization Concentrate Management

Pursuant to your request, this memorandum has been prepared to provide a summary of how current issues affecting the referenced project may be addressed by the ongoing rulemaking for demineralization concentrate disposal. In order to develop this summary, I have met with Indian River County Utilities Director Erik Olson as well as several members of his staff. Additionally, I have reviewed the current Consent Order under which the North Plant is operating, as well as additional background information and permit documents regarding the subject facility.

With regard to the current status of the rulemaking for demineralization concentrate disposal, the progress has been disappointingly slow. At the current time, a fourth Technical Advisory Committee (TAC) meeting is scheduled for October 28, 2002, at which time the TAC can hopefully reach a point of having some recommended rule language that will then go through the public workshop and adoption process. Considering these circumstances, it is premature to reach definite conclusions as to the effectiveness and applicability of the rule. However, several principles can be reasonably expected to reach the final rule, which may be of some benefit to the Indian River County Utilities situation.

On August 15, 2002, I met with Erik Olson and several of his senior staff members to discuss their particular circumstances with regard to concentrate management. They provided me some background information as to the concerns that FDEP has expressed regarding their demineralization concentrate disposal issues. The primary difficulty seems to be with their North County RO plant, which currently discharges up to 0.75 MGD of concentrate to the Indian River Lagoon in an area designated as Outstanding

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Florida Waters (OFW). Because of the OFW designation, there are no mixing zones allowed, and thus certain instances where the concentrate has exceeded numerical standards have resulted in charges of water quality violations from FDEP. In addition to numerical standard exceedances, there have been occasional failures of toxicity tests, primarily due to alterations in methodology as explained by the staff members present. The result is a negotiated order and mandated permitting program that removes the discharge from the Indian River Lagoon. Compounding the problems at this time is the near immediate need to double the concentrate discharge from the current 0.75 MGD up to 1.5 MGD to meet potable water demand.

The rulemaking that is ongoing to implement SB 536 has specific elements related to both OFWs and toxicity. The language regarding OFWs allows for a very narrow mixing zone exemption in OFWs for concentrate discharges that meet the toxicity requirements of the rule. In this case, it appears that there have been enough exceedances of other numeric criteria aside from toxicity that the Department would not have reasonable assurance that water quality criteria could be met at "end of pipe", and thus a mixing zone for other parameters would be necessary. As such, the OFW portion of the new rule is not expected to offer any additional relief in the case of the Indian River County North RO Plant.

With regard to toxicity, however, the new rule is almost certain to provide some relief in regards to the cause of observed toxicity in the concentrate. This is supported by information provided by utilities staff indicating that they had consistently passed bioassay tests when salinity adjustments were being used, and failures only occurred after FDEP required that the tests be run without the salinity adjustment.

Based on the information provided in my meeting with the utility staff, toxicity is not their major concern for their concentrate disposal. Rather, they are concerned with the ability of the "North Relief Canal" to provide sufficient dilution of the concentrate discharge when the outfall is relocated to that location. My cursory review of the "base flow" information provided in the Carter Associates "Master Stormwater Management Plan Fast Track Alternative Analysis" indicates that this may not be as large a concern as initially indicated. Although there are many confounding factors that I have not had the opportunity to explore, there seem to be "hard numbers" in the report that would support a concentrate discharge downstream of the "radial gate" after which the report states there are no irrigation demands. Roughly, a 95th percentile $7Q_{10}$ low flow of more than 4 MGD is available for dilution, which should be more than enough to meet state water standards within the presumptive mixing zone limits in Florida Administrative Code.

The remaining issues appear more related to addressing concerns of local constituencies than resolution of the concentrate discharge permit technicalities. It does seem, however, that the utility could benefit from some technical assistance in resolving matters that could possibly simplify their concentrate discharge permitting. Please feel free to call me if you have any questions.

cc: Robert Reiss

1903-3.1.6

NATURAL RESOURCE MANAGEMENT, WETLAND, AND ENVIRONMENTAL PERMITTING SERVICES

EW CONSULTANTS, INC.

RECEIVED
AUG 30 2002
BY:

MEMORANDUM

TO: Robert Reiss

FROM: Ed Weinberg EW EWC PROJECT NO.: 1125.00

DATE: August 27, 2002

RE: City of Melbourne Demineralization Concentrate Management

Pursuant to your request, this memorandum has been prepared to provide an interim summary of how current issues affecting the referenced project may be addressed by the ongoing rulemaking for demineralization concentrate disposal. In order to develop this summary, I have reviewed the current Consent Order under which the Melbourne RO Plant is operating, as well as additional background information and permit documents regarding the subject facility.

With regard to the current status of the rulemaking for demineralization concentrate disposal, the progress has been disappointingly slow. At the current time, a fourth Technical Advisory Committee (TAC) meeting is scheduled for October 28, 2002, at which time the TAC can hopefully reach a point of having some recommended rule language that will then go through the public workshop and adoption process. Considering these circumstances, it is premature to reach definite conclusions as to the effectiveness and applicability of the rule. However, several principles can be reasonably expected to reach the final rule. Unfortunately, there appear to be few if any opportunities to benefit the Melbourne RO situation.

As you will recall, we briefly discussed your meeting with several staff members from the City of Melbourne to discuss their particular circumstances with regard to concentrate management. From that background information as to the concerns that they expressed regarding their demineralization concentrate disposal issues, the primary difficulty seems to be that their RO concentrate discharge has exceeded numerous numeric standards and failed toxicity tests on several occasions. The available options for discharge are to the Indian River Lagoon in areas designated as Outstanding Florida Waters (OFW). Because

735 COLORADO AVENUE, SUITE ONE • STUART, FL 34994 772-287-8771 • FAX 772-287-2988
www.ewconsultants.com

of the OFW designation, there are no mixing zones allowed, and thus when the concentrate exceeds numerical standards a discharge is not permittable. The result is a negotiated order and mandated permitting program that directs the discharge to a deep injection well. There was little detailed information as to why toxicity tests had failed.

The rulemaking that is ongoing to implement SB 536 has specific elements related to both OFWs and toxicity. The language regarding OFWs allows for a very narrow mixing zone exemption in OFWs for concentrate discharges that meet the toxicity requirements of the rule. In this case, it appears that there have been consistent exceedances of other numeric criteria aside from toxicity such that the Department would not have reasonable assurance that water quality criteria could be met at "end of pipe", and thus a mixing zone for other parameters would be necessary. As such, the OFW portion of the new rule is not expected to offer any additional relief in the case of the Melbourne RO Plant.

With regard to toxicity it is difficult to determine whether the new rule could provide some relief in regard to the cause of observed toxicity in the concentrate. There was no supporting information provided indicating the potential cause of failures of the bioassay tests. Although it is possible that ion balance toxicity is causing part or all of the failures, it cannot be determined from the information provided.

At this time, there appear to be few if any opportunities for the pending rule to assist with the Melbourne demineralization concentrate disposal issues. However, additional information regarding toxicity may shed more light on whether some relief could come from the revised toxicity criteria.

I look forward to discussing this matter further with you.

03/25/2003 19:42 3215044035 LS SIMS & ASSOCIATES PAGE 04

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

REGION IV

345 COURTLAND STREET, N.E.
ATLANTA, GEORGIA 30365

MAY 17 1995

CERTIFIED MAIL
RETURN RECEIPT REQUESTED

REF: 4WM-GWP

Mr. Richard Harvey
Department of Environmental Protection
Twin Towers Office Building
2600 Blair Stone Road
Tallahassee, Florida 32399-2400

SUBJECT: Alternative to Tubing and Packer Construction

Dear Mr. Harvey:

As requested by your office the United States Environmental Protection Agency (EPA) Region IV, has reviewed the proposal to allow three underground injection facilities to continue to operate without modifying their current well construction. EPA's Underground Injection Control (UIC) Section, assisted by the Robert S. Kerr Environmental Research Laboratory (RSKERL), in Ada, Oklahoma, has reviewed information on the injection wells operated by QO Chemicals, Inc. (Great Lakes Chemical Corporation), Harris Corporation, and United Technologies-Pratt & Whitney.

Federal regulations require all Class I injection wells, except those municipal wells injecting noncorrosive wastes, to inject fluids through tubing with a packer set immediately above the injection zone. The use of other alternatives to a packer may be allowed if the alternative method will reliably provide a comparable level of protection to underground sources of drinking water.

In memoranda dated April 5, 1995 and May 1, 1995, EPA received technical information on the design, construction, mechanical integrity testing, injectate characteristics and other details of the Class I injection wells operated by the aforementioned companies. This information was reviewed by Region IV and RSKERL. It is EPA's recommendation that the additional tests as outlined in Attachment I would be necessary to reliably provide a comparable level of protection to underground sources of drinking water and serve as an acceptable alternative to the packer requirement.

EPA has made this technical determination based on the information provided, in connection with assisting the State in

-2-

its efforts to be equivalent to the federal program. EPA is prepared to provide technical support to demonstrate that consideration of the presented information and the technical determination made were consistent with the discretion provided under the federal program, and that it is within the expertise of EPA's UIC program to provide this determination. EPA can supply supporting documentation and, if necessary, testimony. If any information provided to EPA was incorrect or materially incomplete, or if the facts change, EPA would need to review the corrected or supplemental information to ensure that the determination is still applicable.

If you or your staff have any questions regarding this determination, please feel free to contact me or your staff contact Tom Hansen at (404) 347-3555, extension 6630.

Sincerely,

R F McGhee

Robert F. McGhee, Acting Director
Water Management Division

Enclosure

ATTACHMENT 1

As an alternative to the packer requirement, the following tests and evaluations shall be performed every thirty (30) months on the Class I injection wells operated by QO Chemicals, Inc. (Great Lakes Chemical Corporation) (injection well IW-3), Harris Corporation (injection wells #1 & #2), and United Technologies - Pratt & Whitney (injection well IW-1).

1. Radioactive Tracer Survey
   timed run method
   cross flow check method

2. Temperature log, injection and shut-in

3. Evaluation of operational and monitoring data

Test procedures shall be performed in accordance with EPA DOC 600R-94/124, Temperature, Radioactive Tracer, and Noise Logging for Injection Well Integrity, July, 1994.

03/25/2003 19:42 3215044035 LS SIMS & ASSOCIATES PAGE 02
Dec-06-02 10:26A P.02

Department of Environmental Protection

file

Jeb Bush
Governor

Central District
3319 Maguire Boulevard, Suite 232
Orlando, Florida 32803-3767

David B. Struhs
Secretary

November 26, 2002

RECEIVED

City of Melbourne
Utilities Administration

OCD-UIC-02-0170

Mr. Bob Klaproth
Utilities Director
City of Melbourne
900 East Strawbridge Avenue
Melbourne, FL 32901

Brevard County – UIC
Application for a Minor Aquifer Exemption by the
City of Melbourne for the D.B. Lee Injection Well System

Dear Mr. Klaproth:

The Department has re-evaluated its position concerning aquifer exemptions and has concluded that, in general, such exemptions are not in the best interest of protecting potential future drinking water supplies. However, we do recognize that a Class I injection well may still be the most environmentally acceptable method for the disposal of demineralization concentrate. In this particular case, at the D. B. Lee Injection Well site, the Department also has determined that reasonable assurance has not been provided that adequate confinement exists.

The Department is of the opinion that the City has other alternatives that can be implemented to bring the facility into compliance. Installation of a new Class I injection well (preferably at a location where confinement is known to exist), blending with reclaimed water for irrigation, or modification of the existing surface water discharge to comply with current permit limitations are all alternatives that should be re-evaluated. Regardless of the method used to attain compliance with Department rules, the City must be in compliance by December 31, 2004, as required by Consent Order OGC No. 98-1562B. Please provide us with the evaluation of alternatives and the City's decision for implementation by February 1, 2003.

Mr. Bob Klaproth
OCD-UIC-02-0170
Page2

If you have any questions, please call us at (850) 245-8600, or (407) 894-7555.

Sincerely,

Richard D. Drew, Chief
Bureau of Water Facilities Regulation

Vivian F. Garfein, Director
Central District

RDD/dw

CC: Allan Bedwell
Mimi Drew
Richard Deuerling
Gary Miller

APPENDIX D

INVESTIGATION OF SUBSURFACE INJECTION

Investigation of Subsurface Injection

In Support of

The Demineralization Concentrate Management Plan – Task C.2

For the

Investigation of Demineralization Concentrate Management Project

by

Reiss Environmental, Inc.
Subconsultants
Parsons Brinckerhoff Quade and Douglas
and Malcolm Pirnie

St. Johns River Water Management District
P.O. Box 1429
Highway 100 West
Palatka, Florida

September 2003

CONTENTS

GENERAL

Subsurface disposal of reverse osmosis (RO) concentrate via deep well injection has been practiced in the state of Florida since the 1980s. According to the most recent tally by the Florida Department of Environmental Protection (FDEP), there are currently 21 Class I and 2 Class V RO concentrate injection well systems around the state either in permitting or in operation. Currently, there are no RO concentrate injection wells in operation in the St. Johns River Water Management District (SJRWMD), but an exploratory RO injection well is under construction at Palm Bay in Brevard County.

Injection of RO concentrate via deep wells can be the preferred disposal method in many circumstances. Proper siting based on accepted feasibility criteria can make the difference between a successful, cost-effective system and one that has regulatory and operation and maintenance (O&M) problems. The feasibility criteria for proper site selection can be grouped into two major categories: regulatory and technical. The regulatory feasibility criteria focus on the ability to permit and operate a system within federal, state, and local rules, while the technical criteria focus on the ability to construct and reliably operate the system as designed.

One way to evaluate feasibility criteria on a regional scale is by the use of geographic information system (GIS) assessments. Recent advances in GIS software have made region-wide feasibility evaluations possible and cost effective. SJRWMD has previously used GIS methods to evaluate suitable areas for brackish water production zones (SJRWMD and CH2M Hill, 1998) and reclaimed water artificial recharge zones (Rabbani and Munch, 2000). These previous efforts have proven the ability of GIS evaluations to provide answers on a District-wide scale.

The purpose of this section is to describe the GIS evaluations performed to assess the regulatory and feasibility criteria for subsurface injection of demineralized concentrate into the Floridan aquifer. The focus of this study was injection into the Floridan aquifer because the data available for the hydrogeologic formations below the Floridan aquifer are too sparse to support District-wide assessments. The evaluations presented in this section evaluate the potential for subsurface injection into the Upper and Lower Floridan aquifers at four different injection flowrates: 2, 5, 15, and 30 million gallons per day (MGD).

IDENTIFICATION OF EVALUATION CRITERIA

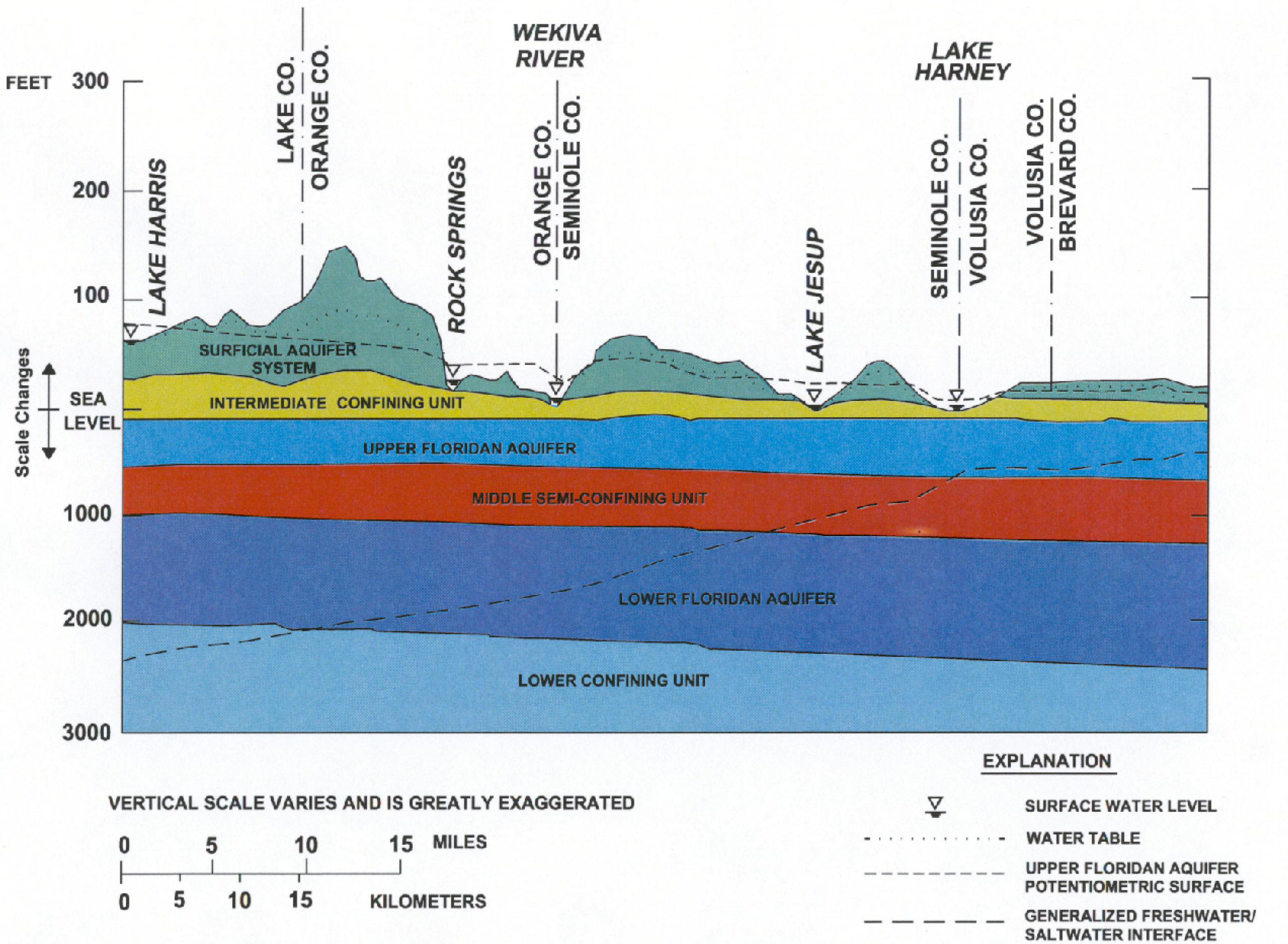
The criteria for assessing the potential for subsurface concentrate injection can generally be classified as either regulatory or technical as described in this section. For the purposes of this District-wide study, the subsurface was conceptualized as presented in Figure 1. The general underlying geologic units consist of unconsolidated sediments which comprise the surficial aquifer, a predominantly clayey unit which forms the intermediate confining unit between the Floridan and surficial aquifers, and marine limestones and dolomites which comprise the Floridan aquifer system. The Floridan aquifer is further divided into Upper and Lower aquifers by a less permeable middle semi-confining unit. Actual site-specific geologic information would be required to make site-specific assessments of the feasibility of concentrate injection.

REGULATORY CRITERIA

The regulatory requirements that relate to subsurface injection of concentrate place constraints on the water quality of the injection zone, on the confinement above the injection zone, and on the required distance between the injection well and potable water supply wells, potential major Floridan aquifer faults and springs. These regulatory criteria are described in Chapters 62-521 and 62-528, Florida Administrative Code (F.A.C.). The regulatory criteria also extend to cultural factors influencing success.

The regulatory requirements vary based on the type of injection well permitted. RO concentrate injection wells have been permitted as two types in Florida, Class I and Class V, Group 4. As stated earlier, 21 RO concentrate injection wells have been or in the process of being permitted as Class I injection wells, while only 2 RO concentrate injection wells have been permitted as Class V, Group 4 injection wells. The Class V, Group 4 wells are generally in coastal areas where the surficial aquifer is brackish and potential upward migration of the RO concentrate would not pose a problem to drinking water supplies.

For the purpose of this regional evaluation, it was assumed that the RO concentrate injection wells will be Class I injection wells because Class I standards generally apply except where local geologic and water quality conditions allow for Class V standards. This type of site-specific investigation is beyond the scope of this study.



Source: Figure modified from USGS Orlando Metropolitan Area Report (Murray and Halford, 1996)

Figure 1. General Hydrogeologic Cross-Section of Central Florida

Water Quality

Groundwater with a total dissolved solids (TDS) concentration below 10,000 mg/L is considered by the FDEP to be a part of the underground source of drinking water (USDW), and the FDEP is responsible for protecting the USDW. Therefore, Chapter 62-528, F.A.C. requires that the TDS concentration of the receiving formation must equal or exceed 10,000 mg/L for a Class I injection well. Injected fluids must also not migrate from the injection zone or into the USDW. Areas where the top of the Upper or Lower Floridan aquifer is below the base of the USDW will be identified as having a potential acceptable water quality for injection.

Confinement

Chapter 62-528, F.A.C. requires that Class I injection wells have at least one confining zone above the injection zone. This confining zone must be of "sufficient areal extent, thickness, lithologic and hydraulic characteristics to prevent fluid migration into underground sources of drinking water." No minimum quantitative guidelines are given for these parameters, and the evaluation of these characteristics is made by the FDEP based upon the reasonable assurance provided by the applicant. This reasonable assurance may be provided in the form of geophysical logging, flow logging, coring results, or video logging.

As the rule states, the main purpose of this confinement is to prevent any upward migration of injected fluid. Therefore, for this study, adequate confinement will be assessed by evaluating the leakance and thickness of the intermediate confining unit for the Upper Floridan aquifer and of the middle semi-confining unit for the Lower Floridan aquifer.

Another method that may demonstrate appropriate confinement within the Upper or Lower Floridan aquifer would be the presence of permitted Class I injection wells. In fact, there are 10 Class I domestic waste injection wells in SJRWMD. A permitted well would have previously presented data that shows the well would meet the necessary regulatory criteria for confinement. Though the regulatory criteria for permitting domestic waste and demineralized concentrate injection wells are slightly different, the presence of either type of injection well will be used to indicate that adequate confinement exists within the Upper or Lower Floridan aquifer.

Separation from Wells, Springs, and Faults

EPA requires that Class I wells be located in geologically stable areas that are free of transmissive fractures or faults through which injected fluids could travel to drinking water sources. Injection well operators must also show that there are no supply wells or other artificial pathways between the injection zone and USDWs through which fluids can travel. The site-specific geologic properties of the subsurface around the well offer another safeguard against the movement of injected wastewaters to a USDW.

Wells

Chapter 62-521, F.A.C. requires a minimum horizontal separation of 500 feet between a Class I injection well and a potable water supply well. Suitable areas identified in this study will be at least one mile away from public supply wells so that they would lie outside of the FDEP-required area of review. Domestic supply wells will need to be identified during site-specific investigations to allow separation to be maintained from these wells.

Springs and Faults

No rules require an injection well to maintain a specific minimum separation from a spring or fault. However, locating a well too closely to either a spring or fault may cause migration of injected water into a USDW. Springs are aquifer discharge features that may draw injected water towards them. Faults also can be discharging features where overlying confinement may be breached. For the purpose of this study, a radial travel distance of one mile was used to identify acceptable injection well locations.

In addition to springs and faults, vertical fractures in an overlying semi-confining unit can potentially act as conduits for concentrate migration. Though these features are known to exist, sufficient data are not available to allow for assessment of these features on a District-wide basis. It is recommended that the existence of vertical fractures be evaluated on a site-specific basis.

Cultural Factors

Cultural factors are also a regulatory criterion because cultural opposition to such projects is most often expressed through the regulatory permitting process. Historically, injection well projects have experienced public opposition from residents concerned about the fate of the injected fluids. Recent failures of some domestic waste injection wells within the state to confine the injected fluids have further galvanized those opposed to the application of the technology and increased the perception of some that the technology is faulty. Because of the nature of the site-specific issues involved, cultural factors and public opposition issues will not be evaluated on a District-wide scale. Further site-specific study must be performed before cultural factors impact the feasibility of an injection well site.

Currently, the EPA is considering a proposed rule that would allow domestic wastewater injection wells in selected counties; including Brevard, Flagler, Indian River, Orange, Osceola, St. Johns and Volusia Counties, to continue disposing underground regardless of the fluid movement into the USDW

(EPA, 2000). However, this proposed rule will only pertain to wells that inject higher quality water and do not cause a USDW to exceed the primary drinking water standards. As would be expected, opponents and proponents have voiced opinions on the proposed rule change.

Though these proposed regulatory changes do not apply to demineralized concentrate injection, they are indicative of the types of changes that can occur and the complex cultural factors that can influence the feasibility of an injection well site.

TECHNICAL CRITERIA

The technical criteria for RO concentrate injection focus on the ability to construct and reliably operate the system as designed. These criteria include the receiving aquifer transmissivity, injection pressure, maximum well depth, and potential geochemical reactions.

Transmissivity and Injection Pressure

Injection into a confined aquifer, such as the Upper and Lower Floridan aquifer systems, causes an increase of the aquifer’s potentiometric surface (mounding). The transmissivity of the receiving formation is the primary parameter used to determine the magnitude and extent of mounding that will occur at the injection well. Lower transmissivity formations generally have slower lateral movement of water that causes a greater increase in the potentiometric surface. Therefore, if a maximum injection pressure is specified, then the flowrate of an injection well can be limited by low transmissivity in the receiving aquifer. The increase in potentiometric surface in a low transmissivity aquifer may cause the injection pressure to exceed the specified maximum flowrate or require additional wells to be constructed to inject the desired flow.

Receiving aquifers will be selected based on their ability to accept injected fluid at various flowrates without exceeding the maximum design pressure.

Maximum Well Depth

Injection wells in Florida are regularly constructed to depths up to 3,500 feet below land surface (bls). In SJRWMD, the bottom of the Lower Floridan aquifer is approximately 3,200 feet bls in the extreme southern and northeastern parts of SJRWMD (Toth, 2003). Therefore, constructing an RO concentrate injection well within the District should not be limited by aquifer depth.

Potential Geochemical Reactions

The injection of RO concentrate into the Floridan aquifer is likely to cause various geochemical reactions. These reactions become unacceptable if they cause the precipitation of substances that clog the well and cause excessive capacity reductions. The prediction of these reactions is beyond the scope of this study and is highly dependent on site water quality. Though the potential for these reactions will need to be evaluated on a site-specific basis, they do not typically preclude injection of RO concentrate.

SELECTION OF AREAS MEETING EVALUATION CRITERIA

GIS DATA

GIS data sets were collected to allow selection of potential Floridan aquifer injection areas using the evaluation criteria previously discussed. Most of these data sets were obtained from the United States Geological Survey (USGS) (Sepulveda, 2002). The USGS has completed a model of groundwater flow in the intermediate and Floridan aquifer systems in peninsular Florida, including the entire SJRWMD. The GIS database supporting this effort was the most updated and complete hydrogeologic information available for SJRWMD at the time of this work. These GIS data have a discretization of approximately 5,000 feet because of the groundwater modeling grid used, and this discretization was considered appropriate for this planning-level analysis.

For the purpose of this study, a map showing TDS concentration contour elevations was desired. However, only isochlor elevation maps were available for SJRWMD. The 5,000-mg/L isochlor elevation data were collected from SJRWMD. Using a relationship between chloride concentration and TDS concentration discussed below, it was determined that the elevation of the 5,000-mg/L isochlor suitably represents the elevation of the 10,000-mg/L TDS interface.

The top and bottom elevations for the hydrogeologic units in the study area were derived from the USGS GIS data. The elevation data utilized were the top of the intermediate confining unit, top of the Upper Floridan aquifer, top of the middle semi-confining unit, top of the Lower Floridan aquifer, and the bottom of the Lower Floridan aquifer. These elevations were used to determine unit thicknesses because the thickness of the receiving formation was used to determine the travel time of injected concentrate and the appropriate setback distances from various features. Also, the thicknesses of units overlying a receiving formation were used to determine the overlying confinement. The unit top elevations were also used to evaluate design considerations and determine the relative vertical location of the isochlor contours.

GIS data representing transmissivity in the Upper and Lower Floridan aquifer systems were collected from the USGS. However, the USGS data lacked transmissivity values in the saltwater zones of the Lower Floridan aquifer, since the data were compiled for a freshwater groundwater flow model. Figure 2 illustrates the areas in which transmissivity values were missing from the data. In the areas where data are absent, the varying transmissivities were derived by multiplying an average horizontal hydraulic conductivity of 88 feet/day by the physical formation thickness. The average hydraulic conductivity was based on the hydraulic conductivity from an area near the center of the area with no data as shown in Figure 2.

Use of a constant hydraulic conductivity resulted in a relatively uniform transmissivity value. Previous studies that simulated the transmissivity of the Lower Floridan aquifer in the vicinity of the study area (Blanford and Birdie, 1993) also used a relatively constant transmissivity value. Data to support more detailed estimates of transmissivity are not available at the present time.

The USGS also provided GIS data representing leakance in the intermediate confining unit and the middle semi-confining unit. However, just as with transmissivity, the USGS data lacked leakance values in the saltwater zones of the Lower Floridan aquifer for the same reasons transmissivity data were absent. In areas where data were absent (Figure 2), an average vertical hydraulic conductivity value of 1.83×10^{-2} feet/day was used for the middle semi-confining unit, based on an average taken from the area shown in Figure 2. The vertical hydraulic conductivity was divided by the middle semi-confining unit thickness to derive leakance values for the saltwater zones.

The locations of major springs and public supply wellfields were provided by SJRWMD in GIS format, and a GIS shapefile representing regional faulting was created and digitized based on data from Miller (1982), Schiner et al. (1988) and Duncan et al. (1994). A setback distance of one mile from these features was used.

GIS ANALYSIS

The GIS data were analyzed to identify areas that satisfied all of the evaluation criteria. An algorithm was created to eliminate areas that were determined to not satisfy the evaluation criteria. A total of eight scenarios were analyzed to assess feasible areas in both the Upper and Lower Floridan aquifers at four projected flowrates as shown in Table 1. The analyses were similar for all eight scenarios, but some of the limiting criteria were varied with four different flowrates.

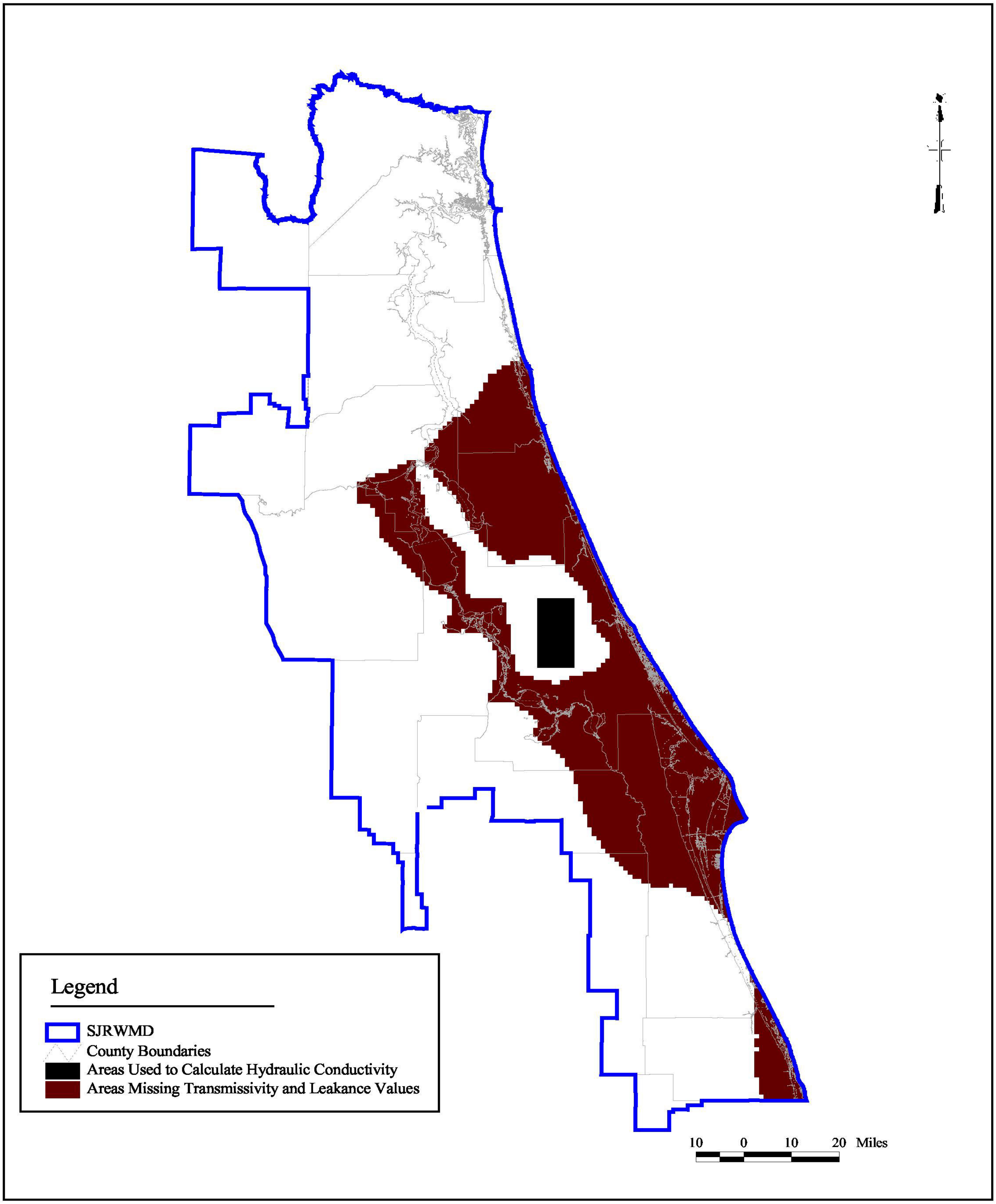


Figure 2. Areas Missing Data and Area Used for Calculating Average Hydraulic Conductivity Values

Table 1. GIS Screening Scenarios

Aquifer	2 MGD	5 MGD	15 MGD	30 MGD
Upper Floridan	Scenario 1	Scenario 2	Scenario 3	Scenario 4
Lower Floridan	Scenario 5	Scenario 6	Scenario 7	Scenario 8

Water Quality

The 5,000-mg/L isochlor was used to estimate where TDS concentrations exceeded 10,000 mg/L. The USGS publication *Geohydrology of Osceola County, Florida* (Schiner, 1993) includes an Osceola County study relating both chloride concentration and TDS concentration to specific conductance. A 5,000-mg/L chloride concentration corresponds to 10,000 mg/L of TDS within a 95% confidence interval using the USGS data.

As discussed previously, the injection zone TDS must be greater than 10,000 mg/L for Class I injection wells, and additionally, migration of injected waters into zones with a TDS concentration less than 10,000 mg/L is not allowed. Therefore, for an Upper Floridan aquifer area to be acceptable, the 5,000-mg/L isochlor had to be above the top of the Upper Floridan aquifer. For a Lower Floridan aquifer area to be considered acceptable, the 5,000-mg/L isochlor had to be above the top of the Lower Floridan aquifer.

Transmissivity

A minimum acceptable transmissivity was determined for the receiving aquifer at each design flowrate (Table 2). These values represented the lowest transmissivity at which mounding of the potentiometric surface stays below a maximum design injection pressure of 40 pounds per square inch (psi) based on the following analytic drawdown equation (Jacob, 1946):

$$s = \frac{Q}{(2\pi T)} \mathrm{K}_0\left(\frac{r}{B}\right) \qquad \text{Equation 1}$$

where:

s = change in potentiometric surface (design pressure), ft;
Q = design injection flowrate, ft^3/day;
T = transmissivity of the receiving aquifer, ft^2/day;
K_0 = modified Bessel function of zero order, second kind;
r = effective well radius, (assumed to be 1 foot for these analyses); and

$$B = \sqrt{\frac{T}{L}}$$ where L is the leakance of the overlying confining unit, day^{-1}.

For the 2 and 5-MGD scenarios, only the effects of one injection well had to be considered. For the 15 and 30-MGD scenarios, injection was assumed to occur through several 5-MGD injection wells, because the larger flows through a single well would require unreasonably high transmissivities. Superposition was used to assess the effects of these multiple injection wells, and the maximum cumulative pressure allowed in any of the wells was 40 psi. In these scenarios, the injection wells were assumed to be configured in a line with a separation distance of 300 feet. This distance was considered the maximum reasonable separation between the wells. For simplicity in these calculations, the leakance of the overlying confining unit was assumed to equal 10^{-5} day^{-1}. The use of this low leakance value provided a conservative estimate of the allowable transmissivity.

Table 2. Minimum Transmissivity Values

Scenario	Minimum Transmissivity (ft^2/day)
1 and 5 (2 MGD)	4,750
2 and 6 (5 MGD)	12,500
3 and 7 (15 MGD)	25,000
4 and 8 (30 MGD)	42,500

Confinement

As discussed previously, adequate confinement was an important consideration in these analyses. As a measure of confinement, the travel time through the confining unit was considered. The travel time was calculated using the following relationship:

$$t' = 0.1/[(33726)(L / b')] \qquad \text{Equation 2}$$

where:

t' = travel time for injected water through the confining unit, years;
L = leakance of the confining unit, day^{-1}; and
b' = thickness of the confining unit, ft.

Equation 2 assumes a design aquifer pressure of 40 psi. This design aquifer pressure was selected because when buoyancy forces and well casing friction are accounted for as losses, an injection pressure less than approximately 70 psi is expected. Equation 2 was applied to each data cell to determine travel time through the confining unit, in order to determine if there was sufficient thickness and/or a low enough leakance to provide sufficient confinement.

In addition to the above equation, empirical criteria were used to further determine areas where adequate confinement is available. Areas with existing permitted injection wells were determined to have adequate confinement because these areas had previously demonstrated sufficient confinement during the permitting process.

Well, Spring, and Fault Setbacks

FDEP wellhead protection regulations require a minimum setback distance of 500 feet between injection wells and potable supply wells. However, as part of the permitting process FDEP requires that all wells within a minimum of one mile of the proposed injection well be identified. Permitting an injection well with a public supply well within one mile increases the difficulty. To be conservative, all areas within a one-mile setback of public supply wells were excluded from consideration for future injection well construction. The one-mile setback requirement also applies to domestic wells, but identification of these wells was determined to be beyond the scope of this study. However, a site-specific survey of domestic wells must be performed before siting a concentrate injection well.

Other features that might impact the permitting of an injection well were also considered. Setback distances were set for springs and areas with identified faulting. A one-mile setback distance from faults and springs was assumed to allow for permitting of a new injection well. Areas within the setback distance of springs and faults were removed from consideration as potential injection areas.

RESULTS OF GIS ANALYSIS

The analysis techniques described previously were used to create maps of potentially highest suitable areas for concentrate injection. Four flowrates were considered for both the Upper and Lower Floridan aquifer (Table 1) resulting in eight scenarios. These eight scenarios were then further refined to one scenario based on results discussed below.

Upper Floridan Aquifer

As detailed previously, the chloride concentration data was used to determine locations where the TDS concentration exceeded 10,000 mg/L for the full thickness of the Upper Floridan aquifer. The analyses showed that there were no areas in which the full thickness of the Upper Floridan aquifer met the water quality criteria. Therefore, the Upper Floridan aquifer was removed from consideration as a potential concentrate injection zone.

Lower Floridan Aquifer

Using the chloride concentration data from the USGS, the areas within the Lower Floridan aquifer where the water quality exceeded 10,000 mg/L of TDS for the full thickness of the aquifer were identified (Figure 3). Additionally, Figure 3 presents areas where only a portion of the Lower Floridan aquifer has water with TDS in excess of 10,000 mg/L shown in gray.

Based on peer review comments, the area where the full thickness of the Lower Floridan aquifer is filled with water having a TDS concentration in excess of 10,000 mg/L was expanded (Figure 4). The areas added are primarily in Brevard and Indian River Counties (Knapp and Sims, 2003). Only areas where the full thickness of the Lower Floridan aquifer exceeds 10,000 mg/L were considered for the remaining analyses.

As discussed previously, the USGS data lacked information in the portions of the Lower Floridan aquifer where the TDS concentration was greater than 10,000 mg/L. In the areas where data were absent, the transmissivities were derived using an average horizontal hydraulic conductivity and the aquifer thicknesses. Similarly, the leakance was derived using an average vertical hydraulic conductivity value and the middle semi-confining unit thicknesses.

For scenarios 5 to 8, the only difference between the potential injection areas is the required minimum transmissivity (Table 2). The minimum transmissivity estimated for the area analyzed was 95,500 ft^2/day. This minimum estimated transmissivity exceeds the transmissivity required for a 30-MGD injection rate (Figure 5). The area meeting the transmissivity requirement for concentrate injection is the entire area where the Lower Floridan aquifer contains a TDS concentration greater than 10,000 mg/L. Therefore, the acceptable areas for injection under scenarios 5 to 8 are the same.

Figure 6 depicts the estimated thickness of the Lower Floridan aquifer. Areas within Brevard and Indian River Counties are shown to have the greatest thickness. The thickness of the middle semi-confining unit was also evaluated using GIS data (Figure 7). The middle semi-confining unit thickness in the area with full-thickness TDS concentrations greater than 10,000 mg/L ranged from approximately 20 to 750 feet with an average of approximately 390 feet. Though evaluated, the Lower Floridan aquifer and middle semi-confining unit thicknesses were not used to determine areas suitable for concentrate injection.

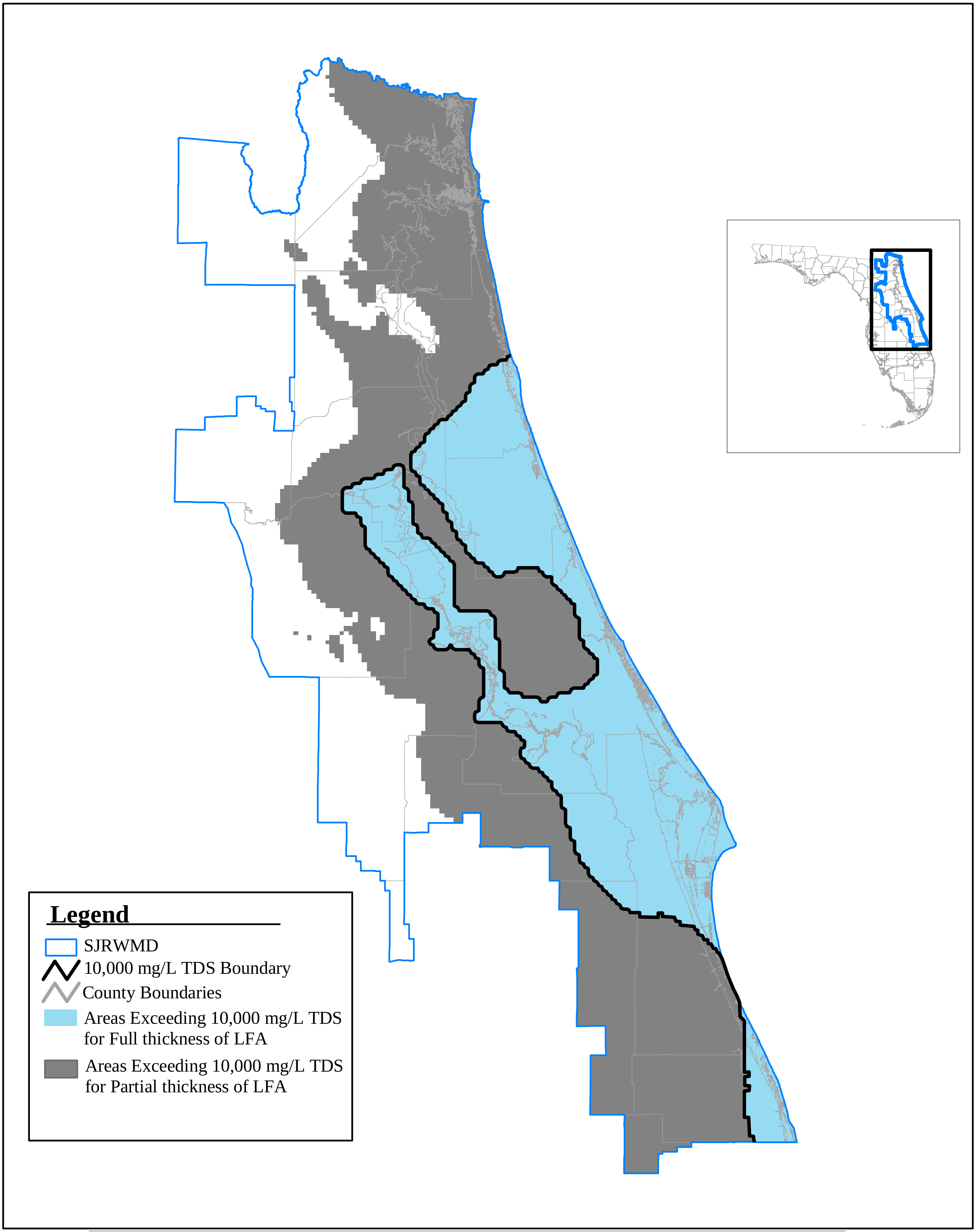


Figure 3. Areas Exceeding 10,000 TDS mg/L Concentration in the Lower Floridan Aquifer

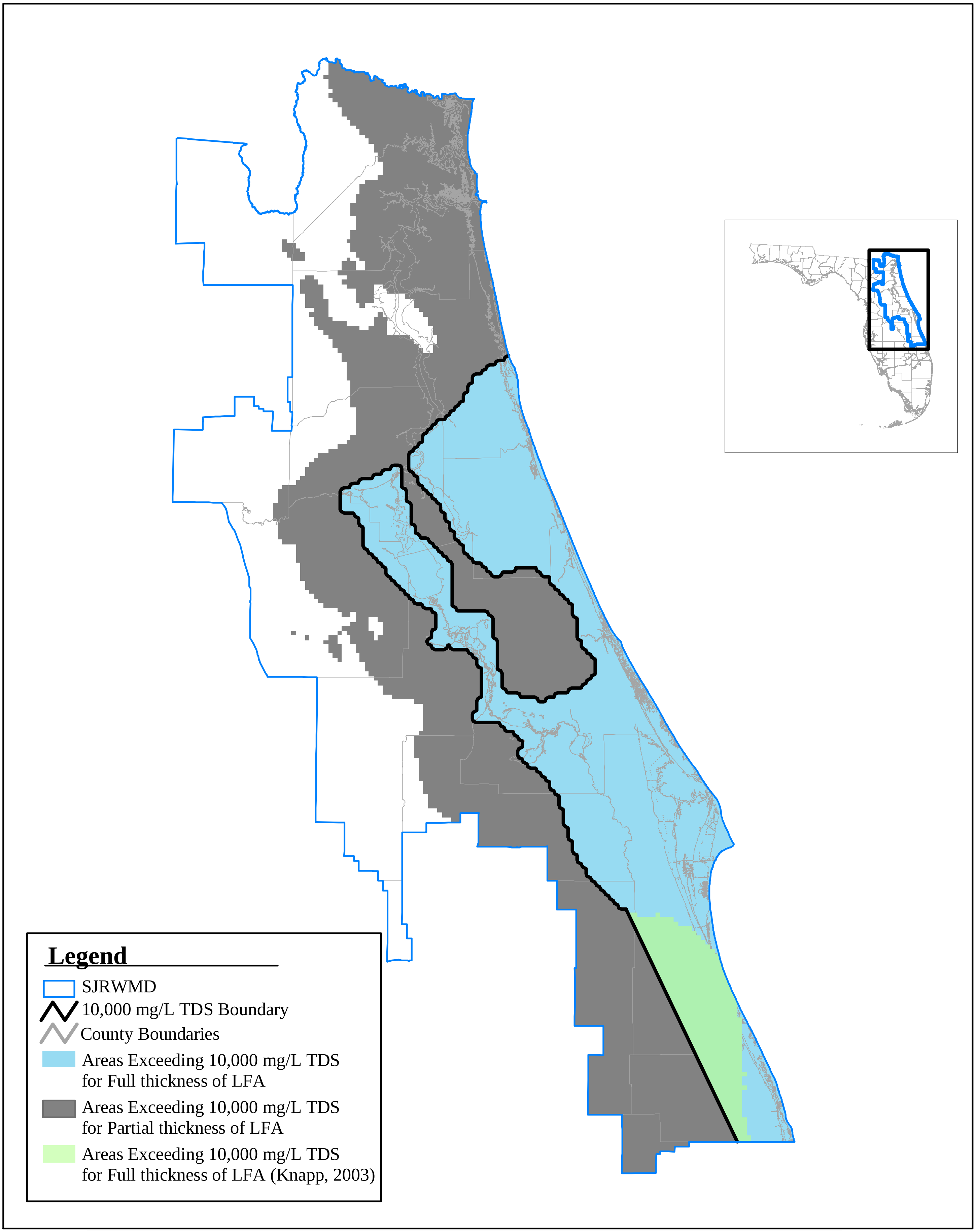


Figure 4. Areas Exceeding 10,000 mg/L TDS in Lower Floridan Aquifer, Revised

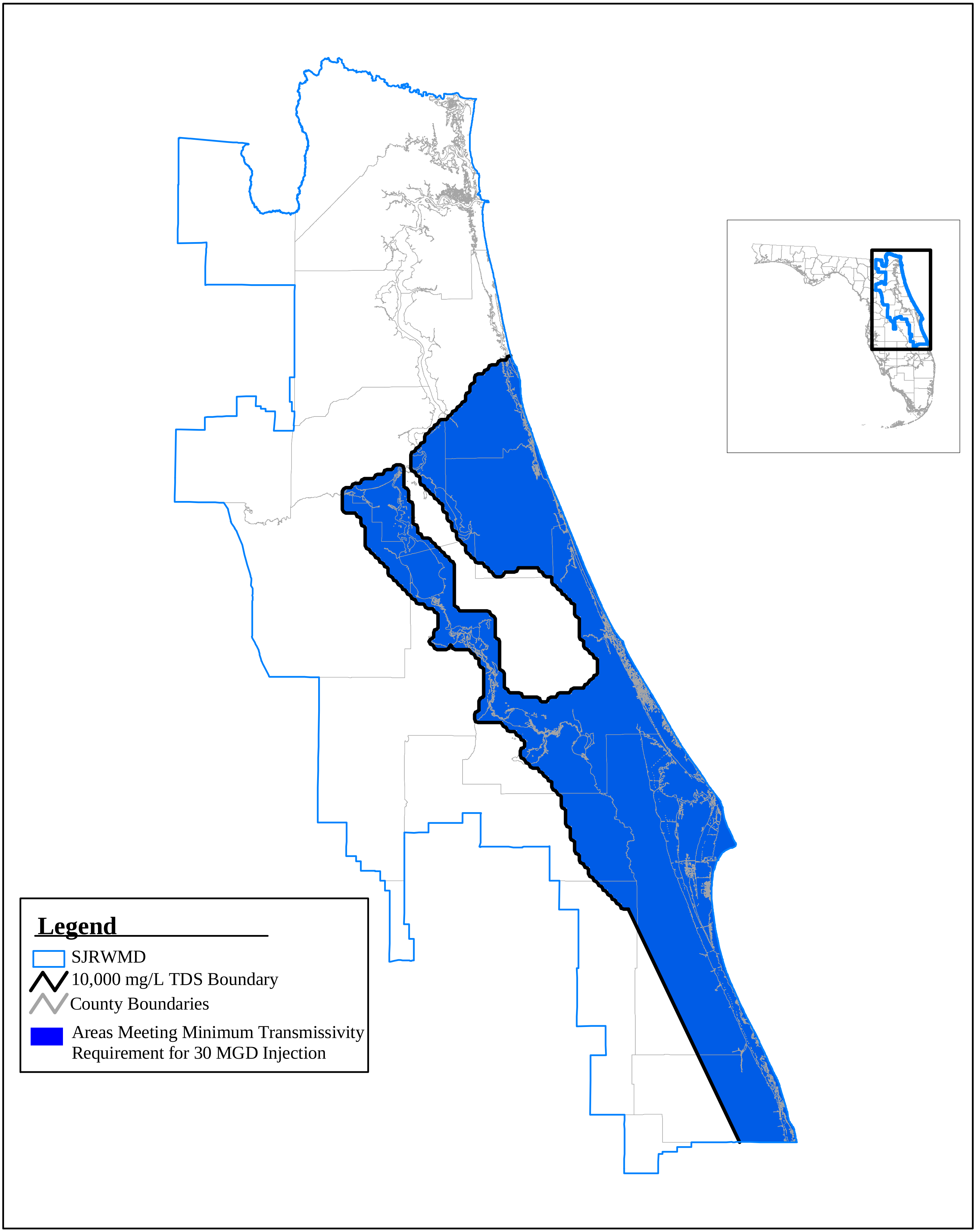


Figure 5. Areas Meeting Minimum Transmissivity Requirement for 30 MGD Injection

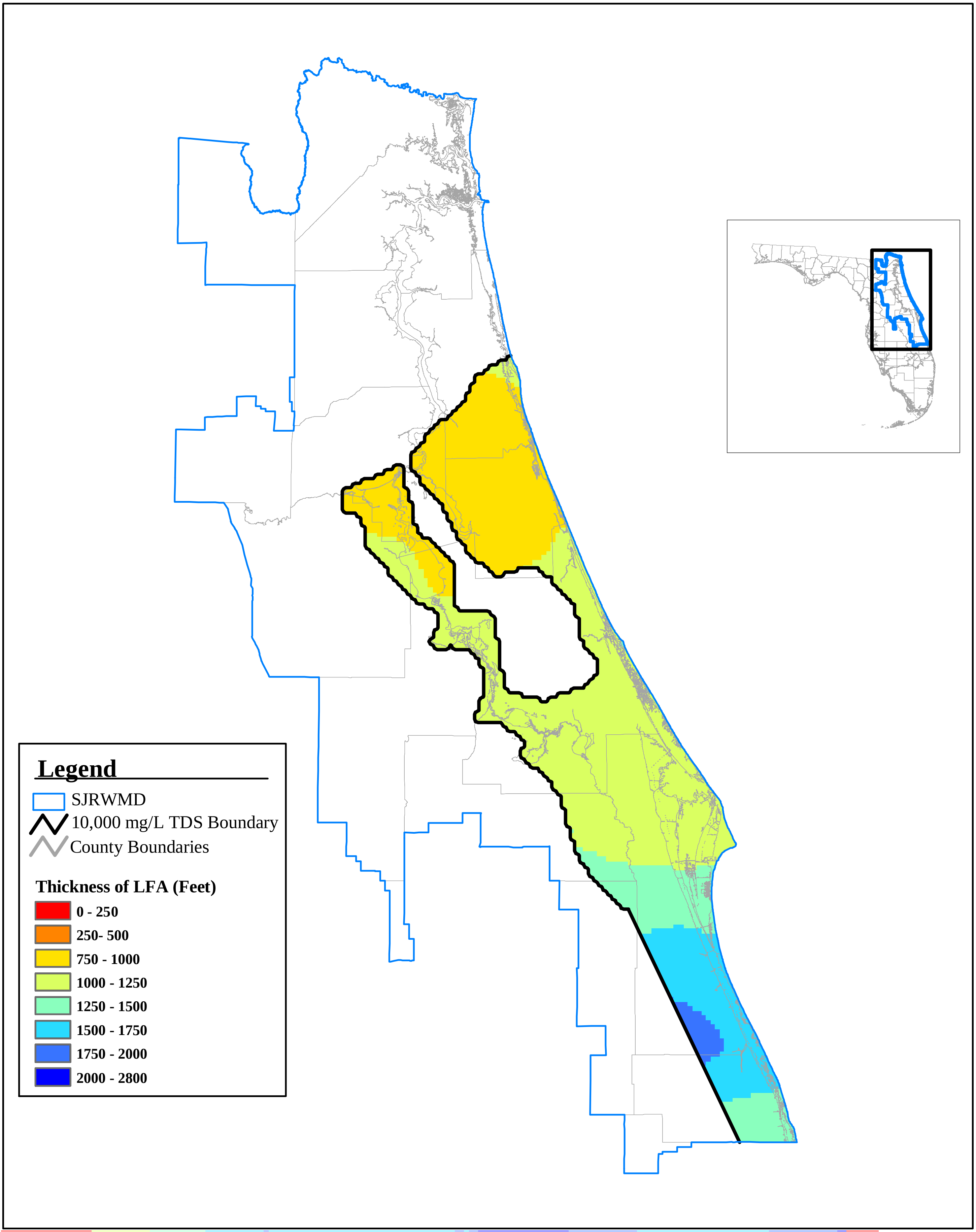


Figure 6. Calculated Thickness of the Lower Floridan Aquifer

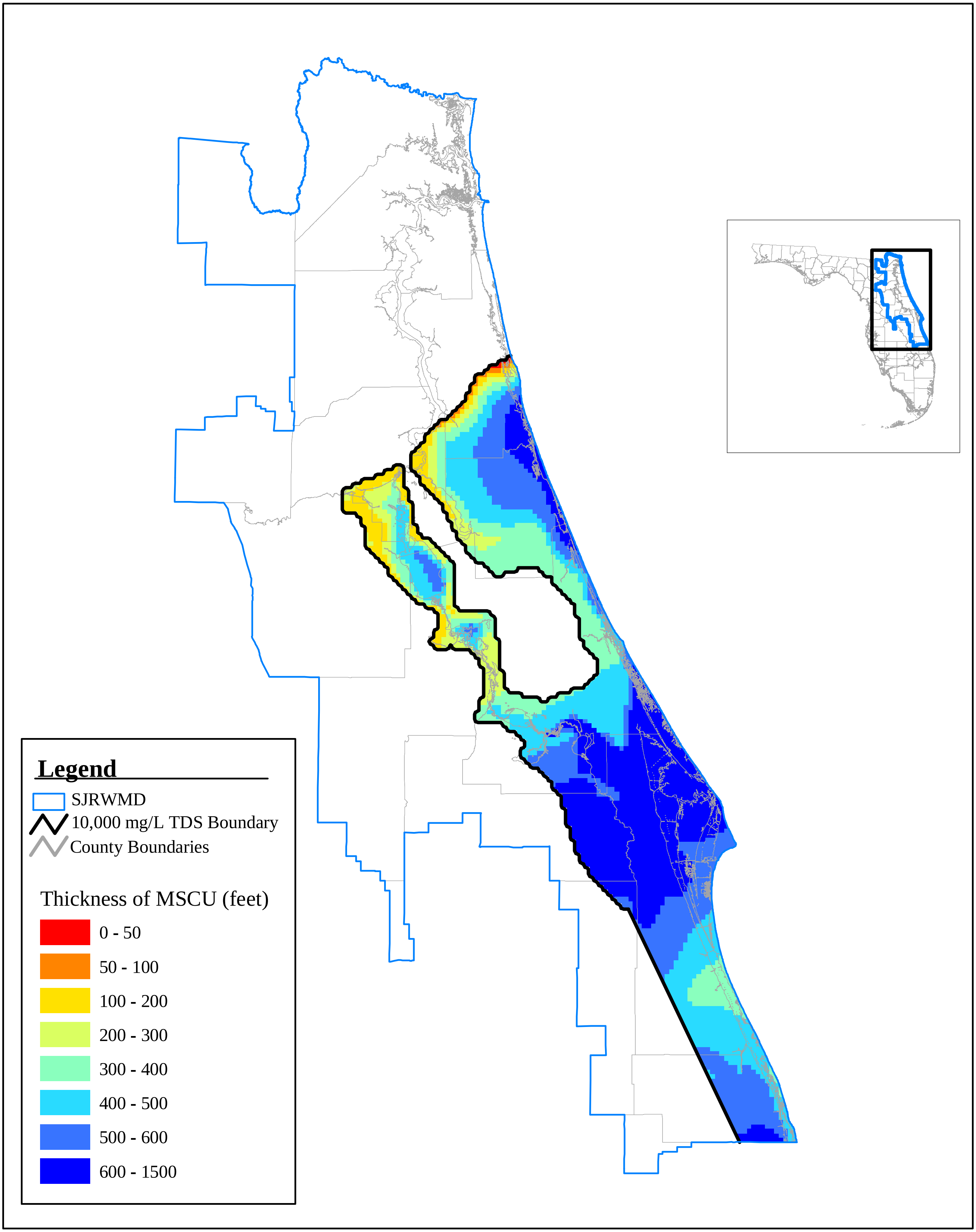


Figure 7. Calculated Thickness of the Middle Semi-Confining Unit

The travel time through the confining unit was used to determine if there was sufficient thickness and/or a low enough leakance to provide sufficient confinement for concentrate injection (Figure 8). Though the existing UIC rules require no migration of the injected fluid, existing permitting experience has indicated that this criterion is somewhat subjective. The time calculated for travel of injected concentrate through the middle semi-confining unit ranged from approximately 0 to 100 years. Based on the FDEP rules which call for no migration of the injected fluid, it was determined that the middle semi-confining unit is not likely to be an acceptable confining unit for concentrate injection within the District. However, the travel time calculations do not account for the potential existence of low permeability confining units within the Lower Floridan aquifer.

Other confining units within the Lower Floridan aquifer have been identified in previous studies (Duncan et al., 1994). Several injection wells have previously been permitted in Indian River and Brevard Counties utilizing these other confining units to prevent fluid migration (Figure 9). Even though these areas do not meet the middle semi-confining unit confinement criteria, sufficient confinement within the Lower Floridan aquifer to prevent upward migration has been empirically demonstrated. Since these confining units within the Lower Floridan aquifer have been identified in permitted injection wells south of Merritt Island, the areas south of Merritt Island were considered the area of potential highest suitability for concentrate injection (Figure 10).

Figure 11 shows the one-mile setbacks around identified public supply wells as discussed previously. In addition, Figures 12 and 13 show the one-mile setbacks around springs and faults, respectively. These setback areas were excluded from the area of potential highest suitability to define the areas of highest suitability (Figure 14).

The algorithm used to select these areas is detailed in Attachment A and is summarized as follows:

1. For each scenario, areas where TDS concentrations were greater than 10,000 mg/L were identified and all other analyses were confined to these areas.
2. Lower Floridan aquifer transmissivities were compared to the calculated acceptable values. The transmissivities within the entire area with TDS concentrations greater than 10,000 mg/L were acceptable.
3. The Lower Floridan aquifer middle semi-confining unit travel times were compared to the FDEP criteria. It was determined that the middle semi-confining unit did not meet the travel time criteria.

4. The location of permitted injection wells was evaluated to empirically determine areas where other confining units within the Lower Floridan aquifer had been identified. The area with permitted wells within Indian River and Brevard County was considered the area of potential highest suitability.
5. Areas within the setback distance from public-supply wells, springs and faults were excluded from the area of potential highest suitability to further define the highest suitability areas.

The sites meriting further consideration for demineralized concentrate injection into the Lower Floridan aquifer are shown in Figure 14. These identified areas should be considered as areas where further site-specific investigations of the feasibility of concentrate injection should begin. Generally, though, the areas lie mainly within Indian River and Brevard Counties.

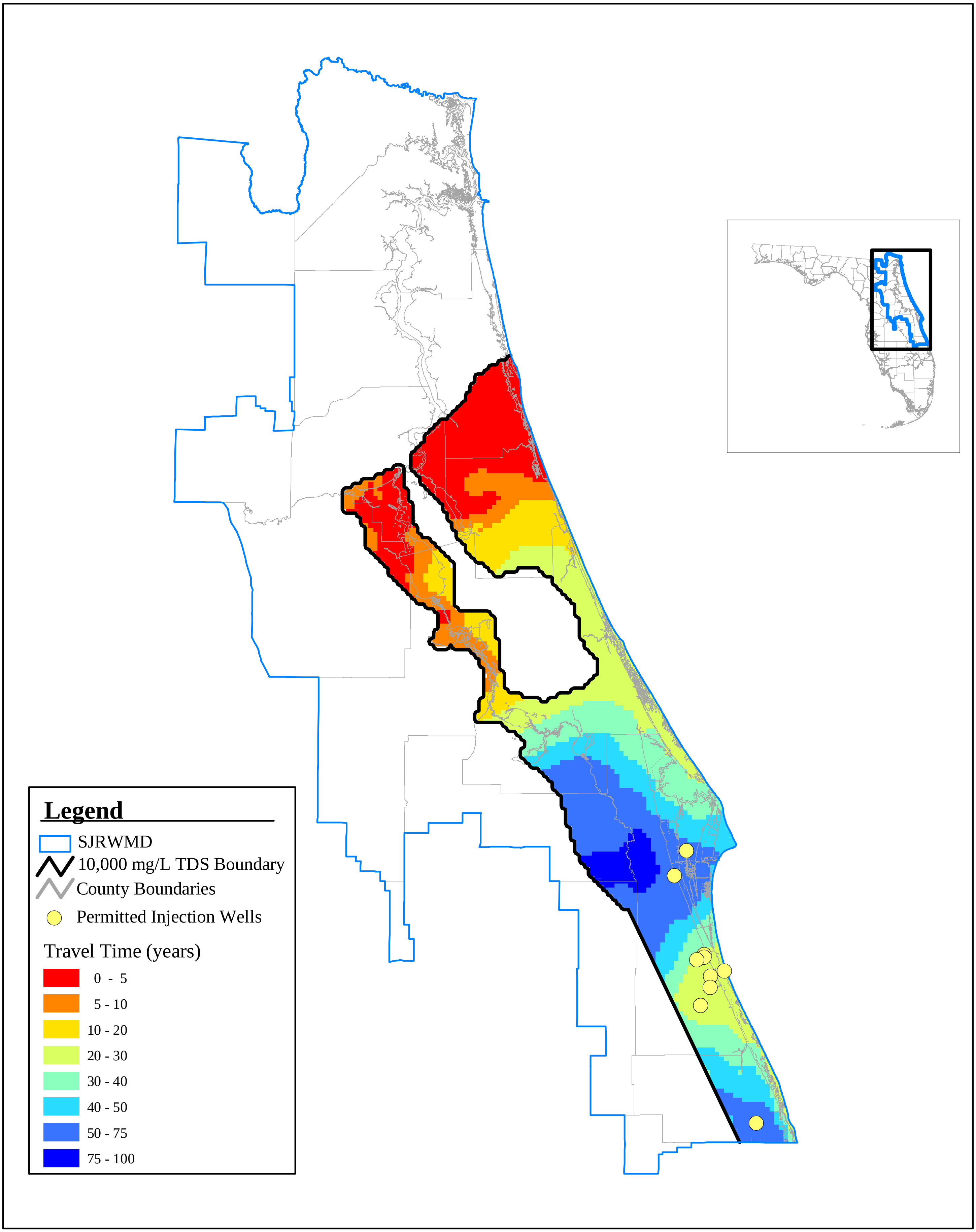


Figure 8. Calculated Travel Time through the Middle Semi-Confining Unit

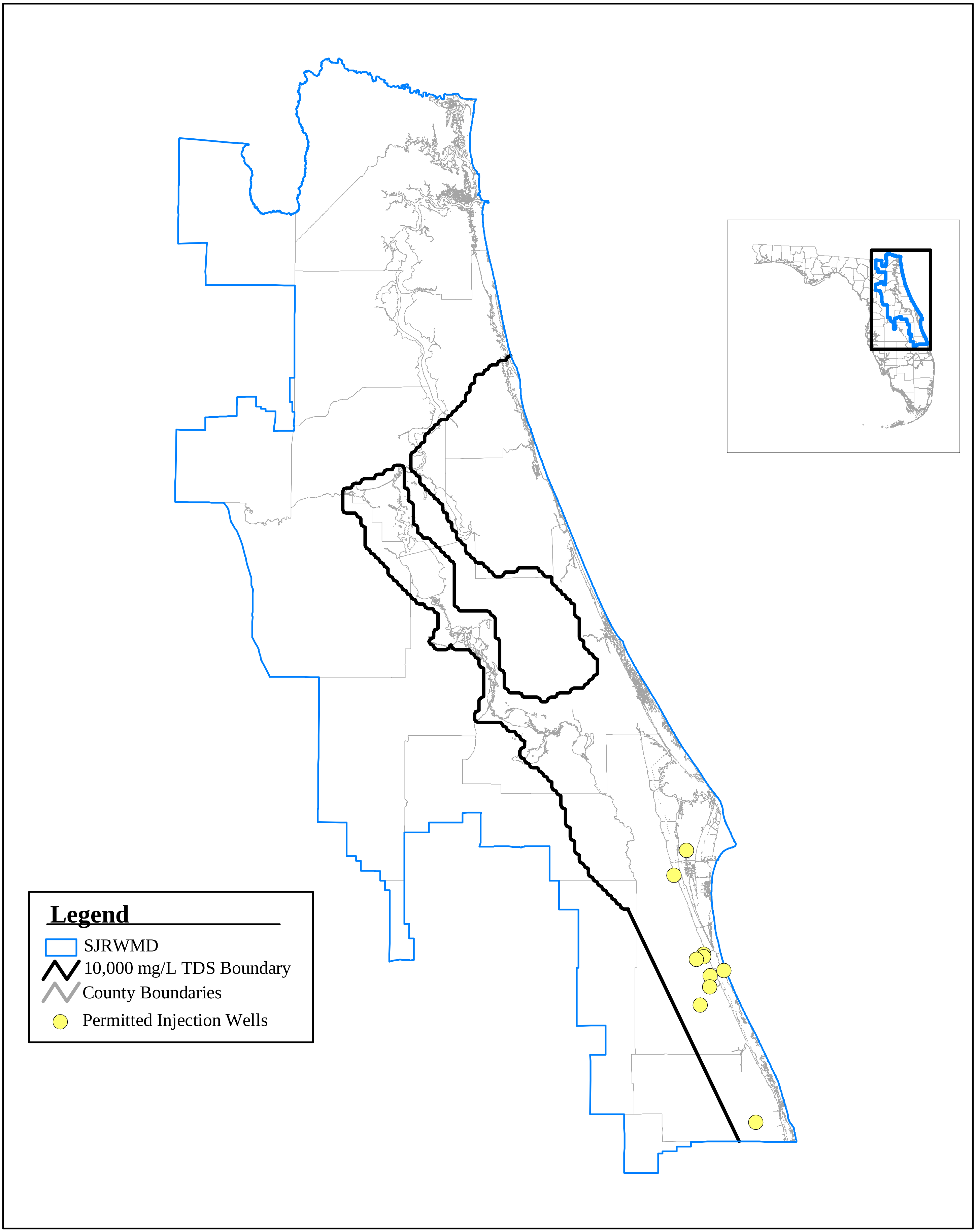


Figure 9. Permitted Injection Well Locations

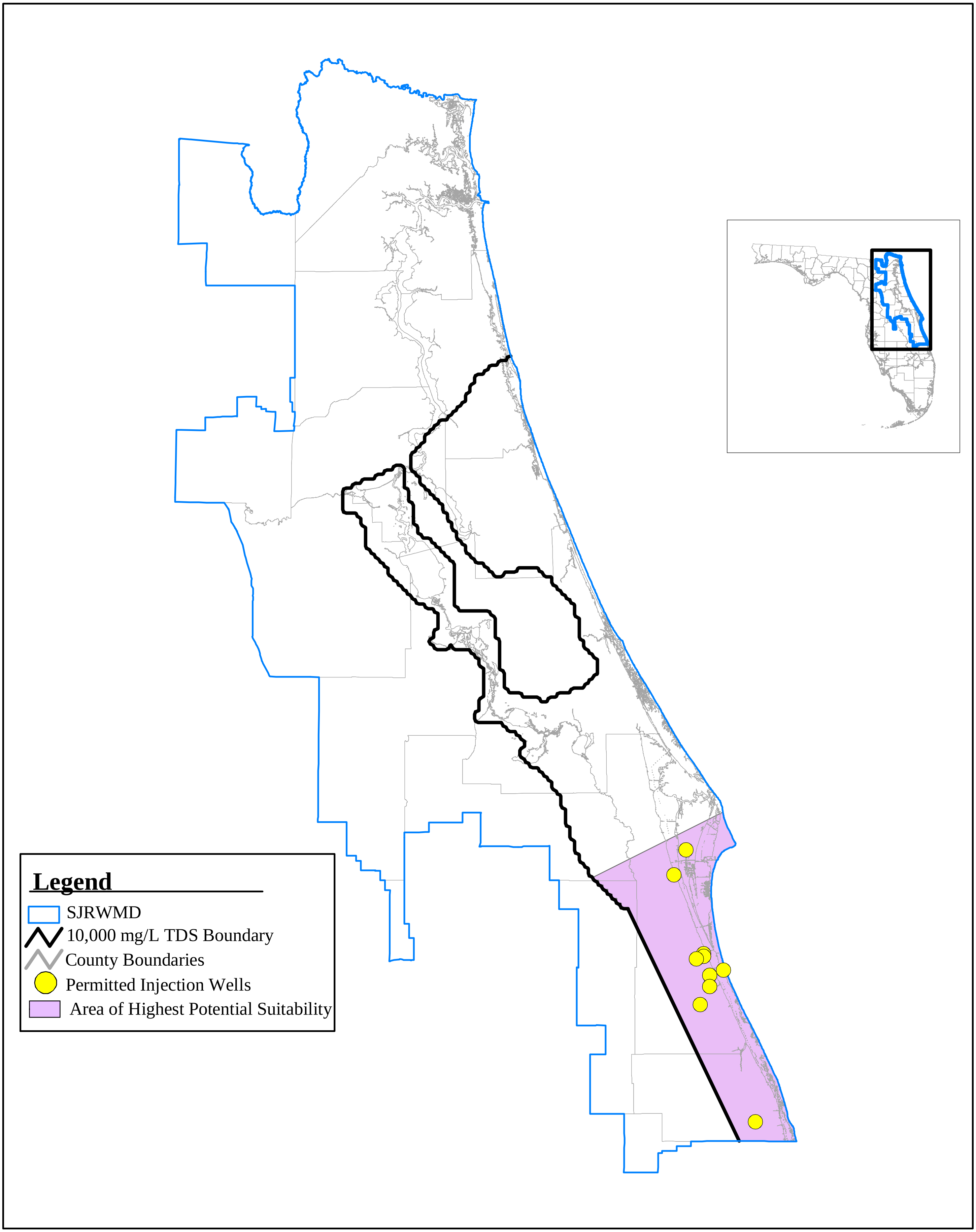


Figure 10. Area of Potential Highest Suitability

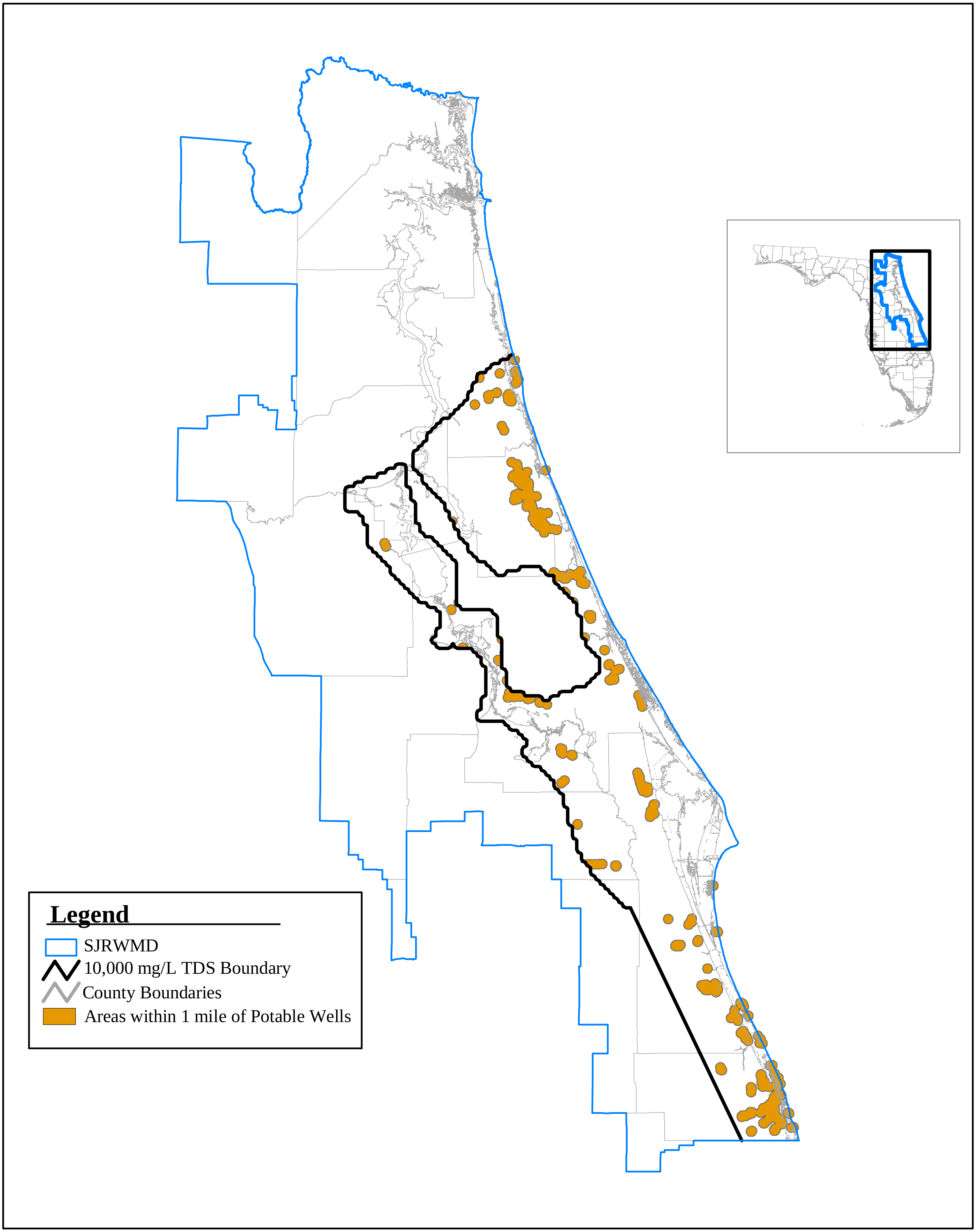


Figure 11. Setback Areas for Public Supply Wells

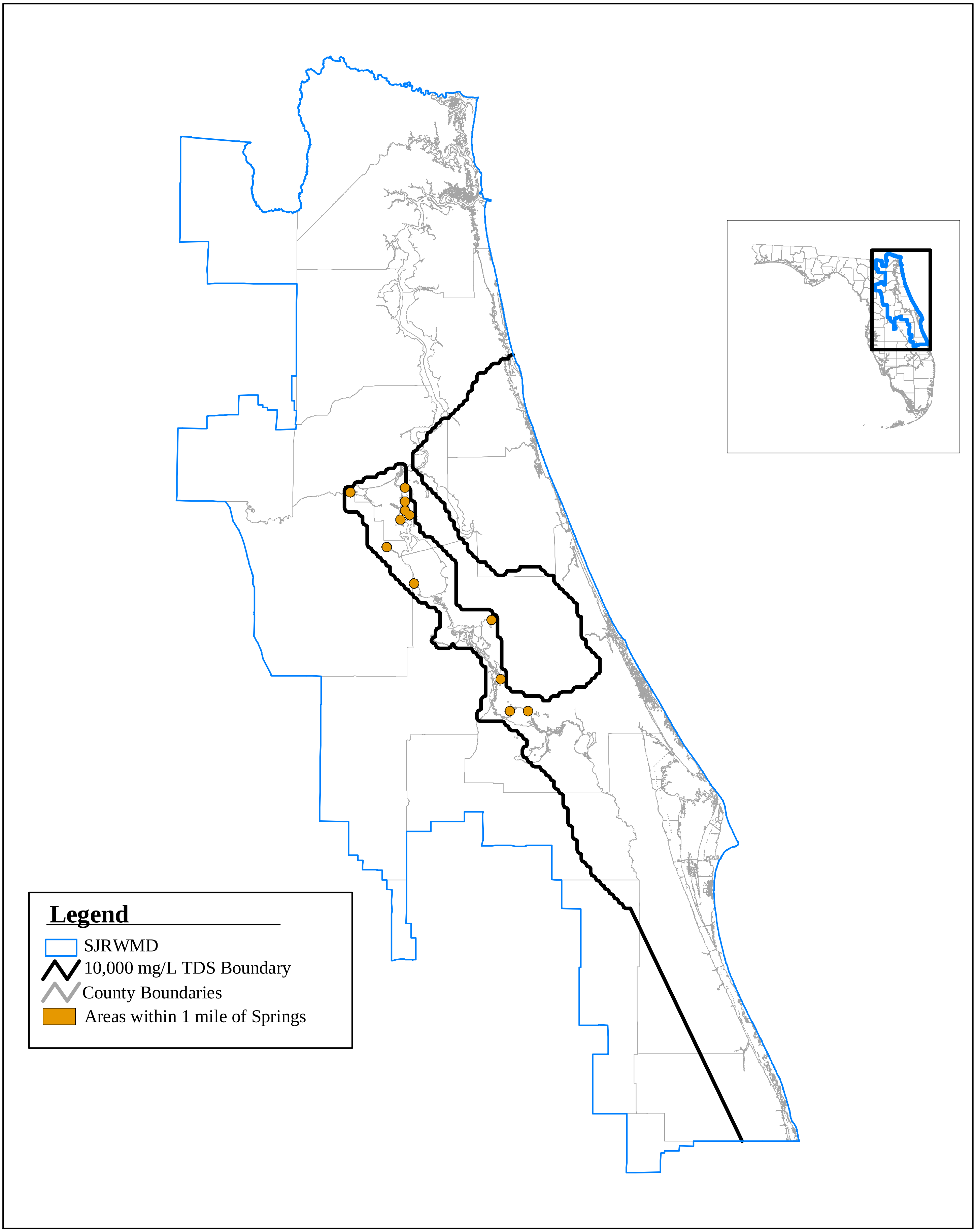


Figure 12. Setback Areas for Springs

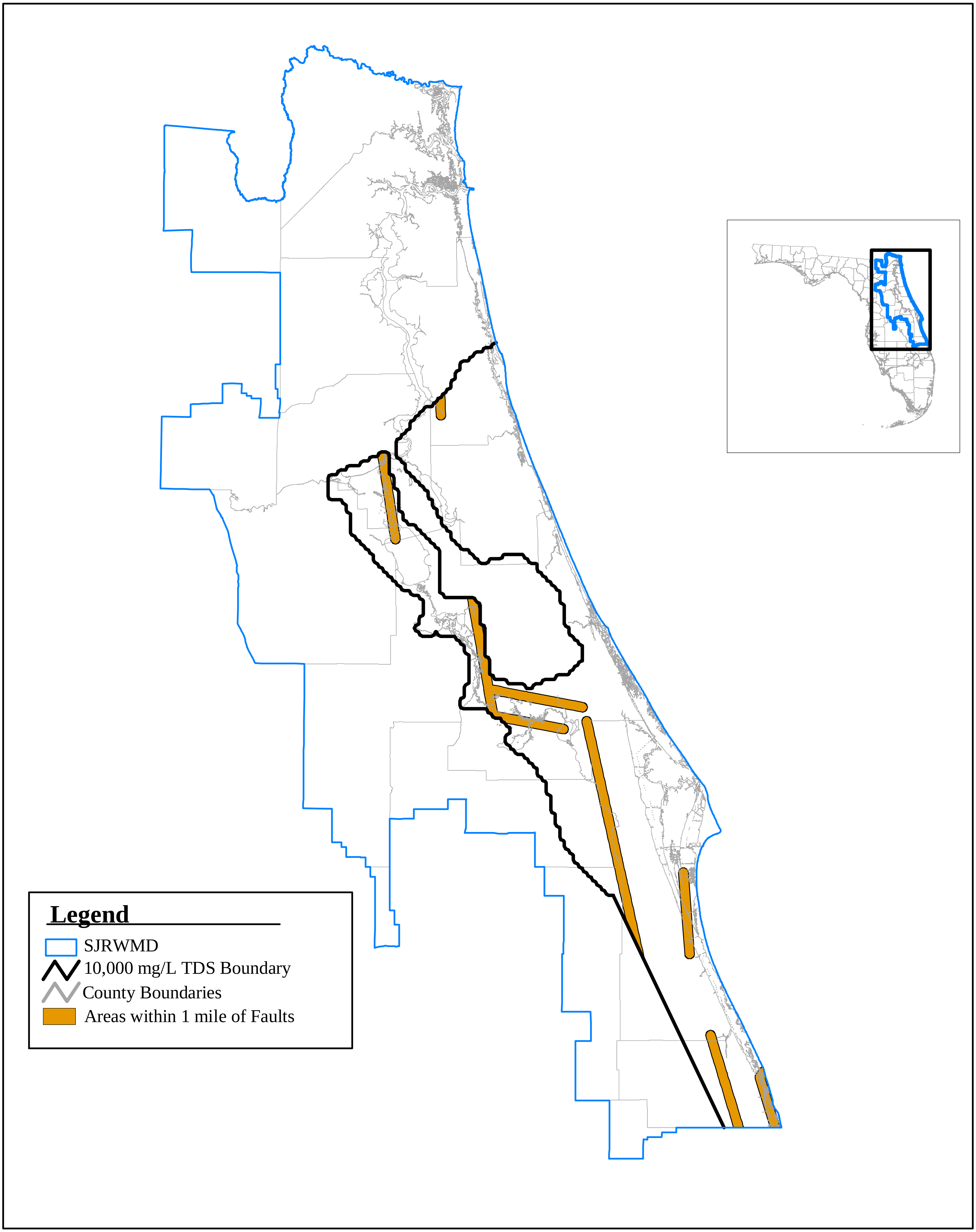


Figure 13. Setback Areas for Faults

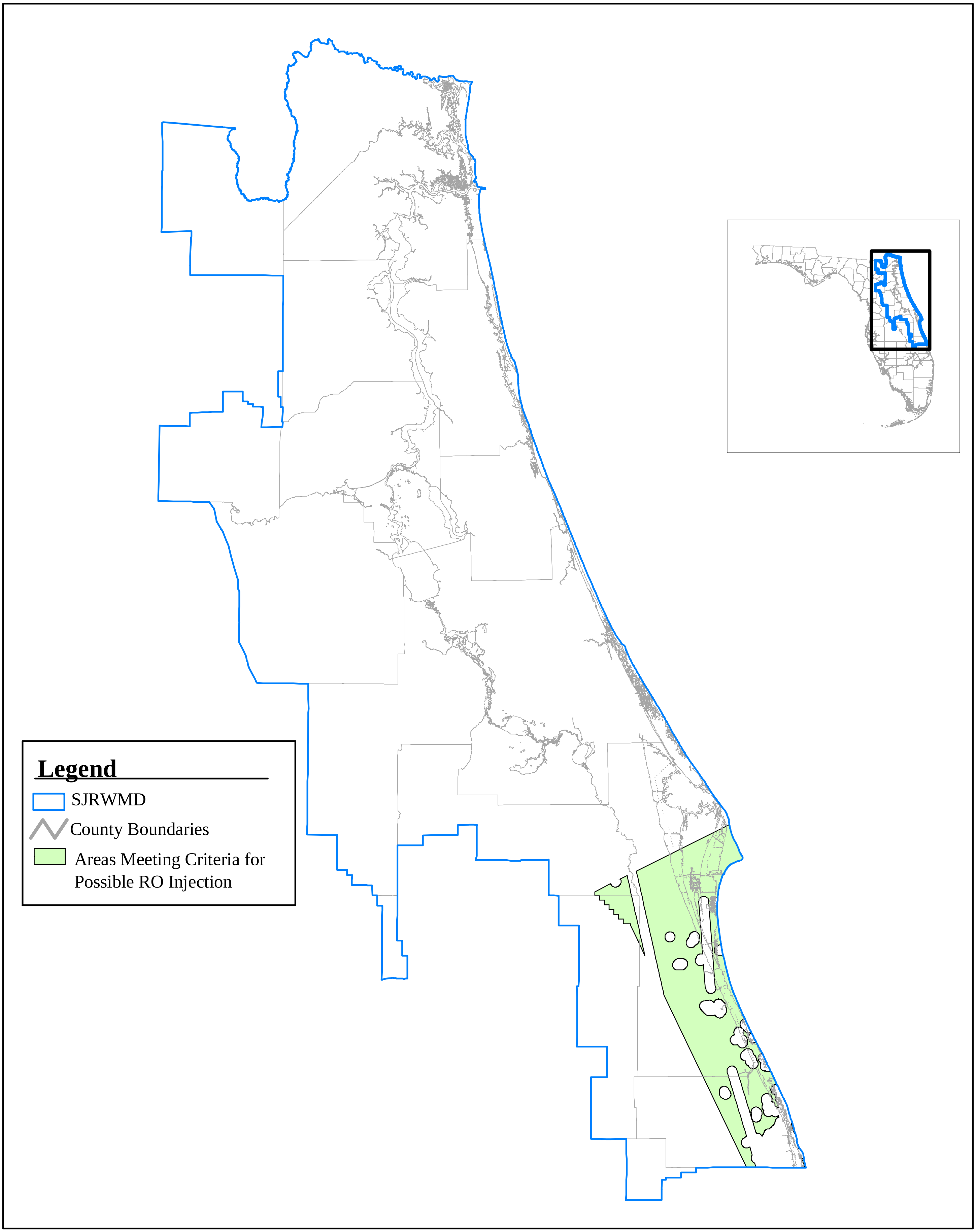


Figure 14. Highest Suitability Areas Meeting Regulatory and Technical Criteria for Potential Lower Floridan Aquifer Injection for all Flow Rates

DESIGN CONSIDERATIONS

The GIS analysis described previously determined areas potentially suitable for concentrate injection in the Lower Floridan aquifer. Hydrogeologic unit thicknesses in the resulting suitable areas were referenced to estimate the design depths for the different phases of well construction. For this investigation, some characteristic ranges were used for each step in the construction of the wells resulting in a generalized design for a Lower Floridan aquifer injection well.

Several generalizations were used to develop the conceptual injection well design. The well was designed as a Class I industrial waste injection well. The injection well will be constructed with a final steel casing extending the entire depth of the well. Fiberglass-reinforced plastic (FRP) was selected for the inner injection tubing for its corrosion-resistant properties and proven use in similar environments. The tubing will extend from land surface to the bottom of the final steel casing. The desired concentrate flowrates and a maximum allowable injection velocity of 10 feet per second (fps) were used to determine the well diameters.

In addition to the well, several appurtenances will be required. The annular space in the well will be filled with pressurized fresh water. This water will be maintained at a constant pressure by hydropneumatic tanks, and the pressure in the annular space will be monitored to ensure the mechanical and operational integrity of the well. A significant change in the annular fluid pressure often indicates a leak in the tubing or final casing.

The wellhead will require both pressure release and vacuum release valves. Meters and instrumentation are also necessary to continuously measure annular pressure, injection pressure, and injection flowrate.

Monitor wells are required at each injection well to allow monitoring of the injection zone and of the base of the USDW. The depth of the monitor wells can be determined on a site-specific basis, but has also been generalized for the purpose of developing conceptual cost estimates.

The design of the injection wells may and likely will vary from that provided here based on site-specific geology. The following is a typical design for a Lower Floridan aquifer injection well, which was used to estimate potential construction costs. The depth and number of intermediate casings will be dependent on the field geology.

LOWER FLORIDAN AQUIFER INJECTION WELL CONSTRUCTION

In this section, generalized procedures for the construction of a Lower Floridan aquifer injection well are presented. However, actual construction methods will vary based on site-specific data. In areas where data do not exist or are inconsistent, an exploratory well is normally drilled. In this case, the construction procedures would be based on the data obtained from this exploratory well.

The sizes of the required boreholes and casings are dependent on the injection flowrate because the FDEP has a 10-fps limit on the downhole velocity of injected concentrate. The proposed casing diameters presented in Table 3 are commercially-available sizes that meet the FDEP's velocity limit. Conceptual schematics of the wells for which construction is described below are presented in Figures 15 and 16.

Table 3. Injection Well Casing Size Based On Flowrate

Design Flow (MGD)	Pit Casing (in)	Surface Casing (in)	Intermediate Casing (in)	Final Casing (in)	Injection Tubing (in)
2	40	32	24	12	8
5	48	40	32	20	14

First, a steel pit casing of the selected diameter will be installed by vibration or rotary drilling to a site-specific depth (typically less than 100 feet) to provide stability for the drill rig.

Then, an 8 to 12-inch pilot hole will be drilled to the approximate top of the Floridan aquifer system using the mud rotary method. Geophysical logging (natural gamma ray, caliper, long and short normal with spontaneous potential, temperature, and fluid resistivity logs) will then be performed on the pilot hole. The pilot hole will be reamed to allow installation of the appropriate steel surface casing with minimum 0.375-inch wall thickness.

An 8 to 12- inch pilot hole will then be drilled to the approximate base of the underground source of drinking water (USDW) using the reverse-air circulation drilling method.

A geophysical logging suite will be performed on the pilot hole including:

- long and short normal electrical resistivity;
- spontaneous potential;
- fluid resistance, both static and pumping;
- temperature, both static and pumping;

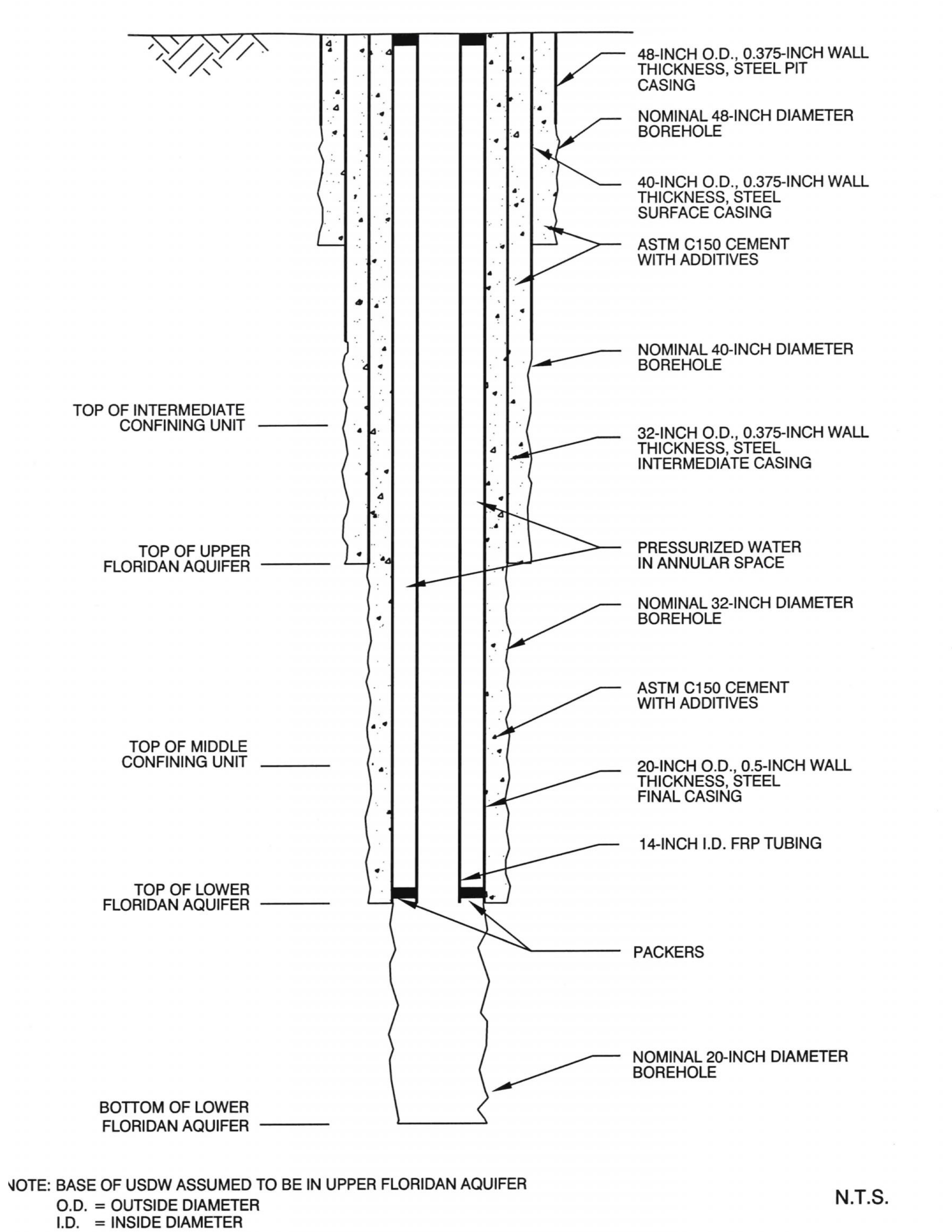


Figure 15. Conceptual Design, Lower Floridan Aquifer RO Concentrate Injection Well, 5 MGD Capacity

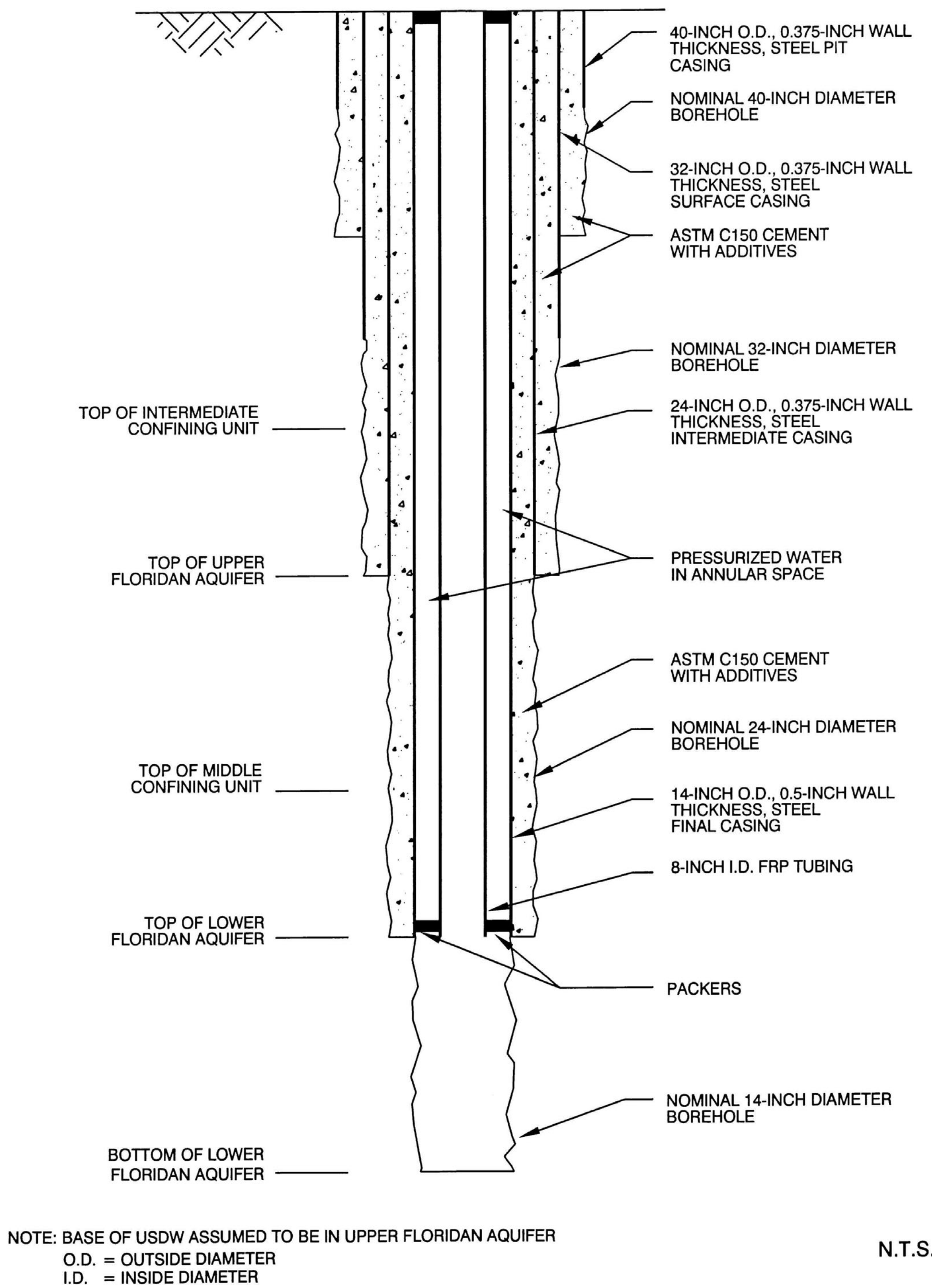


Figure 16. Conceptual Design, Lower Floridan Aquifer RO Concentrate Injection Well, 2 MGD Capacity

- natural gamma ray;
- flowmeter, both static and pumping;
- caliper;
- dual induction log;
- borehole compensated acoustic log with variable density display;
- video survey; and
- borehole televiewer

The geophysical logging will be used to determine the elevation of the base of the USDW. If it is found that the pilot hole was drilled below the base of the USDW, the pilot hole can be back-plugged to the top of the Lower Floridan aquifer. The pilot hole will be reamed to allow installation and cementing of an intermediate casing to the base of the USDW.

An 8 to 12- inch pilot hole will be drilled to the approximate top of the injection zone using the reverse-air circulation drilling method. The same geophysical logging suite previously performed will be performed on the pilot hole. The pilot hole will be reamed to allow installation and cementing of a final casing to the top of the injection zone. This final casing will be ASTM A53B or API 5L steel casing with a minimum wall thickness of 0.5 inches.

A borehole of the appropriate diameter will be drilled through the injection zone using the reverse-air circulation drilling method. The same geophysical logging suite previously performed will be performed on the pilot hole. This geophysical logging will be performed to determine the depth at which the design injection flowrate can be achieved. The depth of this open hole section, therefore, will be field-determined.

Injection tubing will be installed from land surface to the top of the injection zone with packers installed at the top and bottom, and grouted at the bottom of the tubing to allow the annular fluid between the tubing and final casing to be pressurized. After installation of the injection tubing, a video survey of the completed well will be performed and an injection test will be conducted at the design flow rate. Pressure and vacuum release valves, a hydropneumatic tank to hold pressure in the annular space, and a pump with pump housing to provide the injection pressure will be installed.

MONITOR WELL CONSTRUCTION

To meet the permitting requirements for injection well operation, monitoring of the groundwater adjacent to the injection well will be required. The FDEP requires installation of two monitor wells within 150 feet of the injection well for the purpose of monitoring above the injection zone and the base of the USDW. Above the injection zone is monitored to assess the effectiveness of the confining unit. The base of the USDW is monitored to assure that there is no upward movement of injected concentrate. Upward migration of the injected concentrate through the confining unit would be in violation of FDEP rules.

In order to provide for monitoring above the injection zone and base of the USDW, one 6-inch diameter inner casing/14-inch diameter outer casing dual zone monitor well will be constructed within 150 feet of the injection well. However, it is likely that for the multi-well injection well systems, more than one dual-zone monitor well will be required by the FDEP.

OPINION OF PROBABLE COSTS

Order of magnitude estimates of probable construction cost were developed for concentrate injection well systems with a capacity of 2, 5, 15, and 30 MGD and are presented in Table 4. The American Association of Cost Engineers (AACE) defines an order of magnitude estimate as an approximate estimate made without detailed engineering data such as in this case. This estimate has an expected accuracy of + 50 percent and – 30 percent from the nominal value. It should be noted that these costs are highly generalized and are based on very limited site-specific engineering and geologic data. If a site is selected for further study, the level of engineering accuracy will be better defined and the accuracy of this estimate can be improved.

Table 4. Order Of Magnitude Opinion of Probable Engineering, Construction, and Operation and Maintenance Costs For A Lower Floridan Aquifer Demineralized Concentrate Injection Well System

	System Capacity			
	2 MGD	**5 MGD**	**15 MGD(4)**	**30 MGD(5)**
Engineering and Permitting	$1,000,000	$1,000,000	$1,500,000	$2,000,000
Injection Well Construction(1)	$1,600,000	$1,900,000	$5,100,000	$9,900,000
Monitor Well Construction(2)	$600,000	$600,000	$1,200,000	$1,800,000
Wellhead Construction(3)	$100,000	$100,000	$300,000	$600,000
Total	$3,300,000	$3,600,000	$8,100,000	$14,300,000
Operation and Maintenance ($/year)	$50,000	$50,000	$100,000	$150,000

Notes:

(1) The injection well costs for the 2 and 5-MGD injection well systems were based on the cost of one well only. However, an alternative concentrate disposal method will be required for periodic maintenance and mechanical integrity testing of the injection well. Costs for this backup disposal were not calculated.

(2) For the 2 and 5-MGD injection well systems, one monitor well was estimated. For the 15 MGD system, two monitor wells were estimated, and for the 30 MGD system, three monitor wells were estimated.

(3) The cost of the injection well and monitor well wellheads does not include injection pumps, pipelines, or electrical costs.

(4) A total of three 5-MGD injection wells were assumed.

(5) A total of six 5-MGD injection wells were assumed.

CONCLUSIONS AND RECOMMENDATIONS

A GIS screening methodology was used to assess the feasibility of injecting demineralized concentrate into the Upper and Lower Floridan aquifers. The GIS methodology evaluated the feasibility for several regulatory and technical criteria. Based on these criteria, no areas of the Upper Floridan aquifer were deemed suitable for injection of demineralized concentrate.

Application of these same criteria resulted in several areas of the Lower Floridan aquifer being identified as potential injection zones. These areas are generally located in coastal sections of Indian River and Brevard Counties. These areas provide a starting point for future study because site-specific investigations will need to be performed as part of any future injection well implementation.

Several recommendations to improve the results of this study and to improve the application of this study to future efforts have been developed as follows:

- The USGS GIS coverages used for evaluating the Lower Floridan aquifer were based on a limited number of data points. Further work to increase the density of Lower Floridan aquifer data observations and information about confining units within the Lower Floridan aquifer should be undertaken to help improve the reliability of the assessments made as part of this study.
- Future site selection studies in any of the suitable areas should include a more detailed evaluation of local geology and adjacent domestic and public supply wells prior to final site selection.
- During the final selection of casing materials as part of future design efforts, compatibility between the injection well casing materials presented herein and the anticipated concentrate quality must be confirmed.
- For the purposes of this District-wide study, only areas that were expected to meet Class I injection well standards were evaluated. However, along coastal areas of the District, site-specific water quality and geology may be suitable for a Class V concentrate injection well. Construction of a Class V injection well in the District could be explored on a more site-specific basis.

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APPENDIX E

ALGORITHMS

SJRWMD Concentrate Management Plan
GIS Algorithms

C1	SJRWMD
C2	Priority Water Resource Caution Areas
C4	Brackish Groundwater (TDS in Floridan Aquifer)
C5	Surface Water Classification (Classes II, III)
C5a	OFWs
C5 b	Surface Water Classification (Classes II, III) minus outstanding Florida Waters & Parks, & seagrass.
C6	Surface Water TDS (from SJRWMD + EPA salinity coverage)
C7	Wetlands suitability areas

On all scenarios show SJRWMD Limits (C1), County lines, and "Priority Water Resource Caution Areas" (C2)

Source: brackish groundwater
Discharge: subsurface injection well

Figure 24

Distance between site and Groundwater with TDS higher than 500 mg/L (C4)
Plus distance between site and Potential Subsurface Injection Areas is **less** than 15 miles.

Source: brackish surface water
Discharge: subsurface injection well

Figure 25

Distance between site and surface water with TDS higher than 500 mg/L (C5)
Plus distance between site and Potential Subsurface Injection Areas is **less** than 15 miles.

Source: sea water
Discharge: subsurface injection well

Figure 26

Distance between site and shoreline
Plus distance between site and Potential Subsurface Injection Areas is **less** than 15 miles.

Source: brackish groundwater
Discharge: surface water

Figure 27

Areas where
Distance between site and Groundwater with TDS between 500 and 1,000 mg/L (C4)
plus distance between site and class II & III surface water (C5b) having TDS higher than 5,000 mg/L (C6)
is **less** than 15 miles

Figure 28

Areas where
Distance between site and Groundwater with TDS between 1,000 and 3,000 mg/L (C4)
plus distance between site and class II & III surface water (C5b) having TDS higher than 15,000 mg/L (C6)
is **less** than 15 miles

Figure 29

Areas where
Distance between site and Groundwater with TDS between 3,000 and 10,000 mg/L (C4)
plus distance between site and class II & III surface water (C5b) having TDS higher than 30,000 mg/L (C6)
is **less** than 15 miles

Source: brackish surface water
Discharge: surface water

Figure 30

Areas where
Distance between site and surface water with TDS between 500 and 1,000 mg/L (C5)
plus distance between site and class II & III surface water (C5b) having TDS higher than 5,000 mg/L (C6)
is **less** than 15 miles

Figure 31

Areas where
Distance between site and surface water with TDS between 1,000 and 3,000 mg/L (C5)
plus distance between site and class II & III surface water (C5b) having TDS higher than 15,000 mg/L (C6)
is **less** than 15 miles

Figure 32

Areas where
Distance between site and surface water with TDS between 3,000 and 10,000 mg/L (C5)
plus distance between site and class II & III surface water (C5b) having TDS higher than 30,000 mg/L (C6)
is **less** than 15 miles

Source: brackish groundwater:
Discharge: Coastal Ocean

Figure 33

Areas where
Distance between site and Groundwater with TDS between 500 and 10,000 mg/L (C4)
Plus distance between site and Shoreline
Is **less** than 15 miles

Source: brackish surface water:
Discharge: Coastal Ocean

Figure 34

Areas where
Distance between site and surface water with TDS between 500 and 10,000 mg/L (C5)
Plus distance between site and Shoreline
Is **less** than 15 miles

Source: brackish groundwater
Discharge: Open Ocean

Figure 35

Areas where
Distance between site and Groundwater with TDS higher than 500 mg/L (C4)
Plus distance between site and 90’ isobath
Is **less** than 15 miles

Source: brackish surface water
Discharge: Open Ocean

Figure 36

Areas where
Distance between site and surface water with TDS higher than 500 mg/L (C5)
Plus distance between site and 90’ isobath
Is **less** than 15 miles

Source: seawater
Discharge: Open Ocean

Figure 37

Areas where
Distance between site and shoreline
Plus distance between site and 90’ isobath
Is **less** than 15 miles

Source: brackish ground water
Discharge: brackish wetlands

Figure 38

Concentrate Flow = 2 MGD (13 Ac)
Areas where
Distance between site and Groundwater with TDS between 500 and 10,000 mg/L (C4)
Plus distance between site and brackish wetlands with areas higher than 13 Ac (C7)
Is **less** than 15 miles

Figure 39

Concentrate Flow = 5 MGD (31 Ac)

Areas where
Distance between site and Groundwater with TDS between 500 and 10,000 mg/L (C4)

Plus distance between site and brackish wetlands with areas higher than 31 Ac (C7)
Is **less** than 15 miles

Source: brackish surface water
Discharge: brackish wetlands

Figure 40

Concentrate Flow = 2 MGD (13 Ac)
Areas where
Distance between site and surface water with TDS between 500 and 10,000 mg/L (C5)
Plus distance between site and brackish wetlands with areas higher than 13 Ac (C7)
Is **less** than 15 miles

Figure 41

Concentrate Flow = 5 MGD (31 Ac)

Areas where
Distance between site and surface water with TDS between 500 and 10,000 mg/L (C5)
Plus distance between site and brackish wetlands with areas higher than 31 Ac (C7)
Is **less** than 15 miles