Wastewater Technical Assistance Assessment Report

for the

Kingston Wastewater Treatment Plant
Kingston, Tennessee

and the

University of Tennessee
Municipal Technical Advisory Service

Wastewater—Operations

August, 1995

PSG
Your water and wastewater partner

PSG PROFESSIONAL SERVICES GROUP, INC.

September 4, 1995

Ms. Sharon L. Rollins, P.E.
Senior Consultant
University of Tennessee - MTAS
226 Capitol Boulevard, Suite 402
Nashville, TN 37219-1804

Re: **Wastewater Technical Assistance Services - MTAS**
ASSESSMENT Report for Kingston, TN

Dear Ms. Rollins:

Please find enclosed, your copy of the ASSESSMENT report prepared by Professional Services Group Inc., (PSG) for wastewater technical assistance services provided in Agreement with the University of Tennessee - Municipal Technical Advisory Service (MTAS) for the above captioned municipality.

I have also submitted ten (10) copies of the ASSESSMENT report to Ms. Anne Gilbert in MTAS' Knoxville office, for distribution to the Kingston client. I have also provided a copy of the report for Ms. Gilbert for her review and files.

If you have any questions concerning this ASSESSMENT report or should the Kingston Client desire a presentation or workshop meeting concerning our findings, please contact me or Bob Dohoney in our Knoxville office at (615) 693-5579.

Respectfully submitted,

PROFESSIONAL SERVICES GROUP, INC.

Timothy J. Muirhead

Timothy J. Muirhead
Area Manager

cc: Anne Gilbert, MTAS
Bob Dohoney, PSG
MTAS Project, File

Encl.

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INTRODUCTION

Kingston, Tennessee is located approximately thirty (30) miles west of Knoxville in central Tennessee. This municipality owns and operates a wastewater collection system and secondary treatment plant that treats domestic wastewater flows for a population of approximately 4,700 people. The City of Kingston constructed and placed into operation in 1988 their existing extended aeration secondary treatment system using an oxidation ditch. This type of biological treatment system appears to be adequate in regularly meeting its NPDES permit requirements and reliably protecting the receiving body of water. However, the treatment plant frequently operates at or above its hydraulic capacity. The flow and aeration capacity at the treatment plant appears to be a potential community growth limiting factor. Chlorinated secondary effluent is pumped and discharged into the Clinch River at mile 0.28. Biosolids management and disposal is a major concern for the Kingston WWTP.

We received information concerning minor effluent excursions and concerns of treatment plant capacity to handle intermittent high flows and projected community growth loadings. The most recent 'Compliance Evaluation Inspection' report for the Kingston Wastewater Treatment Plant (WWTP) by the Tennessee Department of Environment and Conservation (TDEC) received in January, 1995 indicated an effluent of good quality with some written concerns about an inadequate sludge disposal system and the need to continue upgrading the collection system.

In response to these regulatory agency concerns with municipality support, Professional Services Group, Inc. (PSG) as a sub-contractor to an Agreement between the City of Kingston and the University of Tennessee, Municipal Technical Advisory Service (MTAS), performed in June, 1995 a comprehensive technical assessment of the various operations, maintenance, and management (OM&M) aspects of the Kingston, TN Sewer Collection System and Wastewater Treatment Plant.

In an introductory meeting at City Hall with MTAS and PSG, Mr. Ed Smith, City Manager, provided a description of his assessment of the existing performance levels and future capacity needs of the sewer collection system and wastewater treatment plant. During our initial plant visit, Mr. Gene McClure, Wastewater Treatment Supervisor, provided the plant tour, facility and process descriptions, NPDES permit, and operational/compliance data needed to initiate the assessment of the Kingston WWTP. On a subsequent plant visit, Mr. McClure and the Kingston treatment plant staff assisted us in the assessment of the process control, maintenance, and safety aspects of this wastewater facility.

On our third visit and inspection, a walk-through of the treatment plant and thorough tour and focused assessment of the sewer collection system and infiltration/inflow (I/I) impacts were performed with Mr. Smith and Mr. Gary Davis, Plant Operator. On the fourth plant visit, Arley and Cookie assisted us in our inspection of the laboratory tests and assessment of the analytical QA/QC procedures. Other pertinent information concerning the existing treatment facilities, i.e. monthly operations reports, plant design criteria and drawings, O&M manual and other engineering information were furnished by Mr. McClure for our review and use in preparing this Assessment report. Mr. Smith provided a current map of the Kingston sewer collection system.

Wastewater Collection System

The Kingston sanitary sewer collection system is a separate gravity and pressure system with seven (7) lift stations and one (1) on-site pumping station. A current and reduced drawing of the Kingston sewer system is found in Appendix I as Figure I-1. The influent raw wastewater is discharged by gravity into the headworks of the Kingston WWTP via a force main. The wastewater collection system contains service connections with most of these customers being residential, and some light commercial (i.e. schools). The industries in Kingston are not tied into the city sewer system and have no impact on the collection system or treatment plant at the time of our system inspections and preparation of this Assessment report.

The rehabilitation and expansion of the collection system to adequately support the existing sewer customers and anticipated growth in the City of Kingston was a primary concern of the City Manager. This area of concern was also mentioned by TDEC in their recent Compliance Evaluation Inspection of January, 1995. The City of Kingston has been in the on-going process of rehabilitating the older pipe sections of the sewer system, as well as upgrading and constructing new pumping stations. These activities have been initiated as the result of a historical State mandate to this municipality to reduce the level of infiltration/inflow (I/I) to the treatment plant. The ability to maintain a viable sewer collection and treatment system with sufficient capacity to accommodate the existing population remains an important issue for the City of Kingston. An equally important issue appears to be the need to develop and implement a well defined technical plan which has municipality approved fiscal strategies in place to upgrade the sewer collection system and expand the treatment plant to handle the current and anticipated levels of residential, commercial, and industrial growth.

Accordingly, a thorough tour and inspection of the collection system was performed to generally assess from our field observations, any potential performance limiting factor(s) in the sewered sections of the City with respect to these critical capacity and growth issues. We also utilized the recently updated sewer piping map, as well as recent plant flow and precipitation records and topographical map to complete our assessment of the collection system, described in detail in a later section of this report.

Our review of the sixteen (16) months of most recent daily operating data for flows at the Kingston WWTP indicated continued problems with moderate/severe infiltration and inflow (I/I). During this period of time, a total of twelve (12) bypasses occurred during the months of February through April, 1994 which constituted violations of the City's National Pollutant Discharge Elimination System (NPDES) permit. As defined by TDEC, a 'bypass' is the diversion of wastewater from any portion of a treatment facility or collection system. These bypasses occurred during sustained period of heavy precipitation and excessive I/I, which produced treatment plant flows in excess of 2.00 MGD as the result of potentially numerous leaky manholes, damaged and/or broken lines and covers, lift station equipment malfunctions etc. in the collection system.

As summarized in Table 1, our review of the hydraulic loadings to the Kingston WWTP for the period of operation between January, 1994 through April, 1995 indicates that moderate to severe I/I problems did occur. A corresponding review of monthly process control data and Discharge Monitoring Reports (DMRs) were used to prepare weekly histograms of the effluent quality for the conventional parameters of BOD_5 and TSS (see Figures II-5 and II-6). Histograms were also prepared to compare the number of reported bypasses to the daily levels of rainfall precipitation and plant influent flows, as well as the monthly average variance between the plant influent and effluent flows (see Figures II-3 and II-4). Based upon these plots, an assessment could be made as to the level of reported NPDES permit compliance during these periods of operation when erratic and sudden increases in flows were experienced at the WWTP.

Specifically, Figure II-1 illustrates the levels of weekly influent flows as compared to the design capacity of 1.00 MGD. Figure II-2 shows the direct correlation between total weekly rainfall precipitation (inches) and plant influent flow (mgd). This plot also shows the bypass periods in early 1994 when sustained hydraulic loadings resulted in weekly plant flows which exceeded 1.00 MGD. However, no bypasses were reported during early 1995 when weekly plant flows also exceeded 1.00 MGD. Figure II-3 shows that no significant problems with deterioration of effluent quality or NPDES permit compliance for BOD_5 and TSS occurred during the high I/I periods and sustained peak influent flow conditions. Figure II-4 shows that monthly average effluent flows exceed influent flows, which could indicate that plant bypasses still occur on an intermittent and potentially frequent basis. It is also recognized that a portion of the flow variance can be attributed to the time difference for totalization attributed to the hydraulic detention time between flow meters and any inaccuracies in the monitoring and recording instrumentation.

Accordingly, our assessment is that an adequate level of process control in the biological treatment system was maintained and associated effluent quality deterioration minimized, due to the operation of the swirl device at the headworks of the treatment plant when influent flows exceeded 700 gpm (1.01 MGD). However, the recorded number of actual bypasses of the secondary treatment system when the swirl device should have been operational for high plant influent flows (greater than 1.01 MGD), were not reflected as required by the NPDES permit on the TDEC Monthly Operations Reports or reported in the DMRS. Thus, the actual permit compliance and operational impacts of the existing collection system on the treatment plant may not be fully identified or accurately reflected by the plant operations and regulatory reports.

KINGSTON, TN WWTP
WASTEWATER INFILTRATION/INFLOW
TABLE 1

MONTH	TOTL FLOW MG	AVG FLOW MGD	PEAK FLOW MGD	PK FACTOR RATIO
Jan '94	26.08	0.841	1.534	1.82
Feb '94	29.43	1.051	1.875	1.78
Mar '94	35.12	1.133	2.297	2.03
Apr '94	36.70	1.184	2.184	1.84
May '94	16.73	0.541	0.899	1.66
Jun '94	17.62	0.587	0.931	1.59
Jul '94	18.07	0.583	0.946	1.62
Aug '94	17.18	0.554	0.720	1.30
Sep '94	15.39	0.513	0.654	1.27
Oct '94	14.10	0.455	0.598	1.31
Nov '94	14.80	0.493	1.139	2.31
Dec '94	18.33	0.611	1.515	2.48
Jan '95	27.67	0.892	1.991	2.23
Feb '95	18.52	0.661	1.515	2.29
Mar '95	21.00	0.677	1.853	2.74
Apr '95	15.06	0.502	1.086	2.16
Average	**21.36**	**0.705**	**1.359**	**1.90**
Maximum	**36.70**	**1.184**	**2.297**	**2.74**
Design	**31.25**	**1.000**	**2.000**	**2.00**
Capacity	**68.3%**	**70.5 %**	**68.0 %**	**82.5 %**

A peaking factor, defined as the ratio of the instantaneous daily peak flow to the average daily flow, greater than 1.50 is typical of moderate I/I problems and peak flow ratios greater than the design value of 2.00, indicates high or excessive I/I problems. As can be seen in recent monthly data at Kingston, the average peak factor was 1.90, with eighty percent (80%) of the months showing values well above 1.50. Additionally, seven (7) of the spring time months in the past two years showed high I/I problems, with peak flow ratios equal to or exceeding a value of 2.00. The total, average daily, and peak daily flows for the past sixteen (16) months all show a consistent average utilization of sixty-nine percent (69%) of the design capacity for the Kingston WWTP. Monthly flows were observed to exceed the daily average and peak flows of 1.00 and 2.00 MGD, respectively.

The most important assessment of the Kingston wastewater I/I analysis are the maximum monthly average and peak daily hydraulic loadings of 1.18 and 2.30 MGD, which are both above the respective design capacity loadings of 1.00 and 2.00 MGD. These flow values strongly indicate continued I/I problems in the collection system and the continued need to rehabilitate old sewer pipes and upgrade the transmission and pumping system. These type of high flows at the treatment plant produces a hydraulically overloaded and stressful operating condition, with a resultant bypass in secondary treatment of a substantial portion of the flow, high risk in loss of process control in the biological treatment system, deteriorated effluent quality, and NPDES permit violations. Additionally, the influx of stormwater from surface and ground sources also consumes current collection system and treatment plant flow capacity, which otherwise would be available for additional community growth and/or expansion of sewered customers.

Wastewater Treatment Plant

The Kingston WWTP is an extended aeration activated sludge plant which provide secondary treatment using an oxidation ditch manufactured by Lakeside Equipment Corporation, Inc. This race track oblong-shaped secondary treatment system provides aeration of suspended biological growth system (activated sludge) using rotors. Circular clarifiers provide separation of the biological solids from the wastewater after the treatment in the oxidation ditch. The oxidation ditch was designed to remove both carbonaceous (BOD) and suspended (SS) matter from the wastewater as an extended aeration secondary treatment system. The Kingston WWTP uses a swirl device at the headworks to bypass influent flows to the effluent wet well which exceed 700 gpm (1.01 MGD) and preliminary treatment for debris, grit and grease removal. Additional liquid treatment facilities utilized at the Kingston WWTP include influent and effluent flow metering/sampling, disinfection and outfall discharge.

Waste secondary biosolids are stabilized via aerobic sludge digestion and dewatered using outdoor drying beds. The City of Kingston is pursuing the replacement of this gravimetric filtration and evaporative drying method of dewatering with a liquid land application program (LAP) using a contract hauler to transport by pumper truck to approved application sites for beneficial use on agricultural farms as a soil conditioner and natural organic fertilizer.

The secondary treatment units consist of a rectangular shaped oxidation ditch with circular ends and two (2) rotating-type blade aerators designed to treat a total average daily wastewater flow of 1.00 million gallons per day (MGD). The WWTP is also designed to handle a maximum daily flow of 2.00 MGD during normal wet weather periods of time. Preliminary and secondary treatment are used to provide removal of inorganics, organics and solids. The size and complexity of the Kingston WWTP requires a Grade II certified wastewater treatment plant operator to supervise the daily plant operations and the sewer collection system requires a Grade I certified collection system operator.

The size reduced engineering drawing shown in Appendix I as Figure I-2, depicts the flow patterns and unit processes at the Kingston WWTP. The treatment plant was designed to operate in the extended aeration mode of operation using the Lakeside Equipment Corp. oxidation ditch activated sludge system. As shown in Figure I-2, the raw wastewater enters the treatment plant by gravity from a force main and combined manhole and is discharged into a swirl device. Normal dry weather flows will pass through the swirl device to the preliminary treatment system, which contains a bar screen, aerated grit and grease removal chamber, influent flow meter and automatic sampler. During storm events which cause wet weather flows to exceed 700 gpm or 1.01 MGD, the diluted raw wastewater overflows in the swirl device to the bypass line, which directs the flow to the effluent wetwell for chlorination, prior to outfall discharge.

Large influent debris and solid particles are manually raked and removed from the inclined mechanical bar screen to prevent plugging of downstream piping and protect from damage of equipment. During our plant inspections, we observed this mechanical bar screen to be broken and out of service. Mr. McClure indicated that this piece of equipment is frequently broken with the most recent problem of jammed flights and broken chain resulting in it being out of service for more than three (3) months. The operability of this piece of equipment has been unreliable and problematic for several years and its frequent out of service status was noted as a deficiency by TDEC in their January, 1995 Compliance Evaluation Inspection report. In that report, TDEC recommended to the City that an alternate method or equipment be considered to screen the influent wastewater to address this on-going problem.

The raw wastewater flows through an aerated rectangular grit separator and grease removal chamber. An air diffuser system maintains organic material suspension in the wastewater flow while grit eductors and a dewatering screen remove the settled inert material from the bottom of the chamber and discharges the inorganic solids into an uncovered container. The floating grease and scum are manually skimmed from the aerated chamber and also discharged in the uncovered container with the screenings. The container of screenings, grit, grease, and other debris are hauled off by an outside contractor and properly disposed in the Roane County sanitary landfill.

The influent flow meter, consisting of a channel and parshall flume with a flow sensor, measures and totalizes the treated raw wastewater flow. The bypass flow of wastewater during storm or wet weather events from the swirl device to the effluent wet well is not measured on the influent side, but monitored by the effluent flow meter. The influent flow sensor and meter during our plant inspections appeared to be relatively new and it was observed to be functioning properly. An automatic composite sampler collects a composite during off-duty hours (3 p.m. to 7 a.m.) from the influent channel on a time-proportioned basis and the sample analyzed for BOD_5 and SS.

The preliminary treated wastewater flows by gravity to the biological system for activated sludge treatment. This suspended growth biological treatment process oxidizes and removes both organic matter and suspended solids in one (1) oxidation ditch. The oxidation ditch is equipped at each circular end with a longitudinal and rotating blade-type air diffuser system using two (2) rotors to diffuse oxygen required for the microbial biomass to metabolize and breakdown (oxidize) the organic matter and suspended solids in the wastewater flow. The aerated biomass (mixed liquor) from the oxidation ditch is discharged to two (2) circular secondary clarifiers. The oxidized biosolids are settled from the wastewater flow in the secondary clarifiers and the effluent is discharged over weirs into an effluent wetwell where it is sampled, prior to disinfection.

An automatic sampler is also programmed on a sixteen (16) hour composite basis using a time-proportioned signal to monitor and sample the pre-chlorinated effluent. An ultrasonic type in-line flow meter with a bubbler system is installed in the effluent force main to measure the flow and send a signal to a remote recorder. Chlorine is introduced into the effluent force main and the transport time from the treatment plant to the outfall discharge serves as the contact time for disinfection of the wastewater flow. Chlorine is stored in one-ton cylinders and inventory is measured by a weight scale. The chlorine gas is metered with the use of a chlorinator and injected into the effluent force main using a piping diffuser system. The feed of chlorine is controlled by the operation of the effluent wetwell pumps, which operates intermittently based on an automatic level control system. The flow meter, sampled, and chlorinated effluent is transported and discharged from the sixteen inch (16") force main at Outfall No. 001 into the Clinch River.

The oxidized biosolids which settle to the bottom of the secondary clarifiers are plowed and discharged via hydrostatic pressure to a solids wetwell. A high proportion of the biological solids from the clarifiers are returned to the oxidation ditch via centrifugal pumps to maintain a highly active concentration of biomass under aeration for carbonaceous oxidation (BOD_5 removal) and solids treatment (SS removal) of the influent wastewater. A portion of the oxidized and clarified solids from the wetwell are pumped as wasted solids to the two (2) aerobic digesters for further stabilization and processing. Scum and any floating solids in the clarifiers are manually skimmed, collected and discharged to the solids wet well and then pumped to the aerobic digesters for further processing and disposal.

The stabilized solids in the aerobic digesters are periodically thickened by turning off the aeration blowers and diffuser system in the tanks, which allows for gravimetric settling. The settled digested solids are pumped to the outside drying beds for gravity drainage and evaporative drying. The digester supernatant is returned to the on-site influent pump station. The drying bed solids are staged on a concrete storage pad and periodically hauled off-site by an outside contractor to the Roane County sanitary landfill.

Due to the poor drainage and dewatering performance of the outside drying beds, the City of Kingston was in the process during our plant inspections of obtaining land application permits for beneficial disposal and utilization of digested liquid biosolids. An engineering consultant from Knoxville had been retained by the City to prepare the permits and develop a liquid land application program (LAP). From our inspections of the existing facilities, it appeared that modifications to the aerobic digester piping and the addition of lime or alkaline stabilization facilities may be required at the Kingston WWTP to implement this disposal alternative and achieve compliance with 40 CFR Part 503 Regulations. Agricultural lime is often used by treatment plants to achieve the Part 503 stabilization criteria for pathogen and vector attraction reduction, as well as control the soil pH of the biosolids applied farm land. Other parameters would be required to be monitored and records kept on total and volatile solids content, heavy metals concentrations, fecal coliform density, and nutrients (NPK) levels of the stabilized liquid biosolids. Retention time, temperature, dissolved oxygen and pH operating controls would be required to demonstrate the aerobic digesters as a Process to Significantly Reduce Pathogens (PSRP) as required by 40 CFR Part 257 and 40 CFR Part 503.

NPDES Permit Requirements

The treated effluent from the Kingston WWTP is discharged from Outfall No. 001 at mile 0.28 of the Clinch River. The National Pollution Discharge Elimination System (NPDES) permit parameters for this facility were based on the assimilative capacity of the receiving stream and its ability to handle wastewater discharges. The stream classification for the Clinch River includes domestic and industrial water supply, fish and aquatic life, recreation, irrigation, livestock watering and wildlife uses. In-stream concentration criteria were used as the rationale for establishing final effluent standards for dissolved oxygen (DO) protection and total chlorine residual (TCR) limits at the design flow of 1.00 MGD. Kingston received a DRAFT copy in their NPDES permit (No. TN0061701), which was finalized and became effective August 31, 1992 with the following regulated parameters:

KINGSTON, TN WWTP
NPDES PERMIT REQUIREMENTS
TABLE 2

Permit Parameter	Effluent Limitation
Organic Matter (BOD_5)	30.0/45.0 mg/L (avg./max.)
Suspended Solids (SS)	30.0/45.0 mg/L (avg./max.)
Organics Removal (BOD_5)	40/85 % (min./avg.)
Solids Removal (SS)	40/85 % (min./avg.)
Settleable Solids (Set.S)	1.0 ml/L (maximum)
Dissolved Oxygen (DO)	1.0 mg/L (minimum)
pH	6.0 - 9.0 s.u. (min. and max.)
Fecal Coliform (FC)	200/1000 #/100 ml (avg./max.)
Total Chlorine Residual (TCR)	1.80 mg/L (maximum)

Monthly average limits for the above concentrations are based on a design flow of 1.00 MGD. The City of Kingston is exempt from submitting an industrial user surveys to the Division in accordance with 40 CFR Part 402.8 for the development of an Industrial Pretreatment Program (IPP) since NPDES permit is based upon domestic wastewater with no industrial waste discharges.

PERMIT COMPLIANCE ASSESSMENT

Presented in Table II-1, is a summary of the NPDES compliance performance for the sixteen (16) month period of January, 1994 through April, 1995 for the permit parameters and effluent limitations summarized in Table 2. As shown in this table and Figures II-5 through II-8, no NPDES permit compliance violations occurred for the conventional parameters of BOD_5, TSS and fecal coliform. Only one (1) permit violation occurred in December, 1994 with an effluent TCR concentration of 2.0 mg/L, which exceeded the NPDES limit of 1.8 mg/L. Additionally, a detailed review of the influent and effluent hydraulic loadings revealed a total of twelve (12) plant bypasses, which occurred over three (3) consecutive months between February and April, 1994. Eight (8) plant bypasses were recorded during a ten (10) day period in April, 1994 when a total of seven and half inches (7.5") of rainfall were experienced at the treatment plant. The average influent flow during this same period of time was 1.96 MGD, directly attributable to the severe I/I problems in the collection system.

Based upon the interview information we have obtained, the City of Kingston appears to have been directed in the past by TDEC to implement a corrective action plan for addressing the I/I problems. Such a regulatory agency directive would require a comprehensive program which implements methods towards reducing wastewater flows during wet weather conditions. Our discussions with Mr. Smith and Mr. McClure indicated that some rehabilitation and upgrade efforts have been made in the past two years in the sewer collection system, however, no active program or specific strategy appears to exist in the City of Kingston with the wastewater department to address their I/I problems.

Potential activities to be considered in an active I/I reduction program include frequent checking of manholes for inflows, leaks and needed repairs. Hydraulic cement is also often used to help correct leaky manholes. Other I/I monitoring and reduction strategies could include using the updated piping map to routinely walk and monitor sewer lines for settling or depressions in the ground, which could indicate damaged or broken sewer lines. More detailed line inspections in the collection system using smoke testing or performing camera work of various potential problem areas could reveal substantial leaks and key I/I point locations. Some efforts have been made by the Kingston wastewater collections system personnel to reduce I/I by performing point repairs and in-situ lining of old sewer lines. However, no concerted or extensive I/I reduction activities have been implemented since prior to the start-up of the wastewater treatment plant in 1988.

The City of Kingston should consider retaining an outside contractor or local engineering company to perform detailed field inspection work to prepare an updated evaluation of the existing collection piping and manhole system. This field information could then be used to develop a specific I/I reduction program and thereby prevent wastewater bypasses and/or hydraulic surges at the Kingston WWTP with the resultant benefits of less frequent plant bypasses and more reliable NPDES permit compliance, improved effluent quality, and increased reserve treatment capacity.

Despite the intermittent moderate and severe I/I problems at the WWTP, a reliable and continuous level of NPDES permit compliance was achieved for the effluent limits for BOD_5, SS, fecal coliform, total chlorine residual, and dissolved oxygen. This compliance information suggests that a high level of process control was maintained for the oxidation ditch, clarification and disinfection processes, despite intermittent high plant flows which directly reduced the hydraulic retention time (HRT) in these 'contact time' type of unit operations. Once again, the utilization of the swirl bypass device could be attributed to the protection of the biological treatment system.

During our review of the monthly operations and discharge monitoring reports (DMRs), we observed the routine reporting of inaccurate NPDES permit compliance results for effluent biochemical oxygen demand (BOD_5), suspended solids (SS) and settleable solids (Set. S). A comparison between the monthly operations reports and DMRs revealed an inconsistency in the reporting of effluent BOD_5 and SS concentrations (mg/L) for the monthly average (mo. avg.) and weekly average (wkly avg.) values. Inadvertently, the daily minimums were incorrectly substituted for the monthly averages, and the monthly averages were incorrectly substituted for the weekly averages.

However, the effluent loadings (lbs/dy) calculations for monthly and weekly averages for both BOD_5 and SS appear correctly reported use the proper flow and concentration data. As illustrated in Figures II-9 and II-10, the reporting of actual monthly average BOD_5 and SS concentrations on the DMR had no impact on the level of permit compliance, however, the accurate reporting of discharge data on the State forms is critical to achieving compliance with NPDES requirements.

Additionally, we observed the reporting in the DMRs of zero (0) for the level of Set. S (ml/L) in the effluent, which results in artificially or erroneously low effluent values being submitted to the State. It is possible that the analytical testing procedures, laboratory equipment, and reporting techniques used to monitor Set. S, may have prevented the Kingston WWTP staff from measuring a detectable level (ml/L). Using the standard testing procedures and laboratory equipment for this parameter, a non-measurable Set. S level can only be reported as low as the 'method detection limit' (MDL), which is 0.1 ml/L. Thus, effluent values which show no presence of settleable solids should not be reported on the DMRs as 0 ml/L, rather < 0.1 ml/L, which is recognized by the regulatory agencies as the analytically allowable minimum detection level of an effluent discharge for this NPDES permit parameter. Our review and evaluation of the laboratory testing procedures and/or reporting techniques of analytical data for this parameter will be further discussed in the Laboratory Assessment section of this report.

BACKGROUND ASSESSMENT

An assessment of the current level of hydraulic and organic/solids loadings to the Kingston WWTP was performed as a basis for evaluation of each unit operation for assessment of process control, identification of any performance limiting factors, and development of recommended and prioritized corrective actions. This background assessment was used as a reference point for the follow-up plant visits where areas of concerns in the WWTP could be examined and the feasibility of potential solutions considered during the follow-up visits.

Existing Hydraulic & Organic Loadings

The Kingston WWTP treated an average influent wastewater flow of 0.663 MGD as determined from a review of the monthly operational reports from January, 1994 through April, 1995. As summarized in Table 3, the maximum and peak influent monthly flows recorded over the same time period were 1.184 and 2.297 MGD, respectively. Based on the average daily influent hydraulic loading of 0.663 MGD, the Kingston WWTP is operating at approximately two-thirds (66 %) of the plant design capacity of 1.00 MGD. The average monthly maximum flow of 1.256 MGD is approximately sixty-three percent (63 %) of the maximum design flow of 2.00 MGD for this facility. The peak monthly flows have exceeded fifteen percent (15 %) of the maximum design flow and two hundred and thirty percent (230 %) of the daily average design flow. As previously discussed, these excessive hydraulic loadings to the WWTP have been a primary cause of concern of the existing treatment capacity to reliably achieve NPDES permit compliance and allow for the anticipated and desired future City residential, commercial, and industrial growth.

The organic (BOD_5) and solids (SS) loadings as documented by the operational reports from January, 1994 through April, 1995 are consistent with the high hydraulic loadings and therefore, indicates typical influent characteristics for municipal wastewater treatment plants experiencing moderate to severe I/I problems. Generally, BOD_5 and SS concentrations for raw domestic wastewater are in the range of 200 to 250 mg/L. A diluted wastewater from I/I impacts will often result in influent concentrations of BOD_5 and SS less than 150 mg/L. The average BOD concentration for the Kingston WWTP was approximately 185 mg/L and the average SS concentration was approximately 130 mg/L. These influent concentrations average seventy percent (70 %) of the typical strength of undiluted raw influent wastewater.

A detailed review of daily influent wastewater loadings confirmed the dilution of the raw strength following wet weather or storm events and during subsequent high influent plant flows. Influent concentrations of BOD_5 and SS often were measured below 100 mg/L, which can adversely impact a treatment plant's ability to comply with the required daily and monthly removal efficiencies for organics and solids in the NPDES permit. However, as previously noted in the Permit Compliance Assessment section of this report, NPDES permit compliance was continuously achieved for BOD_5 and SS removal efficiencies (both daily minimum of 40 % and monthly average of 85 %) at the Kingston WWTP.

A monthly analysis from January, 1994 through April, 1995 for influent wastewater loadings (lbs/dy) revealed that the Kingston WWTP is operating well below the design loadings. As shown in Table 3, the design loadings for both BOD5 and SS are 1,668 lbs/dy and only one (1) month of operation in March, 1994 exceeded this design capacity criteria. The following graphical illustrations (page 15) shows the current level of loadings for the three (3) influent parameters for the Kingston WWTP (flow, BOD_5 and SS) which directly relate to design and constructed capacity. As shown, the aggregate available capacity for these conventional treatment parameters for the existing liquid unit operations is approximately forty-seven percent (47 %). The performance limiting factor as shown in the bar graph is flow capacity, with an average utilization rate of sixty-seven percent (67 %).

The key liquid process units which define the constructed level of capacity at the Kingston WWTP are the biological treatment performance of the oxidation ditch and the solids separation performance of the two (2) secondary clarifiers. The performance and treatment capacity of the oxidation ditch are primarily influenced by organics loading (lbs BOD_5/kcf and F/M) and secondarily by flow (HRT). The performance and solids separation capacity of the secondary clarifiers are primarily influenced by solids loading (lb/dy/ft^2 and DOB) and secondarily by flow (gpd/ft^2 and HRT). A comparison of actual levels as compared to design values for these key capacity parameters can be found in Table 4. As shown therein, these two unit operations have been processing wastewater at approximately fifty-three percent (53 %) of their design levels for the raw influent BOD_5 and SS loadings experienced at the Kingston WWTP for the past sixteen (16) months.

This loadings data suggests that almost a doubling of influent wastewater loadings for organics and solids could occur for the existing liquid treatment facilities without risking compliance with NPDES permit limits, if design hydraulic retention times (HRT) and proper biological solids inventory (oxidation MLSS and clarifier DOB) are achieved and maintained on a consistent, reliable, and continuous basis.

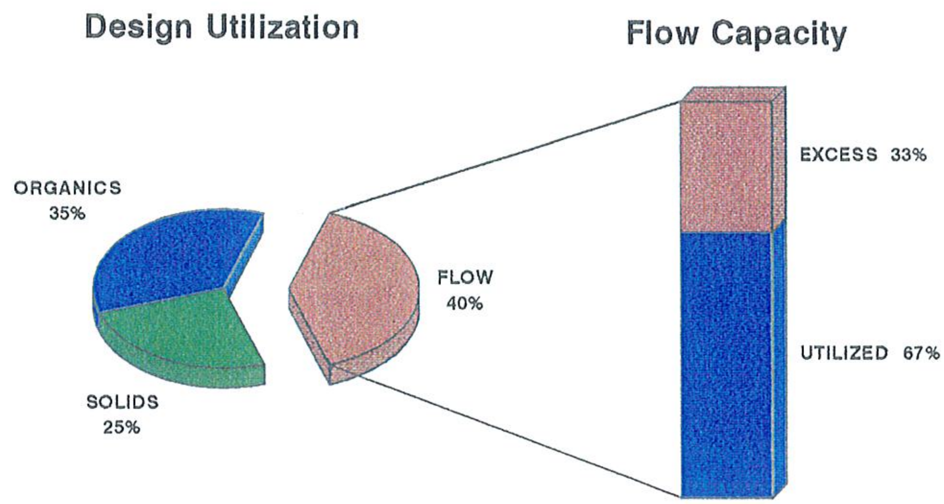
As will be discussed in the section of this report on Liquid Unit Process Assessment, improvements in the aeration system for the oxidation ditch and management practices for biosolids processing and disposal facilities could increase the utilization of available treatment capacity of existing tank structures, and thereby minimize the need for additional capital costs to expand the liquid unit operations at the treatment plant to accommodate increased growth in the community. Based upon the available information we have obtained for the Kingston WWTP, increasing the flow capacity to 2.00 MGD as originally considered in the design and construction layout of the existing treatment facilities and shown graphically on page 15 may become necessary in the future to handle anticipated increased growth and wastewater flows in the City of Kingston. However, the time frame for this necessary plant expansion can be substantially deferred if reduction in I/I were achieved and improvements in the aeration capacity of the existing oxidation ditch were implemented.

The unit process performance summarized in Table 4 for the Kingston WWTP shows the basic operational parameters which were recorded on the monthly Report of Operation of Wastewater Treatment Plant submitted to TDEC. Table 4 reports the recorded operational performance data for the various unit processes and control parameters, averaged from January, 1994 through April, 1995 and compares the actual values to the design criteria of the Kingston WWTP. Actual values which vary significantly from the design criteria are highlighted as potential operational problems and permit non-compliance risk areas.

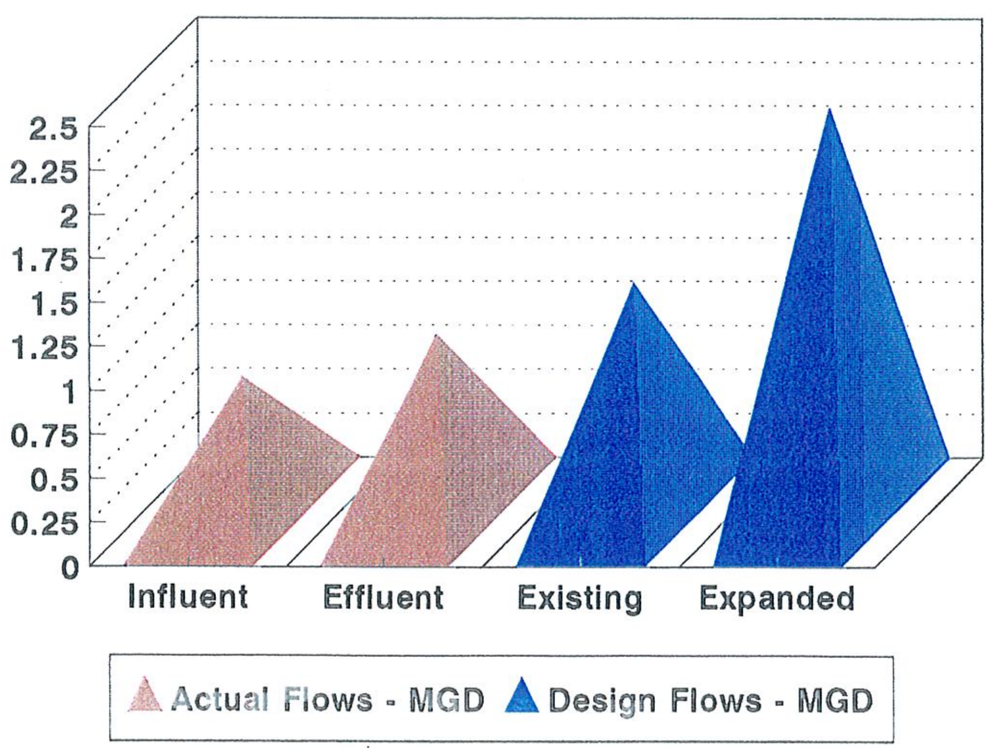
KINGSTON, TN WWTP
INFLUENT WASTEWATER LOADINGS
TABLE 3

MONTH	MAX. FLOW MGD	AVG. FLOW MGD	BOD_5 LBS/DY	SS LBS/DY
Jan '94	1.040	0.519	732	762
Feb '94	1.875	1.051	1,508	1,052
Mar '94	2.297	1.133	1,521	926
Apr '94	2.185	1.184	1,708	1,126
May '94	0.851	0.514	1,192	553
Jun '94	0.951	0.546	865	656
Jul '94	0.946	0.583	901	698
Aug '94	0.720	0.538	817	785
Sep '94	0.580	0.459	743	555
Oct '94	0.598	0.455	755	539
Nov '94	1.139	0.462	705	601
Dec '94	1.000	0.553	862	604
Jan '95	1.700	0.813	1,363	807
Feb '95	1.510	0.661	1,058	755
Mar '95	1.850	0.677	1,050	757
Apr '95	0.862	0.463	772	517
Average	**1.256**	**0.663**	**1,035**	**730**
Maximum	**2.297**	**1.184**	**1,708**	**1,126**
Design	**2.000**	**1.000**	**1,668**	**1,668**
Capacity	**62.8 %**	**66.3 %**	**62.0 %**	**43.8 %**

KINGSTON, TN WWTP
TREATMENT PLANT CAPACITY



KINGSTON,TN WWTP
PLANT FLOW CAPACITY



KINGSTON, TN WWTP
UNIT PROCESS PERFORMANCE SUMMARY
TABLE 4

PROCESS	PARAMETER	UNITS	DESIGN	ACTUAL
Treatment	Bypasses	hrs.	0	131
Influent	pH	s.u.	7.0	6.7
Degritting	HRT	minutes	13	20
Oxidation	HRT	hours	18.0	29.0
Oxidation	F/M	$days^{-1}$	0.09	0.04
Oxidation	OLR	lb/dy/kcf	15.6	9.7
Oxidation	MLSS	mg/L	3,000	4,155
Oxidation	**30M-Settl.**	**ml/L**	**300**	**727**
Oxidation	**SVI**	**ml/g**	**100**	**175**
Oxidation	**DO**	**mg/L**	**>2.0**	**1.1**
Oxidation	**pH**	**mg/L**	**7.2**	**7.3**
Clarifier	HLR	gpd/ft^2	490	325
Clarifier	SLR	$lb/dy/ft^2$	12.3	11.3
Clarifier	**DOB**	**inches**	**18**	**72**
Chlorination	HRT	minutes	75	113
Chlorination	Dosage	lb/MG	18	18
Digester	DO	mg/L	>2.0	1.9
Digester	pH	s.u.	7.3	7.2
Digester	SRT	days	15	146
Disposal	**Solids**	**DT/yr**	**75**	**?**

COLLECTIONS SYSTEM ASSESSMENT

This portion of the Kingston Assessment Report was substantially provided by Mr. Clure Winfree, Director of Collection and Distribution Systems for PSG. In general, Clure's evaluation and recommendations for the Kingston wastewater collection system and lift stations are not unlike most other communities around the country who experience problems related to excessive wastewater flows from storm events and sustained rainfall and attempt to identify sources of infiltration/inflow (I/I) and correct located problems with tight budget contraints and limited resources. However, our detailed inspection of the Kingston wastewater collections system and lift stations on the third plant visit revealed several areas in which O&M problems occur with recommendations provided herein to identify, control and reduce I/I sources using the existing sewer department staff.

BACKGROUND

Figure I-1 in Appendix A shows the current Kingston sewer system and distinguishes between sewer lines and force mains and locates the lift stations and treatment plant within the City of Kingston. This drawing also shows those areas annexed within the City limits which are presently using septic systems as well as those areas which are planned to receive sewer service within the next year. This drawing was completed by the University of Tennessee (UT) School of Planning of Knoxville, TN in early 1995. It shows three large residential areas which are planned for sewer service within the next year, as well as four other areas which currently use septic systems. The drawing also shows a large unsewered area northeast of Interstate 40 which was annexed by the City for development as a commerical and light industrial area.

This recent sewer system drawing indicates desired and active growth in the City of Kingston and associated increased flows in the collection system, lift stations, and wastewater treatment plant. Additionally, the City of Kingston is in a strong position for growth as the Knoxville metropolitan area moves west. Thus, to position the community to respond to the existing and future levels of growth, the sewer system and treatment plant must be adequately sized and properly operated and maintained to handle the increased flows and wastewater loadings. This community growth positioning will require specific short term (1-2 years) and long term (3-5 years) financial planning and commitment towards upgrading the existing collection system, maintaining the existing lift stations, and expanding the wastewater treatment plant flow capacity.

It will strongly be in City's financial interest to actively respond and address their existing concern of the I/I problems to reduce flows in the existing collection system and treatment plant as a short term goal to prepare for the increased sewer sections within the next year. Long term planning and financial budgeting towards replacing the remaining septic systems with sewer system and connecting the newly annexed section along Interstate 40 to attract commercial and industrial customers will require continued upgrades to the collection system and serious consideration of expansion of the treatment plant from 1.00 MGD to 2.00 MGD.

The accomplishment of both short term and long term upgrades of the collection system and expansion of the treatment plant to proactively support existing and future growth may require the near term raising of additional capital funds via increased sewer rates of existing customers until such time that the new customers can provide the necessary additional revenues to support the Kingston wastewater system. Insufficient funding will inhibit critical maintenance of the existing wastewater infrastructure and also prevent necessary upgrades and reduction in current I/I problems, which all may eventually result in severe growth limitations or even a moratorium from the State for new residential, commercial, or industrial sewer customers.

ASSESSMENT

Collection System

The geology of the Kingston area results in gravity sewer lines being located in valleys which generally flow in descending elevation towards the Tennessee and Clinch Rivers. Domestic flow is then picked up by lift stations and transported under pumped pressure across ridge lines for gravity flow to the treatment plant. The Kingston collection system is comprised of primarily clay sewer lines with newer construction of plastic eight inch (8") connection lines made of Polyvinyl Chloride (PVC).

A power rodder is the sole means for responding to emergency stoppages and no preventative cleaning is performed for the sewer lines. I/I of storm water adversely affect the wastewater collection system and result in sudden increases in flow at the treatment plant and subsequent bypass around the biological treatment system for influent flows greater than 700 gpm (1.01 MGD). Similarly during this sustained wet weather or sudden rainfall events, the raw wastewater and stormwater in the collection system can back-up and result in manhole surcharging or overflows. Overflows in the system can occur from inadequate line capacity or partial blockage from lack of preventative cleaning. These type of problems can result in NPDES permit violations and subsequent enforcement actions from TDEC and/or EPA.

Our observations of the collection system and lift stations do not indicate any current or recent problems with diluted sewage/stormwater surcharges or overflows in the City of Kingston. However, the processing of one hundred percent (100 %) of the wastewater and I/I flow at the treatment plant becomes major a technical problem of capacity and protection of effluent quality.

Additionally, it is in the City's financial interest to be concerned about I/I, since extraneous stormwater, ground water, or surface water enters the collection system at numerous sources and potentially large infiltration locations, which becomes inflow that must be pumped and treated. This results in increases in electrical costs, pump and equipment maintenance, interferes in treatment and utilizes valuable existing hydraulic capacity at the treatment plant. Inflow type sources are generally the easier type of extraneous water source to locate and correct. They should be located as soon as practical to prevent any future surcharge, overflow, or plant bypasses.

EPA and TDEC are becoming increasingly aware of the overburden of municipal sewer systems from excessive I/I as further problems become apparent from existing and worn out facilities being strained by deteriorating infrastructure, community growth and resultant system expansions. They have increased their investigations and enforcement actions for I/I related problems. Thus, it is in the City's best interest both technically and financially to immediately begin reducing current flows attributable to I/I in the collection system to maximize existing treatment capacity and at the same time, plan and budget for future and necessary capital improvements in the system and expansion of the treatment plant.

Lift Stations

As shown in Figure I-1 of Appendix A, the Kingston wastewater collection system includes seven (7) lift stations to convey the wastewater to the treatment plant. Pump stations No. 2 through 5 feed into the large lift station No. 1, where the raw wastewater is delivered to the treatment plant via a sixteen inch (16") force main. The treatment plant staff are responsible within the Kingston wastewater department to operate and maintain the lift stations. These lift stations are generally assigned to one plant operator to be inspected daily during the week days and also inspected daily by other weekend operators or the Wastewater Treatment Supervisor.

No monthly O&M log forms were being kept for the lift stations to document facility number and location information, equipment check-list, pump run times and operation, maintenance problems, housekeeping and cleaning activities, etc. Some of the lift stations contained hand written sheets, which simply listed the date, time, and operator's initials who performed the daily inspection. An individual log form should be developed and used for each pump station with daily information recorded at each location in ink pen and collected on a monthly basis for records keeping at the treatment plant. In addition, a weekly log form should be developed and used by the plant operator during their daily inspections to record summary information concerning the performance of the lift stations. This log form should be located at the treatment plant for available review and evaluation by the Wastewater Treatment Supervisor and coordinated with other Kingston sewer department staff.

All of the existing lift stations were visited to assess the pumping capabilities of the system, as well as evaluate these facilities for flow capacity, permit compliance, reliability, maintenance, and safety. In general, all lift stations were in fair operational condition, however the overall level of housekeeping and facility maintenance is lacking and may be adversely affecting system performance. We did not find or observe any written procedures for lift station operation or maintenance (preventative and/or corrective), as well as no safety procedures or emergency response plan in place. Many of the lift stations contain confined spaces (dry and/or wet wells), which require personnel entry, without the use of critical safety equipment.

Financing alternatives should also be developed with this technical plan to support the system as it expands and grows in a fair and cost effective manner. A well defined written plan which contains guidelines and detailed specifications will help developers plan and anticipate costs and contractors to adhere to regulations and control costs. City of Kingston can only benefit from this approach during increased growth, if a fair and proactive budgeting process by City officials is in place to allow for a partnership with developers and customers for the extensions or increased capacity of the system. Sporadic planning and development, coupled with no financial resources, may seriously inhibit desired community growth and at the same time, further deteriorate the existing wastewater infrastructure. The City of Kingston benefits from budgeting annually for anticipated growth and expansions and by having rules and guidelines which promote public support as well as developer and future customer partnership.

Infiltration/Inflow

Our assessment of the Kingston collection system and treatment plant flows suggests that many things can be accomplished with the existing wastewater department staff to reduce current levels of infiltration and inflow (I/I). Initially, a focused and concerted commitment to personnel and financial resources must be made to both locate the sources I/I and then correct the found problems. A monthly budget process and funds acquisition mechanism must be in place to identify and successfully address I/I problems, which result in reduction in flows and wastewater collection/treatment system savings.

The first step in addressing I/I problems is making an effort with City wastewater department personnel to review past records on the collection system with an objective to benchmark problem areas and corrective actions previously performed. If an I/I study has been performed in the past five or ten years for the Kingston sewer system, the review of the report of identified problems may be an ideal starting point. The second step in addressing existing I/I concerns is the development of a plan which isolates the existing sewer system into areas or regions. Each area or region should be mapped for potential sources of I/I, i.e. old trunk lines, nearby streams or bodies of water, manholes, topography, etc. and then systematically examined to identify any obvious problems, i.e. broken lines, leaky manholes, surface water flooding, etc.

At least two times per year, wastewater personnel should physically walk the sewer lines adjacent to nearby creeks and other waterways. It is generally best to walk the lines after frost in the fall and before plants leaf out in the spring. Main interceptor lines can often be large sources of I/I as a result of their location in low depression areas where water drains and pools. These lines may not have many residential and commercial connections, however, they are often some of the oldest lines in the system and can contribute to large amounts of I/I.

An emphasis of system monitoring and inspection should be placed on segments of sewer lines which cross under creeks or other water ways. A key monitoring parameter for these lines is the measurement of temperature of the wastewater both upstream and downstream of the segment.

A noticeable difference between the upstream and downstream monitoring locations will indicate stream water is entering the sewer pipe and a significant I/I problem exists. When an area is suspected of having I/I, temporarily plug the upstream manhole and then visually assess reduced flow in the line as well as monitoring for temperature differential. Also observe if I/I water discharges down stream of the plugged manhole and proceed with this technique until the location is isolated. The exact location for making the point-source repairs to correct the I/I water may require televising the line.

In the summer months, dye testing of the sewer lines for locating I/I sources can also be effective in locating and prioritizing repairs. Depressions, holes, and pooled water with the addition of dye can be used to locate if the dyed water enters the sewer system. Smoke testing the lines is another technique used generally in the warm weather months to help identify inflow sources. Smoke testing equipment is fairly expensive and a well defined plan is always needed before commencing with such activities. Sensitive public areas, i.e. schools and hospitals should always be kept informed as to any scheduled smoke testing and documentation should be made on investigated areas and associated repairs. Smoke testing is particularly useful in locating direct inflow sources, such as drains and roof leaders. Private property inflow from these devices can also contribute to large amounts of flow in a wastewater collection system.

Public education of I/I problems and enforcement of well defined regulations for connections to the sewer system can offer relieve serious overflow and inflow problems with the collection system. Usually digging and isolating point-source repairs is required, however, other more cost effective methods may apply in line locations or problems at major street intersections. If roadway inlets and/or storm catch basins and drains are found connected to the sanitary sewer system, an alternate plan may have to be formulated to reroute and dispose of the drainage and collected water.

Attention should be given to any holes, depressions, or erosion which could indicate undermining problems with sewer lines or other defects in the piping. A thorough inspection of missing manhole lids, damaged manholes, and poor seating of rims and covers should be made to ensure inflow of surface water is prevented. Overflow connections should be identified and inspected to ensure water does not back up into the sewer system. Mark the location of manholes using color plastic tape which is tied to nearby trees, stakes, or shrubbery limbs. This type of marking will make locating manholes during future monitoring much easier and efficient. Manhole covers should be reseated with rubber sealing rings which is a very low cost approach during the period of inspection. Pick or vent holes should be plugged as necessary to stop inflow sources or the inside of manholes covers retrofitted with rain stopper inserts. Preventative measures and markings should be pictured and logs maintained for future reference. Old brick manholes should be replastered and leaks fixed with hydraulic cement type patching mixtures. More extensive manhole repairs should be scheduled and addressed on a prioritized and I/I impact basis.

Lift Stations

The type of problems found in the lift stations show a lack of care and routine attention. The infrequent or inadequate cleaning of barscreens for the proper removal and disposal of rags, grease and debris has resulted in surcharged collection lines. This mode of operation will result in debris being deposited in the lines over time and reduce the wastewater transmission capacity. Its accumulation can result in overflows or stoppages, and potential flooding of homes or businesses. Overflows and/or surcharges should always be prevented to protect from raw and untreated wastes being uncontrollably discharged into the environment, which is a violation of the Clean Water Act under the NPDES program. Since the City of Kingston does not have a hydraulic cleaner, this accumulated debris can be difficult to flush from the collection system after a stoppage. Thus, it is very important that all bar screens at the lift stations be maintained on a frequent (two or three times per week) basis to minimize any surcharging and maximize existing system capacity.

The use of enzymatic bacteria and degreasers to handle problems at the lift stations must be properly added and stored. The addition of bacteria should be added upstream of the lift stations or section of collection system to ensure adequate contact and detention time. The excessive addition or storage of bacteria in the lift stations can result in undesirable colonies of bacteria growing in the wet and moist areas of the facilities and pipes.

General housekeeping problems at all of the lift stations have resulted in unsafe and hazardous work conditions for the wastewater personnel. The excessive equipment, debris, and grease observed on the floors of the lift stations represent trip and slipping hazards. These unsafe work conditions can result in loss work time due to employees being injured from an unnecessary slip or fall, which would adversely impact the level of personnel to properly operate and maintain the system. Public perception and community relations with nearby residents or guests to the City of Kingston will improve if the inside and outside areas around the lift stations are clean, organized and maintained.

A clean and safe work environment, even if it is a wastewater lift station will present a more positive image for the City of Kingston and also promote worker pride and productivity. An employee will tend to be more sensitive and motivated to properly operate and maintain a facility, if the work environment to perform these necessary services appears clean, orderly, and safe. The ability for management to assess the operability of the lift stations and performance of the staff will also be more readily apparent and accurately accomplished, because problems and deficiencies will be more noticeable.

Electrical panels and/or wiring junction boxes which were observed at several lift stations to be open should always remain closed to prevent injury from electrical shock or spark fires. Closed panel doors will also reduce the level of dirt, dust, moisture and corrosion of electrical wires and components. Moisture in wiring increases resistance which can also damage motor windings and blow electrical fuses. We observed many pieces of equipment which were turned off for repairs, but were not properly tagged for identification and locked-out at the energy source.

Accordingly, an electrical lock-out/tag-out system should be immediately put into place to prevent severe injury to an employee from the inadvertent starting of a motor or energizing of an electrical circuit. A development and implementation of a standard set of procedures for the tagging and locking of electrical equipment both at the lift stations and the treatment plant is critical important.

As indicated in each lift station assessment, we recommend as a high priority that run time meters be installed for each wastewater pump for the following beneficial reasons:

- o Provides method to document and monitor pump use and periods of operation.
- o Assures that the motor alternator for the lift station is performing correctly.
- o Points to problems with check valves.
- o Provides an estimate of flow through the pumps when used with discharge data.
- o Indicates system areas which may be subject to adverse impacts from I/I problems.
- o Allows for scheduling of preventative maintenance based upon usage and operation.

Other general recommendations for improving the functionality and performance of the list stations include the development and use of check lists for equipment operation, safety, housekeeping, and maintenance repair activities. Log forms should be developed and maintained at each lift station and a summary log form of all lift stations located at the wastewater treatment plant. This documentation approach is standard for monitoring and reporting on the performance of the raw wastewater pumping system, when wastewater treatment plant staff are directly responsible for these off-site and often remote facilities. These log forms will also elevate the level of attention, care, supervision, and accountability for proper operation, adequate maintenance, personnel safety, and facility housekeeping. They also provide a consolidated history of the O&M performance of these facilities to support recommendations to City officials for funding or capacity adjustments of the collection system and/or treatment plant.

The location of any air/vacuum relief valves should be determined to ensure efficient operation of the lift stations to convey wastewater in the force mains. Additionally, the present daily schedule for visiting the lift stations could be significantly reduced if telemetry equipment were installed with an alarm and annunciation panel located at the treatment plant for automated monitoring and supervision of the pumping system.

LIQUID UNIT PROCESS ASSESSMENT

On-Site Pump Station

Domestic and process wastewater produced at the Kingston WWTP is discharged into an on-site pump station. A six inch (6") line from the Laboratory/Office Building provides the source of domestic wastewater to the pump station. Six inch (6") drain lines from the aerobic digesters and sludge drying beds combine into an eight inch (8") line and discharge the process wastewater into the on-site pump station. The pumped flow is conveyed through a six inch (6") force main and discharged back to the headworks of the treatment plant. The actual discharge is located after the barscreen and before the aerated grit chamber, which is upstream from the influent flow meter and sampler. The on-site pump station is a below ground facility, which contains both a dry well and wet well to return plant process streams and sanitary wastes for biological treatment.

This below grade depth of this facility represents a permitted confined space location, however, no safety signs or equipment were apparent for this pump station. A red beacon light for the dry well was observed to be non-functional and the treatment plant staff were unsure as to the purpose of this alarm, i.e. wet well level or gas levels. The presence of toxic gases in the dry well from the wet well is a serious safety concern and confined space entry procedures with proper personnel protective equipment (PPE) should be used before entering this on-site pump station. The requirement for entry appears to be infrequent due to the intermittent flow and low pumping operation of this on-site station, however, its access must be approached with a high degree of care and concern of personnel safety.

Influent Swirl Device

The raw wastewater from Lift Station No. 1 is pumped to the Kingston WWTP in a sixteen inch (16") ductile iron pipe (DIP) force main. A twelve inch (12") gravity sewer line also combines at a manhole with the pumped flow and the total raw wastewater flow is discharged through a twenty-four inch (24") pipe to the influent swirl device. No sampling or addition of odor control chemicals are performed at the control manhole. All raw wastewater enters the Kingston WWTP through the swirl device, which is a 13.5 feet diameter tank with curving channels and a radial overflow weir. The swirl device is a concrete circular tank with channels and contains no mechanical parts for operation and maintenance. As the influent flow is discharged into this device, the tangential entrance and circular channels cause a swirling motion to enhance settling of solids to the bottom of the tank for downstream treatment and a somewhat clarified wastewater to overflow during high flow periods.

The purpose of the swirl device is to limit the flow to the biological portion of the treatment plant to not exceed 700 gpm or 1.01 MGD. The constructed elevation of the radial overflow weir discharges all flow up to 700 gpm through a twelve inch (12") gate valve and into the headworks of the treatment plant. The overflow weir is located at an approximate radius of 3.75 feet and proper gate valve operation will limit the influent flow to the plant design capacity of 1.00 MGD. This gate valve can be throttled to control the flow above or below 700 gpm using the influent flow meter as the monitoring device for adjusting the valve to desired settings of wastewater to the biological treatment system. Influent flow which exceeds the weir elevation then overflows and is transported through a twelve inch (12") PVC sewer line and discharged into the effluent wet well of the treatment plant. The constructed elevation of the top of the swirl device can handle the peak design flow of 1,400 gpm or 2.00 MGD before an overflow and/or control manhole surcharging problems would exist at the treatment plant.

A review of the influent flow meter records shows plant flows which exceeded 1.00 MGD. As shown in Table 1, Table 3, and Figures II-2, the operation of the gate valve has been in a more open position than design to allow more flow to be treated in the plant than 1.00 MGD. This operating technique also appears to have reduced the frequency and degree of wastewater bypasses around the biological treatment portion of the plant. No plant bypasses have been reported since May, 1994 even though influent maximum plant flows during the months of November, 1994 through March, 1995 exceeded 1.00 MGD.

This flow management practice should be maintained to minimize the degree and frequency of plant bypasses. The maximum amount of flow during both dry and wet weather periods of operation should continue to be directed through the treatment plant, since excess flow capacity (approximately 33%) for average and maximum flow conditions exists. The excellent NPDES compliance performance over the past sixteen (16) months strongly suggests that the direction of one-hundred (100%) of the influent flow through the treatment plant, even when flows exceeded 1.00 MGD, was a very favorable operating plan and illustrates good judgement and process control performance by the treatment plant staff.

The discontinued use of the overflow weir of the swirl device was further supported by our observations of old and dried plastics and paper hung-up on the bypass system. These undesireable materials should be manually removed and the overflow weir system thoroughly cleaned with a disinfectant solution (CCH) to prevent the attraction of vectors, production of odors, and improve the visual appearance of this portion of the treatment plant. The insides of the swirl device should continue to be sprayed down routinely with water to minimize the observed level of raw septic odors (hydrogen sulfide and amines) and maintain proper levels of process facility housekeeping. Given the raw nature of the influent wastewater, this process should be sprayed down daily and operational channels, weirs, and gate valve brushed with CCH solution for disinfection and odor control purposes at a frequency of at least once per week.

We observed the spray water hoses near the swirl device were hazardly strewn on the access stairs and walkway. This facility maintenance equipment should be neatly coiled on the ground adjacent to the swirl device and water hydrant. This uncoiled hosing in the personnel walkways and stairs presents a trip hazard and unsafe work condition. It also prevents from the proper grounds keeping (grass mowing and weed clipping) and other facility maintenance in the affected areas as a result of the loosely strewn and uncoiled hosing.

Potable water is used at the Kingston WWTP for process flushing, tank washing, and facilities cleaning at an average monthly consumption of approximately 845,000 gallons. The Kingston water treatment plant production demand and costs of 28,000 gpd to service the wastewater treatment plant could be eliminated, if flushing and wash water were converted from potable to non-potable water source. Many treatment plants use chlorinated effluent (process water chlorinated - PWC) as the source of non-potable water for the purposes of cleaning and washing. We recommend that this conversion at a minimum, be incorporated at the time of any future treatment plant expansion as a potentially significant costs savings strategy over the existing practice. The technical feasibility and cost savings of using PWC instead of drinking water using interim piping modifications should also be considered, even though the source of effluent from the wet well is upstream of chlorine addition.

Headworks

The headworks of the Kingston WWTP provides preliminary treatment, which consists of a mechanical barscreen, aerated grit and grease removal chamber, grit dewatering screen, and screenings/grit storage. The raw wastewater from the swirl device is discharged through an twelve inch (12") line to the preliminary treatment system. Initially, the raw wastewater flows through a mechanical bar screen which has a flow capacity of 1,400 gpm (2.00 MGD). This single bar screen has a channel width of twenty-four inches (24") and uses a vertically inclined rail, bar and chain mechanism driven by a 1.5 hp motor to convey screenings to an adjacent dumpster. An outside contractor (BFI) is used by the City of Kingston to haul screenings, grit, and other waste materials from the dumpster to the local sanitary landfill in Roane County.

Large influent debris and solid particles are manually raked and removed from the often broken down mechanical bar screen and incline conveyor. The removal of these materials is critical in preventing plugging of downstream piping, protect from damage of process equipment, and control visual esthetics of liquid surfaces in process tanks. The desired operation of the mechanical bar screen is an automatic mode based upon run timers. However, the mechanical reliability of this bar screen has been a constant problem for many years and was again mentioned in the most recent (January, 1995) TDEC Compliance Evaluation Inspection report.

The treatment plant staff indicated during our plant inspections that this bar screen is broken down an average of at least six times per year. Motors have been replaced and an improved grease fitting was installed to correct this historical problem. However, continued mechanical failures with the inclined bar and chain mechanisms have resulted in the bar screen being non-functional. At the time of our plant inspections, the bar screen had not been in service for several months. The manual removal of debris and undesireable materials from the raw wastewater stream was readily apparent by their appearance on the liquid surfaces in the oxidation ditch and secondary clarifiers. The proper frequency and automatic operation of the mechanical bar screen should reduce and even prevent these undesirable materials from entering downstream process tanks.

Accordingly, we strongly support TDEC's recommendation that the City should investigate another method of screening the influent. Beyond an investigation, decisive action should be taken to fund and install a retrofitted or new screening device to protect the downstream treatment facilities. In accordance with TDEC's directive and at the time of our plant inspections, Mr. Gene McClure had solicited an outside contractor to inspect the existing equipment and submit a corrective action proposal. The resolution of this historical and current problem should be made a high priority as a critical corrective maintenance or capital repair, dependent upon the level of necessary expenditures.

On the interim, the treatment plant staff should increase the level of frequency of manual removal of plastics and debris trapped on the bars to reduce the pass-through of these materials to downstream tanks. Additionally, any screenings which passed through should be manually skimmed and removed from the surface of the oxidation ditch and/or secondary clarifiers to improve upon the observed level of process control and effluent quality appearance for the liquid unit operations. The grit eductor and screen system is manually operated daily for 2 or 3 hours.

The screened wastewater flows through the twenty-four inch (24") wide channels to an aerated grit and grease removal. The rectangular grit chamber contains an air diffuser system, grit eductors, and dewatering screen. The depth of 11.25 feet in the aerated grit removal chamber allows for the settling of inert material to the bottom of the tank, which is then educted through a dewatering screen and discharged into the screenings dumpster for ultimate landfill disposal. The grit chamber is sized for the maximum twenty-four (24) hour rainwater flow of 1,400 gpm (2.00 MGD) at a minimum hydraulic retention time (HRT) of approximately 6.5 minutes. This resulted in a required surface area in the degritting tank of 108 ft^2. At the design average flow capacity of 1.00 MGD, the average degritting detention time would be thirteen (13) minutes, with an actual detention time of twenty (20) minutes as shown in Table 4. The diffused aeration system ensures that organic matter and colloidal solids remain in suspension and introduces dissolved oxygen (DO) in the raw wastewater to prevent septicity for odor mitigation.

The diffused air is supplied by one (1) of two (2) Hoffman blowers which are powered by 7.5 hp motors. During our plant visits, we observed Blower No. 5 in service, with Blower No. 4 out of service in a stand-by status. The wastewater treatment staff indicated that the operation of these blowers were rotated on a weekly basis to equalize their run times with preventative maintenance service performed at the first of every third month. The air flow from Blower No. 5 was approximately 80 cfm, which appears to provide an adequate air supply of 1.3 ft^3/hr per ft^3 of degritted volume. No run time meters or maintenance logs were apparent for these two blowers.

Influent Flow Monitoring & Sampling

The degritted wastewater flows under a weir and overflows into an unaerated influent channel, prior to flow monitoring and sampling. The preliminary treated wastewater and process recycle stream are metered using a parshall flume, equipped with an ultrasonic type level sensor, which measures and totalizes these combined flow. The low volume and intermittent flow of unscreened in-house sanitary wastes and biosolids process waste liquids from the on-site pump station are discharged in the open channel between the barscreen and grit chamber. This side stream flow should be discharged downstream of the influent flow meter and sampler so that measurement and sampling of the raw loadings to the treatment plant from the collection system are not biased. This representative sampling procedure for influent monitoring of BOD_5 and SS, before mixing with returned wastewater is required by Kingston's NPDES permit (Part I, Section B).

However, due to the apparently very low and intermittent flow from this side stream, its discharge location does not adversely impact or bias the overall reported influent flow and loadings to the Kingston WWTP. The benefit of the existing discharge location is the measurement of the total flow and loadings to the biological treatment system, which is obviously, the most important unit process from a treatment capacity concern at the Kingston WWTP. Thus, a TDEC approved variance for this NPDES permit influent monitoring issue could be pursued as one alternative to resolve this concern, before it becomes a non-compliance issue or enforcement liability for the City of Kingston. Another in-house alternative could be to relocate the automatic sampler upstream of the point of discharge of the returned wastewater. The intended use of the existing downstream flow meter to pace the automatic composite sampler should satisfy the NPDES permit requirements for representative sampling and influent monitoring.

The nine inch (9") parshall flume measures the combined flow to the biological treatment system and its design capacity at peak flows is 2.00 MGD. A second identical and adjacent parshall flume has already been installed in the influent channel system in anticipation by the design engineer of doubling the plant flow capacity in a future expansion of a parallel biological system. The Milltronics sensor (Model No. ST-25C) appeared to be functional and in proper working order during our plant visits. This Milltronics flow meter (Model No. OCM III) appeared relatively new, with outputs of instantaneous flow (gpm) and totalizer (gpd).

The flow signal from this meter was not connected or pacing the influent automatic sampler to provide a flow-proportioned composite sample as required by the NPDES Permit. We did not observe any plant records which documented the frequency of calibration and maintenance for the flow meter sensor and corresponding control signals. Continuous and accurate flow measurement and flow-paced sampling are crucial to achieving NPDES permit compliance with self-monitoring requirements (Part I, Section B), accurate determination of organic and solids loadings to the WWTP, and determination of hydraulic retention times (HRTs) and treatment capacities of various unit operations. The treatment plant staff indicated that the influent flow metering instrumentation needed to be calibrated, using the outside contractor, MDM Services, Inc. Flow instrumentation should be calibrated at least semi-annually.

The influent automatic sampler is an American Sigma (Model No. 704) unit which is capable of providing a composite sample on a flow-proportioned or timer controlled basis. In accordance with Kingston WWTP's NPDES permit, this sampler should be operating on a composite basis three times per week (3/wk) and analyzed for BOD_5 and SS. The permit (Part I, Section C) requires that a 'composite sample' is a sample collected continuously over a period of twenty-four (24) hours at a rate proportional to the influent flow. We have determined that the automatic sampler is neither programmed on a 24-hr or flow-proportioned basis. This sampler, located in the corner of the Grit Blower Building obtains its samples from the influent channel near the parshall flume. It is programmed on a timed basis (approximately every 5 minutes) over an average sixteen (16) hour period from late afternoon (3:00 p.m.) to early morning (7:00 a.m.). This does not comply with the NPDES permit for obtaining a representative and composite sample, since this sampler schedule is only obtaining samples during low flow periods each day.

The collected sample is stored in a non-temperature monitored refrigerator. Our observation of this piece of equipment was that it was very old, dirty, and may need to be replaced. The temperature of the apparent non-functional refrigerated sample was near the ambient building temperature of approximately 22 deg. C, which is well beyond the desired and proper storage temperature of 4 deg. C. However, the composite influent sample is collected in accordance with the NPDES permit, three times per week (3/wk) on a Monday, Wednesday, and Friday (MWF) schedule and analyzed for BOD_5 and SS.

Equalization

No flow and load equalization basin or facilities exist at the Kingston WWTP, prior to the biological treatment system. The swirl device was provided as the flow protection mechanism using its bypass system. However, the environmentally sensitive approach to eliminating plant bypasses would be the consideration of a flow and load equalization basin for the treatment plant with a capacity that stores a maximum flow which is at least two (2.0) times the average flow. Such a facility improvement for influent storage of diluted wastewater and storm water would provide a much higher level of protection of plant equipment, process control, and NPDES permit compliance during wet weather and excessive I/I periods of operation and most likely eliminate the use of the bypass in the swirl device.

Primary Sedimention

The Kingston WWTP does not include primary sedimentation. The oxidation ditch type (Lakeside Equipment Corp.) secondary treatment capacity was designed and sized as a low-load suspended-growth process to provide carbonaceous organic and colloidal solids removal. Levels of influent carbon and nutrients within Kingston's domestic wastewater were adequate for the successful operation of this biological treatment system, without the need for primary treatment to reliably and continuously meet NPDES permit effluent limits.

Oxidation Ditch

After preliminary treatment the wastewater enters a single race-track shaped oxidation ditch manufactured by Lakeside Equipment Corp. The oxidation ditch is operated as a radial plug-flow type biological treatment system utilizing suspended-growth microbial biomass (activated sludge) to provide oxidation of carbonaceous (organic removal) matter. This activated sludge process was designed and continues to be operated in an extended aeration treatment mode as a single-stage oxidation system.

The preliminary treated wastewater flows through a twelve inch (12") DIP and into the head end of the oxidation ditch. The oxidation ditch is a long tank (inside length of 228 feet) and rounded on each end (inside width of 39 feet) with a side water depth of twelve feet (12'). The tank has one center wall at a radius of 19'6" and two curved guide walls at each end at a radius of 9'6", which allows the flow to move radially around the entire tank before exiting over a rotating effluent weir. The rotation of the two (2) nineteen feet (19') long rotors cause the wastewater to move in a radial plug-flow manner. The liquid level in the oxidation ditch is controlled by this rotating effluent weir with a control range in depth of between eleven and twelve feet (11-12').

The unit capacity of the oxidation ditch of approximately 750,000 gallons (0.75 MG) provides a design average hydraulic retention time (HRT) of 18.0 hours at the capacity flow of 700 gpm (1.00 MGD). Typical HRTs for aeration in an oxidation ditch, range between twelve and thirty-six (12-36) hours. The sizing of the oxidation ditch was also based on a low-load organic loading of 15.6 lbs BOD/dy/kcf, with a design concentration of microorganisms, measured as mixed liquor suspended solids (MLSS), in a range of 2,500 to 5,000 mg/L. Typical volumetric organic loading rates (OLR) for extended aeration processes using oxidation ditches range from 5 to 30 lbs BOD/dy/kcf, with a desired concentration MLSS range of 3,000 to 6,000 mg/L. Combining these two sets of process parameters results in a typical operating range of food to microorganism (F/M) ratios of 0.05 to 0.20 $days^{-1}$ and corresponding aerobic solids retention time (SRT) range of 10 to 30 days.

As summarized in Table 4, the actual OLR has been approximately 9.7 lbs BOD/dy/kcf at an average MLSS concentration of 4,155 mg/L. These low organic loading rates and desireable biomass levels, resulted in an average F/M ratio of 0.04 days-1, which is less than half (50 %) of the design value of 0.09 $days^{-1}$. The average HRT of twenty-nine (29) hours is approximately sixty percent (60%) more oxidation time than the minimum HRT of eighteen (18) hours at design capacity flow of 1.00 MGD. Additionally, the volumetric organic loading rate over the past sixteen (16) months has averaged only sixty-two percent (62%) of the design loading rate. This low level of organic loading per unit aeration capacity and biomass inventory suggests that sufficient biological treatment capacity exists at the Kingston WWTP to provide adequate oxidation of influent organics and solids to meet the NPDES permit limits.

However, the long-term success of this biological treatment system is primarily dependent various performance limiting factors, with the most critical parameter being HRT during sustained high hydraulic loads and peak flow conditions. If the hydraulic loadings to the secondary treatment system were controlled on a continuous basis at or below the design criteria of 1.00 MGD, it appears from a loading analysis that only one (1) oxidation ditch would be required to provide adequate biological treatment of domestic wastewater from an increase in growth in Kingston.

The variances in actual operation from design parameters summarized in Table 4 for the oxidation ditch are a strong indication of the level of the existing reserve treatment capacity. Combining all loading and capacity parameters for flow, organics, and solids, it appears that the aggregate available treatment capacity for the oxidation ditch is approximately forty percent (40%) with flow (HRT) as the performance limiting loading factor. Accordingly, a twenty-five percent (25 %) reduction in the existing average daily flow from 0.67 to 0.50 MGD achieved by positive progress in I/I reduction would result in the increased aggregate available capacity of at least fifty percent (50%) with an equivalent performance limiting influence by flow (HRT), organic loading (OLR), and solids (F/M).

From strictly a capacity perspective, the City of Kingston could double its domestic wastewater loadings to its treatment plant from growth and new sewered customers without the capital requirement of constructing a parallel oxidation ditch. Other concerns in the operability of the existing oxidation ditch, i.e. aeration and clarification, should be factored into this capacity analysis to comprehensively define the available reserves and refine the estimated requirement for treatment plant expansion to accommodate anticipated future growth.

During our plant inspections, the oxidation ditch was actively in service and mechanically functioning properly. The mixing of the biological solids with the influent wastewater and the return activated sludge is accomplished in a co-current and radial pattern by the two (2) rotors and blade aerators. The rotors contain multiple rows of blades in a star configuration to both diffused oxygen from the atmosphere into the mixed liquor and maintain suspension of the biological solids in the ditch. These continuous operating rotors are powered by 40 hp motors.

The treatment plant staff indicated that these rotors can maintain a dissolved oxygen (DO) level in the oxidation ditch above 1.0 mg/L. Each rotor operates independently so a mechanical failure of one of the two units will not completely eliminate aeration in the ditch. Our observations of the mechanical reliability and operability discussions with the treatment plant staff of the rotors' performance suggested an acceptable level of confidence in the performance of this critical process equipment. The most notable mechanical problem with these rotors was the repairs to one (1) of the torque arms which had pulled out of the concrete wall and adjustment in the deflector baffle. An August, 1993 Evaluation Report prepared by J.R. Wauford & Co., indicated that these mechanical rotor problems were satisfactorily repaired and their observations were that the oxidation ditch was operating well.

We did not find any design data for the aeration capacity anticipated for the oxidation ditch rotors, however, the typical oxygen supply criteria for a low organic loading, extended aeration system providing strictly carbonaceous treatment would be 1.0 lb O_2/lb BOD_5 applied. Based upon the influent design organic loading of 1,668 lbs BOD_5/dy, the required oxygen supply which matches the anticipated oxygen demand for the oxidation ditch would be approximately 11 mg/L/hr. Oxygen uptake rates (OUR) to determine oxygen demand rates are not performed by the Kingston WWTP staff and DO is used as the primary method of monitoring of the aeration aspects of the oxidation ditch. OUR (mg/L/hr) measurements of the mixed liquor in the oxidation ditch allows for the determination of the actual oxygen demand of the activated sludge process for varying operating conditions and shows the general respiration rate and bioactivity of the microorganisms.

The most important environmental factors in the oxidation ditch for a stable activated sludge process are aerobic conditions with a sufficient level of retention time and an active biomass. The process control parameters which directly affect carbonaceous oxidation include pH, temperature, organics, solids retention time, and dissolved oxygen. Organic, oxygen and solids profile monitoring and mass balances around the oxidation ditch should be performed periodically to assess the performance of the oxidation ditch as various flow and loading conditions.

As reflected in Table 4, the levels of HRT, F/M, and OLR were much lower than the design capacity levels and thus, sufficient aerobic solids retention time (SRT) with adequate biomass concentrations existed in the oxidation ditch to adequately and continuously achieve NPDES permit limits for effluent BOD_5 (Figure II-5). The average aerobic SRT in the oxidation ditch during the past sixteen (16) months was approximately twenty-seven (27) days, which is almost 2.5 times the design SRT of eleven (11) days, which provided a much higher period of biological contact time to properly oxidize the influent organic matter. Other process factors, i.e. pH and temperature were at or near desired and design criteria.

However, a detailed review of the operations data for the activated sludge process indicated that oxidation ditch DO concentrations appears to be the performance limiting factor in maintaining continuous and adequate oxidation of organic matter, if influent loadings approached design capacity. Desired minimum DO levels for carbonaceous treatment of wastewater is typically in excess of 2.0 mg/L. The average DO level measured at the end of the oxidation ditch is highlighted in Table 4 to indicate a concern of the actual operating level as compared to the design value. The sixteen (16) month period of operation from January, 1994 through April, 1995 was only 1.1 mg/L, with a range of 0.3 to 4.0 mg/L. This overall level of DO may have provided sufficient oxygen content and driving force to achieve NPDES permit limits at the low-loading and high SRT conditions, but is anticipated to be inadequate at design values achieved by continued growth in the City of Kingston and could result in loss of process control in the oxidation ditch and subsequent NPDES permit violations. Our review of the daily operations data for DO levels, showed sustained periods of time when the DO levels in the aeration basins were well below 1.0 mg/L as illustrated in the following daily histogram. Table 5 summarizes the monthly DO levels in the oxidation ditch as compared to the minimum desired level of 2.0 mg/L for adequate carbonaceous treatment.

Our assessment is that levels of DO provided by the existing rotors may be inadequate to provide carbonaceous treatment of organic matter above the existing low-loading conditions and achieve compliance with effluent limits for BOD_5 in Kingston WWTP's NPDES permit. As the community grows the organic loading to the existing oxidation ditch increases, the oxygen demand will also increase and require higher levels of oxygen supply to maintain adequate treatment. The increased food will also increase the level of secondary biosolids growth, which in turn will create a higher consumption of dissolved oxygen to maintain the bioactivity. The net result will be a lower hydraulic and solids retention times for treating the influent wastewater at increased oxygen supply and demand conditions. The existing two rotors appear to be supplying a maximum amount of dissolution of oxygen into the mixed liquor from the atmosphere.

Thus, increased aeration devices, i.e. additional rotors, fixed mechanical surface aerators, floating boat aerators, or retrofit of the oxidation ditch to fine-bubble diffused aeration will seriously need to be considered for expansion of the oxygen supply capacity to match the increasing oxygen demand from any significantly higher and sustained organic loadings. The ability for the City of Kingston to double its domestic wastewater flow without building another oxidation ditch will not only depend on decreased I/I, but also a significant increase in the oxygen supply and diffusion equipment for the existing oxidation ditch. A desired residual DO in the mixed liquor which provides adequate driving force of oxygen into the bacterial floc for proper and complete metabolism of organic matter in a carbonaceous treatment system is usually 3.0 to 4.0 mg/L, with a critical minimum of 2.0 mg/L.

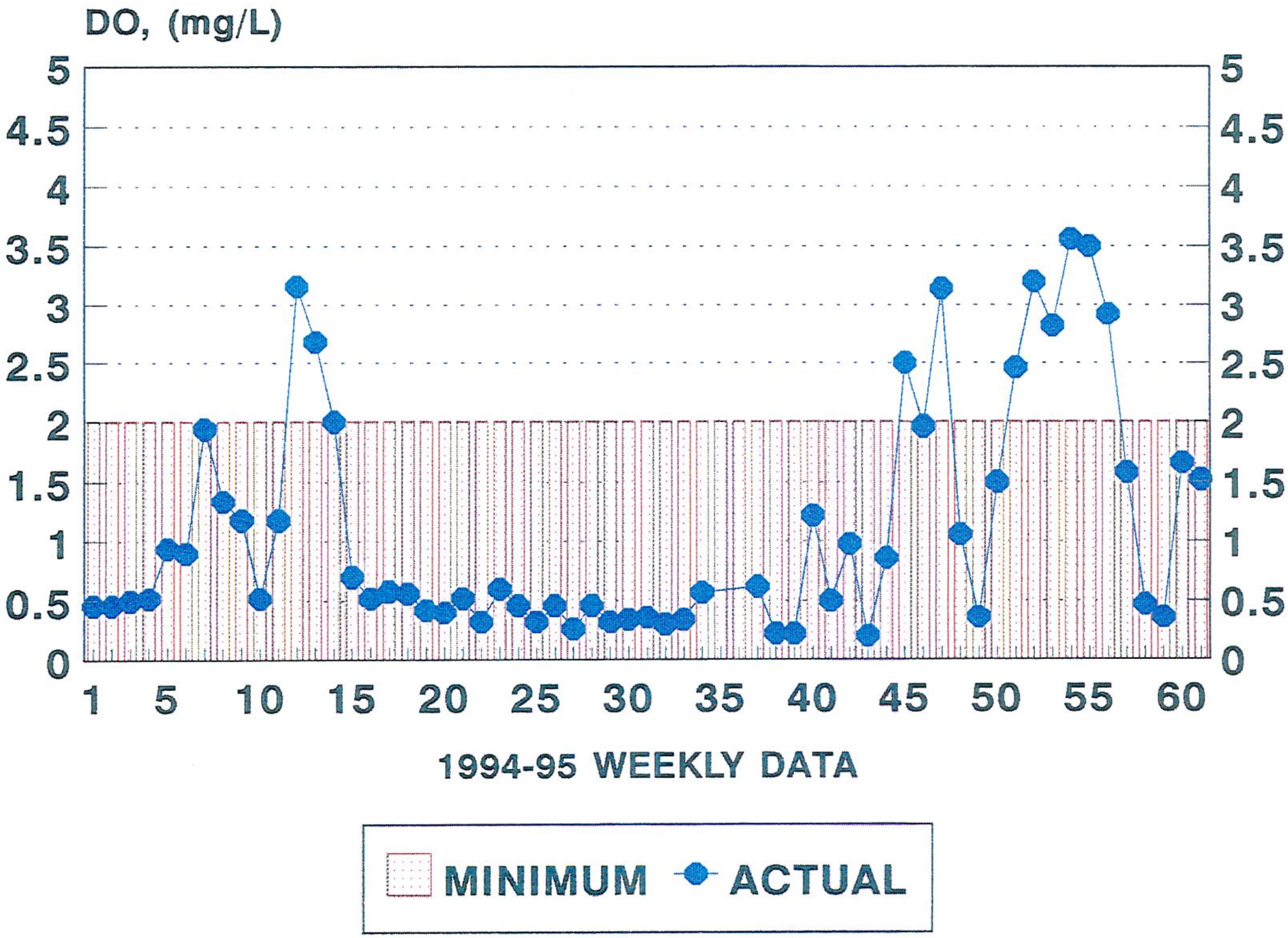
Other operational and performance aspects of the oxidation ditch are highlighted in Table 4. A detailed review of the monthly operations reports in which a normalized analysis was performed for the MLSS concentration, revealed an adequate concentration of biomass of 4,155 mg/L was maintained in the oxidation ditch. This level of biomass is approximately forty percent (40%) higher than desired concentration of 3,000 mg/L as a result of backlogged solids inventory at the Kingston WWTP. This overall plant problem of biosolids processing and inventory will be discussed in detail in the Biosolids Management and Disposal Assessment section of this report.

The biomass in the oxidation ditch showed consistently lower bioflocculation and slow settling characteristics. The settling of oxidized mixed-liquor in the Kingston WWTP ditch showed an average thirty-minute (30-min) laboratory settleometer of 727 ml/L and a corresponding sludge volume index (SVI) value of 175 ml/g. This settling performance was very consistent for each of the sixteen (16) months of operational data we evaluated and substantially varies from the design criteria for 30M-Settl. of 300 ml/L and SVI of 100 ml/g. This performance data strongly indicates an older aged and excessive inventory of microbial biomass, which supports our visual observations of the activated sludge for density, color, mixing, odor, and foam during our plant visits. The mixed liquor looked old aged by its darker brown color, however, no scum or foam was observed floating on the surfaces in the oxidation ditch.

KINGSTON, TN WWTP
OXIDATION DITCH PROCESS CONTROL
TABLE 5

MONTH	MIN. DO MG/L	MAX. DO MG/L	AVG. DO MG/L	SETPT. DO MG/L
Jan '94	0.3	3.8	1.0	2.0-4.0
Feb '94	0.2	3.0	1.1	2.0-4.0
Mar '94	0.4	5.2	1.5	2.0-4.0
Apr '94	0.2	4.0	1.6	2.0-4.0
May '94	**0.3**	**0.8**	**0.4**	**2.0-4.0**
Jun '94	**0.2**	**0.9**	**0.4**	**2.0-4.0**
Jul '94	**0.2**	**1.0**	**0.3**	**2.0-4.0**
Aug '94	**0.2**	**1.1**	**0.3**	**2.0-4.0**
Sep '94				**2.0-4.0**
Oct '94	0.2	1.9	0.5	2.0-4.0
Nov '94	0.2	1.9	0.7	2.0-4.0
Dec '94	0.2	6.5	2.0	2.0-4.0
Jan '95	0.8	4.9	2.0	2.0-4.0
Feb '95	0.3	3.7	1.3	2.0-4.0
Average	**0.3**	**3.0**	**1.0**	**3.0**
Minimum	**0.2**	**0.8**	**0.3**	**2.0**
Maximum	**0.8**	**6.5**	**2.0**	**4.0**
Desired	**>2.0**	**3.5 - 4.0**	**3.0**	**2.0 - 4.0**

KINGSTON, TN WWTP
OXIDATION DITCH PROCESS CONTROL



The report received from Dr. David Jenkins of Jenkins and Associates, Inc. found in Appendix III of this report, summarizes his microscopic examination of the mixed liquor sample from the Kingston WWTP. Dr. Jenkins microscopic observations and corresponding comments were in close agreement with our observations of the oxidation ditch biomass and settling characteristics in the secondary clarifiers and our overall assessment of the secondary treatment performance. Dr. Jenkins observed the mixed liquor to contained weak, irregular, diffuse flocs, which are characteristics of an old age and oxygen deficient biomass. The positive Neisser stain of cell clumps (biofloc) and some motile unicells (i.e. flagellates) suggests damaged cells and an imbalance of lower and higher life form of microbes in the activated sludge.

The consistently poor settling characteristics is confirmed by the overall filamentous organism level of 'abundant', which was sufficiently present to cause a bulking sludge problem. The filamentous organisms caused interference with settling by interfloc bridging and creating a diffused stretched out floc, which settles poorly and result in higher effluent turbidity. As identified in Dr. Jenkins report, the type of filaments which predominated in the activated sludge are indicative of a very low F/M (high biomass and SRT) and low DO environment. These filaments also showed signs of damage which included missing cells, broken and empty sheaths. This type of microscopic analysis indicate that the existing health and stability of the biomass in the oxidation ditch could further deteriorate and result in potential NPDES permit violations.

Secondary Clarifiers

Oxidized MLSS from the oxidation ditch flows by gravity to the secondary clarifiers for liquid/solid separation. These two (2) circular secondary clarifiers are located adjacent to the tail end of the oxidation ditch. Each tank is thirty-six feet (36') in diameter with a fourteen feet (14') side water depth to provide an effective total clarification volume of 24,430 ft^3 or 0.183 MG. Each peripheral drive clarifier is equipped with a 0.75 hp motor, where the MLSS enters the center well and is distributed in a quiescent flow throughout the volume of the tank, where gravity settling of the biomass occurs. The required depth of the clarifiers was designed by the Lakeside Equipment Corp. using an assumed SVI of 100 ml/g and allowing for proper zones for biosolids separation, thickening, and storage. Accordingly, the design surface loading rate (SLR) at the average design flow of 1.00 MGD is 490 gpd/ft^2 with a corresponding hydraulic detention time (HDT) of 5.5 hours. The design solids loading rate of 12.3 lbs/dy/ft^2 was based on an average MLSS of 3,000 mg/L and a return activated sludge (RAS) recycle of twenty-five percent (25%) of the design influent flow of 1.00 MGD.

Mixed liquor flows over an adjustable aluminum weir/baffle plate at the tail end of the oxidation ditch and travels by gravity through a twelve inch (12") line to a flow splitter box between the two (2) clarifiers. The flow is diverted equally by means of visual observation of flow over the effluent weirs and is discharged in the center of each clarifier inside a steel skirt. Clarified effluent flows over V-notch 90 degree weirs at the outer peripheral ring of the tanks and is discharged into the effluent wet well through a ten inch (10") line.

Settled biosolids are removed from the bottom of the clarifiers by rotating scraper mechanisms, equipped with two (2) arms and four (4) plow blades on each arm, which convey the biosolids to the sloping center coned and twelve inch (12") deep hopper on the floor of the clarifiers. The settled biosolids are discharged through an eight inch (8") line via hydrostatic pressure to a wet well, which is level controlled by floats and a mercury switch. This wet well is equipped with two (2) 1,000 gpm pumps, which recycle settled biosolids through six inch (6") lines to the oxidation ditch at a discharge location upstream of the influent gate valve and first rotor. Settled biosolids can also be wasted from the wet well along with clarifier scum, and intermittently pumped to the two (2) aerobic digesters. Scum is collected from the surface of the clarifiers into pits and pumped through four (4) inch lines to aerobic digesters.

Both clarifiers were operational and in service during our plant visits, with observations of broken and missing sections of hand railings for Clarifier #2. The plant staff indicated historical problems with a broken rake arm mechanism, which was confirmed by our review of the August, 1993 Engineering Report by J.R. Wauford & Company. Many of the other mechanical problems with these clarifiers, i.e. twenty (20) feet below ground and concrete covered plug valves which isolates flow to clarifiers, missing scum scrapers and brushes on clarifier rake arms, etc. identified in Wauford's evaluation still exist during our plant visits and continue to be an aggravation to the plant O&M staff approximately two (2) years later.

Accordingly, this Engineering report should be reviewed again by City officials with respect to planning and budgeting the proposed corrective actions stated therein for these tanks. We have reviewed the same and support these corrective actions as being reasonable and necessary. The mentioned improvements for the valve pit for influent flow and drains should perhaps be implemented at the time of plant expansion to a second oxidation ditch. Other recommendations concerning the scum removal problems could be acted upon when a commitment is made by the City to address and resolve this problem. The flow isolation problems with difficult or inoperable plug valves and back-log of solids have prevented these tanks from being removed from service on a desired once per year schedule during low flow periods to perform detailed inspection, cleaning, and corrective maintenance activities.

Our plant visits, field observations and discussions with operations staff indicated a 'biosolids bound' or excessive inventory (backlogged processing) situation with the oxidation ditch and clarifiers. As a result of inadequate biosolids disposal from the Kingston WWTP, the various liquid biosolids processing tanks were at nearly full storage capacity and well beyond desired operating levels. Table 4 highlights the average depth of blanket (DOB) operated in the past sixteen (16) months was seventy-two inches (72"), which is four (4) times more solids stored in the clarifiers than desireable levels. During the plant visits, the operational staff indicated that the clarifier DOBs were operating between four and five feet (4-5'). A much lower level of solids inventory in the clarifiers should be achieved and maintained at the Kingston WWTP to adequately protect from solids washout conditions and deteriorated effluent quality when plant flows increase from community growth and/or continued impacts of I/I.

The maximum DOB for effluent quality protection during dry weather operating conditions is typically twenty-four inches (24") and treatment plants which experience problems with I/I, such as the Kingston WWTP, should control the DOB at a lower maximum level of twelve to eighteen inches (12 to 18") to minimize solids loss to the effluent during wet weather periods. A well controlled and minimum DOB in the secondary clarifier is critical to maintaining effluent quality and achieving consistent and reliable NPDES permit compliance at the Kingston WWTP with the existing wastewater collection system and adverse impacts from I/I.

We did not observe any blanket level measurement device, i.e. sludge judge at the plant or any DOB data recorded on log forms or the monthly operations report. However, the plant staff indicated that a sludge judge is used to measure DOB on a schedule of once per week. This monitoring frequency should be increased to daily (seven days per week) to elevate the level of attention in reducing and controlling the DOB levels in the secondary clarifiers to desired levels through increased biosolids wasting and recycle.

A RAS meter is used to measure the instantaneous and totalized recycle flow. The local readout is used to track the recycle rates, however, its signal transmission to the remote chart recorder located in the Laboratory/Office Building is broken. A review of the monthly reports indicates an average recycle rate of sixty-one percent (61%) as determined by the ratio of influent/RAS flows. As shown in Table 4, the hydraulic and solids loading rates (HLR and SLR) have been operated at lower values than design values, as a result of the lower influent flows than design capacity experienced at the Kingston WWTP.

The average total monthly volume of settled biosolids wasted over the past sixteen (16) months was approximately 34,760 gallons. The concentration (mg/L) of the return or wasted biosolids streams is not routinely measured by the Kingston WWTP staff to determine the mass (DT/dy) amounts of solids being return or wasted from the secondary biological system. We did not find any solids wet well measurement data in our review and thus, we recommend that a suspended solids (SS) test should be performed at a frequency of once per week (1/wk). This important process information would also allow for the monitoring of clarifier biosolids thickening performance, determined by computing a ratio of RAS/MLSS concentrations. A well performing secondary clarifier of properly oxidized biosolids will exhibit a thickening RAS/MLSS ratio of approximately 2.5 to 3.5.

Our observations of the clarified effluent flowing over the V-notch weirs during our plant visits was fairly clear with some degree of observable turbidity. We did observe a substantial level of floating solids, scum, and debris (plastics) on the effluent surfaces of both clarifiers. The plant staff appeared to providing an adequate and frequent level of clarifier weir cleaning, and we observed no algae or debris on the weirs. A chlorine solution prepared from granular CCH is used in the weir cleaning process. The routine manual skimming and removal of floating sludge, scum, and debris (plastics) will significantly increase the visual appearance and performance of the secondary clarifiers and aesthetic perception of the secondary effluent.

Secondary Effluent Sampling and Flow Monitoring

The clarified wastewater flows by gravity from the secondary clarifiers to the common effluent wet well through ten inch (10") lines. Any raw influent bypass from the swirl device which flows through a twelve inch (12") line is combined with the clarifier effluent into an eighteen inch (18") line before discharge into the effluent wet well. The dimensions and storage volume of the effluent wetwell was not determined from the information we obtained during our site visits. The effluent wetwell is controlled by level using three (3) vertical turbine pumps with a unit capacity of 1,050 gpm. These pumps were equipped with 40 hp motors, and they all observed to be automated by a pump sequencer to control level and run time. A 'Confined Space Entry' sign was observed to be located over the hatchway door to the effluent wet well. The intermittent and cyclic operation of the effluent pump was evidenced by the downstream flow meter chart recorder.

A SIGMA 1600 series automatic sampler with refrigeration is used on a MWF schedule to obtain a composite sample of the effluent from the wet well, prior to the introduction of chlorine for disinfection. This composite sample is time proportioned even though the NPDES permit requires it to be flow-proportioned using the effluent flow meter. This effluent sampler is programmed to sample every five (5) minutes from the period of time when it is manually turned on (later afternoon - 3:00 p.m.) until the period of time when it is manually turned off (early morning - 7:00 a.m.). As previously discussed for the influent sampler, this time-composite method for the effluent sampler is neither a NPDES permit acceptable or representative sampling schedule of the flow from the Kingston WWTP. Accordingly, both samplers should immediately be programmed on a twenty-four (24) hour time composite basis and then wired by an outside commercial electrician (as soon as possible) for flow-pacing. Each sampler should be wired to its respective flow meter and programmed to pulse at specified totalized flow intervals over each 24-hr period to obtain a representative and adequate volume of sample, i.e. 1,000 ml or 3.75 gallons.

The effluent sampler receives its flow from hydrostatic pressure through a 1.5" rigid PVC pipe which is connected to the discharge side of the effluent wet well pumps. The flow through the sampler is then activated by the timer to use its dipping arm to obtain a sample and discharge into the refrigerated composite container. Due to the intermittent operation of the effluent wet well pumps, which we observed to be once every thirty (30) minutes for a duration of five to fifteen (5-15) minutes, a substantial portion of the effluent sample could be backflow from the sixteen inch (16") effluent outfall line instead of forward flow from the effluent pumps. The sampler is independently activated once every thirty (30) minutes for a duration of approximately five (5) minutes. These equipment operations should be interrelated to achieve a representative sample of unchlorinated effluent being pumped from the wet well into the flow metering manhole and outfall transmission line. Additionally, the existing continuous flow source through the sampler from an intermittent effluent flow system may introduce a low bias as a result of settling of solids and organic matter in the unmixed effluent wet well or the backflow from the flow metering manhole. This sampling and analysis of a clarified/supernated effluent would produce erroneously and consistently low values for effluent BOD_5 and SS concentrations, which may support the apparent discrepancy between the DMR results (Figures II-4 and II-5) and our observations of the effluent.

During our inspections, the sampling equipment appeared functional and the observed refrigerator temperature of 14 deg. C was also well above the desired value of 4 deg. C. A laboratory log sheet for both the influent and effluent samplers should be developed and used weekly for routine inspections of the equipment and to record sampler refrigerator temperatures and collection volumes. Routine adjustments should be made to the samplers and refrigerators to control the 24-hr sample volume to prevent under filling or overfilling of the composite container and maintaining a constant temperature of 4 deg. C.

The effluent flow meter is located inside manhole #16, which is outside and adjacent to the effluent wet well and at the head end of the sixteen (16") outfall line. This in-line probe and transducer type flow meter could not be clearly inspected due to the observed build-up of scum and grease in the effluent wet well. It appeared that this instrument had not been cleaned or inspected for a long period of time and the transmission of its signal for flow recording and totalizing at the remote chart recorder in the Laboratory/Office Building was viewed as being adequate. A much higher level of care should be given to the routine cleaning of the effluent flow metering manhole, inspection, and calibration of the effluent flow metering equipment. The poor visual appearance of this flow metering area presents the perhaps misguided perception and a lower level of confidence in the accuracy and reliability of the effluent flow information generated at the Kingston WWTP and reported to the TDEC in the DMRs.

Disinfection

Disinfection at the Kingston WWTP is accomplished in the approximately 10,000 feet long and sixteen inch (16") diameter force main between the wet well and Outfall No. 001, located at mile 0.28 of the Clinch River. Chlorine is injected at the beginning of the outfall line and after manhole #16 to provide disinfection of the secondary effluent and any bypassed raw influent. The effluent force main is ten thousand feet (10,000') long which provides at the design capacity flow of 1.00 MGD, an approximate contact time (CT) for bacterial kill of one hundred and fifty (150) minutes. At the observed peak effluent flow of 2.30 MGD, the CT for disinfection was sixty-five (65) minutes.

As shown in Table 4, the sixteen (16) month average CT was one hundred and thirteen (113) minutes, which provided a high level of disinfection performance as reflected in Table II-1 and Figure II-7. No NPDES permit violations were recorded for inadequate bacterial kill, with an average effluent fecal coliform (FC) count of only 1#/100 ml. This high level of disinfection performance demonstrates that the size and disinfection capacity is more than adequate for the existing flow capacities of the Kingston WWTP. It also appears that this level of performance could be maintained if the Kingston WWTP were expanded in its flow capacity. The minimum desired CT of thirty (30) minutes will still be met, if the peak plant flow capacity were expanded to 4.00 MGD through the installation of another oxidation ditch.

Chlorine (Cl_2) feed logs are maintained at the treatment plant and recorded on the monthly operations report. The average Cl_2 feed during the sixteen (16) months of performance data we evaluated was twelve (12) lbs/dy, which is equivalent to a dosage of 18 lbs/MG and identically matched the design dosage. Typical secondary effluent required a chlorine dosage in the range of 15 to 45 lbs/MG to achieve the normal NPDES permit FC limit of 200 #/100 ml. The daily usage of chlorine is recorded on a log form, kept at the weight scale of the one-ton cylinders. This daily feed and usage information is also recorded on the monthly operations report submitted to TDEC. Total chlorine residual (TCR) concentrations are not monitored by the operations staff at the head end of the outfall line to measure chlorine demand for varying flow and secondary effluent conditions to achieve a more cost effective control of the disinfection process. The measurement of TCR at both the injection (front) end and the discharge (back) end after contact can allow for reducing the dosage and feed rates of Cl_2 while maintaining adequate bacterial kill. The benefit of these process measurements would be reducing chemical costs while maintaining NPDES permit compliance for effluent FC densities.

Mr. McClure explained that only the final effluent TCR is measured at the designated downstream manhole, prior to outfall discharge at the NPDES permit required five days per week (5/wk) schedule. The accuracy of the final effluent TCR may be adversely affected by the operators' practice of transporting the grab sample from the outfall manhole to the WWTP laboratory. This short time period (few minutes) between the sample collection and analysis may deplete the actual level of TCR in the effluent in the small volume container and bias low the analytical results. The HACH DR 100 calorimetric analyzer used for TCR analysis should be used at the outfall sampling location by the operator to immediately perform this laboratory procedure in the field to yield accurate results and ensure that chlorine levels are not being discharged above the NPDES permit limit maximum of 1.8 mg/L. One permit violation was recorded in the month of December, 1994 when the effluent TCR was measured to be 2.0 mg/L.

The major components of the disinfection process at the Kingston WWTP includes the one-ton chlorine cylinders and weight scale, the chlorinators, and the injection piping. Two (2) chlorinators at unit capacities of 100 lbs/dy and Sta-Rite pumps (5 hp) are used to inject chlorine at a pressure of 100 psi into the effluent line using a two inch (2") PVC injection pipe. Potable city water is used for chlorine injection. Chlorine can be introduced into the plant influent and RAS streams for the respective purposes of odor reduction and filamentous bacteria growth control, but neither of these chemical uses were in operation during our visits. We observed the chlorine solution piping to be color coded with yellow painted lines with orange bands.

The chlorine storage and feed facilities are monitored for gaseous leaks using a wall-mounted Cl_2 gas detectors by Capitol Controls. The Kingston WWTP also possessed a 'B' Kit for emergency repairs or leaks to the chlorine system, which was stored in a back corner of the maintenance storage room. Adequate ventilation is also provided in each of the chlorine storage and feed rooms using large fans and wall louvers to remove any dangerous chlorine gas from these facilities. Based upon the average dosage of 10 lbs/dy, a one-ton cylinder is depleted and changed on the manifold at an approximate frequency of once every six (6) months.

We did not observe a wind sock located in the chlorine gas area of the Kingston WWTP and this type of safety equipment should be considered for installation on top of the northeast corner of the Equipment Building. This wind sock can be very important for the indication of local wind direction and chlorine gas exhaust in relation to accessing personnel protective equipment (PPE) or a plant evacuation in the unlikely event of a major cylinder rupture and chlorine gas leak.

Both chlorine rooms are kept locked and only accessed by a key. Additionally, we observed during our plant visits, two (2) new self-contained breathing apparatus (SCBA) tanks stored in an outside wall mounted cabinet adjacent to the chlorine storage and feed rooms, with a third unit being serviced. The two (2) on-site MSA units, equipped with 30-minute air tanks were functional and available for use to safely and adequately respond to any confirmed chlorine leaks. From our discussions of this critical PPE and the infrequent schedule for changing one-ton cylinders, an annual refresher training from the chlorine supplier or equipment vendor on the use of the 'B' kit, as well as the SCBAs and other chlorine system components should be performed.

BIOSOLIDS MANAGEMENT AND DISPOSAL ASSESSMENT

Aerobic Digestion

The secondary biosolids are gravimetrically thickened and surface skimmed from the secondary clarifiers and periodically pumped to two (2) aerobic digesters. These two above ground, open topped, rectangular shaped tanks are each fifty feet (50') by thirty-two feet (32') with a side water depth of fourteen feet (14'), which holds approximately 167,550 gallons of aerobically digested biosolids. They were designed to provide an average aerobic solids retention time (SRT) of fifteen (15) days to provide both total (%TS) and volatile solids (%VS) reduction. Verbal discussions with Mr. McClure indicated that the average SRT is unknown for these digesters, since no actual flow metering of feed or withdrawal exists for these tanks. Assuming constant level for both digesters, with one active unit in service, the average monthly WAS flow of 34,760 gallons would result in an estimated aerobic digester SRT of approximately 146 days.

This very high SRT is consistent with the observed one tank (Digester #1) in service containing a thick layer of scum and old age sludge blanket on top of the liquid surface. Digester #2 was out of service during our plant visits due to inadequate air supply to properly operate both tanks (which will further be discussed herein). During our initial plant visit, this tank was full of old age solids that also contained a thick blanket and scum layer on the surface. On the second plant visit, the solids from this tank had been discharged to the drying beds and the remaining liquid in the tank had a much higher water content and appeared dark brown and greenish in color with some algae and scum on its surface. The digested biosolids sample taken from Digester #1 for microscopic analysis by Dr. Jenkins also appeared unhealthy with weak, irregular, diffuse flocs and an abundance of filamentous organisms, predominately *Type 0041* and *Type 0092,* which are indicative of a long MCRT and low DO environment.

The wasted biosolids are pumped to the above ground digesters using the RAS pumps through a six inch (6") DIP line. A blower and fine-bubble diffuser system provides the aeration to the digesters for maintaining solids in suspension and dissolved oxygen levels. The aeration is periodically turned off to allow supernating and biosolids thickening (approximately once per week), prior to discharge through a six inch (6") DIP line to the drying beds for evaporative and filter dewatering. The digester supernatant is gravity flows through a six inch (6") line using a telescopic valve and returned to the on-site pump station as a process recycle stream within the treatment plant. The quality of this process recycle is not monitored for organic and solids content to assess its loading impact on the oxidation ditch. A cationic flocculant polymer (Nalco 8777) from a fifty-five (55) gallon barrel is diluted with water in a mixing tank and injected into the digested biosolids withdrawal lines. Lobeflo polymer (0.5 hp) pumps are used to mix the flocculant with the digested biosolids prior to discharge on the drying beds to aid in the release and gravity drainage of intracellular-bound water within the solids on the filter media.

Aerobic digestion is a complete mix process in which the microorganisms use oxygen to reduce the total and volatile content of the biosolids. As the food source in the aerobic digesters decreases, the microorganisms begin to digest their own cell tissues for energy in an endogenous respiration mode of operation. Based upon the long SRTs, these microbial cells undergo lysis and death. Since this decay and death rate is much higher than the rate of cell reproduction and growth, an overall reduction in cell mass will occur. A well functioning aerobic digester will result in a total and volatile solids mass reduction between twenty-five to forty percent (25 to 40%). No process sampling of the feed and digested biosolids occurs routinely at the Kingston WWTP for analysis of the influent and effluent solids %TS and %VS content and thus, no information was available to assess the level of digestion, stabilization, and mass reduction. The importance of this sampling and process information will be further discussed in the next section of this report on Drying Beds/Disposal. However, the biosolids under aeration inside the uncovered digesters are sampled twice per week (2/wk) and analyzed for SS, %VS, DO, temperature and pH. These are key process control parameters for the aerobic digestion process.

The byproducts of the biosolids digestion and death cycle are carbon dioxide (CO_2), water (H_2O) and ammonia (NH_3). The ammonia will subsequently convert to nitrate (NO_3) as digestion proceeds. Due to the nitrification of ammonia and production of carbonic acid in the digestion process, alkalinity will be consumed and a depression in pH may occur. Normally, the pH of an aerobic digester needs to be maintained in a slightly alkaline range of 7.0 to 7.6 s.u. As summarized in Table 4, the average pH of the aerobic digesters at the Kingston WWTP during the sixteen (16) month period of operation we evaluated was appropriately 7.2 s.u., with a general operating range between 6.9 and 7.7 s.u. A review of the weekly analytical data for the aerobic digesters revealed a couple of instances when a depression in pH below 6.7 s.u. was recorded, which indicates a 'sour' or organically overloaded system. These periods of stress on the digester biomass were apparently short term (one to two weeks) and had no long term impacts on returning to a desirable pH range for the biomass in the aerobic digesters.

Oxygen is supplied to the aerobic digesters from three (3) Lamson blowers, which contain 60 hp motors and air flow meters with a unit capacity of 2,200 acfm. The air is supplied to the digesters in a twelve inch (12") underground line, which has had a history of leaking problems. The treatment plant staff showed two (2) locations where air loss appears to still occur, with one location underground near a sidewalk and the other at ground level of the air supply riser pipe, which is adjacent to the digester tanks. Both locations showed obvious sign of air leaks as evidenced by dead grass in these areas and whistling sounds. This loss of air could represent significant loss in operating costs, since two (2) blowers are continuously run to provide aeration to one (1) digester. The design of the aeration system for the digesters generally provided operation of one (1) blower for each tank and a third blower for back-up, stand-by, and additional supply, if required. If these air leaks were eliminated, the estimated annual costs savings in lower electrical power from shutting down one of the aeration blowers (60 hp out of an estimated plant operating total 285 hp) would be approximately $12.5K or (350,000 kwh/yr). Based upon Mr. McClure's estimate of the monthly WWTP electrical bill of $5K, this represents two and half months of power savings or an overall reduction of more than twenty percent (20%). This type of operating cost savings should be an incentive to immediately pursue a capital repairs project for the digester air leaks.

An understanding of the air leak problems by the treatment plant staff and review of the Wauford Engineering Report indicates that the rubberized gaskets continue to dry rot and crack from the elevated temperatures of the hot air stream. The intrusion of cold ground water on the buried air line causes a differential temperature, which fatigues the gaskets and causes their eventual failure and subsequent air leaks. We concur with J.R. Wauford's recommendation in their August, 1993 report that these air line leaks need to be repaired. The treatment plant staff indicated to us that the City spent approximately $1,200 a year ago to excavate the leaks in-house and replace the faulty gaskets with heat resistant gaskets. However, our plant visits and discussions with the treatment plant staff indicate that these gaskets also failed and the access problems to the existing leaks remains a deterrent to decisive corrective action.

Accordingly, we recommend that the buried line be abandoned (removed only if necessary) and replaced with an above ground line, which is insulated and equipped with new gaskets to eliminate the air leaks. This approach may be more costly than the recently spent $1,200, however its success in reducing the differential temperature from exposure to cold ground water and accessability for inspection and future repairs or replacement of the gaskets should prove to be more cost effective. The benefits are either economical from the pay back within an acceptable period of time from the projected power savings from shutting down one of the blowers or the technical ability to operate both aerobic digesters and increase the biosolids processing and disposal through-put of the plant. Increasing the biosolids through-put by operating two (2) aerobic digesters and routinely hauling liquid biosolids to land application sites may also yield economic benefit of reduced equipment maintenance costs. Eliminating the 'sludge-bound' conditions observed during our visits at the Kingston WWTP which prevents a build-up, back-log and excessive inventory of solids in these process tanks, should also reduce the wear and tear on the oxidation ditch and clarifier mechanical equipment, i.e. rotors, drives, and pumps.

The dissolution of oxygen into the bulk liquid tank of biosolids for achieving aerobic digestion is accomplished with an air diffusion system, manufactured by Sanitaire Corp. Each digester is equipped with two (2) diffuser headers which are four inches (4"O) in diameter spaced sixteen feet (16') apart from each other and eight feet (8') feet from the side wall. These headers and diffusers (25 per diffuser) are constructed of stainless steel and mechanically transfer oxygen from the air stream to the biosolids. Each diffuser is staggered every two feet (2') to maximize the surface area of the grid system on the floor of each digester tank. During our initial plant visit, we observed less than twenty-five percent (25%) of the diffusers operational in Digester #1 and no diffusers operational in Digester #2 using two (2) aeration blowers. A demonstration of the total air flow to only Digester #1 showed an increase in air flow from the diffusers, which could be observed from the surface was approximately half (50%). These field observations indicate a severe problem in air supply, oxygen transfer, solids mixing and diffuser plugging.

The treatment plant staff indicated that a new type of Sanitaire diffuser that is a non-clog type with a screen cap was being pursued as a retrofit of the existing diffusers to reduce plugging. The J.R. Wauford Engineering report also mentioned the same replacement strategy, however, at more than a year later, discussion and no decisive action has taken place to resolve this critical process problem. We did not confirm as to whether the Sanitaire representative ever furnished to the City of Kingston as mentioned in the J.R.Wauford Engineering report, some new diffusers to try in the digesters. We strongly recommend that this initial step be diligently pursued to improve upon the apparent poor condition of the existing diffusers and improve the level of oxygen transfer.

Furthermore, we recommend that a vent pipe be installed on supply air line to prevent a potential back-siphoning of solids in the diffusers and headers and thus plugging when periodically turned off for supernating and thickening purposes. We do not recommend intentional plugging of every other diffuser in the digesters as suggested in the J.R.Wauford Engineering report as an attempt to alleviate the clogging of the existing diffusers. This plugging problem may be a combination of inadequate mechanical driving force from reduced air supply (caused by the leaks), as well as some back-siphoning from no diffuser caps or bleed-off abilities in the air piping.

Typically, a well aerated digester with a DO residual in the bulk liquid solids will range between 1.0 and 2.0 mg/L. As shown in Table 4, the average DO was 1.7 mg/L, with a normal operating range recorded between 0.3 and 3.6 mg/L. There were many weeks when the measured digester DO was below the minimum desired value of 1.0 mg/L, which could be attributed to inadequate air supply (leaks) and poor oxygen transfer (plugged diffusers). Low DO environment will correspondingly decrease the digestion efficiency of total and volatile solids. The average solids concentration during the sixteen (16) month period of operation between January, 1994 and April, 1995 was approximately 28,500 mg/L or 2.85 %TS, with a volatile fraction of thirty-seven percent (37 %VS).

Additionally, the City's reluctance to pay the tipping fee of $33.50 per ton at the Roane County landfill for disposal of dried cake solids has also inhibited the proper and timely disposal of biosolids from the Kingston WWTP. We generally concur with the specific recommendations concerning the operability problems and poor performance of the drying beds. Additionally, we support Wauford's and TDEC's recommendations that an alternate method of biosolids disposal than landfill, which promotes beneficial use of the biosolids, i.e. land application should be implemented and in a manner which achieves full compliance with 40 CFR Part 503 Regulations.

The desired alternative approach of hauling liquid biosolids to a liquid pumper/spreading truck for land application will require demonstration by the Kingston WWTP of achieving compliance with both 40 CFR Part 503 and 40 CFR Part 257 for acceptable biosolids stabilization, metal content, pathogen and vector attraction reduction as a Class B wastewater residual. While direct pumping of stabilized biosolids from the digesters to a spreading truck will allow for the increased frequency of disposal, the utilization of the drying beds for continued biosolids dewatering and disposal of dried cake using a farm spreader on agricultural land should also be considered in the application permits to allow maximum flexibility and biosolids disposal capacity at the Kingston WWTP. Discussions with the treatment plant staff also indicated that the City would initially contract the hauling and spreading services to a local outside commercial hauler as a more cost effective approach than purchasing its own tanker truck for in-house hauling and application. Mr. Gene McClure indicated that a local hauler owns a 1,000 gallon tanker, which could spread the liquid biosolids at an estimated contract rate of $90/load or 9 cents per gallon.

Beneficial use of biosolids requires the preparation of a wastewater residual which is safe and suitable for application to the land. 40 CFR Part 257 requires that the biosolid be stabilized, prior to disposal using a '*Process to Significantly Reduce Pathogens*' (PSRP), i.e. the aerobic digesters. The purpose of aerobic sludge digestion is to reduce the mass (lbs) of solids which must be disposed of via land application and also stabilize the biosolids to reduce pathogens, control vectors, and prevent odors. PSRP requires a minimum %VS reduction of thirty-eight percent (38 %) to ensure proper pathogen reduction and vector attraction reduction for land application of the liquid or dried biosolids as a Class B wastewater residual. This will require the additional routine measurement, i.e. twice per week, of the inlet and outlet %VS content of the biosolids to determine stabilization efficiency and document compliance with the PSRP requirements for digestion and disposal. Presently, the %VS of the biosolids under aeration are measured 2/wk.

40 CFR Part 503 Regulations requires various management practices, monitoring, record keeping, and annual reporting to be implemented by treatment plants (greater than 1 MGD) who land apply Class B wastewater residuals. The sections of the Regulations which will apply to Kingston WWTP include the General Provisions (Subpart A), Land Application (Subpart B) and Pathogen and Vector Attraction Reduction (Subpart D). Additionally, other municipalities in Tennessee who land apply biosolids also have requirements found in Part III, Section C of their NPDES permits which require the submittal of a monthly report to TDEC for the quantity of disposed wet biosolids (gallons), the dry weight of the biosolids (tons), the volatile solids reduction (%VS), and the ultimate disposal site locations and field application practices.

Pathogen reduction requirements for a Class B wastewater residual can be accomplished with the PSRP of thirty-eight percent (38 %) volatile solids reduction in the aerobic digesters or an allowable fecal coliform (indicator organism) density of less than 2,000,000 MPN per gram of total solids on a dry weight basis. Vector attraction reduction is also accomplished by the same volatile solids reduction criteria. If 38% VS reduction is not achieved in the aerobic digesters, then alkaline treatment can be achieved by adding an alkaline material, i.e. lime or kiln dust to raise the pH of the biosolids above 12.0 s.u. for a period of two (2) hours and maintaining the pH above 11.5 s.u. for an additional twenty-two (22) hours. Records must also be kept on the stabilization, pathogen reduction and vector attraction reduction practices, as well as the land and crop usage controls when application occurs. Record keeping requirements for Class B pathogen reduction for PSRP using aerobic digestion include DO concentration, % VS before and after digestion, SRT of biosolids in digester and logs showing temperature for a minimum period of time of forty (40) days at 20 deg. C or a period of sixty (60) days at 15 deg. C. Option 1 for record keeping requirements for vector attraction reduction require measurement of the dry weight (mg/kg) volatile solids concentration of the inlet and outlet biosolids and calculation showing the thirty-eight percent (38 %) reduction in the digesters, which may be a problem for Kingston.

The dry weight concentration of heavy metals of the biosolids for a Class B wastewater residuals must also be below the pollutant concentration limits found in Table 3 of the Part 503 Regulations. Our review of the liquid biosolids sample collected on February 27, 1995 and analyzed by an outside commercial laboratory in Mt. Juliet, TN showed the heavy metals tested (cadmium, copper, lead, nickel, and zinc) were well below the Table 3 concentration limits. The other metals listed in Table 3, which were not analyzed in the February sample include arsenic, mercury, molybdenum, and selenium. Another liquid biosolids from the outlet of the digesters should be sampled and a full background test of all metals and fecal coliform bacteria be analyzed to assess the level of compliance with 40 CFR Part 503 Regulations. When biosolids are applied to the land, nitrogen analysis must also be conducted at the same frequency as the metals testing. Based upon the projected annual biosolids disposal amount of approximately 75 dry tons per year (720,000 gallons at 2.5 %TS), the required monitoring frequency will be once per year.

Agricultural lime or kiln dust may be required for elevating the pH to ensure that the proper soil pH of greater than 7.0 s.u. is achieved at the application sites. Most alkaline products, such as lime or cement kiln dust can be delivered in bags or bulk as a dry product for an estimated price of $30 to 40 per ton of material. Regardless of the selected alkaline material type, it must be handled with care and caution because of the very high pH and associated safety concerns with caustic materials. If PSRP is not reliably achieved with the aerobic digesters and alkaline stabilization is used by Kingston to achieve pathogen reduction and vector attraction reduction requirements, then the pH of the biosolids must be first increased above 12.0 s.u. for at least two (2) consecutive hours and then incorporated into the soil within six (6) hours of the liquid biosolids being sprayed on the land. Otherwise, to meet vector attraction reduction criteria, the pH of the biosolids must be maintained above 11.5 s.u. for at least twenty-two (22) consecutive hours, once pathogen reduction at the higher pH of 12.0 s.u. has been achieved. Alkaline stabilization will require a well defined strategy for digestion, storage, hauling, and application.

PROCESS/OPERATIONAL CONTROL ASSESSMENT

Process control at the Kingston WWTP is primarily based on monitoring the oxidation ditch for various conventional process control parameters, i.e. pH, temperature, DO, MLSS, and Settl. on a five (5) days per week (M-F) schedule. The aerobic digester is monitored twice per week and the biosolids in the tank analyzed for pH, temperature, DO, MLSS, and VSS. The other parameters listed on the monthly TDEC Operations Report show the required NPDES permit influent and effluent parameters are routinely monitored and reported. No process control monitoring and routine adjustments appears to be applied specifically for the clarification, chlorination, and polymer addition/drying bed processes. A well defined process control program will be need to be developed for the proper monitor and recordkeeping of land application of liquid or dried biosolids.

Addition of several important and key operational variables should be considered for the Kingston WWTP, as listed herein:

- o Secondary influent BOD_5 and SS (1/week)
- o Volatile suspended solids content of mixed-liquor in oxidation ditch (1/week)
- o Dissolved oxygen depletion in 5 or 10 minutes for MLSS in oxidation ditch (1/week)
- o Depth of sludge blanket in secondary clarifiers (7/week)
- o Suspended solids content of return activated sludge stream (2/week)
- o Total and volatile solids content of inlet and outlet digester solids (withdrawal days)
- o Total and volatile solids content of filter bed dried solids (disposal days)

The measurement of the aforementioned operational variables will allow for the determination of the following critical process control parameters:

- o Secondary Organic Loading Rate (lbs BOD_5 /1000 ft^3/dy)
- o Oxidation Ditch Oxygen Uptake Rate (mg O_2/L/hr)
- o Food to Microorganism Ratio (lb BOD_5 /lb MLVSS/dy)
- o Aerobic Solids Retention Times (days)
- o Secondary Clarifier Thickening (mg/L RAS/ mg/L MLSS)
- o Digester Total and Volatile Solids Reduction (% Red.)
- o Drying Bed Total and Volatile Solids Reduction (% Red.)

For the routine process measurements and treatment parameters in place at the Kingston WWTP, an appropriate emphasis is placed on the analysis of influent and effluent quality for the purposes of monitoring NPDES permit compliance. However, a daily process control monitoring program (including weekends), which includes daily solids measurements of the secondary clarifiers should be implemented so that necessary control adjustments and/or corrective actions can be initiated more routinely and responsively to changing operating conditions with the benefit an improved level of NPDES permit compliance and compliance with the 40 CFR Part 503 Regulations for beneficial use and disposal of biosolids.

MAINTENANCE AND EQUIPMENT ASSESSMENT

The most critical process equipment at the Kingston WWTP appeared to be in operation and functioning properly. However, we observed many important pieces of equipment which were broken, needing some type of corrective maintenance and/or out of service, including the mechanical bar screen, influent sampler refrigerator, clarifiers scum skimmers, digester air supply line, digester aeration diffusers, and drying bed media. Mr. McClure communicated his concerns of the lack of healthy wastewater staff to properly respond to maintenance problems with the pumping stations and the treatment plant. Our observations of the productivity level of the treatment plant staff also support this concern, which is clearly evident in the poor levels of facility maintenance and housekeeping activities at the lift stations and treatment plant. The housekeeping and cleanliness of the lift stations and buildings at the treatment plant were poor and exhibited a general lack of concern to the affected equipment and processes, as illustrated by various observations described in the following paragraph.

Dried plastics and other debris were observed to be caught on the overflow weir of the swirl device, with hosing strewn on the steps of the observation platform. Trash was observed on the ground around the grit chamber and backside of the bar screen. Pink chipped paint and rust was readily apparent for this equipment, with hosing loosely strung around barscreen and dumpster area. The grit blower room and influent sampler area was very dusty and dirty with cob webs and old equipment, i.e. filters, spare chains, boxes, old chair, electrical switches etc. strewnly loosely on the floor. One of the floor drains was plugged to the rotor pits of the oxidation ditch and the pit was full of water and debris. Polymer room on backside of digesters was dirty with towels, broken handles and shovels on floor, and the entrance to the Office/Laboratory Building had an uncoiled spray hose strewn on the sidewalk as well as a full trash bucket, cigarette butts, and broom and shovels. These plant conditions do not give a positive appearance or indicate a proper level of attention and care for the City's treatment plant equipment and facilities. We did observe the plant grounds to be mowed with the office and laboratory, and cleaning supplies area to be clean, orderly, and organized.

However, our assessment is that the Kingston WWTP staff do attempt to place an emphasis on scheduled preventative maintenance (PM) to minimize costly corrective maintenance and repairs. A daily equipment checklist is used for evaluating the general operability of the treatment plant. This list includes swirl, bar screen/conveyor, grit chamber/screen, dumpster, parshall flume, oxidation ditch rotors, clarifier collectors, clarifier scum removal, RAS and effluent pumps, blowers, digesters, polymer system, drying beds, on-site pump station, samplers, and flow meters. Mr. McClure indicated that this equipment receives a full PM service, i.e. greasing, oil changes, filters, belts, etc. at the first of every third month. We observed some spare parts on-site (i.e. grease, belts, filters) for implementing a preventative and predictive maintenance program. However, we observed no detailed written log or records of a preventative or predictive maintenance program. The card files used for the PM program and all other maintenance records were destroyed in the recent fire that occurred in one of the storage rooms of the Office Building.

Mr. McClure indicated that the treatment plant staff is continuously in a 'catch-up' mode in performing corrective maintenance repairs. Maintenance work orders are not issued in the plant to track and record equipment histories, repair tasks, priorities, spare parts, preventative maintenance schedules, and costs. Accordingly, we recommend that an emphasis be placed on developing a documented and functional maintenance program, which is essential in protecting the existing equipment at the plant, achieving maximum treatment performance and capacity from these facilities, planning for capital repairs or replacement of equipment, and supporting documentation for future plant expansions or the need for hiring skilled mechanical and electrical personnel.

The City of Kingston has not hired any skilled maintenance personnel with mechanical, electrical, and instrumentation experience to perform the necessary services for the sewage collection, pumping, and treatment systems. All maintenance of these facilities is relied upon the operations personnel assigned to the treatment plant, however no maintenance shop exists. The treatment plant has a small room where spare parts and a bench-top grinder provide the basic elements of a workshop, however we did not observe much other tools or maintenance equipment. We did observe a brand new bearing press unused and stored in a corner in its shipping crate. Major mechanical maintenance and electrical repairs are performed by an outside contractor, NDM Services, Inc.

LABORATORY ASSESSMENT

The laboratory at the Kingston WWTP is spacious and adequately equipped. All areas of the laboratory were generally clean and uncluttered. Discussions were held with Arley and Cookie concerning the laboratory techniques, analysis troubleshooting, and quality assurance/quality control (QA/QC) procedures used for NPDES permit compliance monitoring and process control. After a plant tour of the sampling equipment and monitoring locations by Ms. Carolyn McFalls, PSG Regional Laboratory Standards and QA/QC Coordinator, the discussions during our laboratory and QA/QC inspection were primarily focused on sample representativeness, collection, and analysis and the defensible quality of the analytical data produced at the Kingston WWTP.

During the laboratory audit, we discussed with the Kingston WWTP staff several recommendations for improving their laboratory records keeping and documentation, as well as improving the level of QA/QC and analytical results for the pH, DO, BOD_5, SS, Set. S, FC , and TCR laboratory procedures. A summary of our findings and recommendations are as follows:

Records Keeping and Documentation:

A central work sheet was being used to document various laboratory tests, however, not all of the information required by the NPDES permit was being documented for samples and analyses. Accordingly, the recommended information which should be recorded for the NPDES permit parameters include:

- o Exact place, data, and time of sampling
- o Exact person(s) collecting samples
- o Date and time the analyses were performed
- o Person who performed the analyses
- o Analytical techniques or methods used
- o Results of all required analyses

A separate worksheet should be prepared for each NPDES permit parameter with a specific column which documents the required information listed above. The analytical method for each parameter should be listed at the top of the worksheet. It is preferable that these worksheets and analytical results be recorded in ink pen (preferably black) in a bound laboratory bench book for proper and defensible records keeping. A 'Chain of Custody' record is suggested to show the type of sample collected and the sample handling procedures. This work sheet should provide a specific place to document the following information:

- o Exact place, date, and time of sample collection
- o Person(s) collecting the sample
- o Type of sample, i.e. grab or composite
- o Volume and temperature of sample
- o Date and time of sample delivery to the laboratory
- o Date and time of sample shipped to an outside commercial laboratory
- o Analytical procedures to be performed
- o Sample preservation

Documentation of composite samples, i.e. plant influent and effluent should show the date and time the collection was started and the date and time the collection was completed. The NPDES permit required twenty-four hour (24-hr) flow-proportioned composite samples should show a time period that generally covers one complete operating day and the amount of totalized flow for that period of time. The sampler activation counter should be recorded daily and the volume of sample in the composite containers to verify that a proper amount of sample was received, based upon the totalized flow.

Quality Assurance and Quality Control:

No records were available or existed to show the daily temperature readings of laboratory equipment or composite samplers. Calibration of the laboratory meters and probes should also be recorded each time the equipment is calibrated. Calibration of the laboratory equipment is performed periodically by Labtronix in accordance with their 'Accuracy Assurance Program'. The following recommendations will provide documentation to ensure higher quality analytical data generated at the Kingston WWTP laboratory:

o Provide a worksheet showing the temperature of all laboratory equipment and composite samplers. The following equipment should be monitored daily with the required operating temperature:

- Sampler refrigerators - 4.0 deg. C
- Laboratory refrigerator - 4.0 deg. C
- BOD_5 incubator - 20.0 deg. C (+/- 1.0 deg. C)
- Fecal Coliform water bath - 44.5 deg. C (+/- 0.2 deg. C)
- Solids drying oven - 103-105 deg. C

The thermometers for the BOD incubator, laboratory, and sampler refrigerators should be placed in distilled water and then placed in the equipment to accurately measure the wet bulb temperature and the reading of the samples being preserved.

An established quality assurance and quality control (QA/QC) program is required by the NPDES permit. The following suggestions are recommended to ensure more reliable sample results and a more defensible analytical data:

o Duplicate sample analysis (analyze the same sample twice) for each NPDES permit required parameter on at least a ten percent (10 %) of the samples analyzed each week. According to Kingston's NPDES permit, this would result in approximately four (4) duplicates per week, which should be rotated between the seven (7) parameters of BOD_5, SS, FC, DO, TCR, Set. S, and pH. This would allow every NPDES permit parameter to be analyzed in duplicate at a frequency of once every two (2) weeks.

o To ensure accurate calibrations and analytical technique, analyze a known standard for each NPDES permit parameter on at least a ten percent (10 %) of the samples analyzed each month. This would result in each NPDES permit parameter being analyzed and compared against a known standard at least once per month. Sample standards can be obtained for all of Kingston's NPDES permit parameters.

Specific details for performing QA/QC procedures and establishing a program can be referenced in the 18th Edition of 'Standards Methods for the Examination of Water and Wastewater'.

Sampling, Collection, and Preservation:

Our assessment is that noted deficiencies in the sample collection and preservation of Kingston's influent and effluent composite samplers could adversely affect the result of the analytical data being generated from these samples. Improved sampling technique and procedures will not only achieve NPDES permit compliance (previously discussed), but also improve the overall data reliability, representativeness, and defensibility at the Kingston WWTP. The following recommendations for sampling, collection, and preservation are as follows:

o Maintain the composite sample refrigerators at 4.0 deg. C for proper preservation of the samples being collected.

o The raw influent sample line should be collected upstream of the discharge point of the on-site pump station which contains plant process recycle streams and thereby provide a more representative sample of the raw influent flow. A thermometer stored in a small beaker of DI water should be located in each sampler to accurately monitor and document the preservation temperature of the composite samples.

o The influent and effluent samplers should be programmed to collect a flow-proportioned composite sample over a twenty-four (24) hour period as required by the NPDES permit. The current practice of time composite sample collected from late afternoon (3:00 p.m.) to early morning (7:00 a.m.) retrieves a sample during low flow periods. High flow periods generally occur during the daylight hours of late morning (11:00 a.m.) to mid-afternoon (2:00 p.m.), and another more moderate increases in the evening after dinner time (6:00 p.m. to 10:00 p.m.). A 24-hour flow-proportioned composite sample will result in a much higher fraction of sample collected during the high flow periods of each day and result in a much more representative sample of the influent and effluent quality.

o A mechanical counter should be installed on each sampler if the automated program does not contain such a feature so that a totalized value is determined each day as to the number of times the sampler was activated by reaching the predetermined flow milestone, i.e. every 5,000 gallons. This counter information can be compared to daily plant flows so that a consistent twenty-four (24) hour sample volume is obtained for analysis by making adjustments to the flow milestone when necessary for varying plant flow conditions, i.e. dry weather, wet weather, heavy rain events.

o The composite sampler collection tubing should be cleaned regularly (preferably weekly) and change the tubing periodically (preferably monthly) to prevent grease accumulation and other growth which can adversely affect the samples, i.e. elevated BOD_5 from oxygen demand caused by microbes in the tubing or artificially lower SS values from siphoning and attachment of solids to any grease and/or biological growth inside the tubing.

o The composite sample containers should be cleaned daily, with two (2) containers recommended for each sampler so that while one is being used, the other can be cleaned and made ready for the next twenty-four (24) hour sampling period.

During our laboratory audit, we inspected and evaluated the analytical procedures in place for the NPDES permit parameters of biochemical oxygen demand (BOD_5) and suspended solids (SS) and pH. Discussions were also held regarding the procedures used for settleable solids (Set. S), fecal coliform (FC), dissolved oxygen (DO), and total chlorine residual (TCR). Our recommendations for these parameters can be referenced using the 18th Edition of Standard Methods:

Biochemical Oxygen Demand (BOD):

The five-day test results for biochemical oxygen demand (BOD_5) showed good results and the calculations are being performed correctly. However, the current practice of calibration of the DO probe of the YSI meter is not the correct procedure. The following specific recommendations will improve the overall reliability of the BOD_5 test:

o Calibrate the DO probe according to the manufacturer's instruction manual. This can be done either by using the air calibration technique or the Winkler titration technique. Currently the probe is calibrated using a combination of both. The probe is placed in a flask of water which is being continuously aerated and adjustments are made using the air calibration procedures. Air calibration requires that the probe be placed in a moist environment, not a wet or aerated environment. Water that has been aerated is used in the Winkler titration procedures, where the air has been turned off for approximately twenty (20) minutes to allow for stabilization and equilibrium with atmospheric pressure.

To properly calibrate the probe using the air calibration technique, place the DO probe in a BOD bottle containing approximately one to two inches (1-2") of distilled water and follow the current procedures for air calibration. Do not immerse the probe in the water. Allow enough time (approximately five minutes) between each step to ensure reading stabilization.

o BOD_5 samples should have a neutral pH between 6.5 and 7.5 s.u. Check the pH of each sample and adjust it if necessary using a small amount of a weak acid or a weak base chemical.

o Prepare the dilution water fresh with each BOD_5 set up, which results in a three times per week basis (3/wk). Prolonged storage of the dilution water (more than 24 hours) is not recommended since it can become contaminated with bacteria and adversely affect the results. If the degree of contamination causes the dilution water blank to exceeds a DO depletion greater than 0.2 mg/L, then the BOD_5 samples will also be adversely affected.

o Deionized water (DI) as opposed to distilled water could be used to prepare laboratory dilution water, since DI water is higher grade.

o Thoroughly clean the siphon tubing used in the dilution water after each use. The siphon tube should be cleaned with diluted sulfuric acid (50% solution by diluted in half with water). As an alternative, the tubing can also be cleaned with household chlorox and allowed to soak overnight. After either procedure, the tube should be rinsed thoroughly with tap water followed by a rinse with distilled water.

o Change the siphon tubing and air stone used to aerate the dilution water on a monthly basis and between uses, store the tubing in a clean storage bag to prevent contamination.

o Place an air filter in the tubing between the air pump and the air stone to prevent contamination from the air source.

o Include the BOD stoppers in the acid washing procedures and store the stoppers in the BOD bottles. Acid wash the BOD and dilution water bottles after each use.

o Flush approximately 300 mls of dilution water thorough the siphon tubing prior to filling the blank bottles and thoroughly rinse the DO probe with distilled water prior to taking the initial reading of each bottle.

o Keep the BOD bottles stoppered until the initial DO reading is taken to minimize or prevent atmospheric contamination. During the initial DO reading, place the stopper on a clean paper towel.

o The BOD incubator should be maintained at 20 deg. C and adjusted if the temperature gets any colder, since colder water dissolves more readily and absorbs a higher level of oxygen. A colder temperature will also artificially increase the DO depletion during the five-day incubation period.

o If the BOD bottles are supersaturated the DO, indicated by an initial reading greater than 9.0 mg/L, then release the excess DO by warming the sample in warm/hot water. If the DO remains greater than 9.0 mg/L, then try aerating the sample for approximately fifteen (15) minutes using a separate air stone and tubing.

Suspended Solids (SS):

The suspended solids (SS) samples at the Kingston WWTP laboratory are being filtered and placed in the drying oven overnight. If the drying oven does not maintain a constant temperature throughout the overnight period, solids may be volatilized during the drying process resulting in low solids results.

The SS samples are placed in a desiccator using a moisture indicating desiccant for cooling prior to weighing the samples for the final reading. However, the desiccant used in the desiccator appeared to be saturated with moisture, a pink color had developed. The indicating desiccant should be blue in color. The following recommendations should improve the quality of the data generated for the SS samples:

- o Place the SS samples in the drying oven for one (1) hour. Repeat the drying cycle of cooling, desiccating, and weighing until a constant weight is obtained. A constant weight is obtained when the weight loss is less than four percent (4 %) of the previous weight or 0.5 mg., whichever is less.

- o Regenerate the desiccant at least monthly by placing it in the drying oven overnight. This will remove the moisture and return the desiccant to a pink color.

- o Calibrate the analytical balance on a daily basis with two (2) weights which bracket the applicable weights measured.

- o Prewash the filter papers before use by filtering three (3) 20 ml washings of distilled water through the filter paper. Place the papers in the drying oven for a minimum of one (1) hour and store in the desiccator until needed for sample use.

pH:

The pH testing was being performed using an Orion 901 pH meter. According to Orion Technical Services, this meter is obsolete and should be replaced with a more modern and accurate meter. The Orion 901 meter does not provide any means of compensating for the temperature of the sample being measured. pH is very temperature sensitive and therefore, the temperature the sample must be known and compensation made in order to provide accurate results.

During our laboratory review, we also noticed that the reported pH for the effluent was being obtained from the composite sample and not a grab sample from the outfall manhole. pH is an instantaneous measurement and can change significantly with time and varying temperature. According to the NPDES permit and standard procedures, all pH measurements should be taken on grab samples and analyzed within fifteen (15) minutes of sample collection.

The practice of measuring effluent pH from the time composite sample should be immediately discontinued and the grab sample procedure implemented at the designated NPDES Permit discharge location at the downstream outfall manhole.

To correct the known deficiencies of the pH sampling and testing, the following recommendations should be implemented as soon as possible:

o Purchase a new pH meter which is capable of temperature compensation, with HACH Company a reputable and cost effective vendor for this standard analytical equipment. On the interim, temperature compensation should be performed manually or by using an automatic temperature compensation (ATC) probe.

o Collect all pH samples by the instantaneous grab procedure and analyze within fifteen (15) minutes of collection.

o Calibrate the new pH meter daily by using three (3) buffers at pH of 4.0, 7.0, and 10.0 s.u. in accordance with the manufacturer's instructions. Use pH buffers which are NIST (National Institute of Standard Technology) traceable and certified. Begin the pH meter calibration procedure with the neutral pH 7.0 s.u. buffer first, since it provides a good set point for the following buffers used in the calibration. Proceed with the low and high buffers, and then finish the calibration test by resampling the probe in the nuetral 7.0 s.u. buffer. Then commence with the process samples, allow for temperature compensation and more accurate results will be produced.

Settleable Solids (Set. S):

The settleable solids (Set. S) samples at the Kingston WWTP laboratory are being properly performed in accordance with Standard Methods using Imhoff cones. However; the Imhoff cones used in this analytical procedure were dirty to the point of appearing difficult to obtain accurate readings. Dried solids were observed in the cones at sufficient amount in our assessment to prevent accurate reading of the level of settled matter, especially at the bottom (effluent samples). As previously discussed, the monthly Operations Report and DMR reported zeros (0 ml/L) for the effluent samples. Accordingly, the following recommendations are provided to increase the level of accuracy of Set. S measurements and proper reporting of effluent results:

o Clean the Imhoff cones daily to ensure that accurate readings can be obtained.

o If no Set. S are visually observed in the bottom of the Imhoff cone, the first graduated marking on the bottom of the Imhoff cone as 0.1 ml/L is the detection limit for this analytical method, and thus, the result should be reported as less than (<) 0.1 ml/L as Below Detection Limit (BDL).

Fecal Coliform (FC):

The fecal coliform (FC) effluent samples at the Kingston WWTP are being improperly collected in a non-sterile container and then transferred to a sterile fecal bottle. The grab sample at the outfall manhole is used to perform the effluent fecal coliform analysis. Its collection in a non-sterile container in the field could allow for contamination of the effluent sample and result in increased fecal counts. However, the effluent quality for fecal coliform counts as evidenced in Figure II-7 does not indicate this contamination problem to be adversely impacting this test.

The NPDES permit requires that fecal coliform colonies be reported by the number of colonies per 100 ml of effluent sample. The current procedure used by the Kingston WWTP staff for counting fecal coliform colonies is incorrect. Only 10 ml of the sample is being filtered by the Kingston staff, and thus only ten percent (10 %) of the proper and required volume of effluent sample was being analyzed. Colony counts should respresent 100 ml of the effluent sample. This significant shortage in sample for fecal coliform analysis may explain the very low effluent values for Kingston's secondary effluent as compared to our experience with secondary effluents of similar levels of turbidity, suspended solids, and total chlorine residual.

If no growth is obtained after analyzing 100 ml of effluent sample, the FC result should be reported as if one (1) colony is present as the detection limit of this method. Even at the lower sample volume of 10 ml, the calculations by the Kingston WWTP staff were not properly being computed to account for the smaller volume by making the result equivalent to the colonies which would be present in a 100 ml sample. For example: 10 ml of the sample was filtered and no colonies grew on the plate, the sample results should be reported as 10 colonies per 100 ml. The formula for calculating fecal colonies is as follows:

- Fecal coliform $= \dfrac{\text{Number of Fecal Colonies Counted}}{\text{Volume of Sample Filtered}} \times 100$

One (1) fecal colony counted divided by 10 ml sample filtered x 100 = 10 colonies per 100 ml.

To improve the accuracy of the fecal coliform test at the Kingston WWTP laboratory, the following recommendations should be implemented:

- Prepare a minimum of three (3) dilutions per sample. The permissible chlorine residual in the effluent should be high enough to allow for sample volumes of 25, 50, and 100 ml which produce acceptable growth of colonies. Plates which produce 20 to 60 colonies produce the most reliable counts. If no plates at these concentrations and sample volumes produce the desired 20 to 60 colonies, use the count closest to the desired range for calculation and reporting of sample results. If no colonies develop on any of the plates, use the highest sample concentration and volume, and report as if the plate contained one (1) fecal colony. No growth on the 100 ml sample could then justify a reported result of one (1) fecal colony.

o Filter and incubate a blank sample of sterile buffer water each time the test is performed. This will ensure that the filtration device and measuring device are free from contamination.

o Prepare the fecal buffer water by adding 5 ml of magnesium chloride solution and 1.25 ml of stock phosphate buffer solution (pH of 7.2 s.u.) to one (1) liter of distilled water. Fill the buffer water bottles and autoclave the bottles for fourty-five (45) minutes. The current practice by the Kingston WWTP staff is to only add the stock phosphate buffer solution. Additional information on this procedure can be referenced in the 18th Edition of Standard Methods.

o Maintain the fecal water bath at a temperature of 44.5 deg. C with an allowable variation of +/- 0.2 deg. C. We observed the water bath to be 45.8 deg. C, which is approximately 1.1 deg. C higher than the allowable range.

Dissolved Oxygen (DO):

During our audit of the laboratory procedures and review of the analytical documentation, we identified that the initial reading of the final effluent BOD_5 samples is being reported as the final effluent dissolved oxygen (DO) concentration. According to Kingston's NPDES permit, the final effluent DO reading should be obtained in the field at the designated discharge outfall manhole using a grab sample as an instantaneous measurement to produce accurate results. The current practice of using the effluent BOD_5 sample from the composite sampler allows for significant reduction in the level of DO in the sample and the testing of the BOD_5 sample has also been diluted with BOD_5 dilution water. Furthermore, the measurement of the initial DO reading with the current and improper aeration practice of the BOD_5 samples further biases the accuracy of this test. Accordingly, the following procedures should immediately be implemented to properly analyze for effluent DO and achieve NPDES permit compliance for self-monitoring of this discharge parameter:

o Purchase a field DO probe and meter, such as the common and very reliable YSI model and obtain the final effluent reading in the field at the designated NPDES discharge outfall manhole.

o Calibrate the field DO probe using either the air calibration or Winkler titration techniques previously discussed in the BOD section of this report.

Total Chlorine Residual (TCR):

We observed either a HACH DR 100 colorimetric meter or a Spec 20 are used to measure Total Chlorine Residual (TCR) concentrations of the effluent from a grab sample obtained at the NPDES designated outfall manhole and transported back to the laboratory. The measurement of the TCR in the final effluent should be performed in the field at the grab sample location as an instantaneous measurement, because chlorine will dissipate from a small sample volume in a short period of time and thereby result in erroneously lower values.

During our review of the analytical procedure using the HACH DR 100 meter, we noticed that the sample vial used in the test requires 10 ml of the effluent sample for proper measurement. However, the DPD reagent pillows being used were specifically for a 25 ml sample volume. Thus excessive amount of reagent used in the test will result in a positive bias of sample results because of the over development of color produced by the supersaturated reagent conditions. This could result in the overstatement of the actual amount of TCR present in the effluent and result in the reporting of a NPDES permit violation, which is caused by an inaccurate and falsely high reading. To correct the underbias and overbias problems with the current TCR sampling and measurement procedures, the following changes should immediately be implemented:

o Continue to use the HACH DR 100 colorimetric meter for TCR analysis as an EPA approved method and instrument, and discontinue any use of the less reliable and difficult to calibrate Spec 20.

o Transport the HACH DR 100 meter in its plastic carrying case to measure TCR in the field at the discharge outfall manhole as an instantaneous measurement of the grab sample.

o Purchase and use DPD reagent pillows specifically for 10 ml samples and read the proper bottom scale on the DR 100 meter for use of 10 ml vials with the measuring range of 0.0 to 3.0 mg/L.

o As recommended by the manufacturer's instructions manual for the DR 100 meter, a minimum of three to six (3 to 6) minutes should be allowed for proper color development prior to reading the sample results. The current practice by the Kingston WWTP staff of reading the TCR concentration immediately should be lengthened to the proper waiting period. However, the sample should be read before six (6) minutes to prevent an over development of color or dissipation of chlorine from the small sample vial, which would bias the results.

Other general recommendations for improving the overall analytical performance at this facility would include the following:

- o Provide training to the wastewater staff regarding proper laboratory and analytical QA/QC procedures. The Tennessee Water and Wastewater Association (TWWA) in Murfreesboro provides a two (2) week course for laboratory procedures. Roane College also provides a more lengthy, but detailed laboratory program in their 2-year curriculum. One of the existing Kingston WWTP operators, Mr. Gary Davis expressed to us a strong interest in participating in this type of training to become certified in the laboratory with a desire to be responsible for the various tests and analytical functions at this facility.

  This type of interest should be considered and developed, so that most of the laboratory tests during the week our performed primarily by one (1) staff member, who develops a higher level of proficiency and precision in their techniques to enhance the accuracy, reliability, and defensibility of the analytical data generated at the Kingston WWTP. This training and instructional knowledge must also be routinely transferred and passed-on in a methodical manner to another staff member so that adequate back-up and staff coverage in the laboratory is achieved.

- o Laboratory testing and procedures for Total and Volatile Solids concentration measurements should be reviewed and implemented in anticipation of the required influent and effluent digester biosolids sampling. This will be required to demonstrate PSRP for compliance with 40 CFR Part 503 Regulations, if land application is implemented at the Kingston WWTP. The required Total and Volatile Solids (% TS and % VS) procedures can be found in the 18th Edition of Standard Methods in Part 2540G.

STAFFING AND TRAINING ASSESSMENT

The Kingston Wastewater Department has generally four (4) employees on staff who operate the collection system, lift stations and treatment plant. All of the four (4) wastewater department employees are full-time. Two (2) of the employees are scheduled on an eight (8) hour work day from Tuesday through Saturday. Two (2) other employees, including the Wastewater Treatment Supervisor (WTS), are scheduled on an eight (8) hour workday from Sunday through Thursday. This staffing schedule allows for weekend coverage and a full plant staffing of four (4) employees during the weekdays of Tuesday through Thursday. Mr. Gene McClure, the WTS, holds a Grade II Wastewater Operators license and it did not appear that the three (3) Plant Operators were certified. None of the treatment plant employees are certified in collection systems. During our plant tours, it was mentioned that another City of Kingston employee in the Sewer Department is certified for operation of collections systems, but this individual is assigned to the field crew and does not work at the treatment plant or support the existing collection system or lift stations.

Our general assessment is that the City of Kingston Wastewater Department is adequately staffed in terms of the number of employees, however, the health problems of the three (3) plant operators adversely impacts the level of productivity and personnel resources at the treatment plant and lift stations. It appears that a disproportionate level of work and responsibility is being placed on the Wastewater Treatment Supervisor (WTS) to handle most of the operations, maintenance, and management (OM&M) functions of the Kingston WWTP and collections system.

However, the NPDES permit compliance, operations, process control, biosolids management and disposal, safety, record keeping and compliance reporting, administration, and process/preventative maintenance can not be sufficiently and adequately accomplished with long term reliability and success if only one (1) of the four (4) employees is functioning at a normal and acceptable level of work effort and productivity.

This staffing assessment is based upon our identification of various performance limiting factors and areas needing improvement in the treatment plant and lift stations, as well as our direct observations of the low level of worker activity during four (4) plant visits. To elevate the level of OM&M at the Kingston wastewater facilities in the numerous areas discussed in this Assessment Report will require a much higher level of effort, commitment, and productivity by the existing three (3) plant operators. If health problems limit these employees on a longterm basis from performing normal and desired responsibilities at the treatment plant and lift stations, then the City of Kingston management should seriously review and evaluate these current personnel and consider making adjustments in the allocation of assignments and level of staffing.

This Assessment Report strongly indicates that despite a healthy and motivated WTS, the Kingston wastewater collection and treatment system is in need of immediate and full-time support to address and correct the identified deficiencies and recommended corrective actions. A dependable, fully productive and proficient Assistant WTS should be considered with a specified requirement of this individual obtaining a Grade II wastewater operators license within a reasonable period of time (i.e. two years) to serve as the back-up to the WTS. One candidate the City of Kingston should consider for this type of position is the certified collections system employee presently assigned to the sewer field crew. This individual could be primarily assigned to daily inspect and oversee the OM&M aspects of the lift stations and support the WTS in heavier duty plant operations, i.e. biosolids pumping and processing. A reassignment of this individual to the treatment plant would also facilitate the WTS in obtaining the necessary collections system certification.

Additionally, the City of Kingston should consider making it a priority to train and develop a plant operator to be the primary staff member responsible for the weekly (M-F) laboratory tests and analytical functions of the treatment facilities to increase the overall level of QA/QC and data reliability, accuracy, and defensibility. This individual should also be assigned lighter duty responsibilities in the operations of the treatment plant, i.e. sampler inspection and cleaning, process sampling, tank/weir washing, general housekeeping and facility cleaning, monthly Operations Report and DMR preparation, etc.

The fourth plant operator should also be proficient in the basic process control laboratory tests and the NPDES Permit parameters which require analysis on the weekends for support of the analytical functions of the WWTP, and have an emphasis in preventative maintenance of equipment, assistance to the Wastewater Treatment Supervisor in major corrective maintenance or specific operational tasks, and groundskeeping, i.e. lawn mowing, clipping, washing, sweeping, painting, and other housekeeping tasks.

A formalized training program on process control, plant safety, and preventative maintenance should be emphasized for all treatment plant staff, with a goal of obtaining basic levels of certification for specific employees which are providing support to specific areas, i.e. collections or laboratory. Process areas which require the highest level of operations and control training include oxygen supply and demand in activated sludge systems, clarification, and aerobic digestion. If the City of Kingston implements land application of liquid biosolids on agricultural farms, training and thorough knowledge of the required operations, sampling, monitoring, and record keeping requirements of 40 CFR Part 257 and 40 CFR Part 503 Regulations will be critical and essential to achieving compliance. A land application program will require a well managed biosolids program and increased control of solids inventory to achieve successful implementation and ensure its viability as a long term beneficial use and disposal method of biosolids from the Kingston WWTP. In-house hauling and application of biosolids would appear to necessitate another plant operator to oversee the various technical and regulatory aspects of a viable LAP.

SAFETY ASSESSMENT

No strong evidence was observed or identified that a formal or well documented safety program was in place. Personal protection equipment (PPE), i.e. safety goggles or glasses, steel toed foot wear, hard hats, gloves, and hearing protection equipment should be made available and worn by the employees on a daily basis during routine operations, process control, and maintenance activities. Appropriate laboratory safety equipment should also be used, i.e. safety goggles, laboratory coats, and rubber gloves and aprons as a required part of the analytical procedures for the Kingston WWTP. Eating of food and drinking of beverages should not occur in the laboratory for basic contamination and sanitary reasons. The Occupational Safety and Health Association (OSHA) requirements and details for use of PPE can be referenced in 29 CFR Part 1910.133, 135 & 136, Subpart I.

Refresher training on at least an annual basis should be held for all aspects of chlorine gas storage, handling, injection, leak detection and repairs, provided by the chlorine supplier or manufacturer of the chlorine safety and repair equipment. A high emphasis should be placed in the concern area of confined space entry with the numerous pumping stations in the collection system, the on-site pump station, and effluent wet well.

Many physical hazards were noted during our plant visits and the following specific areas were observed by Mr. David Sams, Regional Safety Health and Compliance Officer for PSG, during our second visit to the Kingston WWTP:

o General Housekeeping - Inside of process buildings, i.e. lift stations, grit blower/influent sampler room, digester blowers & polymer room were very dirty, dusty, and floors cluttered with debris, broken equipment, trash, etc. which present a trip hazard and unsafe work environment for performing routine and detailed inspection and maintenance of affected equipment.

o Equipment Storage - Numerous hoses lying around the entire facility, i.e. swirl, grit chamber, effluent weir of oxidation ditch, secondary clarifiers, entrance to Laboratory/Office Building, which creates a potential slip, trip, and fall hazard.

o On-Site Pump Station - This below ground facility should be labeled with a sign and permitted as a 'Confined Space Entry' location with the standard operating procedures to be followed as outlined in 29 CFR 1910, Part 146.

o Grit Chamber - The damage to eye bolts that secure the gaurd chains on the railings should be repaired and chains should be installed in unsecured and open areas to the grit chamber. The divider plates which are located within the grates should be painted a bright color (preferably yellow or orange) where the rise of six (6) inches is above ground to warn against and prevent a slip, trip, or fall hazard.

o Grit Blower Room - The bolts on the electrical panel should be secured and this panel door closed to prevent from a spark or electrical shock hazard. The influent composite sample should be labeled for identification of liquid contents in refrigerator. Debris and broken equipment should be picked from floor and thrown away and any useful spare parts stored neatly on a shelf above ground to prevent a slip, trip or fall hazard.

o Oxidation Ditch - Repair and/or replace damaged railing at the side nearest the Laboratory/Office Building, as well as the railing which leads to the coupler motor. A gaurd should be placed over the exposed shaft of the coupler motor. The butt chain should be replaced on the rotor pit nearest the Laboratory/Office Building to prevent a slip, trip, and fall hazard. The hosing at the effluent end of the oxidation ditch over the grating should be neatly coiled and stored adjacent to the personnel walkway. An orange painted tubular life preserver (ring buoy) should be available at the oxidation ditch.

o Secondary Clarifier - The hosing strung across the walkways at the secondary clarifiers should be neatly coiled and stored on the ground, but adjacent to these personnel areas to prevent a slip, trip, and fall hazard. The broken and bent railing around the secondary clarifier #2 should be repaired and/or replaced. The eight inch (8") P.V. valve openings are uncovered and should be guarded at all times. At the time of safety walk-through, we observed the grating to the secondary scum pump pit to be removed for equipment inspection and maintenance, however, a red or orange safety tape should be installed around the opening to warn and gaurd about the fall hazard. An orange painted tubular life preserver (ring buoy) should be hung on the railing of the secondary clarifiers.

o Digester Blower/Generator Building - The battery used for the back-up generator should have boot covers installed over the exposed terminals. The numerous loose equipment, files, furniture, and other debris should be organized, neatly stored, or waste thrown away to allow safe and unrestricted access to the digester blowers and effluent sampler and prevent a general slip, trip, and fall hazard in this area. Electrical panels should be closed and secured to prevent a spark or shock hazard.

o Chlorine Storage/Feed Rooms - 'Danger - Chlorine' signs should be installed on the outside of the doors leading to these rooms. The emergency 'B' kit stored in the corner of the Maintenance Room should be relocated to the Chlorine Feed Room for quick and more immediate access to the adjacent Chlorine Storage Room. A fire extinguisher should be installed inside the Chlorine Feed Room. The chlorine ton container valve should have a valve stem installed for emergency shut-off. A monthly inspection log needs to be established and maintained for the SCBA's, which documents pressure and functionality as required by Occupational Safety and Health Association (OSHA).

o Aerobic Digester - The six inch (6") P.V. valve located next to the stairs of the digesters is missing its cover, which leaves the valve exposed and this device should be gaurded. An orange painted tubular life preserver (ring buoy) should be hung on the railing of the digesters in the event of an emergency for floatation.

o Drying Beds - The debris and broken tools on the floor of the polymer room should be removed to prevent a slip, trip, and fall hazard. A 'Hazard - Slippery Polymer' sign should be installed on the outside door of the Polymer Room to indicate the dangers of residual polymer on the floor and around the storage equipment which poses a real concern for slip, trip, and fall hazard. The polymer tank should also be labeled for chemical identification. The presence of a fire extinguisher for the Polymer Room and drying bed area should be installed if not already present, since this area of the plant is fairly remote.

o Laboratory/Office Building - The loosely strewn hosing on the sidewalk outside the Laboratory/Office Building should be neatly coiled on a wall mounted hose bib to prevent a slip, trip, and fall hazard. The laboratory door should have a sign posted outside which states the required PPE for this room, i.e. lab coats, safety glasses, etc. No food or drink should be stored in the lab refrigerator which contains any chemicals or samples and food or drink should not be consumed in the laboratory on the bench-top counters for sanitary reasons. The fire extinguisher in the laboratory should be recharged and included in the routine inspections by Buck Fire Control.

Various OSHA regulations and potential violations of same for the physical hazards observed during our plant walk-throughs should be referenced for Facility Grounds, Floors, Aisles, and Stairways (29 CFR Part 1910.21- 23, 176 as Subpart D); Housekeeping (29 CFR Part 1910.22,252,253); Offices (29 CFR Part 1910); Machine Gaurd and Safety Devices (29 CFR Part 1910.212), and Signage and Color Coding (29 CFR Part 1910).

During our second plant visit, which included an emphasis on personnel safety and health, we did not observe an OSHA 200 log posted on the main hallway bulletin board or the presence of Material Safety Data Sheet (MSDS) binders in the Laboratory/Office Building. However, we did observed posted on the bulletin board, a Citation and Notification of Penalty by the Tennessee Department of Labor (TDL), Division of Occupational Safety and Health, issued on August 16, 1994 for two (2) serious and two (2) nonserious violations of 29 CFR Part 1910. An inspection of the Kingston WWTP by the TDL was performed on August 4, 1994. It appears that the two (2) serious violations of 29 CFR 1910.215 concerning equipment spacing for the grinding machinery has been corrected.

The two (2) nonserious violations of 29 CFR 1910.22 for place(s) of employment being not kept clean and orderly and 29 CFR 1910.146 for dangers of permitted entry of confined spaces have not been adequately corrected. We observed many facilities and buildings which require personnel access and operation which are not kept clean or orderly. While a Confined Space Entry sign exists at the noted location of the TDL Citation for the effluent wet well hatch in the corner of the Pump Room, other locations, i.e. on-site and off-site pump station dry and wet wells do not contain posted danger signs and other effective means of informing employees to the exposure of dangerous gases and permitting requirements for entry of confined spaces. These two (2) nonserious violations were supposed to be abated by September 18, 1994 and we did not find any documentation concerning the response to the Citation and Notification of Penalty.

In response to our concerns of personnel safety, as well as continued risk of violation(s) of various 29 CFR 1910 requirements and future citations by TCL, Division of Occupational Safety and Health for serious violations, several important site-specific written programs need to be developed in a summary format for the Kingston WWTP and training provided for all of the Wastewater Department employees for the following:

o Hazard Communications - A Material Safety Data Sheet (MSDS) for all chemicals used at the treatment plant and lift stations should be readily available and routinely updated, if a new or different grade of chemical is used. Chemicals include all process, maintenance, and laboratory fluids used by the Kingston Wastewater Department. A notebook or binder of all chemicals used should be developed and maintained in the Laboratory/Office Building, with the individual types organized alphabetically and protected with individual plastic sheets. Site specific locations of chemicals, i.e. chlorine, CCH or HTH, polymer, lift station degreaser, lift station deodorant, etc. should have its MSDS in a plastic sheet for water/dirt protection and mounted on the wall of each chemical storage room or area. Additionally, training of all wastewater personel should be conducted for all chemicals at least annually and before any new or different type/ grade of chemical is introduced into the work environment. This Chemicals Hazard Communications program can be referenced in detail as 29 CFR Part 1910.1200, Subpart Z.

o Confined Space - A written program should be developed to identify confined spaces, i.e. on-site pump station , effluent wet-well, lift station dry and wet-wells, etc. and include standard operating procedures for identifying hazardous conditions which may occur before and/or after entry. All confined spaces must be labeled as such and training conducted with all wastewater personnel for entry, attendant, supervisor and rescue operations using gas monitoring, retrieval and self-contained breathing apparatus (SCBA) equipment. This Confined Space Entry program can be referenced in detail as 29 CFR Part 1910.146.

o Lockout/Tagout - An energy control and dissipation control program using lockout/tagout procedures should be developed and implemented to eliminate the control of energy sources during operations where an employee has the potential for exposure to electrical or mechanical hazards. All wastewater employees who may be exposed to mechanical and electrical components should be trained on the proper use of locking and tagging equipment to control energy sources, dissipate power, and prevent electrical shock and potential serious burns and physical injury to personnel. This Lockout/Tagout program is described in 29 CFR Part 1910.147.

o Emergency Response - In the event of an emergency, i.e. rupture of a chlorine one-ton cylinder or fire, an emergency response and injury prevention plan should be developed and discussed among treatment plant and other City department personnel. This emergency response plan should identify wastewater personnel responsibilities during such an emergency to mitigate equipment damage and prevent personnel injury, which may require total plant evacuation and notification of evacuation of nearby residents and the support of City fire, ambulance, or other emergency response equipment and personnel. This Emergency Preparedness program can be referenced in detail as 29 CFR Part 1910.37,38 & 151 and a Fire Protection program as 29 CFR Part 1910.106,157 & 166.

o Chemical Hygiene - This program lists the inventory of hazardous chemicals in the wastewater laboratory which pose an occupational hazard, permissible exposure limits for air contaminants from these chemicals, standard operating procedures and hygiene practices to be followed when using these chemicals in the laboratory, and control measures to ensure proper and adquate performance of protective equipment, i.e. fume hoods, ventilation, eye protection, eye wash stations, lab coats, etc. This Chemical Hygiene plan is described in 29 CFR Part 1910.145.

BUDGET AND ENERGY ASSESSMENT

Limited financial, budget and electrical consumption was made available for our evaluation, and accordingly, no detailed economic assessment was performed for the Kingston WWTP and collection system. Observations during the on-site visits did indicate areas in which power consumption and thus electrical cost savings could be achieved with the implementation of various corrective actions discussed in this Assessment Report. Specific components of the Kingston wastewater system will require an immediate financial commitment to implement the recommended corrective actions, which should yield the benefits of an improved operating system, reduced power consumption and thereby result in a timely payback of the investment and sustained lower operating costs.

Installation of run timers on the lift station wet well pumps will produce valuable information on the operability and efficiency of these motors. Reduction in I/I in the collection system will reduce the overall level of pumping in both the collection system and treatment plant from lower wastewater flows and result in electrical power savings. The repairs of the supply air leaks to the aerobic digesters by replacing the buried line and dry rot gaskets with above ground and insulated line could result in reduced blower operation and associated electrical savings as much as $12.5K per year. The conversion of potable water to chlorinated process water (PWC) for facility spray and wash water and thereby save the cost to the City of Kingston associated with a water demand of 28,000 gpd for the wastewater treatment plant.

During our plant visits, we did not observe any glaring deficiencies in equipment and supplies that would indicate shortfalls with the existing operating budget. However, it appears that some expenditures are deferred or minimized, i.e. biosolids disposal due to undesireable landfill tipping fees or equipment repairs/instrument calibrations due to outside contractor costs, have been detrimental to the operations, process control, and maintenance of the Kingston wastewater facilities. An emphasis should be placed on spending funds for preventative maintenance and housekeeping to minimize and reduce more expensive corrective maintenance and repairs. Additionally, the City of Kingston should initiate and adopt an annual capital spending budget for maintaining and building the wastewater infrastructure and developing a more longterm capital fund for planning for growth and necessary expansion.

PERFORMANCE LIMITING FACTORS

Overall, the moderate to severe I/I problems experienced intermittently at the Kingston WWTP, coupled with the lack of sufficient operator attention to the operational/process control practices of specific unit operations, maintenance/housekeeping of various facilities, and methods of sampling, laboratory procedures, and analytical data reporting have limited the levels of compliance, quality, stability, efficiency and cost effectiveness of this facility. The specific factors which contribute to limitations of optimal operations, maintenance, and management (OM&M) performance in the Kingston wastewater collection system and at the WWTP are summarized as follows:

Wastewater Collection System

- The continued levels of moderate to excessive infiltration/inflow (I/I) have placed an elevated and undesirable burden on the older sections of the collection system and thereby require its rehabilitation and expansion to adequately support existing sewer customers and anticipated growth.

- No written specific technical and financial plan has been developed by City management and approved by City officials and the community to systematically upgrade the existing wastewater collection system infrastructure. Without a plan, no annual budgeting process and mechanism for expending approved funds occurs sufficiently to attract new sewer customers (tax revenue base) and adequately upgrade and expand the system to prepare and handle the projected growth levels in the City of Kingston.

- No specific program or strategy exists with approved technical and financial resources to address the I/I problems beyond point-source repairs. No active I/I reduction program, which includes review of past records and corrective actions, mapping of problem areas, walking of sewer lines, inspection and repair of manholes, flow and temperature monitoring, dye and/or smoke testing, and public education.

- Insufficient commitment to sub-contract, lease or own equipment and utilization of personnel to adequately implement an on-going preventative maintenance and scheduled sewer line cleaning program to prevent loss of needed existing capacity and lower risk of collection system problems in blockage, surcharges or overflows.

- Lack of recent review of standard plans and specifications for new system construction to ensure updated criteria for use of proper materials and methods of installation by developers and contractors, which protect from regulatory violations and prevent future problems of insufficient upstream capacity for new growth.

o General poor level of care and attention to operation and maintenance (O&M) of pump stations, resulting in clogged barscreens, reduced transmission capacity, excessive pumping, unsafe and hazardous work conditions, unkept and dirty facilities, no log forms or documentation of O&M activities, and no or broken runtime meters on pumps. Inadequate routine inspection by management personnel to identify and correct obvious deficiencies.

Wastewater Treatment Plant

o Continued moderate to severe infiltration/inflow (I/I) problems have a direct adverse impact on the ability of the treatment plant to maintain process control and achieve NPDES permit compliance by preventing internal plant bypasses of raw influent around the biological treatment system.

o The continued I/I problems reduce the hydraulic treatment capacity of the existing oxidation ditch and thereby presents an impression to the Kingston wastewater staff of the immediate need to construct a second oxidation ditch and two more secondary clarifiers to handle near future flows and loads from anticipated growth.

o Inadequate operations and maintenance efforts assigned to resolving the long term problems with the influent mechanical bar screen, which results in regulatory agency concerns and adversely impacts the downstream processes in the treatment plant and physical appearance of the dried biosolids for disposal or beneficial use.

o Improper influent and effluent sampling by automatic equipment which does not provide twenty-four (24) hour, flow-proportioned, and refrigerated composite sample as required by the NPDES permit for representative and accurate self-monitoring of treatment plant performance. Additional concerns of representativeness of effluent composite sample from potential intake of supernated flow in effluent wet well and/or backflow of clarified and chlorinated effluent from discharge manhole and outfall line.

o Improper reporting of analytical data of discharged effluent on monthly TDEC Discharge Monitoring Report (DMR) for BOD_5, SS, and Set. S parameters, which result in the misrepresentation of actual effluent quality and high risk of notice of violations of NPDES permit and enforcement actions by TDEC.

o Insufficient operational monitoring and process control applied to specific operations of oxidation ditch oxygen demand, secondary clarification thickening and solids inventory, chlorination TCR, and aerobic digester volatile solids reduction, which limits knowledge of performance, reliability, and efficiency.

o Insufficient level of oxygen supply and dissolution to properly match existing oxygen demand from current flows and loads, and thereby creates oxygen deficit conditions and potential bleed-through of organics into effluent. Inadequate oxygen supply from existing aeration equipment to operate existing oxidation ditch at design organic loading capacity to meet NPDES permit limits and thus, no ability to reliably and efficiently operate biological system as constructed capacity is approached and reached from anticipated future growth.

o Excessive biosolids inventory in the oxidation ditch and secondary clarifiers from insufficient solids processing and disposal at treatment plant. Undesirable 'sludge bound' operating conditions create excessive oxygen demand in oxidation ditch, poor biosolids settling characteristics and high risk of solids washout in clarifiers during wet weather and peak hydraulic loadings, resulting in unintentional loss of solids in effluent and subsequent deteriorated quality.

o Severe and costly air supply leaks to aerobic digesters resulting in the continuous operation of a third blower and the inability for adequate aeration and mixing to achieve proper and desired performance for both digesters. Limited aeration supply and oxygen transfer inhibits ability to operate both digesters and results in fifty percent (50 %) loss of digestion capacity. Problems with aerobic digesters severly impedes the level of biosolids stabilization and process control needed to achieve PSRP and compliance with 40 CFR Part 503 Regulations to implement desired beneficial use of biosolids via liquid land application.

o Reluctance to spend operating funds on tipping fees of Roane County landfill for dried biosolids results improper processing and removal of biosolids from WWTP and created a severe back-log and 'sludge bound' condition in process tanks, i.e. oxidation ditch, secondary clarifiers, and aerobic digesters and significantly increases risk of solids washout during peak flows, deteriorated effluent quality and violations of NPDES permit.

o Unknown management strategy, regulatory compliance approach, processing schedule, residuals testing, records keeping and documentation in place for changing from dewatering via drying beds and disposal of cake biosolids in landfill to a liquid land application program (LAP) for beneficial use of biosolids on agricultural farms.

o Inadequate focus and efforts in process corrective maintenance to resolve and/or replace broken down and unrepaired equipment, i.e. bar screen, P.V. valves to clarifiers, digester air line, sampler refrigerators, etc. and maintain proper housekeeping and facility maintenance, which adversely impacts personnel safety, staff morale, plant appearance, and positive image for the City of Kingston.

o Improper sampling, collection and preservation procedures, as well as, deficiencies in analytical procedures for BOD, SS, pH, Set. S, Fecal Coliform, DO, and TCR to achieve accuracy in results and NPDES permit compliance for self-monitoring and reporting requirements. Needed QA/QC procedures and documentation to support laboratory analyses and ability to produce defensible data, troubleshoot and resolve questionable data.

o Need to evaluate current level of productivity, commitment, and functioning capacity of existing wastewater personnel in relation to health and ability to fulfill assignments at treatment plant and lift stations to elevate overall OM&M performance of these facilities and implement the recommended corrective actions and deficiencies noted in this Assessment report. Appearance that Wastewater Treatment Supervisor needs immediate personnel members who can fully support the priorities and needs of operations, maintenance, and laboratory for the treatment plant and pumping stations.

o Lack of specific staff assignments and scheduling of various required tasks resulted in a lower level of personnel coordination, coverage, efficiency, and productivity. Need to train and/or hire staff with areas of emphasis or expertise for various wastewater functions, i.e. analytical laboratory, collections system/lift stations, facility maintenance, biosolids LAP, safety, etc. to ensure adequate coverage with certified and skilled personnel to reliably and productively handle multiple tasks and provide quality service for numerous treatment plant and collection system responsibilities.

o Little or no emphasis on personnel safety and ensuring a safe work environment in various plant areas (especially inside buildings), which creates a high risk of an accident or injury to an employee or guest, and appears to adversely impacts staff morale, motivation and productivity, plant appearance, and positive image for the City of Kingston. Lack of any site specific and written summary safety programs or personnel training for Chemical Hazards Communication, Confined Space Entry, Lockout/Tagout, Emergency Action and Fire Prevention, and Chemical Hygiene risks continued violation of OSHA standards and future citations by TDL for same.

o Problem areas in lift station and treatment plant operations which haven't been diligently addressed which could reduce overall annual electrical and biosolids disposal costs with installation of pump run timers, repairs of aerobic digester air supply leaks, etc.

RECOMMENDED CORRECTIVE ACTIONS

Operational data from January, 1994 through April, 1995 showed some plant bypasses and few effluent limit violations of the NPDES permit parameters for the discharge from the Kingston WWTP to the Clinch River. Various operational and process control improvements, discussed previously herein, should be considered and implemented to minimize risk of future NPDES permit non-compliance events and maximize utilization of the capacity of the existing facilities.

An overall emphasis should be placed on achieving higher levels of performance from the existing collection system and treatment plant unit operations with increased efforts in maintenance, housekeeping, and safety. Improvements in representative sampling and laboratory procedures should be implemented to generate accurate and higher quality data for monitoring, evaluation, documentation of performance, and regulatory agency reporting purposes.

Accordingly, the following prioritized corrective actions are suggested, based upon our assessment of the potential risk of regulatory non-compliance, personnel and environment protection, O&M reliability, and cost control impacts using all available data we received and our on-site evaluations of the Kingston Wastewater Collection System and WWTP:

HIGHEST PRIORITY - Requires immediate attention and active efforts towards implementation to mitigate high risk and concerns of regulatory compliance, personnel safety, process control reliability, system capacity, and costs.

Collection System

o Continue and elevate efforts with a the developed of a specific and detailed technical plan and financial commitment to begin reducing current I/I levels. Implement an approved approach which accomplishes specific tasks and budgets for immediate and future capital requirements in the system. Establish a routine budgeting process and funds acquisition mechanism to support the on-going activities of the technical I/I reduction program. Activities include review of past records and I/I study, mapping of problem areas or known points of concern, systematic examination and inspection of sewer lines, interceptors, manholes, catch basins, etc., temperature profiling, dye testing, smoke testing, camera work, manhole marking and repairs, public education, and sewer code enforcement.

o Inspect and remove accumulated rags, debris and grease from wet wells on a frequency of at least three times per week to prevent plugging of bar screen, flooding of wet well, influent line back flow or surcharging, and reduced collection and transmission system capacity.

o Purchase and install run time meters on all lift station pumps to ensure proper alternation of the equipment, identify periods of no or multiple pump operation, increase ability to monitor sources of I/I from excessive run time, maintain desired wet well levels, identify check valve problems, and define allowable scheduling for preventative and corrective maintenance.

o Evaluate and purchase a portable mult-gas meter with an extendable line for the probe sensor, which monitors for oxygen, carbon monoxide, hydrogen sulfide, and methane gases and use everytime before descending into any dry or wet well of the lift stations for personnel safety.

o Purchase and locate safety warning and hazard signs over wet wells at the top of the grating to indicate 'Confined Space Entry' locations and use OSHA specified safety equipment, i.e. gas monitor, SCBA, harness and retrieval system, ventilation fan, etc. and follow approved procedures, i.e. permits, attendant, etc. before entering areas.

o Maintain closed and secured electrical panels in all lift stations to prevent injury from potential electrical shock or spark fire. Purchase safety tags and locks and implement OSHA specified lock-out/tag-out procedures to prevent severe injury from uncontrolled energy sources to out-of-service equipment for repairs.

o Cover exposed high speed turning shaft of the exhaust fan in Lift Station No.1 with a metal cage gaurd to protect from personnel injury, should an employee slip and fall into this operating equipment. Remove and dispose of debris and broken equipment in lift stations to reduce trip and fall hazards. Coil up and store on wall bibs, electrical chords and water hoses strewn hazardously on floors and in walkways to reduce trip and fall injury. Remove grease and wash floor in Lift Station No. 1 to remove slip, fall, and injury hazard. Replace open or missing retaining chain for internal pump pit in Lift Station No. 4 to install fall protection and reduce hazard and injury should an employee slip and fall.

Wastewater Treatment Plant

o Contract MDM Services, Inc. or other qualified firm to wire flow signals from influent and effluent flow meters to pace their respective automatic samplers, repair or replace sampler refrigerators, and program samplers to obtain a representative twenty-four (24) hour, flow-proportioned composite sample, which is controlled at a preservation temperature 4.0 deg .C and desired volume of 1,000 ml (or 3.75 gallons).

o The effluent sampler operation should be activated only when the effluent wet well pumps are in operation to ensure forward flow into the flow-proportioned, 24-hour composite sample. The representiveness of the effluent sample should be evaluated by measuring for Total Chlorine Residual (TCR) to ensure that no backflow of chlorinated effluent from the flow metering manhole and outfall line is being introduced into the composite sample. A depth profile for BOD_5 and SS in the effluent wet well should also performed to assess the concerns of settling of solids and organic matter as supernated forward flow being introduced to the sampler. This testing will identify any low bias to the effluent quality and resolve an apparent descrepancy between observed appearance of the clarifier effluent and the higher quality DMR results. A mixer may need to be installed in the wet well.

o Implement a weekly inspection and written log of the functionality and performance of the influent and effluent flow meters, samplers, and refrigerators. The log form should also include the actual volume of sample obtained in the 24-hour composite samplers as compared to the desired 1,000 ml volume. Schedule routine cleaning and preventative maintenance (i.e. sampe tube replacement, manual activation to check purge cycles and sample discharge, etc.) and semi-annual calibration schedule of flow instrumentation (especially effluent flow meter in man hole) and document these activities in a bound log book with an ink pen for regulatory documentation and records keeping purposes.

o Immediately correct the identified inconsistencies for the reporting of BOD_5 and SS concentrations for the monthly average and weekly average values in the preparation of the DMRs to properly and accurately report effluent quality data. Additionally, the effluent Set.S should be reported as <0.1 ml/L for Non-Detectable (ND) values on the DMR as the acceptable and allowable minimum detection level for this NPDES discharge permit parameter.

o Place a higher priority and emphasis on correcting known infiltration/inflow (I/I) problems in the wastewater collection system and lift stations to mitigate bypass of raw influent flow around the biological treatment system and reduce the risk of NPDES permit violations from plant hydraulic surges and solids washouts.

o Prioritize improvements in the liquid unit operations and process control of the wastewater treatment plant for the oxidation ditch and the secondary clarifiers. The level of oxygen supply and aeration capacity to the activated sludge in the oxidation ditch needs to be increased to ensure adequate DO for carbonaceous treatment and an aerobic biological environment for existing and future flows and organic loadings. Specifically, a minimum DO level of 2.0 mg/L should be achieved with a desired range between 3.0 and 4.0 mg/L to ensure reliable and adequate operation when full flow and organic loading capacity of the existing oxidation ditch is reached as the City of Kingston experiences growth.

o A much lower level of biosolids inventory should be maintained in the oxidation ditch to eliminate the excessive and inefficient oxygen demand by the old age biomass and increase the quality of bioflocculation and settling characteristics of the activated sludge. Increased biosolids wasting should be implemented to decrease the MLSS below 3,000 mg/L so that the desired settling characteristics of 30M-Settl. of 300 ml/L and SVI of 100 ml/g is reliably achieved to protect the performance of the secondary clarifiers during high hydraulic and solids loadings.

o A much lower level of biosolids inventory should be maintained in the secondary clarifiers to adequately prevent solids washout conditions and deteriorated effluent quality when plant flows increase from community growth and/or suddent impacts from I/I. Specifically, the maximum DOB during dry weather should be twenty-four inches (24") and reduced to eighteen inches (18") during wet weather and storm events. The DOB levels should be monitored daily (7 dys per week) with a sludge judge and controlled through increased biosolids wasting and recycle.

o Develop and implement a routine and well defined biosolids management/disposal program to remove and prevent the biosolids back-log and 'sludge bound' condition in the process tanks to decrease the risk of solids washout during peak flows, deteriorated effluent quality, and violations of Kingston WWTP's NPDES permit. Until such time that an alternate biosolids disposal program (i.e. liquid LAP) is developed, approved, and implemented, a financial commitment to landfilling dried biosolids at the Roane County Landfill should be made to correct the numerous technical problems caused by the excessive inventory of biosolids at the WWTP.

o A detailed and written management strategy for achieving compliance with 40 CFR Part 257 and 40 CFR Part 503 Regulations for operating a liquid Land Application Program (LAP) should be developed, approved by City officials, and trained thoroughly with treatment plant staff for proper implementation. This strategy should include a well defined approach for meeting various regulatory limits (i.e. contaminants, pathogen and vector attraction reduction), biosolids processing schedule, residuals testing and self-monitoring program, records keeping and documentation, etc. of all aspects of the beneficial use of biosolids via surface application on agricultural farms.

o The safety concerns of the on-site pump station for the presence of toxic gases in the dry and wet well and the requirements as a permitted confine space entry location should be comprehensively addressed for this intermittent operating system. The safety concerns include the purchase and use of a portable multi-gas detector and analyzer, use of proper PPE and equipment for entry and egress of this confined space, and the installation of warning/hazard signs.

o Until such time that a liquid LAP is developed, approved, and implemented, the historical operating problems with the drying beds for biosolids dewatering and disposal should be addressed by first reviewing J.R. Wauford's Engineering report and secondly, implementing a more concerted effort to utilizing these beds to increase the drying and disposal through-put of biosolids via the landfill to reduce the biosolids back-log and 'sludge bound' conditions at the Kingston WWTP.

o Review and implement the recommended addition of several important and key operational variables for the oxidation ditch, secondary clarifiers, aerobic digesters, and drying beds to elevate level of process control of various treatment systems, including weekend monitoring of clarifier sludge DOB to continuously assess and reliably achieve NPDES permit compliance.

o Initiate the recommended adjustments in the analytical procedures for the five-day BOD, SS, Set. S, FC, pH, DO, and TCR tests to achieve compliance with self-monitoring and analytical measurements required by the NPDES permit. Implement the recommended corrective actions for identified deficiencies in the existing sampling, collection and procedures which currently and adversely affect the results of the analytical data. Implement the recommended quality assurance and quality control (QA/QC) procedures and specific records keeping and level of documentation to achieve accurate, representative, and defensible quality of the analytical data generated at the Kingston WWTP laboratory.

o Evaluate current level of productivity, commitment, and functioning capacity of existing wastewater personnel in relation to health and ability to fulfill assignments at treatment plant and lift stations to elevate overall level of OM&M performance of these facilities. Provide immediate support to Wastewater Treatment Supervisor to respond and implement recommended and prioritized corrective actions and deficiencies documented in this Assessment report. Consider the hiring of the apparently qualified and certified collections system personnel in Kingston's sewer field crew as a desirable candidate for a position of Assistant Wastewater Treatment Supervisor when assessing and consolidating level of existing plant operations staff. Formalize treatment plant staff areas of responsibility and specifically define individual roles and assignments, i.e. lift stations, operations, maintenance, laboratory, safety coordinator, biosolids disposal, etc.

o Pursue recommended training, certification and personnel assigment of a plant operator to the analytical functions of the WWTP, i.e. samplers, flow meters, laboratory tests, records keeping, database documentation, and regulatory reporting. Assign the priority of training and thorough understanding of a LAP and knowledge of the requirements of 40 CFR Part 257 and 503 Regulations to the Wastewater Treatment Supervisor. Consider the necessity of hiring an additional and certified plant operator to oversee this critical aspect of the Kingston WWTP.

o A high priority needs to be immediately placed on personnel safety and creating a safe work environment at the treatment plant and lift stations. The recommended PPE, i.e. hard hats, steel toed boots, safety glasses and goggles, should be purchased by the City of Kingston and furnished to the treatment plant personnel. Appropriate laboratory safety equipment, i.e. coats, rubber gloves/aprons should be purchased and furnished for personnel and eating of food and drinking of beverages should be prohibited in the laboratory. All of the physical hazards documented in this Assessment report for each plant area should be immediately and completely addressed.

o A working knowledge by the Wastewater Treatment Supervisor, as well as general overview training for all wastewater personnel of the various safety programs required by 29 CFR Part 1910 for the Kingston WWTP should be achieved as soon as possible, with the most critical risk of personnel injury from a lack of understanding of the dangerous hazards of Confined Space Entry. Other safety hazards we observed at the treatment plant and lift stations which demonstrate a lack of knowledge and safety concern, include Lockout/Tagout of electrical sources, Hazard Communications of chemicals, Chemical Hygiene in the laboratory, and Emergency Response in the event of a fire or chlorine one-ton cylinder rupture.

o An emphasis should be placed on spending funds for preventative maintenance and housekeeping to minimize and prevent more costly expensive corrective maintenance and repairs. A high priority should be immediately placed on correcting the numerous poor facility housekeeping and equipment storage problems to eliminate unsafe work conditions, i.e. slip, trip and fall hazards, improve plant personnel morale and worker pride, increased motivation and productivity to care for and protect the facilities, and increase the overall wastewater system appearance and a more positive image for the City of Kingston.

MEDIUM PRIORITY - Requires active attention and scheduled efforts towards implementation in a systematic and controlled manner to mitigate risk and/or prevent the development of a HIGH PRIORITY concerns or issue.

Collection System

o Thorough clean and organize the insides of all lift stations and wash the dirty equipment and buildings to improve the safety and desired work environment. Implement routine, i.e. monthly housekeeping program as a standard preventative maintenance procedure for each lift station to improve inward and outward appearance and public perception.

o Develop and use a weekly log form for recording summary performance information of each pump station and locate at the treatment plant for routine review and directives by Wastewater Treatment Supervisor. Develop and locate an individual log form at the each pump station which records daily information in ink pen, i.e. operator's initials, date, time, equipment check-list, pump run times and operation, maintenance problems, housekeeping and cleaning activities, odors, etc. to develop a detailed historical monthly OM&M record of the lift station and collection system.

o Consider procuring a contractor to systematically clean the entire collection system or purchase a new or used trailer mounted hydraulic sewer cleaner to implement an in-house and on-going cleaning program. Also consider the purchase of a portable main line camera or a push camera television system to assist in preventative and corrective maintenance, as well as, assisting in a proactive I/I identification and reduction program.

o Review the current standards and specifications for sewer and water line construction and materials and update criteria if necessary to comply with all State regulations and achieve consistency among local developers and proper planning for future upstream growth. Develop a well defined written plan which contains the guidelines and detailed specifications to help developers plan and anticipate costs and contractors to adhere to regulations and control costs.

Wastewater Treatment Plant

o Several important and site-specific written programs needs to be developed in a summary format for the Kingston WWTP and detailed training provided to all wastewater personnel to prevent the risk of future violations of 29 CFR Part 1910 and citations by TDL. The highest safety concern is the development and implementation of a Confined Space Entry program with proper supporting equipment, i.e. signs, portable multi-gas detector, harness and retrieval system, permits, etc. due to the numerous confined spaces at all lift stations and in the treatment plant.

o Prioritize, repair and/or replace the identified pieces of plant and pumping station equipment which affects plant process control and then adversely affect cost efficiency. Broken equipment identified and discussed in this Assessment report, include the influent bar screen, P.V. valves to clarifiers, digester air supply line, sampler refrigerators, oxidation ditch rotor pit drain valve, etc.

o Develop and implement a written preventative and predictive maintenance program, which includes a written schedule of tasks, i.e. greasing and lubrication, vibration and temperature monitoring, process tank cleaning, spray washing, etc for both the pumping stations and wastewater treatment plant. Document corrective maintenance with work orders and organize filing of maintenance documents by plant processes for future reference, budgeting and planning purposes. Future hiring of plant personnel should include an individual with skilled mechanical, electrical, and instrumentation experience to obtain on-site expertise and emphasis on maintenance services for the collection, lift station, and treatment systems.

o A concerted effort should be placed on performing a technical evaluation and financial analysis of costs savings which could be realized if run timers were installed for the lift stations, lower raw wastewater pumping from reduction in I/I flows, reduced blower operation from repaired air leaks to the digesters, retrofit to efficient and non-clog air diffusers for digesters, and retrofit of spray water from potable city water to process chlorinated effluent water.

o Develop and implement a weekly debris removal and tank weir/wall cleaning program using CCH or HTH (chlorine solution) for the swirl device, grit chamber, oxidation ditch and secondary clarifiers to improve the overall level of aesthetics and appearance for these facilities. The effluent flow meter manhole (No. 16) should also be cleaned weekly to remove grease and scum and disinfect with a weak chlorine solution so that proper inspection and operation of this important instrumentation can be maintained and calibration performed at least semi-annually.

o Install industrial duty size hose bibs or neatly coil water hoses at the swirl device, headworks and bar screen area, effluent side of oxidation ditch, and secondary clarifiers to eliminate the trip hazard and cluttered appearance of the hazardously strewn spray water hoses observed at these unit operations.

o Implement the recommended secondary influent sampling and monitoring program to analyze for BOD_5 and SS with the plant recycle stream from the on-site pump station to more accurately define loadings and assess impacts to the oxidation ditch for carbonaceous treatment and utilization of design capacity. The strength of this side stream should be evaluated with respect to its impact and bias on the influent flow meter and sampler to accurately report raw influent loadings to the treatment plant in the monthly DMR. The results of the field sampling and analysis may indicate the need to relocate the influent composite sampler upstream from the point of discharge of the recycle wastewater stream or repipe the discharge to a location downstream of the existing flow meter and sampler pick-up point. These actions will prevent any NPDES permit non-compliance issue or TDEC enforcement liability of unrepresentative influent sampling/flow metering.

o Sample and monitor weekly, the oxygen uptake rate (OUR) and volatile solids content of MLSS as two (2) additional key process parameters to routinely assess performance of biomass in the oxidation ditch. The OUR measurement will allow for the determination of oxygen demand at various operating conditions and reveals the respiration rate and bioactivity of the microorganisms. The MLVSS measurement also allows for the determination of the viable fraction of the biomass and the proper determination of carbonaceous treatment capacity using the F/M ratio (BOD/MLVSS) at various aerobic SRTs (estimated by taking the inverse of the F/M ratio).

o Add to the laboratory solids testing program, the recommended once per week sampling and monitoring of the suspended solids (SS) concentration in the solids wet well to be able to assess clarifier biosolids thickening performance by computing the ratio of clarifier underflow SS (as RAS) to clarifier feed solids SS (as MLSS). Additionally, the recommended clarifier equipment improvements as discussed in J.R. Wauford's Engineering report should be reviewed by City officials with a developed plan, budget, and schedule for implementing the proposed corrective actions.

o Utilization of the existing drying beds with the addition of an alkaline stabilization chemical, i.e. lime, LKD, or CKD to achieve PSRP should be considered as an alternative for beneficial use and disposal of dried solids in the development of a Land Application Program (LAP). The ability to back-up the liquid LAP approach using the existing drying beds should be considered to provide maximum flexibility and biosolids disposal capacity at the Kingston WWTP.

o Review and implement the general recommendations concerning records keeping, documentation, laboratory QA/QC, personnel training on analytical functions to increase overall reliability, accuracy, troubleshooting, and defensibility of NPDES permit compliance and plant process control data.

o Provide for process control and laboratory analysis training for plant employees for the particular operations of aeration demand (OUR), secondary clarification (DOB and thickening ratio), aerobic digestion (%VS reduction), and biosolids land application (Part 503 Regulations). Request and receive safety training (especially chlorine gas hazards) provided by chemical vendors or equipment suppliers on a routine basis for all wastewater personnel. This introductory and routine type of training should also be provided for any use of an alkaline material for stabilization of biosolids should land application of dried solids be implemented at some point in the future at the Kingston WWTP.

o An emphasis should be placed in the future hiring of treatment plant staff who are motivated and willing to obtain wastewater operator certifications for reliable longterm management and supervision of treatment plant. The allocation of other Kingston personnel resources who have obtained some type of wastewater system certification, i.e. collections system should be considered attractive candidates for management support and back-up to the Wastewater Treatment Supervisor for improving the existing level of OM&M of the treatment plant and lift stations and planning for expanded services or facilities, i.e. liquid/solids LAP or construction of a second oxidation ditch.

LOWEST PRIORITY - Requires future consideration and planned efforts towards implementation in a systematic and controlled manner to minimize treatment costs whilemaximizing operating reliability and efficiency using available resources.

Collection System

o Ensure proper storage, dosage, and injection of enzyematic bacteria and degreasers for lift stations for achieving desired results from sufficient contact and detention time upstream of the wet wells and bar screens.

o Ensure proper operation of any air/vaccuum relief valves in the force mains for pump efficiency at lift stations.

o Paint the inside and outside of Lift Station No. 1 to improve upon its appearance and promote positive image in community and with visible neighbors.

o Consider the installation of telemetry and alarming for pump operation and wet well levels from lift stations to common annuciator panel at the treatment plant to increase level of supervision and monitoring of remote lift stations and reduce level of labor to perform daily inspections to a less frequent schedule, i.e. three (3) times per week on MWF.

Wastewater Treatment Plant

o Consider the installation of a flow equalization basin at the treatment plant with potential payback of construction costs with energy savings from reduced secondary aeration and blower operation at the time when plant expansion is actively being planned. The conversion of plant spray/wash water from City potable water to process (effluent) water which has been chlorinated should be incorporated at the time of a plant expansion as a potentially significant cost savings strategy over the existing practice and ensure proper levels and frequent cleaning of tank weirs/walls occurs.

o Organic, oxygen, and solids profile monitoring and mass balances around the oxidation ditch should be performed periodically to assess the performance of the oxidation ditch at various flow and loading conditions. This type of process information would more clearly define the actual biological treatment capacity of the existing oxidation ditch and when the construction of a second oxidation ditch would be necessary to maintain full compliance with NPDES permit limits. An entire new inlet/isolation P.V. valve system should be installed for both the existing and new secondary clarifiers at the time of any plant expansion to eliminate known problems.

o The purchase and installation of a wind sock on top of the Northeast corner of the Chlorine/Equipment Building should be considered as an important type of safety equipment to indicating wind direction and the atmospheric path of any chlorine gas, in the unlikely event of a tank rupture or line leak.

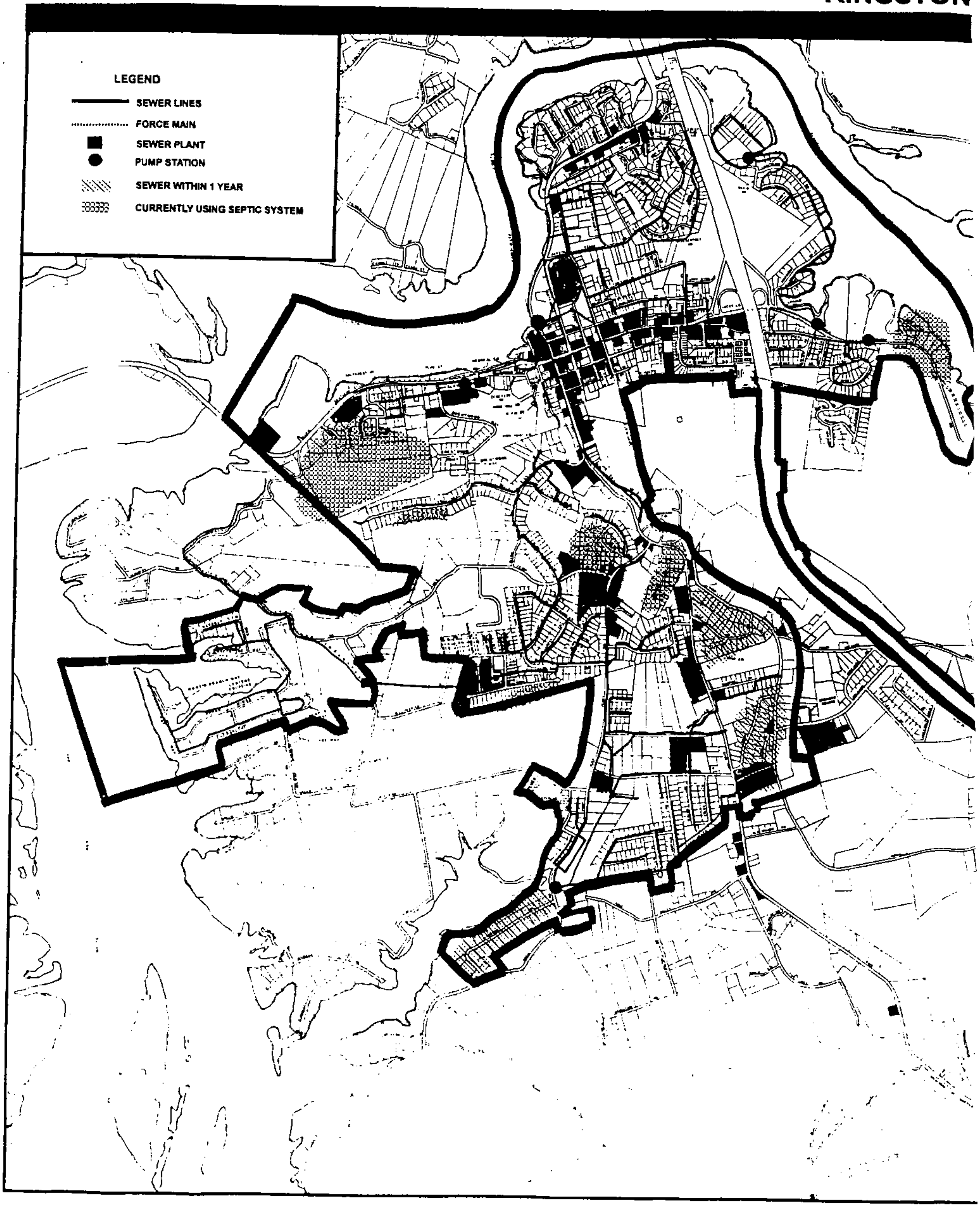
o An additional digested biosolids (tank outlet) sample should be obtained and analyzed by an outside commercial laboratory for the various Part 503 regulated parameters, i.e. metals and fecal coliform to assess the anticipated quality and compliance level as a background self-monitoring test. The pH of the soil at the approved land application agricultural sites should also be evaluated to assess the requirements for lime or alkaline material addition. Background material availability and unit cost information should be researched for various alkaline materials, i.e. agricultural lime, LKD, or CKD to assess the most technical feasible and cost effective approach, if required for Kingston's LAP.

o The grit and screenings dumpster will eventually need to be replaced based upon our observations of the corroded and rusted bottom. Additionally, the influent bar screen, grit system and secondary clarifier equipment should be repainted to significantly improve the physical appearance and aesthetics of these treatment plant areas.

KINGSTON WWTP
FACILITY & PROCESS SCHEMATIC

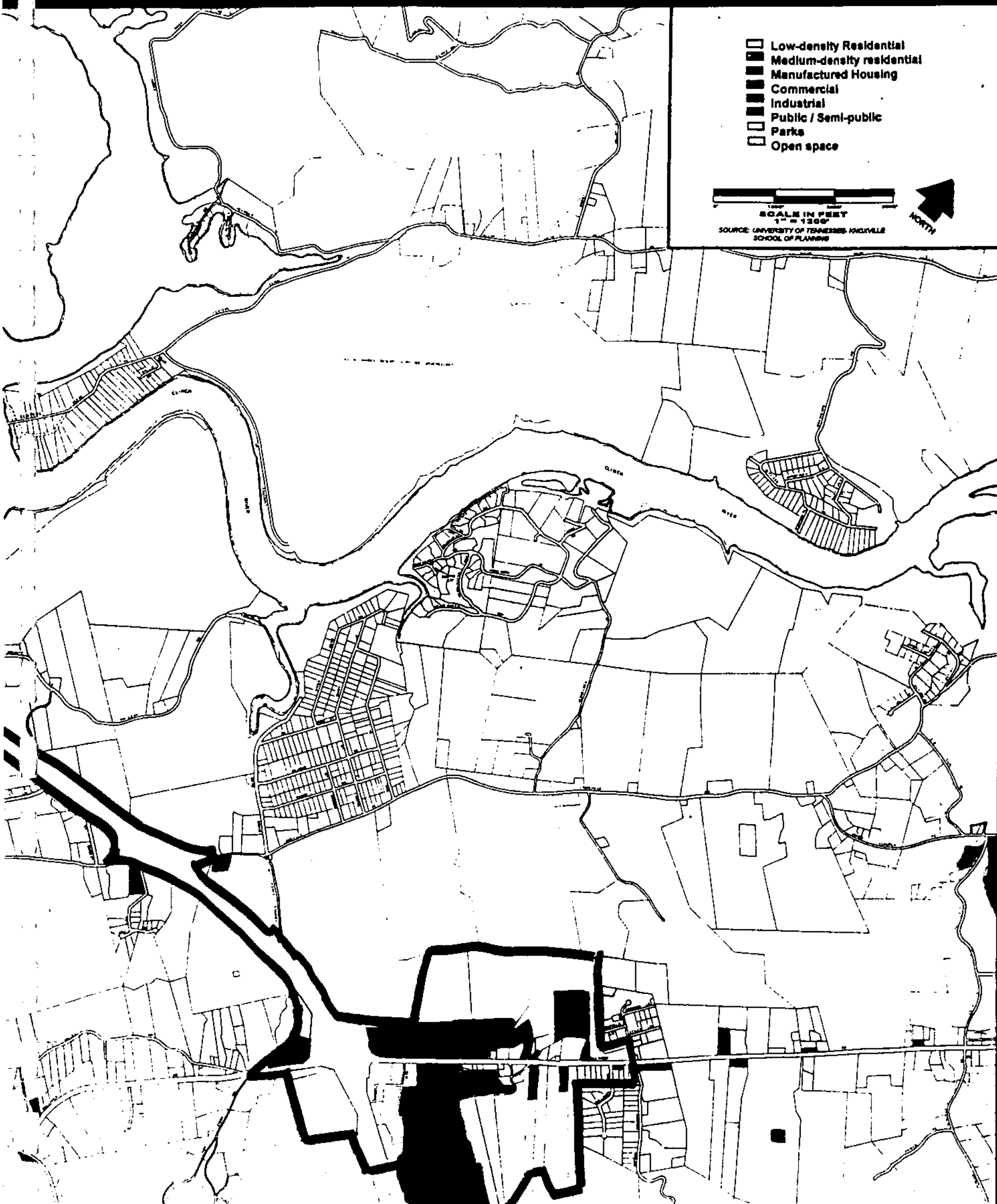
APPENDIX I

SEWER
KINGSTON



SYSTEM

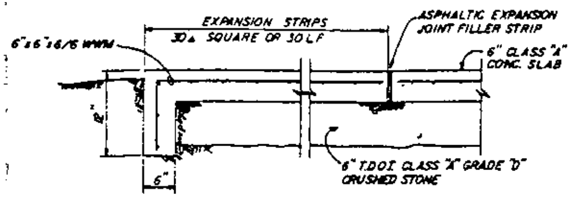
ENNESSEE



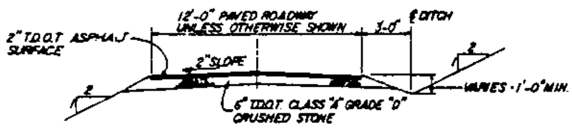
CHAIN-LINK FENCE
CONTOURS
POWER POLE
CONCRETE SIDEWALK
FENCE
CONTOUR
DRAINAGE PIPE

NOTES

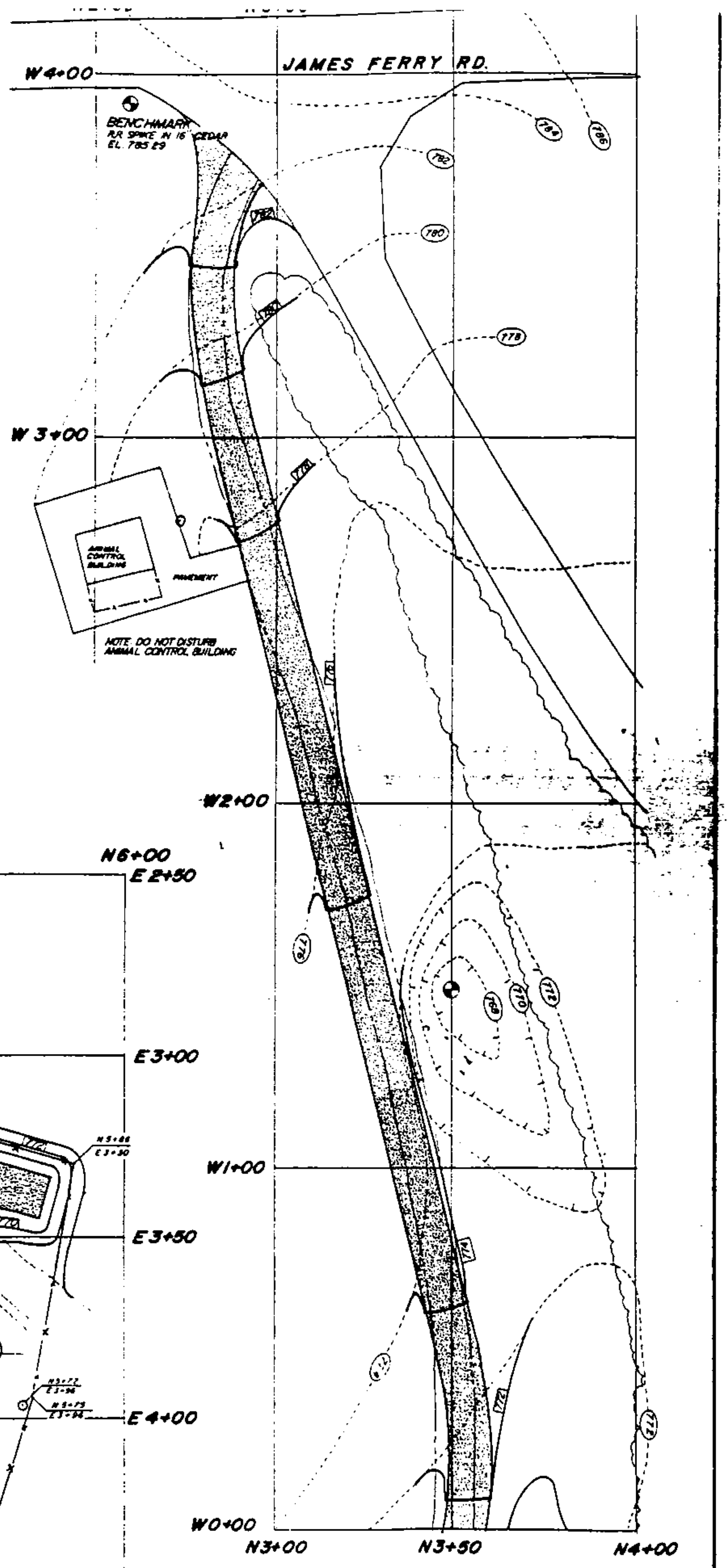
1. COORDINATES REFER TO OUTSIDE ABOVE GRADE CORNERS OF STRUCTURES.
2. STRUCTURES NOT LOCATED BY COORDINATES ARE LOCATED FROM OTHER STRUCTURES.

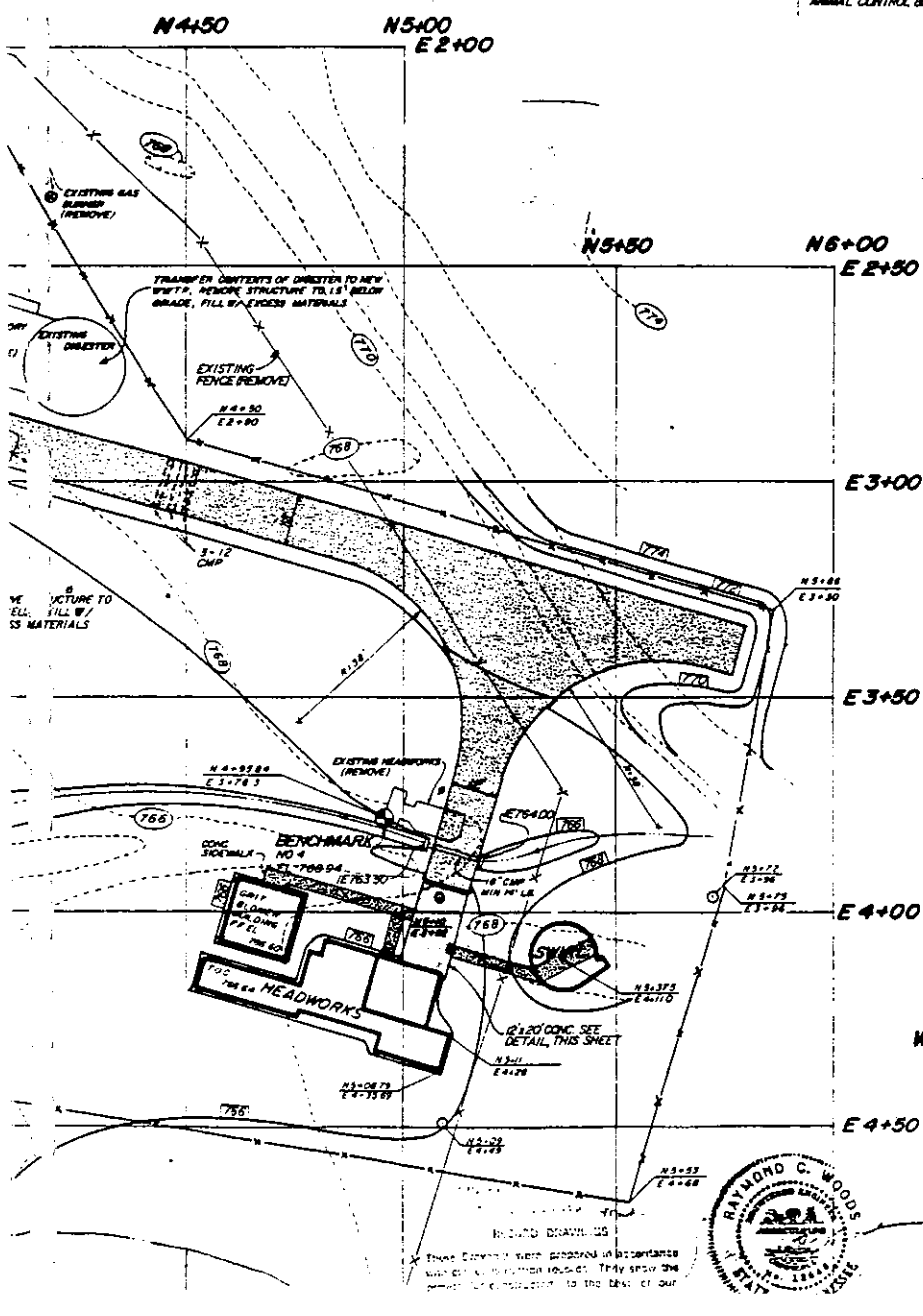


CONCRETE PAVING DETAIL
NTS



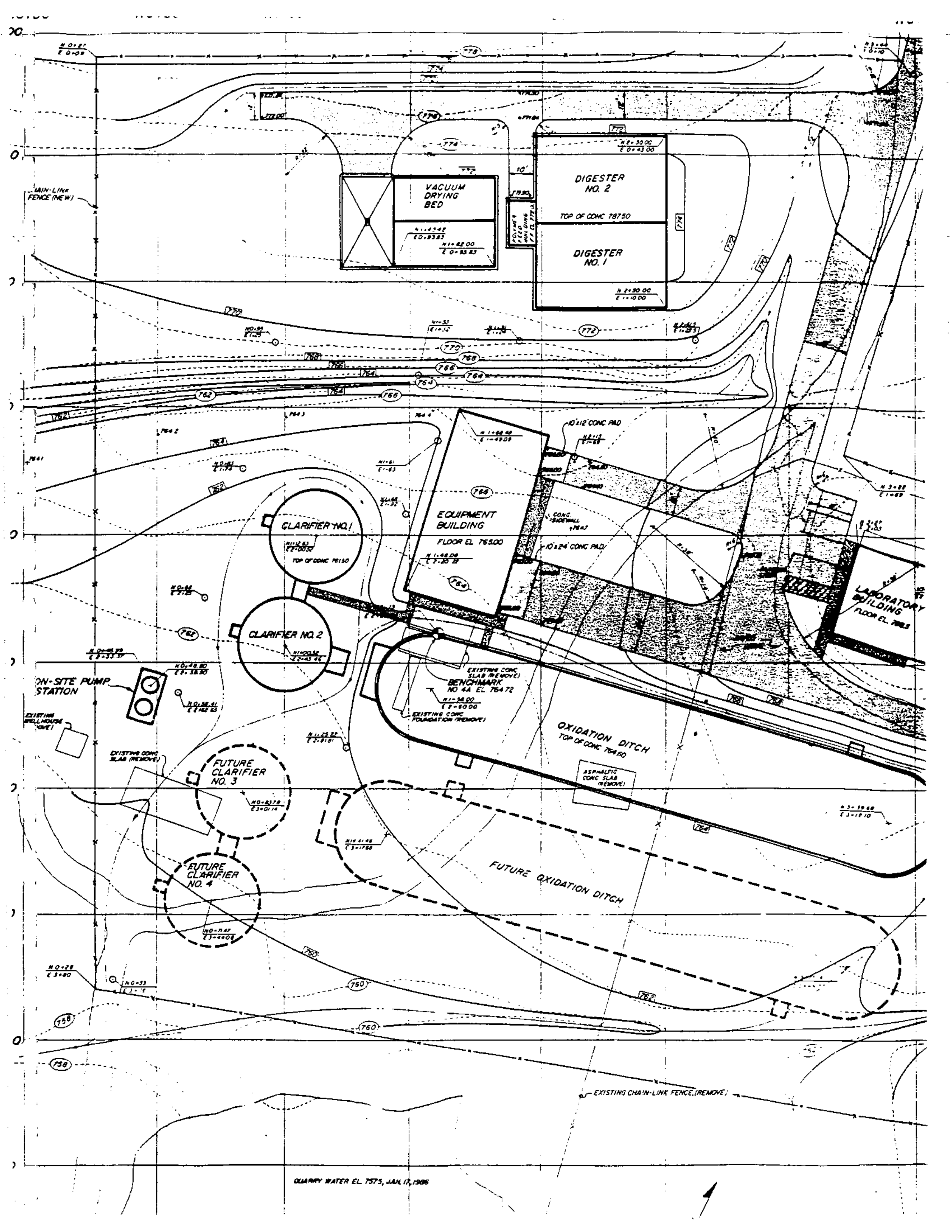
TYPICAL ROADWAY CROSS SECTION
NTS





EPA NO. C470441

SHEET 2 OF 32	SANITARY SEWER SYSTEM IMPROVEMENTS CONTRACT IV - WASTEWATER TREATMENT PLANT
REVISIONS	GRADING PLAN



CHAIN-LINK FENCE (NEW)
VACUUM DRYING BED
DIGESTER NO. 2
TOP OF CONC 787.50
DIGESTER NO. 1
10'x12' CONC PAD
EQUIPMENT BUILDING
FLOOR EL. 765.00
CONC SIDEWALL
10'x24' CONC PAD
CLARIFIER NO. 1
TOP OF CONC 761.50
CLARIFIER NO. 2
LABORATORY BUILDING
ON-SITE PUMP STATION
EXISTING CONC SLAB (REMOVE)
BENCHMARK NO 4A EL. 764.72
EXISTING CONC FOUNDATION (REMOVE)
OXIDATION DITCH
TOP OF CONC 764.60
ASPHALTIC CONC SLAB (REMOVE)
FUTURE CLARIFIER NO. 3
FUTURE CLARIFIER NO. 4
FUTURE OXIDATION DITCH
EXISTING CHAIN-LINK FENCE (REMOVE)
QUARRY WATER EL. 757.5, JAN. 17, 1986

KINGSTON WWTP
NPDES PERMIT COMPLIANCE SUMMARY DATA

APPENDIX II

CITY OF KINGSTON, TN
WASTEWATER TREATMENT PLANT

NPDES PERMIT COMPLIANCE PERFORMANCE

YEAR 1994	MONTH	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
EFFLUENT PARAMETER	PERMIT LIMITS												
BOD5													
M Avg	30 mg/L												
W Avg	40 mg/L												
D Max	45 mg/L												
D Min	40 %												
M Remvl	85 %												
TSS													
M Avg	30 mg/L												
W Avg	40 mg/L												
D Max	45 mg/L												
D Min	40 %												
M Remvl	85 %												
COLIFORM													
M AM	200 #/vol												
D Max	1000 #/vol												
TCR													
I Max	1.8 mg/L												2.0
pH													
D Min	6.0 s.u.												
D Max	9.0 s.u.												
SET.S													
D Max	1.0 ml/L												
D.OXYGEN													
D Max	1.0 mg/L												
BYPASSES													
No.	#/month			4	8								

PERMIT VIOLATIONS	**#/mo.**	**0**	**0**	**4**	**8**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**

CITY OF KINGSTON, TN
WASTEWATER TREATMENT PLANT

NPDES PERMIT COMPLIANCE PERFORMANCE

YEAR 1995	MONTH	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC

EFFLUENT PARAMETER	PERMIT LIMITS												
BOD5													
M Avg	30 mg/L												
W Avg	40 mg/L												
D Max	45 mg/L												
D Min	40 %												
M Remvl	85 %												
TSS													
M Avg	30 mg/L												
W Avg	40 mg/L												
D Max	45 mg/L												
D Min	40 %												
M Remvl	85 %												
COLIFORM													
M AM	200 #/vol												
D Max	1000 #/vol												
TCR													
I Max	1.8 mg/L												
pH													
D Min	6.0 s.u.												
D Max	9.0 s.u.												
SET.S													
D Max	1.0 ml/L												
D.OXYGEN													
D Max	1.0 mg/L												
BYPASSES													
No.	#/month												

PERMIT VIOLATIONS	#/mo.	0	0	0	0								

CITY OF KINGSTON, TN
WASTEWATER TREATMENT PLANT

NPDES PERMIT COMPLIANCE PERFORMANCE

YEAR 1994	MONTH	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
EFFLUENT PARAMETER	PERMIT LIMITS												
BOD5													
M Avg	30 mg/L												
W Avg	40 mg/L												
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D Min	40 %												
M Remvl	85 %												
TSS													
M Avg	30 mg/L												
W Avg	40 mg/L												
D Max	45 mg/L												
D Min	40 %												
M Remvl	85 %												
COLIFORM													
M AM	200 #/vol												
D Max	1000 #/vol												
TCR													
I Max	1.8 mg/L												2.0
pH													
D Min	6.0 s.u.												
D Max	9.0 s.u.												
SET.S													
D Max	1.0 ml/L												
D.OXYGEN													
D Max	1.0 mg/L												
BYPASSES													
No.	#/month			4	8								
PERMIT VIOLATIONS	**#/mo.**	**0**	**0**	**4**	**8**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**

CITY OF KINGSTON, TN
WASTEWATER TREATMENT PLANT

NPDES PERMIT COMPLIANCE PERFORMANCE

YEAR 1995	MONTH	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC

EFFLUENT PARAMETER	PERMIT LIMITS												
BOD5													
M Avg	30 mg/L												
W Avg	40 mg/L												
D Max	45 mg/L												
D Min	40 %												
M Remvl	85 %												
TSS													
M Avg	30 mg/L												
W Avg	40 mg/L												
D Max	45 mg/L												
D Min	40 %												
M Remvl	85 %												
COLIFORM													
M AM	200 #/vol												
D Max	1000 #/vol												
TCR													
I Max	1.8 mg/L												
pH													
D Min	6.0 s.u.												
D Max	9.0 s.u.												
SET.S													
D Max	1.0 ml/L												
D.OXYGEN													
D Max	1.0 mg/L												
BYPASSES													
No.	#/month												

PERMIT VIOLATIONS	**#/mo.**	**0**	**0**	**0**	**0**								

KINGSTON, TN WWTP

INFILTRATION/INFLOW IMPACTS

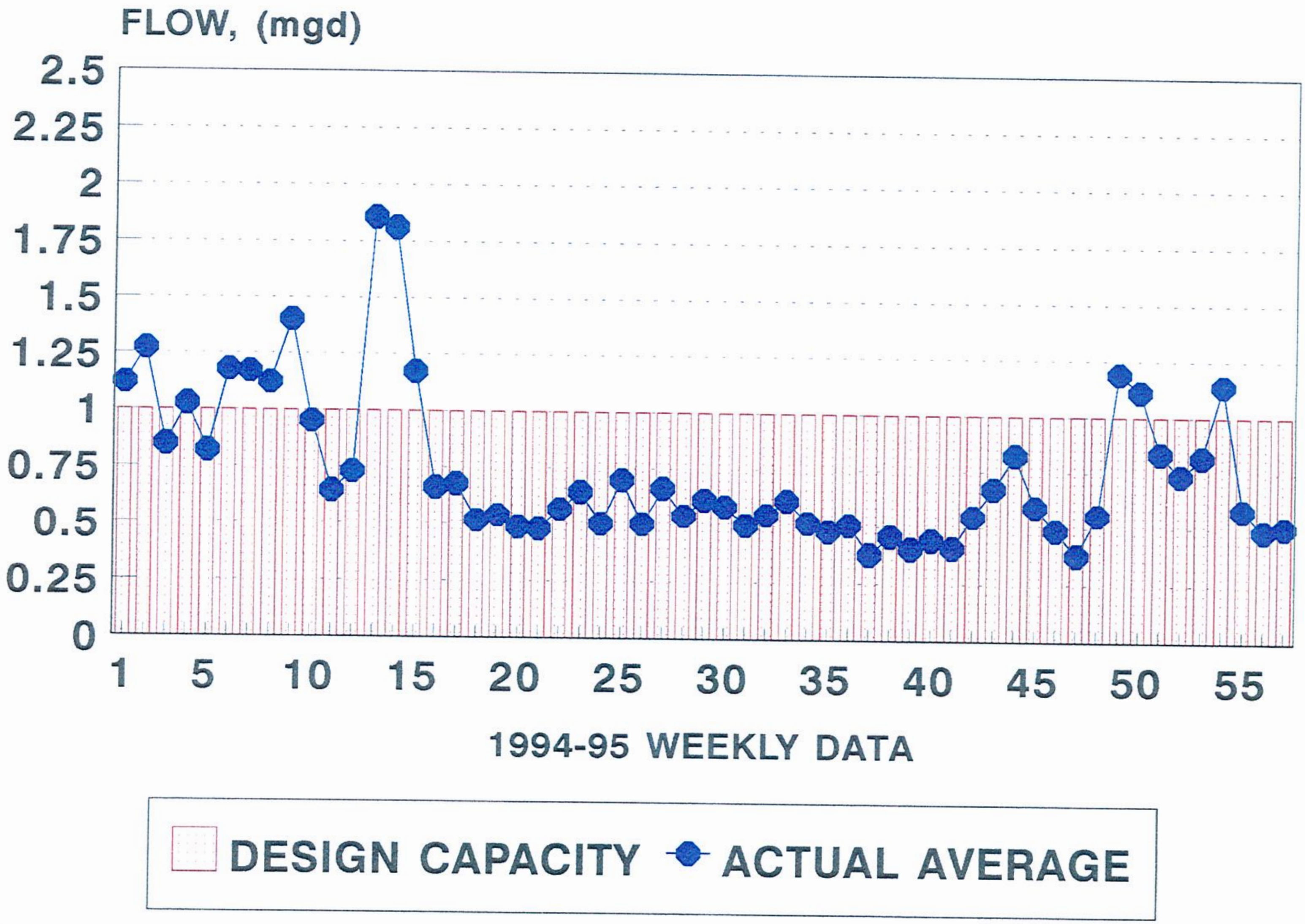


Figure II-1

KINGSTON, TN WWTP
INFILTRATION/INFLOW IMPACTS

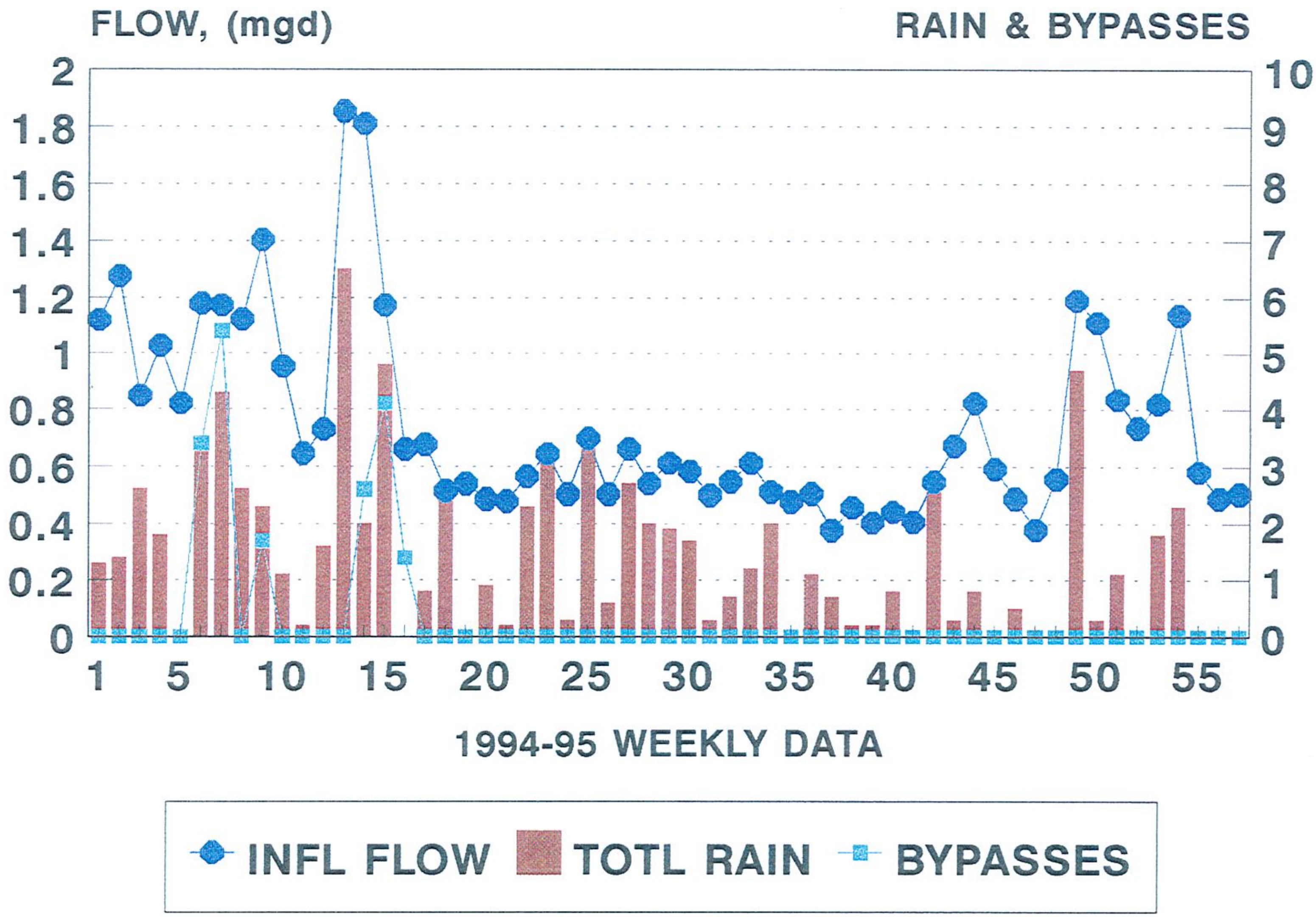
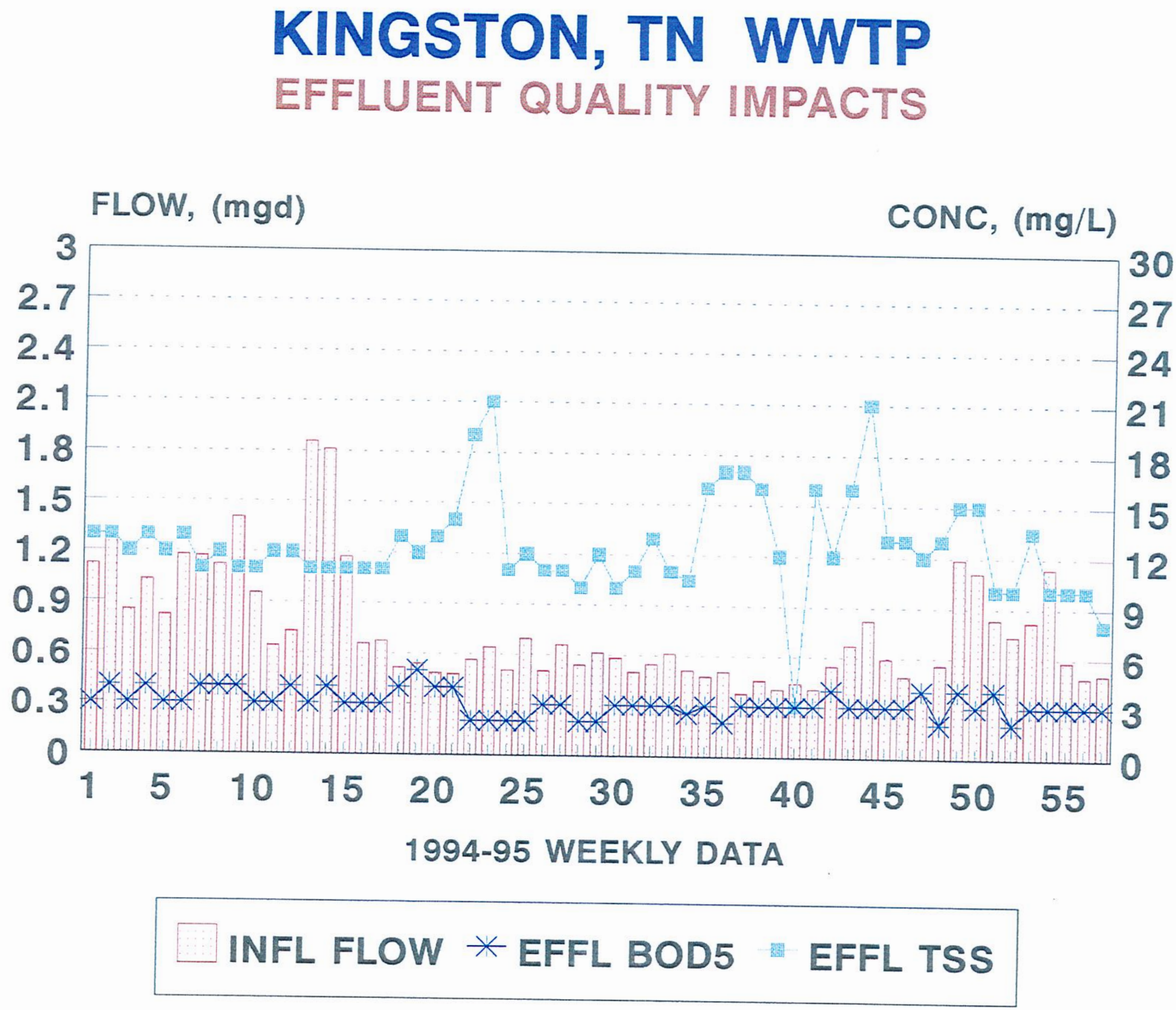


Figure II-2



KINGSTON, TN WWTP
EFFLUENT QUALITY IMPACTS
FLOW, (mgd)
CONC, (mg/L)
3
2.7
2.4
2.1
1.8
1.5
1.2
0.9
0.6
0.3
0
30
27
24
21
18
15
12
9
6
3
0
1
5
10
15
20
25
30
35
40
45
50
55
1994-95 WEEKLY DATA
INFL FLOW
EFFL BOD5
EFFL TSS

Figure II-3

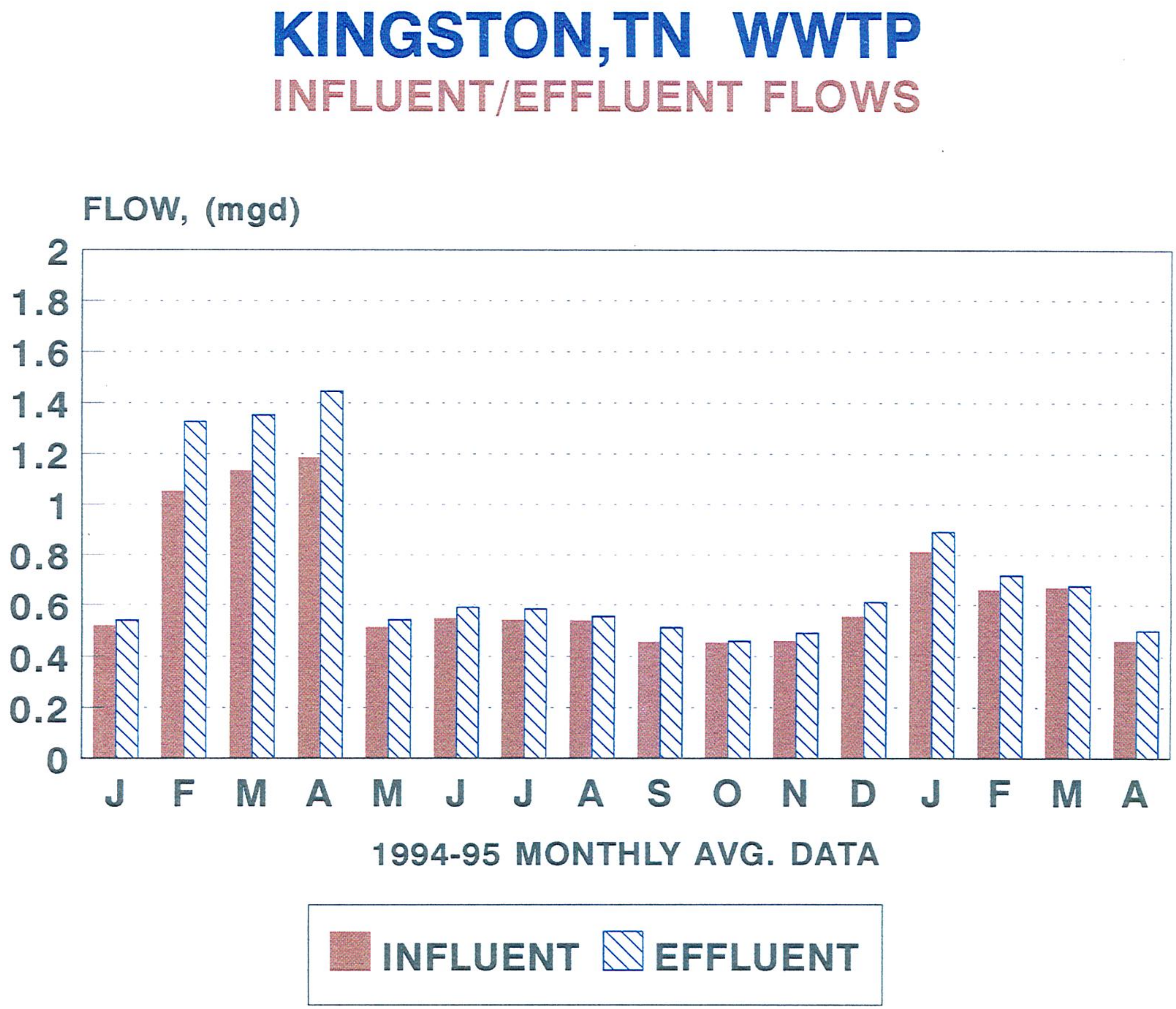

KINGSTON,TN WWTP
INFLUENT/EFFLUENT FLOWS
FLOW, (mgd)
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
J F M A M J J A S O N D J F M A
1994-95 MONTHLY AVG. DATA
INFLUENT
EFFLUENT

Figure II-4

KINGSTON,TN WWTP
NPDES PERMIT COMPLIANCE

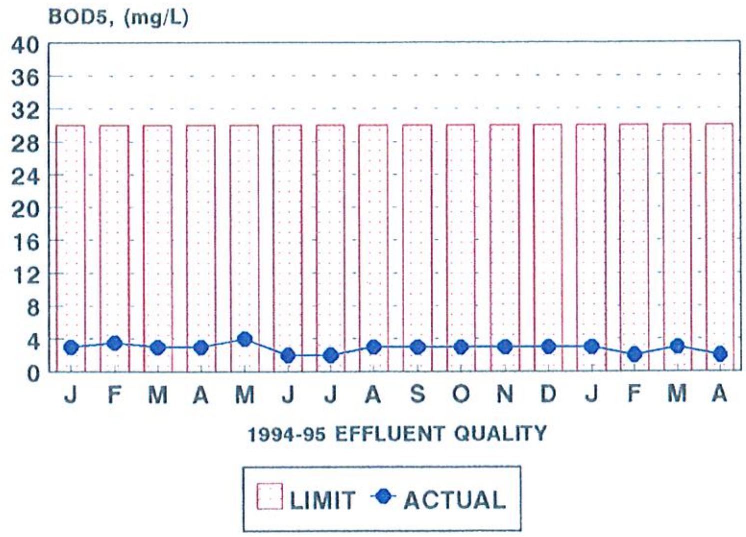


Figure II-5

KINGSTON, TN WWTP
NPDES PERMIT COMPLIANCE

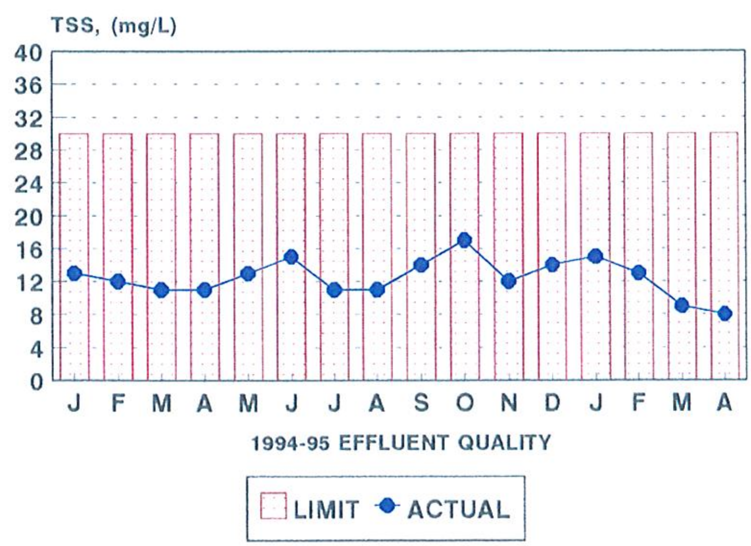


Figure II-6

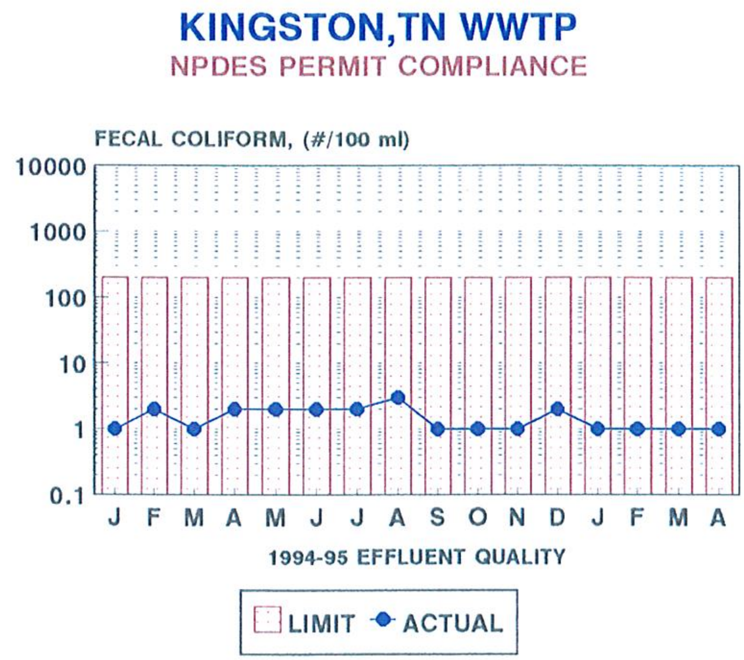


Figure II-7

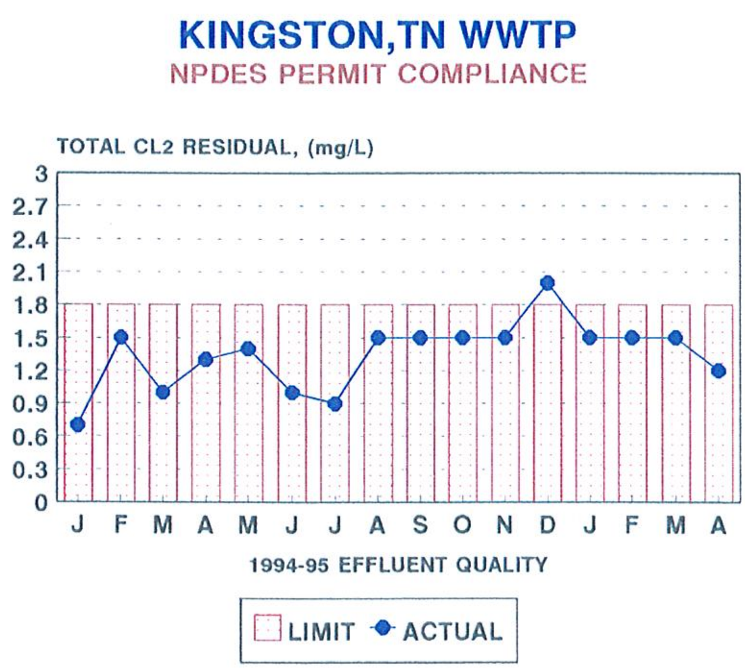


Figure II-8

KINGSTON, TN WWTP
NPDES PERMIT COMPLIANCE

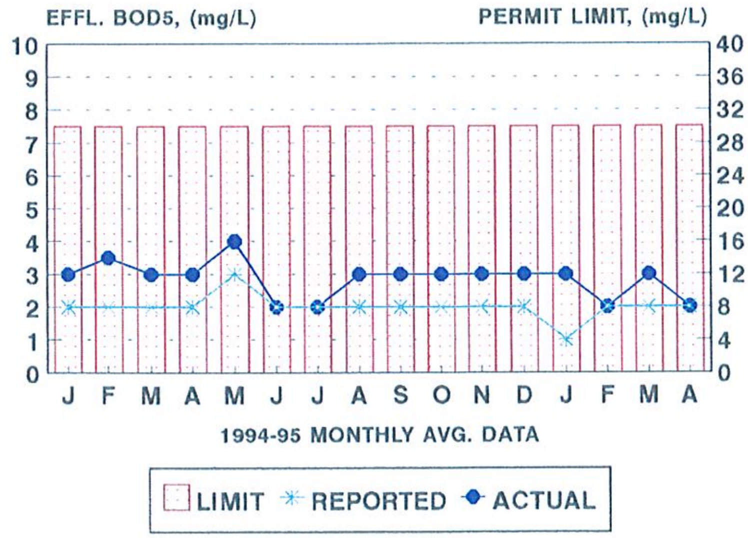


Figure II-9

KINGSTON, TN WWTP
NPDES PERMIT COMPLIANCE

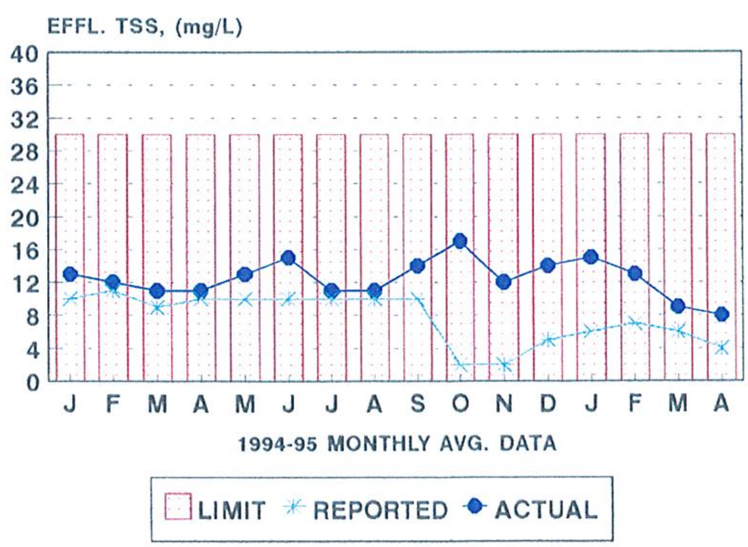


Figure II-10

KINGSTON WWTP
MICROBIOLOGICAL EXAMINATION REPORT

APPENDIX III

RECEIVED JUN 2 1 1995

DAVID JENKINS AND ASSOCIATES INC.
11 YALE CIRCLE
KENSINGTON
CALIFORNIA 94708

DAVID JENKINS, PRESIDENT

Phone or Fax
(510) 527-0672

Mr. T. Muirhead
PSG
408 N Cedar Bluff Road
Suite 462
Knoxville, TN 37923-3611
Fax 615-693-0329

June 14, 1995

Dear Mr. Muirhead,

Please find enclosed a summary of the microscopic analysis of the oxidation ditch and aerobic digester sample taken on 6/9/95 from Kingston, TN.

Both samples were fairly similar with the filamentous organisms in the aerobic digester looking less healthy than those in the oxidation ditch. The filamentous organisms abundances were not significantly different between the two samples. The samples contained weak, irregular, diffuse flocs, containing some Neisser positive cell clumps. There were some motile unicells. The flocs contained some carbon particles and inorganic particles and fibers.

The overall filamentous organism level was "abundant" which is sufficient to cause a bulking problem. The filamentous organisms caused interference with settling by some interfloc bridging but mainly by producing a diffuse stretched out floc. The filaments in the aerobic showed signs of damage that included missing cells and broken and empty filaments.

The major filamentous organisms were type 0092 and type 0041. Also seen were smaller amounts of type 0675, type 1851, **Thiothrix** II and **Sphaerotilus natans**.

The major filamentous organisms are indicative of very low F/M and **Sphaerotilus natans** a minor filamentous organism, is a low DO filament. All of these filamentous organisms can be killed by proper chlorination. Selectors will control type 1851 and **Thiothrix** II but if there are significant anoxic zones in a long MCRT selector system, type 0092 will not be controlled.

Yours sincerely,

David Jenkins

David Jenkins

Sample Number 3222

Sample Date 6/9/95

Observation Date 6/14/95

Filament Abundance:

0 None	1 Few	2 Some	3 Common	4 Very Common	5 Abundant	6 Excessive
☐	☐	☐	☐	☐	☒	☐

Filament Effect on Floc Structure: ☐ Little or None ☒ Some Bridging ☒ Open Floc Structure

Morphology of Floc: ☐ Firm ☒ Weak ☐ Round ☒ Irregular ☐ Compact ☒ Diffuse

Size (μm): (% in range)

<150	150-500	>500
50	40	10

Features:

Free cells in suspension Some

Zoogloea's /

Spirochaetes Some

Inorganic/Organic Particles Carbon, Inorganic particles

Neisser positive cell clumps Some

India Ink Test /

Chlorine damage to filaments /

FILAMENTOUS MICROORGANISM SUMMARY:

	Rank	Abundance		Rank	Abundance
Nocardia sp.			M. parvicella		
Type 1701			Type 0581		
S. natans	6	Some	Type 0092	1	Abundant
Type 021N			Type 0803		
Thiothrix sp. II	4	Some - Common	Type 1851	4	Some - Common
Type 0041	2	Very Common	Type 0961		
H. hydrossis			Type 0675	3	Common
N. limicola			Other		
Fungus			Other		

Remarks PSG. Kingston, TN. Oxidation Ditch.
Type 0092 dominant inside activated sludge floc. Thiothrix II and Type 0675 producing diffuse & stretched out floc.

Sample Number 3223

Sample Date 6/9/95 Observation Date 6/14/9.

Filament Abundance: [ ] 0 None [ ] 1 Few [ ] 2 Some [ ] 3 Common [ ] 4 Very Common [X] 5 Abundant [ ] 6 Excessive

Filament Effect on Floc Structure: [ ] Little or None [ ] Bridging [X] Open Floc Structure

Morphology of Floc: [ ] Firm [X] Weak [ ] Round [X] Irregular [ ] Compact [X] Diffuse

Size (μm): (% in range)

<150	150-500	>500
90	10	

Features:

Free cells in suspension Common

Zoogloea's /

Spirochaetes /

Inorganic/Organic Particles Carbon Inorganic material

Neisser positive cell clumps Some

India Ink Test /

Chlorine damage to filaments /

FILAMENTOUS MICROORGANISM SUMMARY:

	Rank	Abundance		Rank	Abundance
Nocardia sp.			M. parvicella		
Type 1701			Type 0581		
S. natans	3	Some	Type 0092	1	Abundant
Type 021N			Type 0803		
Thiothrix sp. II	3	Some	Type 1851	3	Some
Type 0041	2	Very Common	Type 0961		
H. hydrossis			Type 0675	3	Some
N. limicola			Other		
Fungus			Other		

Remarks PSG. Kingston TN. Aerobic Digester.
Type 0092 dominant inside and outside floc. Floc more broken than activated sludge sample. Missing cells for Thiothrix and Type 0675.