The "Town Lake" project is an integral part of the plan to invigorate the downtown area of Clearwater and promote development. The downtown area was developed with little or no landscaping, significant asphalt and impervious surfaces, and no provision for flood protection or stormwater quality treatment. As a result, the area is subject to frequent flooding and the existing two-acre pond, which persists with nuisance algal blooms, is aesthetically unpleasant and has generally poor water quality.

The project involves constructing a four-acre stormwater treatment pond and park amenity in downtown Clearwater to reduce flooding problems and provide stormwater treatment to protect the water quality of Clearwater Harbor, an Outstanding Florida Waterbody. Construction is commencing at the time of this writing.

Existing Conditions

As with many areas of Pinellas County, Clearwater was developed with little thought to future infrastructure needs. The project is located on the site of a historical wetland system which drained to Stevenson Creek and then to Clearwater Harbor. The site was filled for development in the early to mid 1950s and was the location of a Winn Dixie grocery store for many years. The discharge to Stevenson Creek was severed and stormwater was piped directly to Clearwater Harbor. As the downtown area continued to be developed, flooding became an issue. In 1979 the area was excavated to create a two-acre pond that has served to attenuate small rain events.

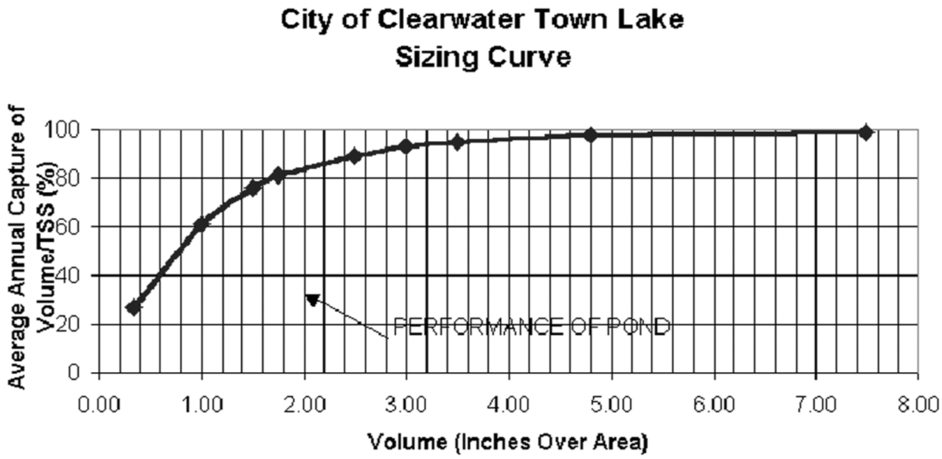
The pond, which was constructed with vertical concrete walls and excavated until blue clay was encountered at shallow depth, is relatively small for the 100-acre watershed that it serves. Consequently, it is visually unattractive and the quality of its water is rated poor. The need for a larger pond to produce better water quality became apparent.

Also, the city of Clearwater had created a Downtown Redevelopment District where the redevelopment of older properties would be encouraged. Because the district drains to Clearwater Harbor, an Outstanding Florida Water and Aquatic Preserve, the discharge of this water must be highly treated to state, regional and local regulations. The City NPDES MS4 Permit, issued in 1997, requires that areas of development and significant redevelopment adhere to the treatment standards set forth in state water policy and Chapter 62-25 FAC and 40D-4 and 40D-400.

The stormwater discharges from the drainage area to Clearwater Harbor are below the quality required by state regulations. Any increase in discharge due to redevelopment would require permits with the 95-percent pollutant load reduction treatment requirement. Change in land uses to transportation-related activities will also trigger the need for additional treatment. Development without a regional facility will require onsite treatment, reducing the land area available for development. Also, the existing pond is too small to provide the standard level of service for flood control, so in order to encourage redevelopment, the city decided to rehabilitate the facility to accommodate the stormwater treatment requirements of the Downtown Redevelopment District.

Project Development

The city entered into an agreement with the Southwest Florida Water Management District (SWFWMD) in which the district has committed to fund half the cost of the design and construction of the project. An additional $1.295 million has been provided through the U.S. Department of Housing and Urban Development (HUD) for land acquisition and $400,000 has been provided through the Surface Water Restoration Grant from the Florida Legislature for construction. The city has made co



pond. After much engineering consideration and review, it was determined that this assumption could not be supported. In addition, the SWFWMD has expressed concern that should the service district remain as currently delineated, the 114 acres will be redeveloped without any stormwater treatment, increasing the pollutant discharge to Clearwater Harbor and compromising state and district water-quality criteria. City staff members recognized the SWFWMD concern to be sufficient to jeopardize funding support and diminish the project's success.

The size of the Downtown Stormwater Service District was reduced from 214 acres to 146 acres, including that area of downtown that directly overlaps, with minor exceptions, the 100-acre contributory drainage basin. Since only 100 acres of the proposed 146-acre Downtown Stormwater Service District drains naturally to Town Lake, the desired water quality improvements for Clearwater Harbor would be difficult to achieve. The addition of other stormwater pollutant source control measures within the remaining 46 acres will help achieve the desired water quality in Clearwater Harbor.

In order to maintain compliance with the City NPDES Permit, water quality treatment would be required outside the Downtown Stormwater Service District, without exception. It was determined that a pond 3.84 acres in size at normal pool with chemical addition could meet the desired standards. The proposed expansion of the existing facility maximizes the size of a pond that can be constructed on available land, expanding north through two local streets, adjoining properties, and nearby proposed residential development. Townhouse development along Cleveland Street required the city to pursue additional property acquisition well into the design phase.

The local streets around the project are prone to flooding from significant rainfall events. One goal of the project was to increase the flooding storage capacity of the pond and the conveyance capacities of the incoming storm sewers to reduce local street flooding up to the 10-year precipitation event. With additional land made available through the city’s land acquisition program, the pond could be expanded as much as practicable. Incoming storm sewers were enlarged to better convey flow into the pond. Ultimately, during the development of the project and other downtown redevelopment, it was determined that significant improvements to the storm system in Myrtle Avenue downstream of Town Lake would also be required to meet the desired level of service for flood protection, not only in the vicinity of Town Lake, but also along Myrtle Avenue.

Storm Analysis

An analysis was undertaken to determine if the physical size of the proposed pond would be able to physically and biologically remove the influent pollutant loads. The analysis was based on the results given by a computer model known as Storage Treatment Overflow Runoff Model (STORM). STORM routes runoff based on the rational method and the local historical rainfall from 51 years of collected data. These parameters included the 100-acre water quality tributary basin, the storage in Town Lake (existing and proposed), an impervious runoff coefficient (0.95 to 1.0), and the historical rainfall. Another critical input parameter involved the bleed down, or discharge rate of the treatment volume. For purposes of analysis and conforming to local regulatory requirements, the SWFWMD criteria for wet detention, half the treatment volume would be discharged in 60 hours. The results from the model shown in Figure 1 provide an average annual capture of rainfall volume, and accordingly, total suspended solids based on pertinent treatment volumes.

Figure 1 contains the results from STORM. The results of the model indicate that for the existing pond layout, an annual capture of 27 percent is achieved, based on 0.34 inches of runoff. At these levels, the SWFWMD criteria of the treatment volume not exceeding 1.5 feet of depth is accomplished, but the annual capture falls below the required capture percentage of 95 percent. A capture of 95 percent is equivalent to the capture required for discharge into an Outstanding Florida Water. The SWFWMD permitting criterion of treating 1.5 inches of runoff was adhered to as the basis from which subsequent treatment will be accomplished. STORM predicts that this will be approximately a 27-percent average annual rainfall volume capture. The 27-percent capture corroborates the understanding that the existing pond is not physically/ biologically functioning as needed in removing pollutants, and that the 1.5 inches of treated volume will need to be augmented by a larger pond and/or chemical treatment to achieve 95-percent capture.

Proposed scenarios involving varied runoff volumes were also simulated in Figure 1, based on the proposed normal pool acreage. The results from these scenarios reveal that the 95-percent capture is achieved at 3.5 inches of runoff; however, at 3.5 inches of runoff, the proposed live treatment of the pond would require a depth of approximately 7.6 feet. The proposed layout of the pond will not be able to provide a treatment depth of 7.6 feet because of the physical constraints of available property. It was therefore recommended that chemical treatment be warranted.

Water Quality Solution

As previously stated, simply expanding the pond would not address the total water-quality issue. The addition of a chemical coagulant would be necessary to achieve the water quality desired. Alum has been used previously with success elsewhere in Florida as a chemical coagulant to treat stormwater and remove pollutants. Other stormwater ponds treated with alum in Florida were visited to observe how the chemical treatment problems of this project might be similar to those of previously designed construction projects elsewhere. The authors wish to acknowledge the input and assistance of Jeff Herr, P.E., with Environmental Research and Design Inc., who gave us a tour and advised us on design issues that work best.

A chemical injection system to improve water quality was designed with a treatment sludge pumping removal system, composed of a flow sensor measuring instantaneous stormwater inflow rate and accumulated flow volume. After an accumulated inflow volume of the equivalent of 1.5 inches of runoff over the 100-acre drainage basin has entered the pond, injection of coagulant ceases.

Laboratory jar testing was performed with iron-free alum and a concentrated poly-aluminum hydroxychloride called Hyperion. The Hyperion has a concentration of aluminum that is threefold that of alum and was determined to be a good alternative to standard alum in the use of treating stormwater runoff. Furthermore, the use of Hyperion may be necessary if the stormwater runoff has a low alkalinity, as some testing has indicated.

Jar Test Analysis

It was determined in the STORM analysis that physical and biological treatment of existing influent stormwater runoff to the pond will not be sufficient to achieve the treatment goal, which means that a coagulant chemical must be added; therefore, the first 1.5 inches of runoff from the 100-acre basin will be treated with a chemical additive to clarify the water quality prior to discharge from Town Lake to meet the 95-percent treatment goal. Field adjustment will be possible to vary the treatment dosage as necessary.

A bench-scale laboratory jar-testing program was conducted to determine the optimum chemical additive and dosage needed to clarify incoming stormwater runoff in order to meet the treatment goal. Several coagulant salts were tested. The selected coagulant is expected to produce the required water quality with the minimal sludge accumulation when compared to other coagulants.

Storm Event Sampling

The purpose of the sampling effort was to collect a sufficient volume of runoff from the watershed to conduct bench-scale testing on the stormwater. The laboratory bench-scale testing was conducted to screen certain coagulants. At that time, actual rainfall runoff was not available for collection; a grab sample from the pond was collected for preliminary analysis. Subsequently, rainfall occurred seven months later and a runoff sample was collected for the final analysis.

Bench-Scale Jar Testing Protocols and Experimental Plan

Bench-scale jar testing was performed to evaluate coagulation, flocculation and sedimentation treatment of the stormwater runoff samples. The jar test criteria were designed to allow comparison of untreated stormwater runoff versus treated runoff.

A Phipps and Bird“ six-paddle stirrer, Model Number 7790-400, was used to perform the jar tests. The stirrer used individual paddles to mix samples contained in up to six square, two-liter sample jars. An adjustable-speed motor was mounted on the stirrer to provide a range of 0 to 350 revolutions per minute (rpm). To initiate the jar tests, two liters of the sampled stormwater runoff were poured into each jar. The jars were placed onto the stirrer and the mixing paddles were lowered into the water. The stirrer was turned on at approximately 350 rpm to mix the sample rapidly with the coagulant.

The coagulant was added to the sample at the specified dosage using pipettes. The dosages of the coagulant ranged from 5.0 to 20 mg/L as aluminum (Al). The rapid mix stage lasted for one minute. After the flocculation stage was completed, the stirrer was turned off and the sample was allowed to settle for 60 minutes. It is believed that the operation of mixing treatment chemicals in the incoming flow stream to Town Lake will simulate mixing methods conducted in this laboratory analysis.

Three types of coagulants were tested: polyaluminum hydroxychloride, aluminum sulfate, and polyaluminum chloride. General Chemical and Kemwater each provided four coagulants (three specific coagulants were provided for both the polyaluminum hydroxychloride and the polyaluminum chloride, and two specific coagulants were provided for the aluminum sulfate).

Bench-Scale Experimental Plan and Results

Coagulant Scan

Eight sets of jar tests were performed as an initial coagulant scan to directly compare the eight coagulants without polymer optimization. Coagulants known as Hyperion 1033, Hyperion 4090, Hyperion 1090, iron-free liquid alum, aluminum sulfate, PAX-18, PAX-28, and PAX-XL 19 were used. Each coagulant was administered in doses varying from 5.0 to 20 mg/L as Al. To directly compare the performance of each coagulant, polymer was not added in this jar-testing event.

From this initial coagulant scan, one manufacturer’s specific coagulant was chosen from each coagulant group for continued testing. Based on the field water quality analyses (lower settled water turbidity, larger floc particles, and quickest settling), the following three coagulants were determined to perform best within their respective coagulant group: PAX-18 (polyaluminum chloride), Hyperion 4090 (polyaluminum hydroxychloride), and Iron-Free Liquid Alum (aluminum sulfate). These three coagulants produced the lowest concentration of turbidity ranging between 0.4 to 0.5 NTU with the following coagulant dose: PAX-18 at 10 mg/l as Al, Hyperion 4090 at 15 mg/l as Al, and Iron-Free Liquid Alum at 10 mg/l as Al.

In conclusion, it appeared from this testing event that these three coagulants performed better than the remaining five coagulants. Based on this testing event, it was decided to proceed with the testing of PAX-18 at 10 mg/l as Al, Hyperion 4090 at 15 mg/l as Al, and Iron-Free Liquid Alum at 10 mg/l as Al to refine the dosage to an optimum level and experiment with polymer for fast settling of turbidity. PAX-18 at 10 mg/l appeared to produce a minimum turbidity. Iron-Free Alum was increased to 12 mg/l to find a minimum turbidity, and Hyperion 4090 was decreased to 11 mg/l to find and acceptable turbidity at less dosage.

Dosage Refinement

Next, the three coagulants were tested with both A-1849-RS and AP1120 polymer added at doses of 0.25 and 0.50 mg/l as product to observe the value of adding polymer to further facilitate reduction in turbidity. The polymers that were used in the jar tests aided in in reducing high turbidity readings representative of influent stormwater runoff to the pond. Generally, turbidity readings dropped below one NTU within 30 minutes for treated samples with and without polymers.

The practicable application of the project will be that Town Lake will provide longer detention times for sedimentation of the coagulants than those demonstrated in the jar testing analysis. Consequently, the use of polymer in the final specifications of the project was eliminated. In summary, Hyperion at 11 mg/l, Iron-Free Alum at 12 mg/l and PAX-18 at 10 mg/l resulted in an acceptable turbidity level.

Water Quality Testing Event

The two preferred coagulants, Hyperion 4090 and Iron-Free Alum, are easily available and were used to dose samples of the raw stormwater runoff. One sample contained Hyperion 4090 at 11 mg/l and the second sample contained Iron-Free Alum at 12 mg/l. The raw stormwater sample and the two coagulant samples were tested for the parameters shown in Table 1.

Examination of the water-quality data in Table 1 shows that both tests exhibit reductions in pollutants or are neutral with a few exceptions. Total Kjeldahl nitrogen, turbidity, total phosphorus, BOD5, and ortho phosphorus showed significant reductions with all exceeding about 90 percent removal. Suspended solids showed a 75-percent removal. Other parameters that were reduced included pH, ammonia, and lead.

Parameters that appear unaffected by either additive include nitrate plus nitrite, hardness, cadmium, copper, and oil and grease. For alkalinity, Hyperion 4090 reduced the concentration by only 5 percent, but Iron-Free Alum reduced alkalinity by 98 percent. Also, Hyperion 4090 reduced zinc by 61 percent while Iron-Free Alum did not reduce zinc. Finally, parameters that increased during the tests included total dissolved solids (approximately 100-percent increase), specific conductance (21 to 72 percent increase), and dissolved oxygen (72 percent increase).

Total and monomeric aluminum were tested by the laboratory after delivery of samples. Concentrations of aluminum in the treated samples increased beyond the values observed in the raw sample; however, according to EPA (U.S. EPA, 1988), the acceptable concentration of aluminum allowed to be discharged to a saltwater body must not exceed 1.5 mg/l. From the values reported in Table 1, only the Hyperion 4090 sample met the criteria. The application dosage of Hyperion 4090 or Iron-Free Alum may need to be field-adjusted during test trials to treat incoming stormwater after completion of the project to regulate the concentration of total aluminum.

Table 1
Water Quality Data Results

				Hyperion 4090		Iron Free Alum	
Parameter	Units	Standard	Raw Inflow	Value	% Reduction	Value	% Reduction
pH		6.5 to 8	7.4	6.7	9%	4.3	42%
Total Kjedahl Nitrogen	mg/l	-	1.4	<0.2	93%	<0.2	93%
Total Dissolved Solids	mg/l	-	62	120	-94%	130	-110%
Total Suspended Solids	mg/l	-	10	<5	75%	<5	75%
Nitrate + Nitrite Nitrogen	mg/l	-	0.3	0.27	10%	0.23	23%
Specific Conductance	umhos/cm	< 50% of background	99	120	-21%	170	-72%
Ammonia Nitrogen	mg/l	-	0.34	0.13	62%	0.22	35%
Alkalinity as CaCO3	mg/l	> 20	22	21	5%	<1	98%
Turbidity	ntu	< 29 above natural background	7.9	0.6	92%	0.5	94%
Dissolved Oxygen	mg/l	> 5	4.3	7.4	-72%	7.4	-72%
Zinc	mg/l	0.034	0.14	0.055	61%	0.16	-14%
Hardness as CaCO3	mg/l	-	27	37	-37%	35	-30%
Total Phosphorus	mg/l	-	0.46	<0.1	89%	<0.1	89%
Biochemical Oxygen Demand (5-day)	mg/l	-	16	<2	94%	<2	94%
Ortho Phosphorus	mg/l	-	0.36	<0.05	93%	<0.05	93%
Cadmium	mg/l	0.4	<0.005	<0.005	0%	<0.005	0%
Copper	mg/l	0.004	<0.02	<0.02	0%	<0.02	0%
Lead	mg/l	0.006	0.0081	<0.005	69%	<0.005	69%
Oil & Grease	mg/l	< 5	<5.0	<5.0	0%	<5.0	0%
Monomeric Aluminum	ug/l	-	22	24	-	1611	-
Total Aluminum	ug/l	1500 (saltwater)	174	493	-	2920	-

Chemical Treatment Recommendation

Turbidity results using just Hyperion 4090 or Iron-Free Alum were comparable after one hour, with or without the use of polymer. Turbidity measurements less than 1.0 NTU were reported. In order to simplify the chemical treatment system and minimize the cost of the project, the use of polymer was considered but was not recommended for the final project design. Based on laboratory turbidity results, either Iron-Free Alum or Hyperion 4090 can be used to treat the influent stormwater, but due to the low pH reading (4.3) exhibited by the treated sample with Iron-Free Alum, it was recommended that Hyperion 4090 be used to treat incoming stormwater runoff to Town Lake.

A 6,000-gallon tank is to be constructed in a chemical storage building. The tank will release the coagulant at the required dosage up to 1.5 inches of runoff flow through an electronic totalizer installed within the inflow storm sewer. The totalizer serves to activate the metering pumps to properly dose the influent stormwater. At the chemical injection point, air will be blown into the flow stream to aid in further mixing the coagulant and to keep floatable debris in the stormwater treatment structure.

Sludge Accumulation and Removal

Chemical addition to the pond to achieve better water quality is possible, but the accumulation of sludge in the bottom of the pond is an undesirable side effect. It is anticipated that the majority of sludge accumulation will occur at the outfall of the storm sewer located in the north half of the pond. To completely fill the permanent north pool volume with sludge, depending on the percent solids (2 to 16 percent), will take from approximately nine to 84 years. The city desired to have an automated pond cleaning system by which accumulated sludge could be removed periodically. Methods of draining the pond periodically or operating a mechanical dredge were felt to be not aesthetically pleasing.

Typically, stormwater treatment with an alum-based coagulant produces a sludge that is difficult to collect and dispose of. Flat pond bottoms typically have localized areas where the sludge accumulates, making it difficult to collect the sludge by vacuum methods. A design was researched that employs wastewater treatment technology using concrete hoppers underneath the pond. This design calls for two concrete hoppers in the bottom of the north cell of the pond to serve as a place for treatment sludge to collect. The sludge can then slide down the smooth 2:1 concrete sideslopes of the hoppers to a small area in the bottom of the pond. An underground sludge pump vault and suction lines to the concrete hoppers will allow the owner to pump the accumulated treatment sludge from the bottom of the pond periodically to the local sanitary sewer system. Figure 2 displays the project site plan.

It is suggested that sludge removed from the pond be pumped to the city sanitary sewer system quarterly. Figure 2 shows a plan view of the proposed pond and a cross-section view of the sludge collection hoppers. The city has discharge parameters assigned to its wastewater discharge permit. To address this issue, a volumetric sample of treatment sludge was produced, treating raw incoming stormwater with the two most promising chemical coagulants that were analyzed. This analysis resulted in the probable treatment sludge characteristics that meet the city's industrial pretreatment program limitations; however, approval for discharge is contingent on testing the material for a period of time to determine that the effluent does not exceed those standards. In addition, information on the volume and frequency of discharge needs to be reviewed to ensure that the sanitary collection system can accommodate the discharge.

Conclusion

The completed project is expected to presumptively meet the desired pollutant load reduction, improving water quality in Town Lake and reducing urban flooding. The city plans to conduct a water-quality sampling program to monitor the success of this design. In conjunction with the new facility, the creation of the Downtown Stormwater Service District, together with the pretreatment of stormwater runoff from land development, will improve stormwater discharged to Clearwater Harbor. The peninsula of land that is currently a local street will create a gathering area in the center of the pond. The facility will also allow for recreational and educational opportunities. The improved site will incorporate landscape architecture amenities to create a pleasant environmental setting in downtown Clearwater.

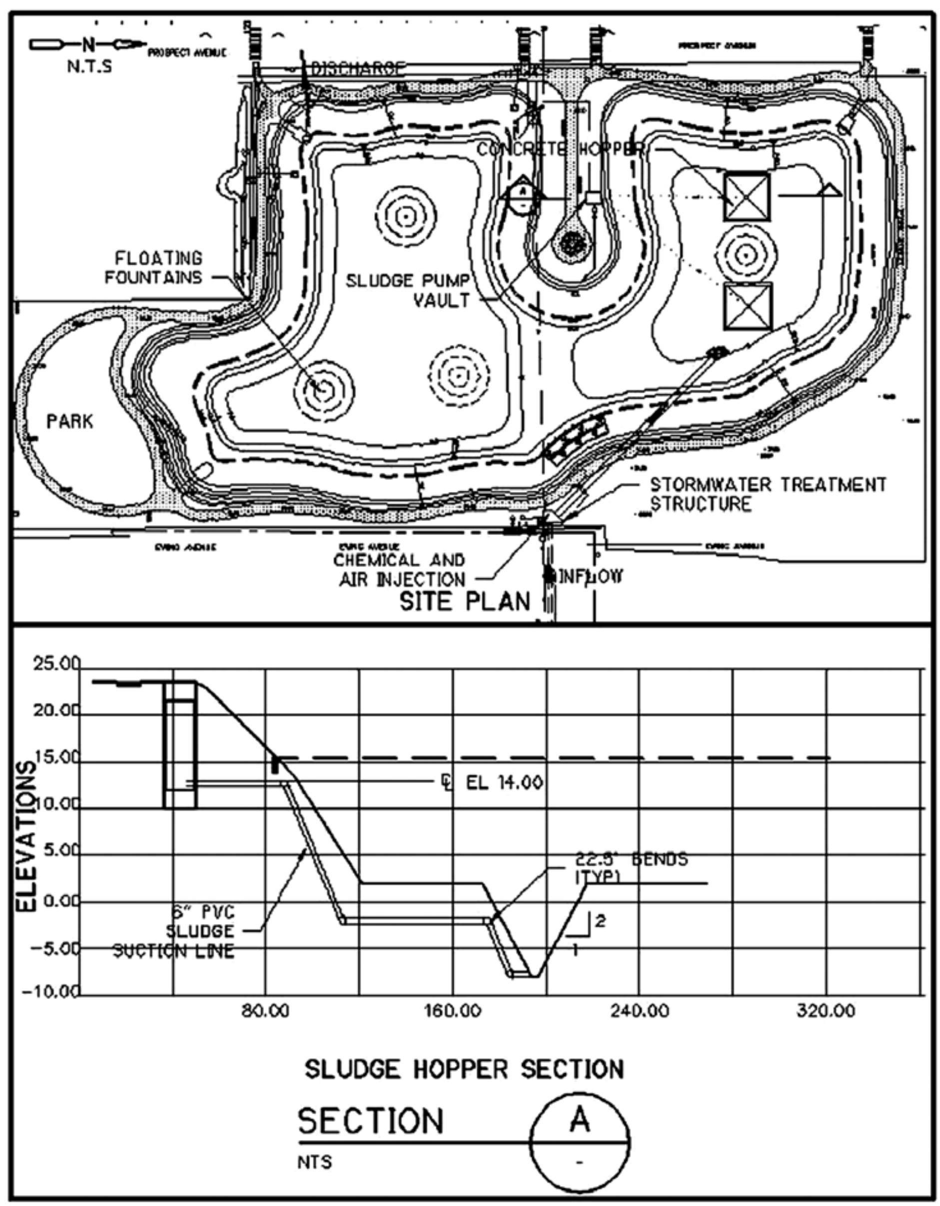


Figure No. 2
Town Lake Rehabilitation Project
Site Plan & Cross Section