INDIANA HARBOR AND CANAL MAINTENANCE DREDGING AND DISPOSAL ACTIVITIES – DESIGN DOCUMENTATION REPORT

EFFLUENT TREATMENT SYSTEM

APPENDIX D

U.S. Army Corps of Engineers, Chicago District
Hydraulics and Environmental Engineering Branch
March 2000

EFFLUENT TREATMENT SYSTEM
APPENDIX D
TABLE OF CONTENTS

LIST OF PLATES

LIST OF TABLES

LIST OF ATTACHMENTS

PURPOSE

1. This appendix will discuss the results of treatability testing completed in order to determine the effluent characteristics and treatment requirements for the design of an on-site treatment facility. The facility will process water from three (3) different sources. These include effluent from pore water released from the deposited sediment (#1), precipitation run-off (#2), and water from the groundwater gradient control system (#3). The final effluent from the treatment system will be discharged to the Lake George Branch of the Indiana Harbor and Canal (IHC). As part of the treatability testing, each of the aforementioned (#1-#3) wastestream(s) were evaluated. In addition, a combined wastestream (#4) incorporating anticipated volumes of the previous three wastestream(s) was also evaluated. This last wastestream (#4) is characteristic of the water to be processed through the treatment system, since it is anticipated that the three wastestreams will be combined prior to treatment. The design of the treatment facility will be presented in the Treatment Plant Design Documentation Report (DDR).

EFFLUENT TREATABILITY STUDIES

2. The design of the wastewater treatment system needed for treatment of effluent from the CDF required that treatability studies be conducted to screen, evaluate, and test potentially viable treatment options. The Chicago District accomplished this task using a two-phased approach. The first phase was to evaluate treatment options by completing an analysis based on a literature review and in-house experience with similar systems. The second phase involved processing and evaluation of potential unit operations, which were recommended in the first phase. Unit operations were evaluated at the “bench-scale” in the laboratory.

Phase I (treatability design)

3. The first phase was completed by contracting with Maxim Technologies Inc., and the results of that effort are documented in a report titled <u>Treatability Study Design for the Indiana Harbor Confined Disposal Facility (CDF) Effluent, Volumes 1 & 2</u>, dated December 1998. The study objectives were as follows:

a. Evaluate IHC sediment pore water data, as well as the data associated with precipitation runoff from the sediment material to define the chemical characterization of the CDF effluent. This effluent represents one of the influents to the treatment train to be developed through the treatability study process.

b. Define the chemical characterization of ECI site groundwater.

c. Define the effluent limitations (regulatory targets) the proposed treatment plant will have to achieve prior to discharging the final effluent to the Lake George Branch of the IHC.

d. Based upon a review of the water quality estimates prepared by the Chicago District, propose a laboratory methodology to simulate a CDF effluent (treatability study influent) using sediment collected from the IHC.

e. Screen unit operations and unit processes appropriate for the treatment of the various analyte groups predicted to be present in the CDF effluent and the ECI site groundwater. Using preliminary screening techniques recommend a treatment train for both CDF effluent and the ECI groundwater for further treatability testing to verify anticipated achievable performance.

f. Develop a treatability study test plan addressing the evaluation of the individual treatment technologies comprising an optimized treatment train appropriate for the following aqueous waste streams at different times or as a combination wastestream:

#1 -- Sediment pore water (interstitial water)
#2 -- Precipitation runoff water
#3 -- ECI site groundwater
#4 -- Combination wastestream

Phase II (Bench-scale Evaluation)

4. As part of the Scope of Work (SOW) for the Phase II treatability testing the Chicago District compiled an estimate of the quantity and quality of the effluent expected from the CDF. A copy of this estimate, including the methodology is included as Attachment D-1 to this Appendix.

5. The study test plan developed in phase I was used to conduct the Phase II bench scale evaluation of the treatment unit operations and treatment train. The results of this effort are documented in a report titled Treatability Study Report for the Indiana Harbor Confined Disposal Facility (CDF) Effluent, dated July 1999.

The project objectives of the treatability study were as follows:

a) Collect and transport representative sediment and ECI groundwater samples to the analytical laboratory.

b) At the lab generate representative samples of sediment pore water, precipitation run-off, and a combination wastestream comprised of the pore water, precipitation water and groundwater at a pre-determined ratio.

c) Characterize, through laboratory analysis, samples of the wastestream(s) which could be part of the CDF effluent.

d) Implement treatability testing.

e) Evaluate the results of the treatability testing for specific unit operations or processes to define pollutant removal efficiencies (performance).

f) Compare treated operational effluents to conservatively based discharge criteria to determine if proposed treatment train will be of acceptable quality for discharge to the Lake George Branch of the IHC.

g) Define potential limitations of unit operation and processes of the proposed full-scale treatment train.

h) Provide recommendations for further activities to proceed to the design of the proposed CDF effluent treatment system.

6. The level of design of the wastewater treatment plant, for this project DDR, is based on the results from the Phase II treatability testing. The final design of the wastewater treatment system will be included in the Treatment Plant DDR.

METHODOLOGY

7. The treatability testing and evaluation was divided into two separate setups. The first setup (Screening) was a screening evaluation; the purpose was to define the initial ability of the unit operations/processes to remove pollutants of concern (POCs) from the wastestream(s). Each unit operation was run in a batch mode. In addition, screening evaluation allowed for adjustment of the unit operations to be made in later confirmation testing.

8. The purpose of the second setup (Confirmation) treatability testing was to provide confirmation of the screening evaluation, and evaluate the performance of the entire treatment train in a flow-through setup. This work involved two runs. The first run, (Run I) used wastestream samples of the same composition that were used during the screening level evaluation. Due to changes in sampling requirements it was discovered that the amount of sample generated for the specified treatability study would not be of sufficient volume to perform all of the second run (Run II) testing. It was decided to create a synthetic feed to make up the difference in volume required for the second run. The desired objectives associated with the creation of a synthetic (spiked) feed were as follows:

a. Create enough wastestream sample volume to complete Confirmation; Run 2 activities.
b. Create influent feeds with POC concentration high enough so they can be tracked throughout the entire CDF effluent treatment train.
c. Further assess the overall performance of the CDF treatment train being introduced to variable influent feeds.

GENERATION AND CHARACTERIZATION OF CDF EFFLUENT

9. As discussed in the Phase I treatability work plans (Maxim, 1998), a treatment train was to be evaluated using bench-scale equipment to evaluate its ability to successfully

treat four different wastestream(s). These include sediment pore water, precipitation runoff, and ECI groundwater. Each of these sources was individually generated, and a combination wastestream (consisting of a flow-proportioned mixture) consisting of the previous three was also generated. A description of how this wastestream(s) was generated is provided in Maxim's report (1999).

10. All four wastestream(s) were chemically characterized for the POCs that were determined to be appropriate for that particular wastestream. Table D-1 provides the analytical sampling points taken for wastestream characterization of the Screening testing, while Table D-5 provides similar information for the Confirmation testing.

Treatability Study Implementation

11. The main objective of the treatability study was to evaluate the ability of the treatment train to remove POCs from the CDF effluent wastestream(s) either individually or in a combined wastestream. The treatment train was evaluated through screening and confirmation treatability testing and is outlined below.

General Description of Treatment Train

12. Based on review of historical data and the anticipated effluent limitations presented in the Phase I report (Maxim, 1998), a treatment train was evaluated through screening and/or confirmation treatability procedures consisting of the unit operations presented in Table D-2.

13. The screening and confirmation treatability tests identified in subsequent paragraphs were conducted on the following wastestream(s) (CDF effluent components):

a) IHC sediment pore water (Wastestream #1)

b) Simulated precipitation runoff water (Wastestream #2)

c) ECI site groundwater (Wastestream #3)

d) Combined wastestream (Wastestream #4) comprised of sediment pore water, precipitation runoff and ECI groundwater

Although the three (3) components to the CDF effluent (wastestream(s) 1-3) were evaluated separately, it is likely that when treated, they will be combined as characterized by wastestream #4. The experimental setup and procedures for both the screening tests and the confirmation tests are provided in Maxim's report (1999). For reference, Table D-3 is provided which lists all parameters detected in the raw wastestream(s). It should be noted that the Indiana water quality criteria are based on the lowest value from the Aquatic Life Criteria, and Human Health Criteria (nondrinking). During the permitting process, the actual discharge criteria to be applied to the project will be developed. These criteria could be different then those discussed in this appendix.

RESULTS OF TREATABILITY SCREENING TESTS

14. In this section, the screening test results for all four wastestream associated with the CDF effluent will be presented and discussed. The purpose of the screening tests was to define the initial ability of the unit operations/processes to remove POCs from the wastestream(s). Plate D-1 provides a schematic of the treatment train evaluated in the Screening testing. A summary of the screening test results is provided in Table D-4. It should be noted that only the POCs that are “key” to the given unit operation are presented in Table D-4. A compilation of all analytical results can be found in Maxim’s report (1999).

Oil/Water Separator Testing Results

15. Based upon the analytical results presented and observations made the oil & grease load with the wastestream(s) was much less than anticipated. Based on these results, it appears that the nature of the wastestream(s) tested does not warrant a dedicated oil/water separator. However, based on the expected influent turbidity and suspended solids loading, a preliminary settling device should be incorporated into the CDF effluent treatment train.

16. Although an oil/water separator does not appear to be required, it may be more appropriate to incorporate a wastewater equalization basin, equipped with an oil skimmer to capture any floating oil that may be encountered. In addition, this would tend to dampen pollutant waste loads that will require treatment in subsequent unit operations/processes.

Sand Filter Testing Results

17. The influent to the sand filters was not allowed to settle in any kind of an equalization unit. This was done to simulate pumping the wastestream(s) directly into the sand units without any retention at the head end of the treatment system. Based on the results, sand filtration was effective in the removal of TSS.

Cyanide Oxidation Testing Results

18. Cyanide oxidation (alkaline chlorination) screening tests were performed on raw wastewater that had not been pretreated. This was done to demonstrate the ability of the unit operation to perform under “worst-case” conditions, and to take advantage of adjusting pH required for this operation and the metals precipitation step.

19. Based upon the results shown in Table D-4, cyanide oxidation appeared to demonstrate the ability of removing cyanide concentrations to below the discharge criteria.

Metals Precipitation Testing Results

20. During the chemical precipitation testing, ferric chloride w/polymer, alum w/polymer, and NaOH w/polymer were evaluated for effectiveness. Again, raw wastestream(s) were used during the screening tests to simulate pumping of the CDF effluent(s) directly to a chemical precipitation unit (rapid mix, flocculation, and clarification) without any other type of pretreatment.

21. As noted above different precipitation agents were evaluated, and the results Maxim's report (1999) showed no significant difference between the performance of the agents tested. Therefore, based primarily upon chemical handling considerations, the decision was made to use the combination of NaOH and Betz AE130 polymer in the Confirmation testing.

22. Based on the screening results the initial conclusion regarding chemical precipitation is that it does demonstrate the capability of removing metals to below the conservatively based discharge criteria. However, lead exceeded the criteria in wastestream(s) #2 and #4, while it was below the criteria in wastestream(s) #1 and #3.

Ammonia Stripping Testing Results

23. The effluent from the metals precipitation unit process was exposed to aeration for a significant period of time while screening the wastestream(s) for ammonia nitrogen. It was decided to perform the screening tests on the "worst case" wastestream(s) which contained maximum ammonia nitrogen concentration. As shown in Table D-4, all of the effluents were lowered to the range of 1.5 – 3.0 mg/l ammonia. All effluent wastestream(s) slightly exceeded the conservatively based discharge criteria of 1.51 mg/l. In addition, a significant amount of aeration time was required at higher ammonia concentrations.

Wastewater Neutralization

24. Wastestream(s) will require the pH to be lowered in the range of 7.8-8.2 for the optimal nitrification process to occur in the upcoming biological operation. Neutralization (pH adjustment) of the metals precipitation effluent was performed prior to initiating the biological treatment testing (sequencing batch reactors).

Biological Treatment (Sequencing Batch Reactor--SBR) Testing Results

25. During the SBR screening tests, three batches of feed were introduced to each wastestream. As shown in Table D-4, it appears that the SBRs have the ability of removing ammonia nitrogen concentrations to near or below a concentration of 2.0 mg/l. Wastestream #1 produced the only effluent that exceeded the conservatively based discharge criteria for all three-batch runs. For the SBR runs, in most cases the ammonia reduction was accomplished at a hydraulic retention time of approximately 24 hours.

Activated Carbon Testing Results

26. The activated carbon unit process was included as a polishing step. In order to reduce the organic load to the carbon filters, effluent from the biological treatment system was used as the influent. Activated carbon screening tests were completed to develop carbon isotherms (pollutant capacity estimates) and evaluate the ability of the activated carbon, serving as a polishing step, to remove any remaining levels of POCs under continuous column conditions. The carbon capacity data generated in this study can be used in the future to define the carbon mass required to treat a specific POC waste load. All data generated during the testing can be found in Maxim's report (1999).

27. For the confirmation testing in the next stage, the effluent from this unit operation will represent the final effluent quality to be discharged to the Indiana Harbor Canal. This is not the case for the screening tests. However, three unit processes were hooked up in series -- the metals precipitation, biological treatment and activated carbon. This was done in order to reduce the metals so as not to inhibit the microorganisms in biological treatment and to reduce the organic loading to the carbon filter. Plate D-1 shows the influent and effluent to the unit processes for each screening test. Table D-4 provides data for all the POCs detected during the screening tests. See Table D-1 for a list of all the parameters evaluated, and Table D-3 for all of the parameters detected in the raw wastestream(s).

CONFIRMATION TREATABILITY TESTING RESULTS

28. As previously discussed, the screening tests were performed to assess the ability of a unit operation or process to remove specific POCs with a significant degree of efficiency. The results of the screening tests were used to select and fine-tune the operation of the components of the CDF effluent treatment system for evaluation in confirmation testing.

29. The purpose of the confirmation testing was to verify the performance of the treatment technologies, and to define the final effluent that could be produced by a specific unit operation, as well as the entire treatment train. As in the screening evaluation four wastestream(s) were evaluated:

#1 -- Sediment pore water (interstitial water)
#2 -- Precipitation runoff water
#3 -- ECI site groundwater
#4 -- Combination wastestream

30. The data generated by the confirmation testing was also used to justify the incorporation of a unit process or operation in the recommended treatment train for the CDF effluent treatment.

31. Based on the results of the screening tests, no significant changes were made to the treatability test plan except that an equalization basin was combined with the confirmation testing treatment train in lieu of an oil/water separator. The reason for this is that the wastestream(s) generated at the start of the treatability testing (screening) did not exhibit oil & grease concentrations warranting an oil/water separator. The equalization basin with skimmer would serve both as an initial separation step (removal of suspended solids and floating oil) and as a flow-equalizing device to dampen out hydraulic and pollutant loads introduced to the treatment system. Plate D-2 provides a schematic of the Confirmation testing treatment train.

32. Confirmation testing was divided into two performance tests (Run 1 and Run 2). The purpose for these two runs was to validate unit operation and overall treatment system performance. Table D-5 provides the analyses of POCs and sampling points for the Confirmation testing. As indicated on Plate D-2, after a wastestream was processed through a unit operation or process, samples were collected from the effluent for laboratory analyses. The remaining volume of the processed effluent then became the influent for the next unit operation in the treatment train. In this sense the actual method of wastestream processing used during confirmation testing was considered semi-continuous in nature.

Confirmation testing Run I Results

33. In this section, the confirmation testing results (Run I) for all four wastestream(s) associated with the CDF effluent will be presented and discussed. The purpose of the confirmation testing was to verify the performance of the treatment technologies. A summary of the Confirmation Run I results are provided in Table D-6. It should be noted that Table D-6 provides data only for those parameters that were above the conservatively based discharge criteria. A complete compilation of all analytical results can be found in Maxim's report (1999). A parameter which appeared in the confirmation testing is likely an artifact of the experiment rather then a POC for the CDF project; bis(2-ethylhexyl) phthalate is probably present due to materials of fabrication used to construct the treatment train unit processes. Also, chloroform and carbon tetrachloride are likely artifacts of the experiment rather than POCs in the effluent.

Equalization Basin

34. As previously discussed, the purpose of an equalization basin at the beginning of a treatment system is to dampen fluctuations of water flows and associated POC waste loads to the treatment system. In addition, it will provide sufficient retention time to lower suspended solids concentrations, thus easing the load to downstream unit operations/processes.

35. No equalization basin screening tests were performed to assess suspended solids removal of the wastewater. Based on observations made during the oil/water separator screening tests, it appeared as if the majority of the solids had settled out of the wastestream(s) and the wastewater was clarified significantly in approximately a 24-hour period. Therefore, a preliminary hydraulic detention time of 24-hours seemed reasonable

for the equalization basin testing. At the end of the 24-hour period, wastestream samples were collected to assess suspended solids and POC removal of the process.

36. The resulting suspended solids concentration for the wastestream(s) ranged from 32-108 mg/l. As shown in Table D-6, it appears that removal of suspended solids resulted in the removal/reduction of some key POCs; most notably PCB Arochlor 1248, and metals. This information provides support to what the Corps has experienced with its CDF program, that is, many contaminants become bound with the sediment particle matrix. Removal of sediment particles (TSS) from the CDF wastestream(s) will serve as a key mechanism for POC removal.

37. It should be noted that at the end of the pumping cycle for wastestream(s) 1,2, and 4 (sediment-related streams), it became apparent that a significant amount of solids (1/2-1") had accumulated in the bottom of the storage containers (equalization basins). The observation of these solids leads to the conclusion that the equalization basin will have to be designed with provisions to remove solids from the bottom of the tank as well as skimming off any accumulated oils/solids from its surface.

Sand Filtration

38. Sand filtration was the next component in the treatment train, which further removed suspended solids and minimal amounts of floating solids and oily materials that accumulated on the equalization basin water surface. Wastestream(s) were pumped directly from the equalization storage reservoirs to the sand filtration units using peristaltic pumps. The flow rates to the units were adjusted to simulate a flow:surface area ratio equivalent to a hydraulic flow rate of approximately 1 gpm/ft^2.

39. The resulting suspended solids concentration for the wastestream(s) ranged from <1-24 mg/l. Like the equalization process, it appears that removal of suspended solids resulted in the removal/reduction of some key POCs; most notably PCB Arochlor 1248, metals, total phosphorous, and cyanide.

40. As can be seen in Table D-6, a number of pesticides appeared in the effluent from the sand filtration process. However, laboratory notes indicate that pesticide samples were spiked with pesticide spiking compounds in the analytical lab instead of surrogate spiking compounds. Concentrations detected are related to these spikes and probably not present in water samples based on characterization data.

Cyanide Oxidation (Alkaline Chlorination)

41. Even though insignificant concentrations of cyanide amenable to chlorine were detected in the original wastestream samples, screening results demonstrated that alkaline chlorination had the ability to reduce total cyanide concentrations to below detection.

42. Sand filtered wastestream(s) were placed in a 10-gallon stainless steel vessel equipped with a variable-speed mixer. The pH of individual wastestream(s) was adjusted to 8.5 to 9.0 using NaOH solution. Common household bleach (5.25 %NaOCl) was then

added to an individual wastestream in an effort to increase the Oxidation Reduction Potential (ORP) of the wastestream to the target 600 mV. After the target ORP was achieved the chlorination reaction was allowed to progress for a period of 1-2 hours. At the end of that period, the mixer in the reaction vessel was stopped and samples were collected for laboratory analysis.

43. For this confirmation testing, the effluent from the sand filtration unit reduced cyanide concentrations in all wastestream(s) to below or near the conservatively based discharge criteria. The effluent from the cyanide oxidation step, in all wastestream(s) had cyanide concentrations below detection.

44. As can be seen in Table D-6, carbon tetrachloride appeared in the effluent from the alkaline chlorination process. It is likely that the carbon tetrachloride resulted from chemical impurities used in the oxidation step, since it was not found in the raw wastewater or the previous unit operations.

Metals Precipitation with Neutralization

45. After samples had been taken out of the reaction vessel for the assessment of cyanide oxidation performance, the remaining volume of wastestream was ready for the metals removal unit operation. The above-referenced reaction vessel was used continuously for both the cyanide oxidation and metals removal steps.

46. The pH in the wastestream(s) was increased from 8.5-9.0 to around 11.3 using 10% NaOH under relatively rapid mix conditions. A wastewater polymer (Betz AE130) was added to the reaction vessel and the wastewater mixed. After the solids had settled out on the bottom of the reaction vessel, the sludge was collected and sent to the analytical laboratory for TCLP metals analysis. The pH values of the supernatant were reduced to the optimal range of 8.0-8.5 for nitrification and processing in the SBRs. The details of the operation can be found in Maxim's report (1999).

47. As shown in Table D-6, chemical precipitation demonstrates the ability to remove key metals in the effluents to below the conservatively based discharge criteria. Mercury appeared in some of the wastestream(s). However, in looking at the results of previous operations and the raw wastewater mercury concentrations it appears to fluctuate above and below the criteria. This could be a result of sensitivity, which arises being close to a method detection limit (0.25 ug/l), or from potential experimental cross-contamination.

48. The metal hydroxide sludge's resulting from the operation were analyzed for hazardous characteristics as shown in Table D-5. However, there was not enough sludge mass generated for wastestream(s) 1 and 2 to perform TCLP metals analyses. Here, total metals were analyzed and an estimate of the resultant leachate concentration for the metals was calculated using the following formula:

(100)(sample concentration ug) = Maximum leachate concentration in ug/ml(2)(1000 ml)

49. The above calculation is conservative and assumes that the entire mass of pollutant in the solid leaches to the extracting liquid. Based on the results from these tests (and calculations) it appears that none of the sludges possesses the characteristics of a hazardous waste. Therefore, the sludge resulting from the metals precipitation unit operation is anticipated to being disposed within the CDF. However, this would need to be confirmed by the actual testing from the full-scale system.

Biological Treatment (SBR)

50. Effluents from the chemical precipitation units were used as the influents for the SBRs. Four 8-liter batch bioreactors were set up for the primary purpose of reducing ammonia concentration to below the conservatively based discharge criteria. Performance of the bioreactor systems was monitored daily using Hach method for ammonia analysis (Hach DR2000 method) as well as for nitrates, nitrites, alkalinity and pH. During the study, there were some differences in the ammonia results produced by the analytical laboratory on preserved samples and the results generated by the Hach spectrophotometric method on fresh samples. It is believed that the Hach results are more realistic, and were, in most cases more conservative. Operation of the bioreactor, and a complete compilation of the results are provided in Maxim's report (1999).

51. As shown in Table D-6, biological treatment (nitrification in SBRs) demonstrated the ability to remove ammonia nitrogen to below the conservatively based discharge criteria. The results (Hach) for all the wastestream(s) ranged from 0.51-1.4 mg/l. It can also be seen that except for phosphorous, and an anomalous lead spike, all other POCs have been reduced to below the conservatively based discharge criteria after biological treatment. Since the phosphorous concentration in the wastestream(s) prior to the SBRs was very low, it is likely that the high values found in the effluent were an artifact of the process. During operation of the SBRs, phosphorous and other salts were added as biomass nutrient additions. These additions will have to be fine-tuned in the full-scale system so that what is added to the SBR is consumed by the microorganisms.

52. During the operation of the bioreactors, several tests were performed to gain more information about this technology to further assess its applicability to treat CDF effluents. Some of these tests include sludge settling, and developing oxygen transfer coefficients which can be used as input for future aeration equipment sizing calculations (HP requirements, oxygen needs etc.). These aspects will be developed in the Treatment Plant DDR.

53. After the completion of the Run I bioreactor testing, samples of the biological sludge in the SBRs were collected for complete TCLP analyses and other hazardous waste characteristics analysis as indicated in Table D-5. Based on the review of these results, none of biological sludges from the wastestream bioreactors possess the characteristic of a hazardous waste. Therefore, like the metals sludge, this material will probably be disposed within the CDF.

Carbon Adsorption

54. Carbon filtration was the next component in the treatment train incorporated to polish any remaining trace organics left in the wastestream(s). To simulate the carbon filtration units, 2.75" diameter X 16" glass columns were filled with approximately 375 grams of Calgon F-400 carbon. Wastestream(s)were pumped directly from the bioreactor effluent reservoirs to the carbon filtration units using peristaltic pumps. The flow rates to the units were adjusted to simulate a flow:surface area ratio equivalent to a hydraulic flow rate of approximately 1 gpm/ft^2. A sand filter was not placed between the bioreactor and the carbon filter because the settled bioreactor effluent was relatively free of suspended solids. Complete operational characteristics of the test are provided in Maxim's report (1999).

55. As shown in Table D-6, the POC concentrations exiting the carbon units have been reduced to below the conservatively based discharge criteria, except for an anomalous spike of mercury and ammonia. Considering the entire data set, there was some POC removal at low concentrations, as discussed in Maxim's report (1999). Considering the results of the treatment system, incorporation of carbon filtration in the full-scale system would primarily be for insurance and not for specific POC removal.

Ammonia Stripping (Final Effluent)

56. Ammonia stripping was incorporated into the Run I treatment train because in some cases during screening testing (see table D-4), the bioreactors did not produce an effluent which was below anticipated effluent limitations.

57. The final batch ammonia stripping tests were performed in the 5-gallon carbon filter effluent reservoirs. The pH of the carbon effluents were initially increased from about 8.0 to 11.0 using NaOH. The wastestream(s) were then aerated vigorously with air at a flow rate of 4.0 L/min. Hach ammonia tests were performed at different time intervals to monitor the ammonia removal rate over time. After the ammonia concentrations stabilized, the stripping tests were terminated. The pH of the ammonia stripping effluents for each wastestream were then reduced from 11.0 to around a neutral pH. Samples of the effluents were then collected for laboratory analysis.

58. As shown in Table D-6, and discussed in previous sections, the only POCs (bis (2-Ethylhexl) phthlate and total phosphorous) in the final effluent were most likely artifacts of the experimental setup. As noted earlier biological treatment (nitrification in SBRs) demonstrated the ability to remove ammonia nitrogen to below the conservatively based discharge criteria. The results (Hach) of ammonia stripping for all the wastestream(s) are provided below:

	Influent (mg/l)[1]	Effluent (mg/l)
Wastestream #1	1.43	0.95
Wastestream #2	0.64	0.60
Wastestream #3	1.56	1.40
Wastestream #4	0.80	1.10

[1]effluent from carbon filter

Based on these results the ammonia stripping step did not effectively reduce ammonia concentrations below that achieved by biological treatment.

Confirmation Testing Run II Results

59. At the end of Confirmation, Run I activities, it was discovered that the amount of sample remaining to complete the specified treatability study would not be sufficient volume to perform all of the Run II testing. Sample volume deficiencies can be attributed to additional volume needs for testing and analysis not anticipated during the first two phases of testing. The decision was made to create a synthetic feed to make up the difference in volume required to complete Run II treatability testing activities. The desired objectives associated with the creation of synthetic (spiked) feeds for this phase of the study were as follows:

a) Create enough wastestream sample volume to complete Run II

b) Create influent feeds with POC concentration high enough so they can be tracked throughout the effluent treatment train

c) Further assess the overall performance of the treatment train being introduced to variable influent feeds

The key POCs which were selected for spiking into the synthetic feeds were as follows:

#1—Sediment Pore Water	#2—Precipitation Runoff Water	#3—ECI Groundwater	#4—Combination Wastestream
Phenol (0.1 mg/l)	Pyrene (1.0 mg/l)	Benzene (1.0 mg/l)	No additional spiking
Naphthalene (0.5 mg/l)	Naphthalene (1.0 mg/l)	Ethylbenzene (10.0 mg/l)	
		Toluene (5.0 mg/l)	
		Xylene (15.0 mg/l)	
		Naphthalene (0.5 mg/l)	
		Phenanthrene (0.5 mg/l)	
		Heptachlor (0.25 mg/l)	

60. For wastestream(s) 1 and 2, about 10% of the wastestream volume was obtained from the feed used in Run I, with the remaining volume made up of tap water and POC spikes. For wastestream 3, the entire volume used during this test was original ECI groundwater spiked as noted above. Wastestream 4 was essentially generated through the creation of a flow proportioned composite of the first three wastestream(s).

61. A comparison of the theoretical POC spike concentrations to the associated Run II raw wastewater (see Maxim 1999 for results) leads to the conclusion that recoveries on some of the POCs spiked into the synthetic feeds were low. Potential reasons for low POC spiked recoveries were as follows:

a) Low solubilities of some of the organic POCs

b) Preservation and analytical laboratory processing of the wastestream(s) samples (acidification) in the presence of ammonia and other organics could have produced side reactions which falsely mask the presence of the POC in the wastestream(s)

c) Analytical interference with the presence of significant number of organic and inorganic POCs in both the synthetic and original sediment derived feeds, these were both difficult waste matrices to analyze

62. Despite the fact that recoveries for some POCs in the spiked wastestream(s) were lower than anticipated, there were still POCs detected at a concentration high enough to generate performance data on the treatment configuration tested during Run II.

63. As previously discussed, Table D-5 provides the analyses of POCs and sampling points for the Confirmation testing. As indicated on Plate D-2, after a wastestream was processed through a unit operation or process, samples were collected from the effluent for laboratory analyses. The remaining volume of the processed effluent then became the influent for the next unit operation in the treatment train. In this sense the actual method of wastestream processing used during Confirmation testing was considered semi-continuous in nature.

64. A summary of the Confirmation Run II results are provided in Table D-7. It should be noted that Table D-7 provides data only for those parameters that were above the conservatively based discharge criteria. A complete compilation of all analytical results can be found in Maxim's report (1999). As was the case for Run I, a few parameters which appeared in the confirmation testing are likely an artifact of the experiment rather then a POC for the CDF project. These parameters include chloroform, pyrene, bis (2-Ethylhexl) phthalate, pentachlorophenol, and carbon tetrachloride.

Equalization Basin

65. The procedures used with Run I testing to simulate this unit operation was also used during Run II activities. At the end of a 24hr settling/equalization period, wastestream(s) samples were collected off the top of the unit to assess POC removal. The resulting suspended solids concentration for the wastestream(s) ranged from 16 – 92 mg/l. As shown in Table D-7, it appears that removal of suspended solids resulted in the reduction of some key POCs; most notably PCB Arochlor 1248 and metals. Again, this information provides support to what the Corps has experienced with its CDF program, that is, many contaminants become bound with the sediment particle matrix. Removal of sediment particles (TSS) from the CDF wastestream(s) will serve as a key mechanism for POC removal.

66. Similarly to the Run I results, at the end of the pumping cycle for wastestream(s) 1,2, and 4 (sediment-related streams), it became apparent that a significant amount of solids (1/2-1") had accumulated in the bottom of the storage containers (equalization basins). The observation of these solids leads to the conclusion that the equalization basin will have to be designed with provisions to remove solids from the bottom of the tank as well as skimming off any accumulated oils/solids from its surface.

Sand Filtration

67. Sand filtration was the next component in the treatment train, which further removed suspended solids and minimal amounts of floating material which accumulated on the equalization basin water surface. The procedures used during Run I testing were also used during the implementation of Run 2.

68. The resulting suspended solids concentration for the wastestream(s) ranged from 16-20 mg/l. Like the equalization process, it appears that removal of suspended solids resulted in the removal/reduction of some key POCs; most notably PCB Arochlor 1248, metals, total phosphorous, and cyanide. In addition all of the spiked parameters, discussed earlier, have been reduced to below or near their conservatively based discharge criteria.

Cyanide Oxidation (Alkaline Chlorination)

69. Run 2 testing was performed using the same procedures and equipment as was used during Run 1. As was the case for Run I the effluent from the sand filtration unit reduced cyanide concentrations in all wastestream(s) to below or near the anticipated discharge limit. The effluent from the cyanide oxidation step, in all wastestream(s) had cyanide concentrations below detection.

Metals Precipitation W/Neutralization

70. The procedures used during Run 1 activities were again used during the implementation of Run 2 activities. As shown in Table D-7, chemical precipitation demonstrates the ability to remove all key metals, in the liquid wastestream(s) to below anticipated discharge limitations.

Biological Treatment (SBR)

71. The procedures and equipment used to evaluate biological treatment of the CDF effluent wastestream(s) were again used to perform Run 2 confirmation treatability tests. As shown in Table D-7 biological treatment (nitrification in SBRs) demonstrated the ability to remove ammonia nitrogen to below the conservatively based discharge criteria. The results (Hach) for all the wastestream(s) ranged from 0.45-1.4 mg/l.

72. Two pesticides appeared and are believed to have been incorporated from the SBR operation since they were not found in previous unit operations, or the raw wastewater characterization. Surprisingly some metals (cadmium, copper, mercury, and zinc) re-appeared in the effluent after being reduced to below the discharge criteria after the metals precipitation step. This is believed to have resulted from experimental cross-contamination. As was the case in Run I phosphorous concentrations rose significantly in the SBR effluent. Since the phosphorous concentration in the wastestream(s) prior to the SBRs was very low, it is likely that the high values found in the effluent were an artifact of the process. During operation of the SBRs, phosphorous and other salts were added as biomass nutrient additions. These additions will have to be fine-tuned in the full-scale system so that what is added to the SBR is consumed by the microorganisms.

Carbon Adsorption

73. Carbon filtration was the next component in the treatment train incorporated to polish any remaining trace organics left in the wastestream(s). The procedures used to implement Run II carbon tests were the same as those used during Run I.

74. As shown in Table D-7, the POC concentrations exiting the carbon units have been reduced to below the conservatively based criteria, except an anomalous ammonia spike

75. Considering the entire data set, there was some POC removal at low concentrations, as discussed in Maxim's report (1999). Considering the results of the treatment system, incorporation of carbon filtration in the full-scale system would primarily be for insurance and not for specific POC removal.

<u>Ammonia Stripping (Final Effluent)</u>

76. As was the case for Run I, ammonia stripping was incorporated into the Run II treatment train because in some cases during screening testing (see table D-4), the bioreactors did not produce an effluent which was below anticipated effluent limitations.

77. As noted earlier biological treatment (nitrification in SBRs) demonstrated the ability to remove ammonia nitrogen to below the conservatively based discharge criteria. The results (Hach) of ammonia stripping for all the wastestream(s) are provided below:

	Influent (mg/l)[1]	Effluent (mg/l)
Wastestream #1	0.4	0.41
Wastestream #2	0.45	0.19
Wastestream #3	1.96	1.43
Wastestream #4	0.76	0.28

[1]effluent from carbon filter

Based on these results the ammonia stripping step did not effectively reduce ammonia concentrations below that achieved by biological treatment.

Summary of Confirmation Testing

78. The confirmation testing showed that many of the POC concentrations found in the raw wastewater were reduced in the equalization basin unit operation. Since it appears that some of the POCs are bound to sediment solids, which are probably silts and clays, solids separation serves as a key mechanism for POC removal. A similar process was apparent in the sand filtration operation. Metals were removed through metals precipitation, biological treatment effectively reduced ammonia, and carbon removed trace levels of organics and metals.

79. Some POCs were unexpected because they only appeared in downstream unit operations, or they were effectively removed in upstream unit operations but reappeared in downstream operations. These POCs include chloroform, pyrene, pentachlorophenol, 2,4-dimethyphenol, bis(2-ethylhexyl)phthalate, carbon tetrachloride, pesticides, and phosphorous. It is likely that the appearance of these POCs is an artifact of the experiment and resulted from one of the following: chlorination/oxidation byproducts, media impurities, lab cross contamination, or nutrient additions.

TREATABILITY STUDY CONCLUSIONS AND RECOMMENDATIONS

80. The method in which the CDF is operated will probably impact wastestream(s) characteristics. Based on the knowledge gained through treatability activities, if pore or precipitation water is maintained in the cell for a long period of time, it may provide a wastestream with even less waste load because solids carrying POCs become incorporated into the sediment within the cell. The longer the effluent stays within the CDF cells, the less the POC waste load will probably be. However, storage of effluent within the CDF cells will increase effective dewatering time. Hence there is a tradeoff, and the CDF operation will be a factor in the wastestream variability anticipated for the CDF treatment system. The efficient and effective use of the CDF cells for improving effluent quality and minimizing dewatering time will be developed in the Treatment Plant DDR.

81. Oil and grease concentrations detected in the raw (untreated) wastestream(s) were extremely low (14 – 160 mg/l) and did not justify the incorporation of a dedicated oil/water separator. However, in anticipation of dynamic influent wastestream(s) to the CDF treatment system, an equalization basin equipped with an oil skimmer and bottom solids handling equipment is recommended.

82. Because the total cyanide concentrations were low in the raw wastestream(s) and biological treatment removed total cyanide in non-chlorinated influents, it is concluded that the alkaline chlorination step may not be warranted. Other potential reasons to remove this unit operation from the recommended treatment train include undesirable oxidation byproducts, and significant chemical use and handling requirements (chlorine, NaOH, and sodium sulfite).

83. During the study, there were some differences in the ammonia results produced by the analytical laboratory on preserved samples and the results generated by the Hach spectrophotometric method on fresh samples. For the purposes of evaluating ammonia removals across unit operations, Hach results were used in many cases. It is recommended that the ammonia analytical method and characterization for the CDF wastestream(s) be further evaluated in additional treatability testing.

84. In some cases, spiking wastestream(s) prepared at the beginning of Run II testing had low recoveries but the subsequent data generated provided additional information regarding treatment train POC removal efficiencies.

85. Influent biodegradable organic carbon waste loads to the SBRs were low and may have to be supplemented in a full-scale system with sanitary waste or some other source of organic carbon to maintain a viable biomass. The units were not operated long enough to exhibit signs of potential operational problems.

86. Preliminary separation/settling is a key mechanism for the removal of POCs at the beginning of the proposed treatment system. Based on the treatability data associated with the three separation unit operations (equalization, sand filtration, metals precipitation), it appears as if the sand filtration unit may be redundant since the metals precipitation's effluent can achieve comparable TSS concentrations and associated POC removal efficiencies. It is therefore concluded that the sand filtration unit at the beginning of the treatment system may not be required. However, if the biological treatment unit effluent experiences solids carryover problems, it may be necessary to provide sand filtration upstream of the carbon filtration unit to protect the carbon filters.

87. The sludges generated during the treatability testing, including the metal hydroxide and biological sludges, did not demonstrate the characteristics of a hazardous waste based on the analysis performed on test samples. Therefore, it is feasible to dispose of these sludges within the CDF. It is anticipated that sludge collection systems will need to be incorporated into the aforementioned processes, at a minimum this would include pumps and storage tanks.

88. During the treatability study, POCs sometimes appeared across unit operations but were treated in most cases to non-detectable levels by the time the wastestream had passed through the entire treatment system. The POCs, that appeared in the treatment system included some VOCs, SVOCs, and pesticides. This can possibly be attributed to oxidation byproducts and impurities in filtration media.

89. During the performance of the treatability study various chemicals were added to process various wastestream(s) within unit operations/processes. Examples of these chemicals are as follows:

a. Phosphorous and other salts were added to the bioreactors as biomass nutrient additions. These additions will have to be fine-tuned in the full-scale system so that what is added to the SBR is consumed by the microorganisms. Therefore, the concentration demonstrated during the bioreactor testing is not representative of what will be seen in the full-scale system effluent.

b. Phthalates were present in a significant number of unit operations/process effluents during the treatability testing. The source of these common plasticizer compounds is probably the plastic components used during the treatability study to simulate treatment units.

c. Methylene chloride, methylethyl ketone, and acetone were detected in some unit operation/process effluents. These solvents are considered common laboratory contaminants and are likely not representative of CDF effluent wastestream(s) evaluated.

90. Since the majority of the wastestream effluents generated from the treatability testing were below detection limits, it can be concluded that the treatment train(s) evaluated are appropriate for treating the CDF effluent, and should perform satisfactorily at the full scale level.

91. In most cases, the final effluent qualities produced by the tested treatment trains did comply with conservatively based discharge criteria. However, it is recommended that the anticipated effluent limitations be revisited to consider updated or pending regulations and to address mixing zone considerations, etc. In addition, regulators need to be contacted to confirm the use of water quality criteria as anticipated effluent limitations prepared by an NPDES permit writer.

92. The activated carbon unit did remove organic waste loads and primarily served as a polishing unit. It should be considered a key component of the treatment train and as added insurance at removing trace levels of metals and organics.

93. Ammonia stripping was effective in the reduction of ammonia concentrations as a primary ammonia removal step as shown in the screening test results. However, as a polishing step, the technology was not very effective in transferring low concentrations of ammonia from the liquid to the air phase. This technology could represent a significant cost to remove minimal concentrations of ammonia. In addition, its incorporation into the treatment train will also require the use and handling of chemicals; a base to initially bring up the wastestream pH to 11.0 (optimal ammonia equilibrium value), and then an acid to bring the pH of the wastestream to within the appropriate range for discharge to a receiving stream (typically 6-9).

94. During the operational life of the CDF the characteristics of the CDF wastestream(s) is likely to change due to the temporal and spatial heterogeneity of the sediments within the project area. In some cases, the wastestream(s) characteristics will be similar to those seen during the treatability study and sometimes the characteristics could be somewhat different. However, it is anticipated that the POCs will be similar with varying concentrations.

95. It is anticipated that the treatment train selected for the CDF effluent will be able to handle wastestream variability through the use of extra detention time in unit operations/processes (equalization basin, biotreatment), with extra chemicals (chemical precipitation), and extra filtration media (activated carbon, sand filtration). In addition, operation attention and laboratory analysis will have to be used to closely monitor influent wastestream and resultant effluent water quality. If there is a wide variability in POCs over time, modification of the treatment train configuration may have to be considered. In this sense treatment of the resultant wastestream(s) will be an on-going

learning process. The knowledge gained through the operation of the full-scale system will direct operators on how to respond to changes in wastestream characteristics.

96. Given the variability inherent in the nature of this project it is recommended that the designed treatment system be modular so that unit operations can be added, taken out of service, or bypassed as required.

RECOMMENDED TREATMENT SYSTEM CONFIGURATION

97. Based on the information/data gathered, evaluated, and presented in this appendix and reports (Maxim 1999 & 1998), it is recommended that the configuration for the treatment train, as shown in Plate D-3, is as follows

- Flow Equalization Basin: This unit operation is recommended to remove settleable solids and associated POCs, remove floating oils and solids and to blend and equalize all of the flows associated with the CDF. The equalization basin will have to be equipped with an oil skimmer for the collection and ultimate removal of any floating oil. In addition, the tank would employ bottom solids collection and handling equipment for the removal of sediment solids anticipated to settle in the equalization tank.

  For future design, the equalization tank will have to be sized to match the operation of the CDF and ECI groundwater pumping scheme. In addition, it will also need to be sized large enough to equalize design criteria flows and to provide enough hydraulic retention time to allow for solids settling. If the tank is not sufficiently long enough, the unit operation may be subjected to overload with respect to settable and floating solids.

- Chemical Precipitation System: After the wastestream flows from the equalization basin, it will enter the chemical precipitation system consisting of a rapid mix tank, a flocculation tank and a clarifier (lamella type clarifiers typically are used in this application). The purpose of the chemical precipitation unit operation is to remove concentrations of metals and suspended solids, which become agglomerated in the metal hydroxide floc. This technology can handle fluctuation variations in initial metals and solids concentrations with supplemental chemical addition.

  Chemical characterization of the influent will need to be constantly monitored so that adjustments can be made to chemical additions (NaOH and polymers) for optimal metals removal. During the operation of the treatment system, it may be advantageous to periodically evaluate different chemical additions to optimize metals removal and sludge settling characteristics. If the system is undersized, it may be subject to metals concentration carry-over and hydraulic and solids overloading. A collection system will remove sludge.

- Biological Treatment (Sequencing Batch Reactors): After removal of metals, the wastestream will flow to the biological treatment system which accomplishes the following: removal of ammonia, removal of trace volatile and semi-volatile organics, removal of trace amounts of cyanides, and adsorption of trace concentrations of metals.

  The sequencing batch reactor technology may be subject to upset from hydraulic and organic waste-load overloads. Therefore, operator attention to define wastestream characterization will provide guidance as to the operation of the SBR during a specific waste batch. Other potential limitations associated with this technology are related to low BOD/TKN ratios. If the ratios are low, supplemental organic carbon may have to be added to the bioreactors to maintain a viable biomass. It is recommended that several batch reactors be incorporated into the final design so that while one reactor is treating a batch of waste, the other can be receiving or settling out a waste batch. A collection system will remove sludge.

- Sand Filtration: Sand filtration is recommended for inclusion in the treatment train between the bioreactors and the carbon filters. The primary purpose of this unit operation is to remove any solids carry-over from the bioreactors in order to protect the carbon filters. The main limitation associated with this unit operation is the potential for hydraulic overloading with respect to suspended solids. In addition, it will periodically require backwashing to clean the media beds and prevent solids breakthrough. System pressure and effluent suspended solids will have to be monitored frequently to assess when the system requires backwashing due to solids breakthrough. During the active life of the CDF, the backwashed solids will be disposed of in the CDF, if appropriate.

- Activated Carbon Filtration: The final unit operation in the treatment train is carbon filtration. The purpose of this unit operation is to serve as the final protective/polishing step before discharge to the IHC for the removal of trace metals and organics.

  As with the sand filtration unit operation, the main limitation associated with this unit operation is the potential for hydraulic overloading with respect to organic compounds and suspended solids. In addition, it will periodically require backwashing to clean the media beds thus preventing solids breakthrough. System pressure, effluent organic compound concentrations and effluent suspended solids will have to be monitored frequently to assess when the system requires backwashing due to organic or solids breakthrough.

98. A preliminary treatment plant layout is provided as Plate D-4. Maxim made a rough estimate of the size requirements assuming a normal operating flow of 200 gpm and a peak operating flow of 500 gpm. The peak operating flow would occur only during large storm events. It is assumed that during these events, due to the dilution of rain water, the only unit operations needed to treat the effluent would include: equalization, sand filtration, and carbon adsorption. This assumption will be confirmed in the Treatment

Plant DDR prior to design of the final treatment system. The entire treatment plant and ancillary operations is estimated to require a area of approximately 180 ft. x 800 ft., and would be located in the western portion of Parcel I.

99. The CDF treatment system presented above should be flexible enough to address a wide variation in the POCs of concern. If the characteristics of the CDF wastestream(s) change, the treatment configuration may require modification. Flexibility will have to be built into the design to accommodate wastestream variation. Modular design will be considered to allow for adding unit operations/processes, removing unit operations/processes, or bypassing unit operations/processes based on the actual wastestream characteristics and operational constraints.

100. As presented in this appendix, oil/water separation, ammonia stripping, and alkaline chlorination were also tested as potential components of the treatment train. However, they were eliminated from the treatment train for the reasons listed below.

101. The oil/water separator was eliminated because the oil & grease concentrations in the raw wastestream(s) were not considered high enough to warrant a dedicated unit operation for oil removal. As an alternative, the flow equalization tank will be modified to remove any accumulated floating oil and debris, through skimming, from the influent before it proceeds to downstream unit operations/processes.

102. The alkaline chlorination unit operation was not included in the treatment train primarily because the cyanide concentrations detected in the treatability study wastestream(s) were low enough to be removed in the biological treatment unit. In addition, chlorination of the wastestream matrices cause undesirable byproducts and the operation of the system requires extensive chemical handling.

103. The ammonia stripping was eliminated from the end of the treatment train because it required a significant amount of air to remove minimal concentrations of ammonia. The majority of the ammonia concentrations obtained from the bioreactors appeared to be below the most conservative value of Indiana Water Quality criteria (taken 12/98), which indicates that the stripping operation is not required.

104. In conclusion, the treatability studies have provided information on the performance of the proposed treatment system. The proposed system has been shown to be a viable system, and capable of producing an effluent which meets stringent water quality criteria. The next stage is design of the treatment system. However, prior to the design, a technical review of the treatability process and conclusions will be completed. It is also likely that some additional treatability evaluation will be completed prior to designing the effluent treatment system. After evaluating the results of additional treatability work, additional unit operations could be considered and placement within the treatment train of any given unit operation could change. Another issue to be determined before final design is the kind of and frequency of monitoring of the unit operations.

DEVELOPMENT OF FLOW RATES

Initial Analysis

105. The first analysis of the estimated flows to the treatment plant was performed prior to initiation of the treatability study. The flow analysis was performed over the 30-year life of the CDF and daily flow rates were developed from the annual estimates. Over the 30-year period, the minimum, average and maximum annual flow rates were approximately 75, 115, and 160 gpm, respectively. Refer to Attachment D-1 of the appendix.

106. As stated previously, the flow to the treatment plant consists of three wastestreams: sediment pore water (interstitial water), precipitation runoff, and ECI site groundwater. It was estimated that the influent flow to the treatment plant was comprised of the three components in the following approximate proportion:

pore water -- 16%

precipitation runoff -- 83%

groundwater -- 1%

The largest component of water requiring treatment was the precipitation runoff. Also, of the three components, the precipitation runoff was the most variable. Averaging the precipitation runoff over the entire year dampened the peak flows, therefore, additional analysis to evaluate flows from storm events was required.

Expanded Analysis of Precipitation Runoff from Storm Events

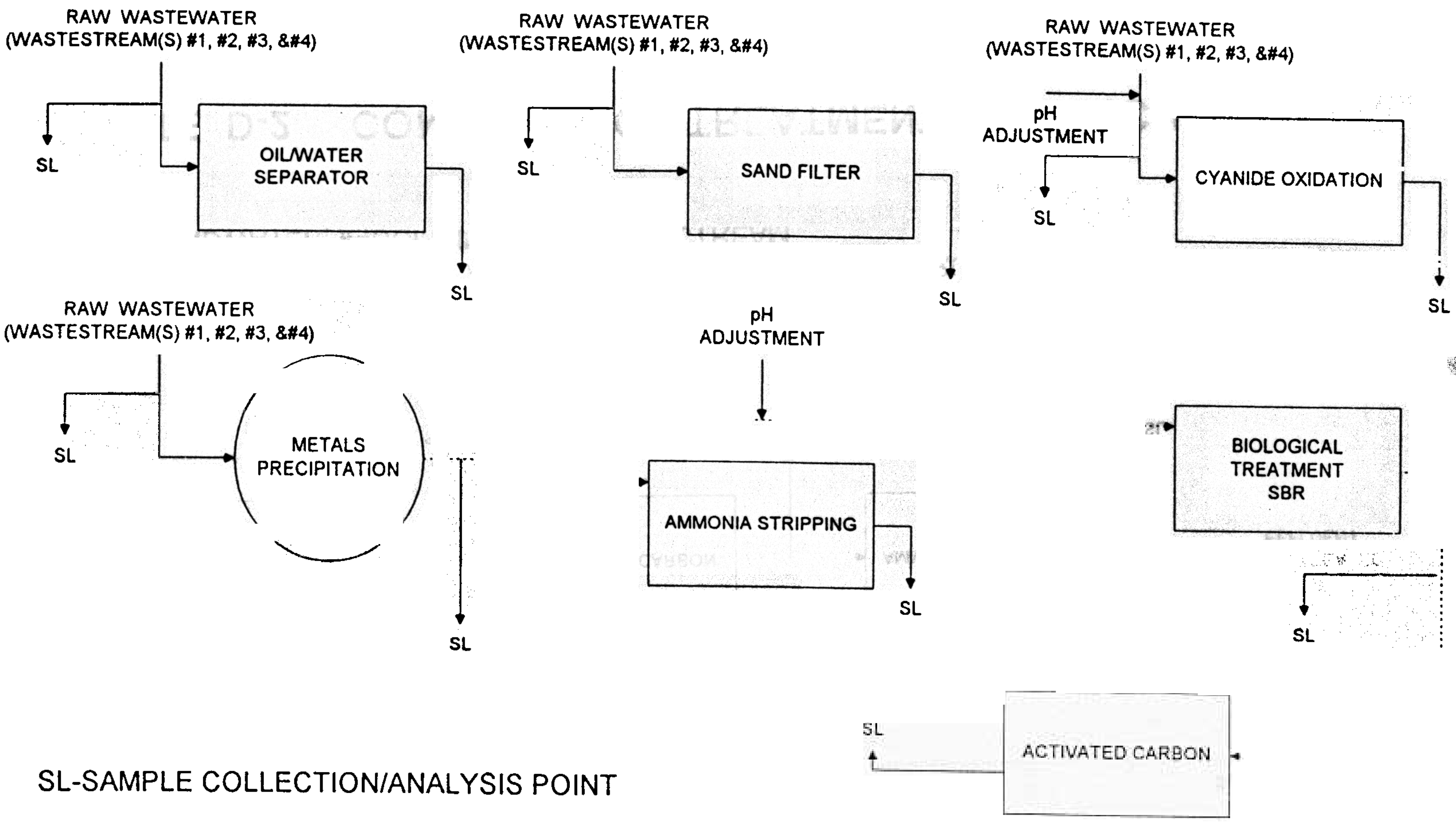
107. The treatment system must have the capacity to treat the variations in flow due to storm events. In order to determine the stormwater variation, a spreadsheet varying the interval and duration of the rainfall event was developed. Rainfall events with recurrence intervals of 1, 2, 10, 25 and 100 year(s) were included in the spreadsheet. A 1-day duration is typically used for flood control projects. With the assumption that stormwater storage in the CDF would extend beyond a 1 day duration, the 10 and 30-day durations were included in the analysis and the corresponding rainfall storage requirements were calculated. Knowing the storage volume required in the CDF for the rainfall events, the number of days that rainwater would remain in the CDF was calculated using varying effluent pumping rates. Attachment D-2 of the appendix contains the CDF storage volume requirements for the rainfall events, the number of days that rainwater was temporarily stored in the CDF, and the percent of CDF surface area innudated at varying pumpout flow rates.

108. Operation of the CDF will require a balance between temporarily storing stormwater versus promoting drainage to allow drying of the dredged material. Also, an increase in the average and peak flow rates to the system will increase the capacity and cost of the treatment plant. To lower capital costs of a treatment plant, it will be necessary to use the CDF as a temporary storage facility for stormwater events. It was decided that a recurrence interval of 2 years was sufficient for the design of the treatment plant and that allowing the rainfall to be stored in the CDF for approximately a month was a reasonable assumption for operation of the CDF. The system will be designed for the average flow of 200 gpm and a peak flow of 500 gpm. At the higher flow rates, it is anticipated that some of the unit operations will be bypassed. Smaller storms will be removed from the CDF in less time. Storms larger than the 2-year event will require additional time beyond 30 days to pump and treat the excess water. The additional time required is acceptable since the storms occur less frequently.

REFERENCES

Maxim Technologies, Inc. (1999).). Treatability Study Report for the Indiana Harbor Confined Disposal Facility (CDF) Effluent (Volume 1 and 2). Prepared for the U.S. Army Corps of Engineers, Chicago District.

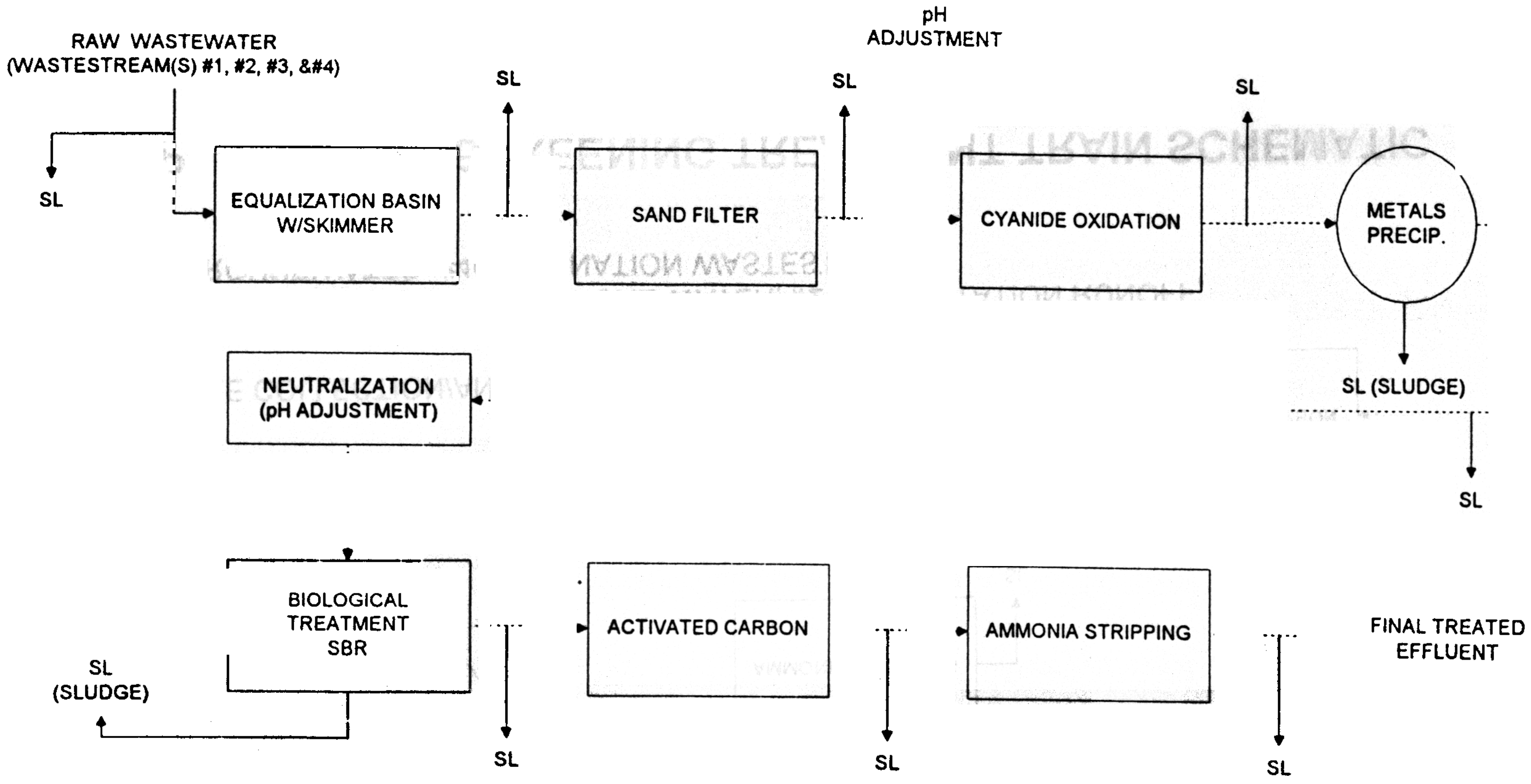
Maxim Technologies, Inc. (1998). Treatability Study Design for the Indiana Harbor Confined Disposal Facility (CDF) Effluent (Volume 1 and 2). Prepared for the U.S. Army Corps of Engineers, Chicago District.



SL-SAMPLE COLLECTION/ANALYSIS POINT

WASTESTREAM(S): #1-SEDIMENT PORE WATER, #2-PRECIPITATION RUNOFF, #3-ECI GROUNDWATER, #4COMBINATION WASTESTREAM

PLATE D- 1 SCREENING TREATMENT TRAIN SCHEMATIC



SL-SAMPLE COLLECTION/ANALYSIS POINT

WASTESTREAM(S): #1-SEDIMENT PORE WATER, #2-PRECIPITATION RUNOFF, #3-ECI GROUNDWATER, #4COMBINATION WASTESTREAM

PLATE D-2 CONFIRMATION TREATMENT TRAIN SCHEMATIC

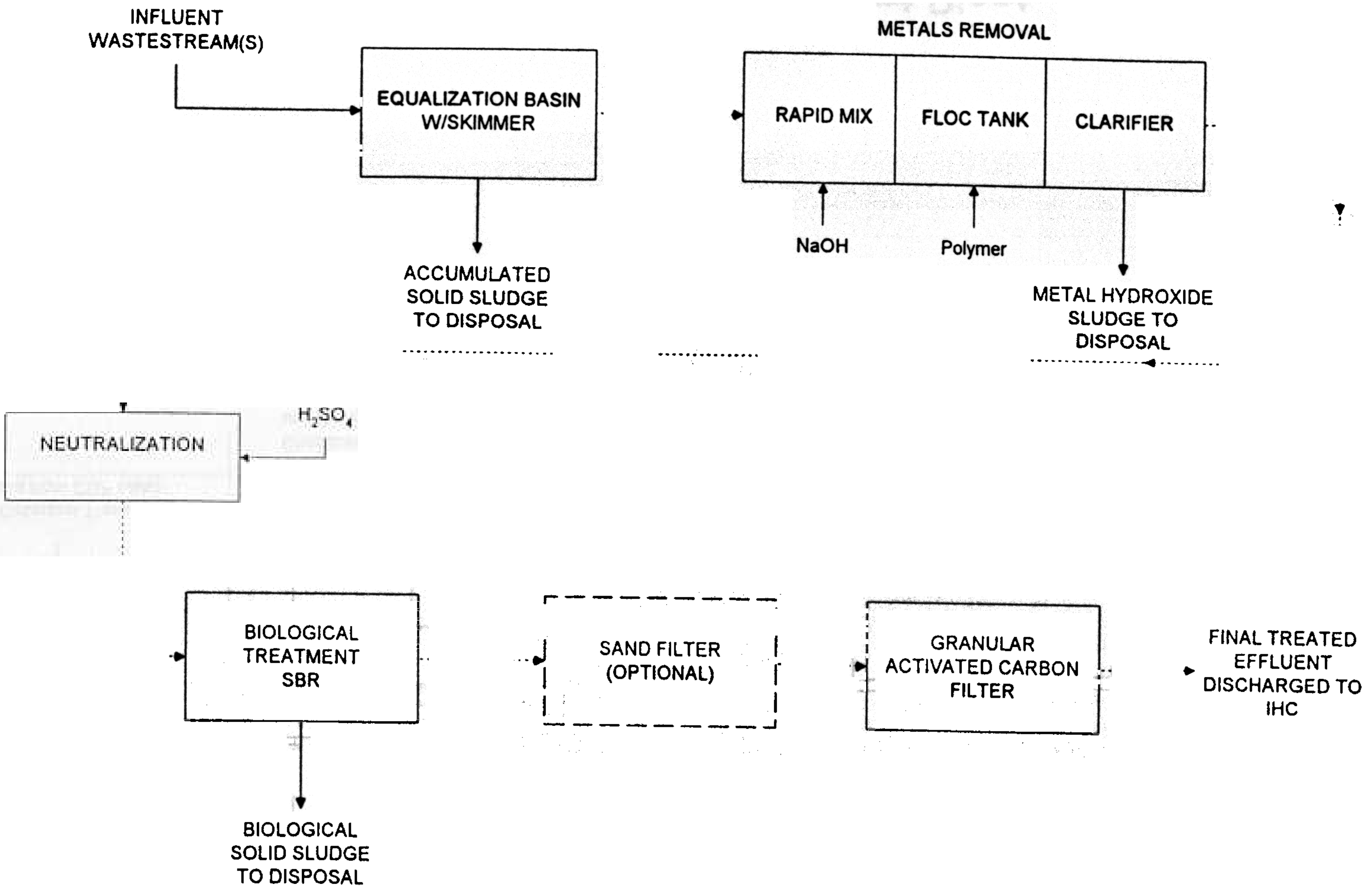
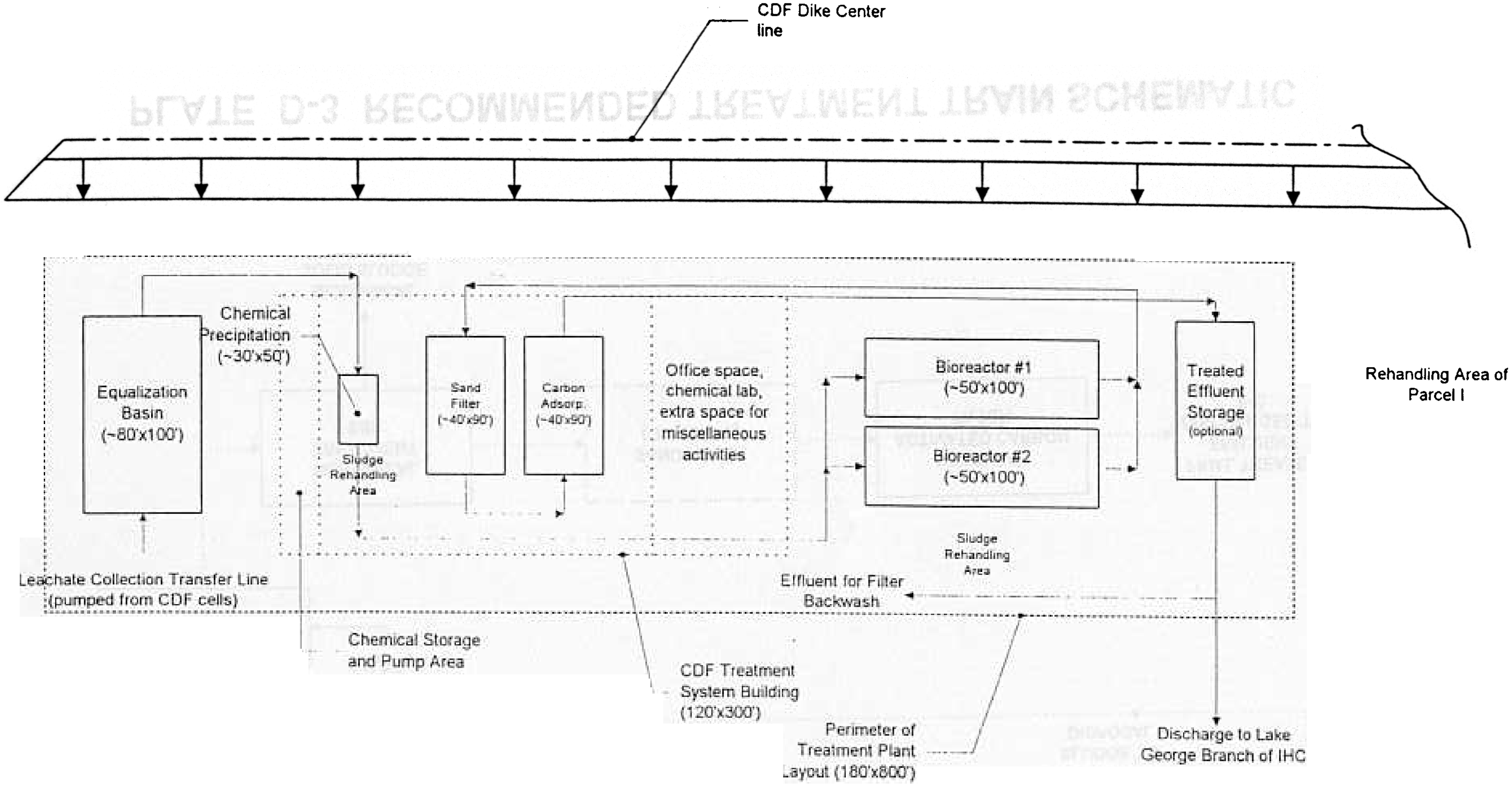


PLATE D-3 RECOMMENDED TREATMENT TRAIN SCHEMATIC



Note: Drawing not to scale

Plate D-4 Preliminary Treatment Plant Layout

Table D-1. Analytical Sampling Points for Wastestream Characterization—Screening[1]

Unit Operation	VOCs[2]	SVOCs[2]	Pesticides /PCBS	Metals	Cyanide	TSS /VSS	TDS	BOD	COD	TOC	NH_3	TKN	O&G	Total Phosphorus
Wastewater Characterization[3]	5	4	5	5	5	5	5	4	4	4	5	5	4	5
Oil/water Separator[4]													8	
Sand Filter	1	1	1	1		4			4	4			1	
Cyanide Oxidation					5									
Metals Precipitation				12										
Biological (SBR) Treatment	4	4	4	4	5	9	4		5	4	16	16		16
Activated Carbon	4	4	4						5	32				
Ammonia Stripping				4	5	4	5		4	4	5	5	4	5

[1]The number of samples shown are for all four wastestream(s): #1-sediment pore water, #2-precipitation runoff, #3-ECI groundwater, #4- combination wastestream
[2]VOCs-Volatile Organic Compounds, SVOCs-Semivolatile Organic Compounds
[3]Includes 1 duplicate sample collected for QA/QC
[4]Wastestream #1 only

Table D-2. Description of Unit Operations

Unit Operation/Process	Function
Flow Equalization	Flow dampening, gross TSS removal
Oil/water Separator	Removal of oil and grease
Filtration (Sand Filters)	TSS removal – removal of organics and metals adsorbed on silts and clays (colloidal solids)
Cyanide Removal (Alkaline Chlorination if required)	Cyanide destruction
Chemical Precipitation/Coagulation/Clarification	Heavy metal removal
Neutralization (pH Adjustment)	Adjust wastewater within the treatment system to a pH so that it is compatible with biological treatment and surface discharge
Biological Treatment (Sequencing Batch Reactor)	Removal of organics, BOD, TSS, and NH_3
Activated Carbon Adsorption	Removal of organics and trace heavy metals (polishing function)
Ammonia Stripping	Removal of lower concentrations of ammonia remaining in the wastestream after biological treatment; serves as a possible polishing step to get ammonia below target water quality criteria

Table D-3 Parameters Detected in Raw Wastestream[1]

Parameter[2]	Stream #1			Stream #2			Stream #3			Stream #4		
	Screen	Run I	Run II	Screen	Run I	Run II	Screen	Run I	Run II	Screen	Run I	Run II
VOCs (ug/l)												
Methylene Chloride (1500)		X			X	X		X			X	X
Acetone (1700)		X			X			X			X	
Chloroform (170)			X									
2-Butanone (1300)								X				
Bromodichloromethane (--)			X									
Benzene (98)			X			X	X	X	X	X		X
Toluene (94)							X		X			
Ethylbenzene (110)							X		X			
Total Xylene (35)							X		X			
SVOCs (ug/l)												
2-Methyphenol (--)									X			
4-Methhyphenol (--)									X			
2,4 Dimethylphenol (21)									X			
Naphthalene (26)							X		X			
2-Methylnaphthalene (--)							X		X			
Acenaphthene (27)					X							
Azobenzene (--)									X			
Fluorene (2.4)					X				X			
Phenanthrene (0.93)					X				X			
Fluoranthene (9.5)		X	X		X	X						
Pyrene (15)		X	X	X	X	X					X	X
Benzo(a)anthracene (0.025)		X	X		X	X						
Chrysene (--)		X	X		X	X						
bis(2-Ethylhexyl)phthalate (2.8)		X	X		X	X			X		X	
Benzo(b)fluoranthene (--)		X	X		X	X					X	
Benzo(k)fluroanthene (--)					X	X						
Benzo(a)pyrene ($2x10^{-5}$)		X			X	X						

[1](#1) = Pore Water; (#2) = Precipitation Runoff; #(3) = ECI Groundwater; (#4) = Combination Wastestream

[2]Value shown is based on most conservative value of Indiana Water Quality Criteria. Taken 12/98 and based on Hardness =184, Stream pH =7.3, Summer stream Temp=26.7 C, Summer stream pH =7.9 Winter stream temp= 10.1 C, and winter stream pH = 7.8

Table D-3 Parameters Detected in Raw Wastestream[1]--Continued

Parameter[2]	Stream #1 Screen	Stream #1 Run I	Stream #1 Run II	Stream #2 Screen	Stream #2 Run I	Stream #2 Run II	Stream #3 Screen	Stream #3 Run I	Stream #3 Run II	Stream #4 Screen	Stream #4 Run I	Stream #4 Run II
Pesticides/PCBs (ug/l)												
Arochlor 1248 ($6.8x10^{-6}$)	X	X		X	X	X				X	X	X
Metals (ug/l)												
Antimony (--)	X	X		X	X					X	X	
Arsenic (147.9)	X	X	X	X	X	X	X	X	X	X	X	X
Beryllium (--)	X	X	X	X	X	X				X	X	X
Cadmium (3.61)	X	X	X	X	X	X				X	X	X
Total Chromium (10.56/122)[3]	X	X	X	X	X	X	X	X	X	X	X	X
Copper (15.08)	X	X	X	X	X	X		X	X	X	X	X
Lead (13.95)	X	X	X	X	X	X	X	X	X	X	X	X
Mercury (0.0018)	X	X		X	X					X	X	
Nickel (87.1)	X	X	X	X	X	X		X	X	X	X	X
Silver (26,000)	X	X		X	X					X	X	
Thallium (--)		X			X	X						
Zinc (196.44)	X	X	X	X	X	X	X	X	X	X	X	X
Micel. Analytes (mg/l)												
Ammonia (1.51)	X	X	X	X	X	X	X	X	X	X	X	X
BOD (--)	X	X	X	X	X	X	X	X	X	X	X	X
COD(--)	X	X	X	X	X	X	X	X	X	X	X	X
Kjeldhl Nitrogen (--)	X	X	X	X	X	X	X	X	X	X	X	X
Oil & Grease (--)	X	X	X	X	X	X	X	X	X	X	X	X
TDS (750)	X	X	X	X	X	X	X	X	X	X	X	X
Total Cyanide (0.0052)	X	X	X		X	X		X	X		X	X
TOC (--)	X	X	X		X	X		X	X		X	X
Total Phosphorous (0.03)	X	X	X	X	X	X	X	X	X	X	X	X
Total Solids (--)		X	X		X	X		X	X		X	X
Total Suspended Solids (--)	X	X	X	X	X	X	X	X	X	X	X	X

[1](#1) = Pore Water; (#2) = Precipitation Runoff; #(3) = ECI Groundwater; (#4) = Combination Wastestream

[2]Value shown is based on most conservative value of Indiana Water Quality Criteria. Taken 12/98 and based on Hardness =184, Stream pH =7.3, Summer stream Temp=26.7 C, Summer stream pH =7.9 Winter stream temp= 10.1 C, and winter stream pH = 7.8

[3]Chromium(III)= 122; Chromium(VI)=10.56

Table D-4. Screening Test results[1]

Unit Operation	POC	Discharge Criteria[5]	Wastewater #1 Influent	Wastewater #1 Effluent	Wastewater #2 Influent	Wastewater #2 Effluent	Wastewater # 3 Influent	Wastewater # 3 Effluent	Wastewater #4 Influent	Wastewater #4 Effluent
Oil/water Separator	Oil & Grease (mg/l)	--	17	ND[2]	19	ND	14	5.4	6.6	ND
Sand Filtration	TSS (mg/l)	--	530	22	750	10	69	8	290	15
	Turbidity (NTU)	--	343	109	501	119	71	27	478	138
Cyanide Oxidation	Cyanide (mg/l)	0.0052	**0.033**	<0.005	**0.024**	<0.005	**0.01**	<0.005	**0.007**	<0.005
Metals Precipitation[3]	Antimony (ug/l)	--	18	10	14	9	<4	<4	15	<4
	Arsenic (ug/l)	147.9	20	<4	21	8	8	<4	17	5
	Beryllium (ug/l)	--	0.4	<1	0.4	<1	<0.2	<1	0.2	<1
	Cadmium (ug/l)	3.61	**11**	<2	**12**	<2	<0.5	<2	**8**	<2
	Chromium (ug/l)	10.56/122[4]	**480**	<5	**530**	<5	5	<5	**375**	<5
	Copper (ug/l)	15.08	**224**	13.6	**248**	12.5	<7.0	8.36	**163**	10.9
	Lead (ug/l)	13.95	**925**	11.3	**916**	**17.2**	8.4	2.7	**651**	**34.4**

[1]Wastewater #1 – Sediment Pore Water; Wastewater #2 – Precipitation Runoff; Wastewater #3 – ECI Groundwater; Wastewater #4 – Combination Stream; bold entries are values above a conservative value for the discharge criteria

[2]ND – Non-detect

[3]Metals precipitation based on NaOH addition with Polymer

[4]Chromium (III)= 122; Chromium (VI)=10.56

[5]Value shown is based on most conservative value of Indiana Water Quality Criteria. Taken 12/98 and based on Hardness =184, Stream pH =7.3, Summer stream Temp=26.7 C, Summer stream pH =7.9, Winter stream temp= 10.1 C, and winter stream pH = 7.8

Table D-4. Screening Test results[1] -- Continued

Unit Operation	POC	Discharge Criteria[6]	Wastewater #1 Influent	Wastewater #1 Effluent	Wastewater #2 Influent	Wastewater #2 Effluent	Wastewater # 3 Influent	Wastewater # 3 Effluent	Wastewater #4 Influent	Wastewater #4 Effluent
Metals Precipitation[3]	Mercury (ug/l)	0.0018	**0.6**	<0.25	**0.8**	<0.25	<0.2	<0.25	**0.5**	<0.25
	Nickel (ug/l)	87.1	70	30.5	54	12.9	<3.0	10.8	36	18.2
	Selenium (ug/l)	--	5	<5	5	<5	<5	<5	<5	<5
	Silver (ug/l)	26000	2.2	4.1	23	<0.5	<0.5	<0.5	2.4	<0.5
	Thallium (ug/l)	--	2	<2.5	2	<2.5	<2.0	<2.5	<0.02	<2.5
	Zinc (ug/l)	196.44	**4680**	50.1	**6270**	96.4	7.3	<22	**4260**	51.8
Ammonia Stripping[4,7]	Ammonia (mg/l)	1.51 (summer)	**95.52 - 6.2**	**1.85**	**22.53 – 3.75**	**2.71**	**5.03**	**2.90**	**31.05 – 15.62**	**1.58**
Biological Treatment SBR[5,7]	Ammonia (mg/l) Batch #1	1.51	**95.52**	**1.66**	**22.5**	1.17	**5.03**	1.12	**31.15**	1.14
	Batch #2	1.51	**95.52**	**2.1**	**22.5**	1.4	**5.03**	**2.12**	**31.15**	**1.84**
	Batch #3	1.51	**95.52**	**2.05**	**22.5**	1.33	**5.03**	**1.54**	**31.15**	1.12

[1]Wastewater #1 – Sediment Pore Water; Wastewater #2 – Precipitation Runoff; Wastewater #3 – ECI Groundwater; Wastewater #4 – Combination Stream; bold entries are values above a conservative value for the discharge criteria
[2]ND – Non-detect
[3]Metals precipitation based on NaOH addition with Polymer
[4]Influent for ammonia stripping varies over time--operation ranges from 4.7hr to 45.5hr.
[5]Results based on HACH DR200 analysis of fresh samples
[6]Value shown is based on most conservative value of Indiana Water Quality Criteria. Taken 12/98 and based on Hardness =184, Stream pH =7.3, Summer stream Temp=26.7 C, Summer stream pH =7.9, Winter stream temp= 10.1 C, and winter stream pH = 7.8
[7]The effluent from the metals precipitation was the influent to the ammonia stripping and biological treatment unit processes.

Table D-4. Screening Test results[(1)] -- Continued

Unit Operation	POC	Discharge Criteria[(9)]	Wastewater #1 Influent	Wastewater #1 Effluent	Wastewater #2 Influent	Wastewater #2 Effluent	Wastewater # 3 Influent	Wastewater # 3 Effluent	Wastewater #4 Influent	Wastewater #4 Effluent
Activated Carbon [(6,7,8,10)]	Acetone (ug/l)	1700	ND	ND	ND	72.7	ND	ND	ND	ND
	COD (mg/l)	--		44.6		37.8		41.2		37.8
	TOC (mg/l)	--		17		16		12		12
	Turbidity (NTU)	--		4.2		5.9		4.3		5.4

[1]Wastewater #1 – Sediment Pore Water; Wastewater #2 – Precipitation Runoff; Wastewater #3 – ECI Groundwater; Wastewater #4 – Combination Stream; bold entries are values above a conservative value for the discharge criteria
[2]ND – Non-detect
[3]Metals precipitation based on NaOH addition with Polymer
[4]Influent for ammonia stripping operation varies over time-- ranges from 4.7hr to 45.5hr.
[5]Results based on HACH DR200 analysis of fresh samples
[6]Influent concentrations varied over time
[7]Effluent concentrations represent final wastestream quality
[8]Only POCs that had a detectable concentration are shown (ammonia not analyzed)
[9]Value shown is based on most conservative value of Indiana Water Quality Criteria. Taken 12/98 and based on Hardness =184, Stream pH =7.3, Summer stream Temp=26.7 C, Summer stream pH =7.9, Winter stream temp= 10.1 C, and winter stream pH = 7.8
[10]The effluent from the biological treatment was the influent to the activated carbon unit process.

Table D-5. Analytical Sampling Points for Wastestream Characterization—Confirmation[1]

Unit Operation	VOCs[2]	SVOCs[2]	Pesticides /PCBS	Metals	Cyanide	TSS /VSS	TDS	BOD	COD	TOC	NH_3	TKN	O&G	Total Phosphorus
Wastewater Characterization	10	10	10	10	9	8	8	8	8	8	9	9	10	9
Equalization	8	8	8	8		8			8	8			8	
Sand Filter	8	8	8	8	8	8			8	8	9	8	8	8
Cyanide Oxidation	8	8	8	8	8	8				8				
Metals Precipitation	8	8	8	8		8			8	8	9	8		8
Biological (SBR) Treatment	8	8	8	8	8	44	16	4	20	8	25	25		25
Activated Carbon	8	8	8	8		8			16	44				
Ammonia Stripping	10	10	10	10	8	8	8		8	8	10	10	10	10
Sludge Samples	TCLP VOCs	TCLP SVOCs	TCLP Pesticides /PCBS	TCLP Metals	Ig/Ret[3]									
Metals Precipitation[4]				2	2									
Biological (SBR) Treatment[5]	3	3	3	3	3									

[1]The number of samples shown are for all four wastestream(s): #1-sediment pore water, #2-precipitation runoff, #3-ECI groundwater, #4- combination wastestream
[2]VOCs-Volatile Organic Compounds, SVOCs-Semivolatile Organic Compounds
[3]Ignitibility/Reactivity
[4]Not enough sample available for wastestream(s) #1 & #2. These were calculated assuming total mass released into leachate
[5]Wastestream(s) #1 & #2 composite into one sample

Table D-6 Confirmation testing Run I Results[1]

Parameter	Raw Wastestream #1	Raw Wastestream #2	Raw Wastestream #3	Raw Wastestream #4	Equalization Basin #1	Equalization Basin #2	Equalization Basin #3	Equalization Basin #4	Sand Filter #1	Sand Filter #2	Sand Filter #3	Sand Filter #4	CN Oxidation #1	CN Oxidation #2	CN Oxidation #3	CN Oxidation #4	Metals Removal #1	Metals Removal #2	Metals Removal #3	Metals Removal #4	Bio-Reactor #1	Bio-Reactor #2	Bio-Reactor #3	Bio-Reactor #4	Carbon Filter #1	Carbon Filter #2	Carbon Filter #3	Carbon Filter #4	NH3 Stripping (final) #1	NH3 Stripping (final) #2	NH3 Stripping (final) #3	NH3 Stripping (final) #4	Most Conservative Discharge Criteria[2]
Volatile Organic Compounds																																	
Chloroform																	[illegible]																170
Semi-Volatiles																																	
Fluoranthene		42.6																															9.5
bis(2-Ethylhexl) phthalate	5.26	20.8						4.86J	16.3B	11.6B	18.1B	12.6B		11.6B	2.91J	11.2B								2.91J								7.3	2.8
Fluorene		10.9J																															2.4
Phenanthrene		30.8																															0.98
Fluoranthene		42.6																															9.5
Pyrene		51																															15
Benzo(a)anthracene	2.98J	73.5																															0.025
Benzo(a)pyrene	3.19J	17.9J							2.07J																								$2x10^{-5}$
Carbon Tetrachloride													57.5	56.8			51.6																19
Pesticides/PCBS[3]																																	
Gama-BHC (lindane)																																	0.5
Aldrin									0.15	0.144	0.219	0.199																					$2.4x10^{-4}$
4,4'-DDT									0.495	0.432	0.529	0.44																					$1.5x10^{-4}$
Dieldrin									0.509	0.486	0.573	0.527																					$5.5x10^{-4}$
Endrin									0.731	0.687	0.904	0.78																					0.036
Arochlor-1248	4.54	43.6		5.08	2.01	3.62		2.03	0.333	0.295	0.212	0.243																					$6.8x10^{-4}$
Metals & Misc. Analytes																																	
Arsenic	550	975																															147.9
Cadmium	118	283		24.6		7.06					5.75																						3.61
Chromium (total)	10600	32000	12.3	1280	128	290		117	38.3	23.8			36.9	21.2																			10.56/122[4]
Copper	3970	10600		308	536	958		39.6	20.5		21.7		21.5			15.9																	15.08
Lead	12300	37600	15.4	1610	203	391		142	60.5	43.4	56.2		53.8	37.7		58.8					71.3												13.95
Mercury	4.29	3.49		3.06		0.36			0.3				0.47			.96	0.49		0.27	1.33								0.27					0.0018
Nickel	793	1270		115																													87.1
Zinc	44700	133000		11500	1400	2420		976					508	282																			196.44
Ammonia-N[2] (mg/l)	90.3	33.3	3.15	36.45		5.41	4.7	40	129	26.8	4.49	37.1	58.9	9.9		10.21	72.7	13.6	1.59	13.3							1.56						1.51
Total Cyanide (mg/l)	0.384	0.635	0.007	0.281					0.023	0.007																							0.0052
Total Phosphorous (mg/l)	29.7	4.05	0.75	3.76					0.48	0.26	0.19	0.19					0.09	0.05		0.05	32.2	29.6	35.8	37.1					29.5	28.5	31.8	32.8	0.03

[1] (#1) = Pore Water; (#2) = Precipitation Runoff; #(3) = ECI Grounwater; (#4) = Combination Wastestream

Blank cells are one of the following: analytical results below discharge criteria; less then detection limit; or not sampled in unit operation.

All units (ug/l) except were noted

B – Analyte was found in the associated blank as well as in the sample

J – Indicates an estimated value

[2] Results from Hatch method DR2000

[3] Value shown is based on most conservative value of Indiana Water Quality Criteria. Taken 12/98 and based on Hardness =184. Stream pH =7.3, Summer stream Temp=26.7 C, Summer stream pH =7.9 Winter stream temp= 10.1 C, and winter stream pH = 7.8

[4] Chromium(III)= 122; Chromium(VI)=10.56

[5] Pesticide samples were spiked with pesticide spiking compounds in the analytical lab instead of surrogate spiking compounds. Concentrations dected are related to these spikes and probably not present in water samples based upon characterization data.

Table D-7 Confirmation testing Run II Results[1]

Parameter	Raw Wastestream				Equalization Basin				Sand Filter				CN Oxidation				Metals Removal				Bio-Reactor				Carbon Filter				NH3 Stripping (final)				Most Conservative Discharge Criteria[4]
	#1	#2	#3	#4	#1	#2	#3	#4	#1	#2	#3	#4	#1	#2	#3	#4	#1	#2	#3	#4	#1	#2	#3	#4	#1	#2	#3	#4	#1	#2	#3	#4	
Volatile Organic Compounds																																	170
[illegible]																			[illegible]28X														78
Benzene[3]	430X	1060X	1340	1040X	413	1300	1030	1120			103																						34
Toluene[3]			2640				1900				112																						110
Ethylbenzene[3]			5040X				2160																										35
Xylene[3]			4500				2860x				240																						
Semi-Volatiles																																	15
Pyrene												27.3																		26.9		[illegible].9	2.8
bis(2-Ethylhexl) phthalate	5.46	4.26	7.25		5.34	2.94J			3.11J			10.2		1370				[illegible]68			2.99J	2.89J	3.69J	4.23									26
Naphthalene[3]			28.9																														0.93
Phenanthrene[3]			92.4				12																										0.05
Pentachlorophenol												46.3																					21
2,4-dimethylphenol			24				40																										2.4
Fluorene			3.10J																														0.025
Benzo(a)anthracene	2.11J	2.83J																															[illegible]x10-3
Benzo(a)pyrene		2.14J																															19
Carbon Tetrachloride																				33.6													
Pesticides/PCBS																																	5.5x10-6
Dieldrin																					0.081	0.028											0.036
Endrin																					0.653												
Arochlor-1248		3.99		1.62		1.52		1.51																									5.8x10-6
Metals & Misc. Analytes																																	3.61
Cadmium	18.4	32.4		166		3.84																14.6											10.56/122[5]
Chromium (total)	845	1560		306	91.1	163		114	22.1	13.3		22.2	16.1	13.4		2.2																	5.08
Copper	233	179		149	34	54.4		36.8	16.4						25.7	15.9					29.9	50.7	29	39.4									13.95
Lead	1190	2100		497	120	223		58	32.4	25		39.3	26.6	24.2		46.8																	0.0018
Mercury																								0.39						0.93			47.1
Nickel		113																															196.44
Zinc	7510	13400		3391	785	1380		110	247	201		323	218	200		364					227	352		288									
Ammonia-N[2] (mg/l)	102	50.8	2.99	59.1	126	43.7	3.12	56.4	129	43.3	2.5	59.1	40.7	26.9		53.5	69.1	34.5		45.8							1.96						1.51
Total Cyanide (mg/l)	0.203	0.336	0.017	0.111							0.018	0.007																					0.0052
Total Phosphorous (mg/l)	5.69	4.38	0.71	2.86																	22.2	19.4	12	13.6					21.4	28.3	25.9	19.7	0.03

[1] (#1) = Pore Water; (#2) = Precipitation Runoff; #(3) = ECI Grounwater; (#4) = Combination Wastestream

Blank cells are one of the following: analytical results below discharge criteria; less then detection limit; or not sampled in unit operation.

All units (ug/l) except were noted

B -- Analyte was found in the associated blank as well as in the sample

J -- Indicates an estimated value

[2] Results from Hatch method DR2000

[3] Synthetically spiked into raw wastewater

[4] Value shown is based on most conservative value of Indiana Water Quality Criteria. Taken 12/98 and based on Hardness =184, Stream pH =7.3, Summer stream Temp=26.7 C, Summer stream pH =7.9 Winter stream temp= 10.1 C, and winter stream pH = 7.8

[5] Chromium(III)= 122; Chromium(VI)=10.56

ATTACHMENT D-1

ESTIMATED QUANITY AND QUALITY OF CDF EFFLUENT

USED TO DEVELOP TREATABILITY TESTING PLAN

INDIANA HARBOR CDF
EFFLUENT QUALITY AND QUANTITY ESTIMATES
PHASE 1

1. Introduction

The U.S. Army Corps of Engineers, Chicago District, performed a first phase estimate of the quantity and quality of effluent expected from the Indiana Harbor Confined Disposal Facility (CDF) proposed for construction in East Chicago, Indiana. This estimate will be refined in later phases of work when more information regarding effluent quality and becomes available.

2. Methodology

The current design for the Indiana Harbor CDF calls for three cells which will be filled in a sequential two year cycle, with the South West Cell accepting the first load of sediment in 1998, and the South East and North Cells accepting sediment in 1999. Subsequent filling will be performed every two, three, or four years in the various cells.

2.1. Effluent Quantity

USACE, Chicago District estimated the effluent quantity for each cell for each year as shown in Table 1 for the South West Cell, Table 2 for the South East Cell, and Table 3 for the North Cell. It is assumed that the total volume of water to be handled at the site will be derived from three sources:

1. Interstitial water that seeps out of the dredged sediment after placement in the CDF;
2. Precipitation run-off;
3. Pumped groundwater from the interior of the cut-off wall.

It is likely that the interstitial water and run-off will be combined (the actual effluent from the CDF) and that the ground water will be handled separately. In order to estimate the effluent quantity from interstitial water, it was assumed that the sediment was placed in the CDF with a solids concentration of 49% solids by weight, and was dewatered to a "final" solids concentration of 60% solids by weight. Tables 1, 2, and 3 show the initial estimated weight of water (column 4) and final weight of water (column 5) for the sediment added that year. This assumes that the dewatering time required to reach a final solids concentration of 60% solids by weight is one year. The estimated interstitial water volume that seeps from the sediment is the difference between the initial and final weight of water. This weight is converted to volume and shown in Column 6.

Columns 7 and 8 show the surface area of the interior of the entire cell (Column 8), and the surface area of the sediment which occupies that interior (Column 7). It is conservatively assumed that the sediment will be spread over the floor of the cell, and piled vertically with each subsequent filling event. This is not the case, but is a reasonable assumption for this phase. Changes in the total interior surface area of the cell (Column 8) are the result of reconfiguration of the interior dikes. The % Area of Sediment (Column 9) is the percent of the total interior surface area that will be covered with sediment. In other words, rainfall entering the interior of the South West Cell in 1998 would contact a surface area that was 91.26% sediment, with the remainder of the surface area being dike material.

To estimate run-off, the Soil Conservation Service (SCS) curve number method was used. It was assumed that dredged sediment had an SCS curve number of 85 the first year, 80 the second year, and 75 the third year. These numbers are consistent with saturated, normal, and dry soils, thus reflecting changes in sediment character during disposal. The curve number for the dike was assumed to be 94 consistently throughout the life of the CDF. A composite curve number was calculated (Column 12) based on the percentage of surface area that was dike and the percentage that was sediment. The "S" value resulting from the composite curve number is shown in Column 13. To determine average annual precipitation run-off, an average annual precipitation value of 33.48 inches and an average annual evaporation value of 13.85 inches were used. The average annual run-off minus infiltration into the soil is calculated using the SCS curve number method, and shown in Column 14. Evaporation is subtracted from this value, and the volume is converted to cubic feet, shown in Column 16. The total effluent volume is estimated as the runoff plus the interstitial water, and is shown in Column 17.

This method for run-off estimation assumes that the average annual rainfall is actually one year-long event falling continuously. While this is clearly a gross assumption, it is sufficient for this level of estimation. More complex run-off estimates using design storms will be performed in future phases of work.

Table 4 shows the volume of effluent (not including groundwater pumpage) for each cell and the total volume for the entire CDF for each year of the filling life. The total effluent ranges from a low of 105,515 gallons per day, to a maximum of 228,148 gallons per day, with an average of 162,727 gallons per day.

2.2. *Effluent Quality*

The concentrations of PCBs, PAHs, ammonia, arsenic, lead, cadmium, chromium, and zinc were estimated for each year of filling life of the CDF, assuming a combined waste stream of groundwater and effluent (run-off plus interstitial) from the CDF. Tables 5 through 12 show the estimated concentrations for each year. These concentrations were calculated by determining the total estimated mass of the contaminant and dividing by the total estimated volume of the combined waste streams.

Contaminant mass from ground water was calculated using the average concentration for all ground water samples from the USACE database. For the purposes of estimating the contaminant mass, non-detect data was assumed to be equal to the reporting limit. Pore (or interstitial) water contaminant mass was estimated using the concentrations identified in the document *"Disposal Alternatives for PCB-Contaminated Sediments from Indiana Harbor, Indiana (Miscellaneous Paper EL-87-9)"* prepared by the USACE, Waterways Experiment Station. The pore water concentration used (shown at the top of each table) was the average of leachate concentration in both aerobic and anaerobic samples (WES, page 59). Run-off contaminant mass was estimated from unfiltered run-off concentrations measured by WES from lysimeter tests on Indiana Harbor sediment (WES, page 63).

The estimated contaminant concentration for the combined waste stream (ground water + run-off + interstitial water) was calculated for each contaminant for each year of the CDF filling life. The maximum, minimum, and average concentrations are shown at the bottom of the last column for Tables 5 through 12.

Table 13 shows the estimated concentrations for the separate waste streams, plus an estimated concentration of filtered effluent. For organic parameters, the filtered concentration assumes that 85% of the initial contaminant mass was removed via sand filtration, and that 95% of the remaining mass is removed via carbon adsorption. Inorganic filtered concentrations are estimated assuming only 85% of the mass removed via sand filtration. Table 13 also provides Indiana Water Quality Standards for Indiana Harbor (where applicable).

Table 1. S[illegible] West Cell

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Year	Vol. Sed. (CY)	Wt. dry solids	Wt. of water (i)	Wt. of water (f)	Vol water drain (cf)	Area (SF)	Eff. Area	% Area Sed.	Sed CN	Dike CN	Comp CN	S	Q (in)	Ev. (in)	Q precp. (cf)	Q total (cf)
1997	0	0	0	0	0	0										
1998	156457	350032785	364319837	233355190	2098792	1430387	1567384	91.26%	85	94	85.79	1.66	31.57	13.85	2,314,592	4,413,385
1999	0	0	0	0	0	1430387	1567384	91.26%	80	94	81.22	2.31	30.86	13.85	2,221,406	2,221,406
2000	161423	361142948	375883477	240761965	2165409	1475411	1567384	94.13%	85	94	85.53	1.69	31.53	13.85	2,309,504	4,474,912
2001	0	0	0	0	0	1475411	1567384	94.13%	80	94	80.82	2.37	30.79	13.85	2,212,836	2,212,836
2002	166464	372420905	387621758	248280603	2233031	1521089	1567384	97.05%	85	94	85.27	1.73	31.49	13.85	2,304,318	4,537,350
2003	0	0	0	0	0	1521089	1567384	97.05%	80	94	80.41	2.44	30.72	13.85	2,204,080	2,204,080
2004	171573	383850994	399518382	255900663	2301566	1567384	1567384	100.00%	85	94	85.00	1.76	31.45	13.85	2,299,040	4,600,606
2005	0	0	0	0	0	1567384	1567384	100.00%	80	94	80.00	2.50	30.66	13.85	2,195,142	2,195,142
2006	0	0	0	0	0	1567384	1567384	100.00%	75	94	75.00	3.33	29.79	13.85	2,081,667	2,081,667
2007	176750	395433216	411573348	263622144	2371013	1363090	1496852	91.06%	85	94	85.80	1.65	31.57	13.85	2,210,766	4,581,779
2008	0	0	0	0	0	1363090	1496852	91.06%	80	94	81.25	2.31	30.86	13.85	2,121,999	2,121,999
2009	0	0	0	0	0	1363090	1496852	91.06%	75	94	76.70	3.04	30.09	13.85	2,025,894	2,025,894
2010	0	0	0	0	0	1363090	1496852	91.06%	75	94	76.70	3.04	30.09	13.85	2,025,894	2,025,894
2011	153386	343162203	357168823	228774802	2057596	1407103	1496852	94.00%	85	94	85.54	1.69	31.53	13.85	2,205,793	4,263,390
2012	0	0	0	0	0	1407103	1496852	94.00%	80	94	80.84	2.37	30.79	13.85	2,113,625	2,113,625
2013	0	0	0	0	0	1407103	1496852	94.00%	75	94	76.14	3.13	29.99	13.85	2,013,552	2,013,552
2014	0	0	0	0	0	1407103	1496852	94.00%	75	94	76.14	3.13	29.99	13.85	2,013,552	2,013,552
2015	158812	355301499	369803601	236867666	2130384	1451667	1496852	96.98%	85	94	85.27	1.73	31.49	13.85	2,200,735	4,331,119
2016	0	0	0	0	0	1451667	1496852	96.98%	80	94	80.42	2.43	30.73	13.85	2,105,084	2,105,084
2017	0	0	0	0	0	1451667	1496852	96.98%	75	94	75.57	3.23	29.89	13.85	2,000,928	2,000,928
2018	0	0	0	0	0	1451667	1496852	96.98%	75	94	75.57	3.23	29.89	13.85	2,000,928	2,000,928
2019	163799	366458644	381416140	244305763	2197282	1496852	1496852	100.00%	85	94	85.00	1.76	31.45	13.85	2,195,583	4,392,865
2020	0	0	0	0	0	1496852	1496852	100.00%	80	94	80.00	2.50	30.66	13.85	2,096,361	2,096,361
2021	0	0	0	0	0	1496852	1496852	100.00%	75	94	75.00	3.33	29.79	13.85	1,987,993	1,987,993
2022	0	0	0	0	0	1496852	1496852	100.00%	75	94	75.00	3.33	29.79	13.85	1,987,993	1,987,993
2023	150330	336325179	350052737	224216786	2016602	1297831	1340499	96.82%	85	94	85.29	1.73	31.50	13.85	1,971,109	3,987,711
2024	0	0	0	0	0	1297831	1340499	96.82%	80	94	80.45	2.43	30.73	13.85	1,885,622	1,885,622
2025	0	0	0	0	0	1297831	1340499	96.82%	75	94	75.60	3.23	29.90	13.85	1,792,549	1,792,549
2026	0	0	0	0	0	1297831	1340499	96.82%	75	94	75.60	3.23	29.90	13.85	1,792,549	1,792,549
2027	146563	327897474	341281044	218598316	1966069	1340499	1340499	100.00%	85	94	85.00	1.76	31.45	13.85	1,966,245	3,932,314
2028	0	0	0	0	0	1340499	1340499	100.00%	80	94	80.00	2.50	30.66	13.85	1,877,386	1,877,386
2029	0	0	0	0	0	1340499	1340499	100.00%	75	94	75.00	3.33	29.79	13.85	1,780,338	1,780,338
2030	0	0	0	0	0	1340499	1340499	100.00%	75	94	75.00	3.33	29.79	13.85	1,780,338	1,780,338

Table 2. South East Cell

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Year	Vol. Sed. (CY)	Wt. dry solids	Wt. of water (i)	Wt. of water (f)	Vol water drain (cf)	Area (SF)	Eff. Area	% Area Sed.	Sed CN	Dike CN	Comp CN	S	Q (in)	Ev. (in)	Q precp. (cf)	Q (cf)
1997	0	0	0	0	0	0	0									
1998	0	0	0	0	0	0	1618319	0.00%		94	94	0.64	32.73	13.85	2,545,620	2,545,620
1999	161463	361232438	375976619	240821625	2165945	1476279	1618319	91.22%	85	94	85.79	1.66	31.57	13.85	2,389,876	4,555,821
2000	0	0	0	0	0	1476279	1618319	91.22%	80	94	81.23	2.31	30.86	13.85	2,293,707	2,293,707
2001	166616	372760966	387975700	248507311	2235070	1522998	1618319	94.11%	85	94	85.53	1.69	31.53	13.85	2,384,596	4,619,666
2002	0	0	0	0	0	1522998	1618319	94.11%	80	94	80.82	2.37	30.79	13.85	2,284,815	2,284,815
2003	171841	384450576	400142436	256300384	2305161	1570401	1618319	97.04%	85	94	85.27	1.73	31.49	13.85	2,379,215	4,684,376
2004	0	0	0	0	0	1570401	1618319	97.04%	80	94	80.41	2.44	30.72	13.85	2,275,729	2,275,729
2005	177139	396303505	412479158	264202337	2376231	1618319	1618319	100.00%	85	94	85.00	1.76	31.45	13.85	2,373,751	4,749,982
2006	0	0	0	0	0	1618319	1618319	100.00%	80	94	80.00	2.50	30.66	13.85	2,266,477	2,266,477
2007	0	0	0	0	0	1618319	1618319	100.00%	75	94	75.00	3.33	29.79	13.85	2,149,315	2,149,315
2008	182501	408299618	424964908	272199745	2448160	1405076	1543798	91.01%	85	94	85.81	1.65	31.57	13.85	2,280,189	4,728,349
2009	0	0	0	0	0	1405076	1543798	91.01%	80	94	81.26	2.31	30.86	13.85	2,188,697	2,188,697
2010	0	0	0	0	0	1405076	1543798	91.01%	75	94	76.71	3.04	30.09	13.85	2,089,646	2,089,646
2011	0	0	0	0	0	1405076	1543798	91.01%	75	94	76.71	3.04	30.09	13.85	2,089,646	2,089,646
2012	158126	353766748	368206207	235844499	2121181	1450716	1543798	93.97%	85	94	85.54	1.69	31.53	13.85	2,275,032	4,396,214
2013	0	0	0	0	0	1450716	1543798	93.97%	80	94	80.84	2.37	30.80	13.85	2,180,014	2,180,014
2014	0	0	0	0	0	1450716	1543798	93.97%	75	94	76.15	3.13	29.99	13.85	2,076,850	2,076,850
2015	0	0	0	0	0	1450716	1543798	93.97%	75	94	76.15	3.13	29.99	13.85	2,076,850	2,076,850
2016	163743	366333359	381285741	244222239	2196530	1496933	1543798	96.96%	85	94	85.27	1.73	31.49	13.85	2,269,787	4,466,317
2017	0	0	0	0	0	1496933	1543798	96.96%	80	94	80.42	2.43	30.73	13.85	2,171,157	2,171,157
2018	0	0	0	0	0	1496933	1543798	96.96%	75	94	75.58	3.23	29.89	13.85	2,063,758	2,063,758
2019	0	0	0	0	0	1496933	1543798	96.96%	75	94	75.58	3.23	29.89	13.85	2,063,758	2,063,758
2020	168915	377904395	393329064	251936263	2265910	1543798	1543798	100.00%	85	94	85.00	1.76	31.45	13.85	2,264,444	4,530,354
2021	0	0	0	0	0	1543798	1543798	100.00%	80	94	80.00	2.50	30.66	13.85	2,162,109	2,162,109
2022	0	0	0	0	0	1543798	1543798	100.00%	75	94	75.00	3.33	29.79	13.85	2,050,343	2,050,343
2023	0	0	0	0	0	1543798	1543798	100.00%	75	94	75.00	3.33	29.79	13.85	2,050,343	2,050,343
2024	154823	346377125	360514967	230918083	2076873	1335639	1379849	96.80%	85	94	85.29	1.72	31.50	13.85	2,029,003	4,105,876
2025	0	0	0	0	0	1335639	1379849	96.80%	80	94	80.45	2.43	30.73	13.85	1,941,030	1,941,030
2026	0	0	0	0	0	1335639	1379849	96.80%	75	94	75.61	3.23	29.90	13.85	1,845,251	1,845,251
2027	0	0	0	0	0	1335639	1379849	96.80%	75	94	75.61	3.23	29.90	13.85	1,845,251	1,845,251
2028	150831	337446039	351219347	224964026	2023322	1379849	1379849	100.00%	85	94	85.00	1.76	31.45	13.85	2,023,963	4,047,286
2029	0	0	0	0	0	1379849	1379849	100.00%	80	94	80.00	2.50	30.66	13.85	1,932,496	1,932,496
2030	0	0	0	0	0	1379849	1379849	100.00%	75	94	75.00	3.33	29.79	13.85	1,832,599	1,832,599

Table 3

		3	4	5	6	7	8	9	10	11	12	13	14	15	16	
Year	Vol. Sed. (CY)	Wt. dry solids	Wt. of water (i)	Wt. of water (f)	Vol water drain (cf)	Area (SF)	Eff. Area	% Area Sed.	Sed CN	Dike CN	Comp CN	S	Q (in)	Ev. (in)	Q precp. (cf)	Q total (cf)
1997	0	0	0	0	0	0	0									
1998	0	0	0	0	0	0	1428034	0.00%		94	94	0.64	32.73	13.85	2,246,301	2,246,301
1999	140642	314650741	327493628	209767160	1886642	1288477	1428034	90.23%	85	94	85.88	1.64	31.58	13.85	2,110,472	3,997,114
2000	0	0	0	0	0	1288477	1428034	90.23%	80	94	81.37	2.29	30.88	13.85	2,026,702	2,026,702
2001	145686	325935409	339238895	217290273	1954305	1334351	1428034	93.44%	85	94	85.59	1.68	31.54	13.85	2,105,294	4,059,599
2002	0	0	0	0	0	1334351	1428034	93.44%	80	94	80.92	2.36	30.81	13.85	2,017,989	2,017,989
2003	150831	337446039	351219347	224964026	2023322	1380881	1428034	96.70%	85	94	85.30	1.72	31.50	13.85	2,100,016	4,123,339
2004	0	0	0	0	0	1380881	1428034	96.70%	80	94	80.46	2.43	30.73	13.85	2,009,081	2,009,081
2005	156036	349090904	363339513	232727270	2093145	1428034	1428034	100.00%	85	94	85.00	1.76	31.45	13.85	2,094,641	4,187,786
2006	0	0	0	0	0	1428034	1428034	100.00%	80	94	80.00	2.50	30.66	13.85	1,999,980	1,999,980
2007	0	0	0	0	0	1428034	1428034	100.00%	75	94	75.00	3.33	29.79	13.85	1,896,595	1,896,595
2008	0	0	0	0	0	1428034	1428034	100.00%	75	94	75.00	3.33	29.79	13.85	1,896,595	1,896,595
2009	161305	360878953	375608706	240585969	2163826	1168996	1168996	100.00%	85	94	85.00	1.76	31.45	13.85	1,714,684	3,878,510
2010	0	0	0	0	0	1168996	1168996	100.00%	80	94	80.00	2.50	30.66	13.85	1,637,194	1,637,194
2011	0	0	0	0	0	1168996	1168996	100.00%	75	94	75.00	3.33	29.79	13.85	1,552,562	1,552,562
2012	0	0	0	0	0	1168996	1168996	100.00%	75	94	75.00	3.33	29.79	13.85	1,552,562	1,552,562
2013	131909	295112872	307158295	196741915	1769493	1213313	1303676	93.07%	85	94	85.62	1.68	31.55	13.85	1,922,505	3,691,998
2014	0	0	0	0	0	1213313	1303676	93.07%	80	94	80.97	2.35	30.82	13.85	1,843,178	1,843,178
2015	0	0	0	0	0	1213313	1303676	93.07%	75	94	76.32	3.10	30.02	13.85	1,757,126	1,757,126
2016	0	0	0	0	0	1213313	1303676	93.07%	75	94	76.32	3.10	30.02	13.85	1,757,126	1,757,126
2017	137290	307151492	319688288	204767662	1841677	1258183	1303676	96.51%	85	94	85.31	1.72	31.50	13.85	1,917,418	3,759,094
2018	0	0	0	0	0	1258183	1303676	96.51%	80	94	80.49	2.42	30.74	13.85	1,834,593	1,834,593
2019	0	0	0	0	0	1258183	1303676	96.51%	75	94	75.66	3.22	29.91	13.85	1,744,445	1,744,445
2020	0	0	0	0	0	1258183	1303676	96.51%	75	94	75.66	3.22	29.91	13.85	1,744,445	1,744,445
2021	142310	318382467	331377670	212254978	1909017	1303676	1303676	100.00%	85	94	85.00	1.76	31.45	13.85	1,912,233	3,821,250
2022	0	0	0	0	0	1303676	1303676	100.00%	80	94	80.00	2.50	30.66	13.85	1,825,815	1,825,815
2023	0	0	0	0	0	1303676	1303676	100.00%	75	94	75.00	3.33	29.79	13.85	1,731,433	1,731,433
2024	0	0	0	0	0	1303676	1303676	100.00%	75	94	75.00	3.33	29.79	13.85	1,731,433	1,731,433
2025	125221	280150171	291584872	186766781	1679777	1054287	1096632	96.14%	85	94	85.35	1.72	31.50	13.85	1,613,365	3,293,142
2026	0	0	0	0	0	1054287	1096632	96.14%	80	94	80.54	2.42	30.75	13.85	1,544,014	1,544,014
2027	0	0	0	0	0	1054287	1096632	96.14%	75	94	75.73	3.20	29.92	13.85	1,468,558	1,468,558
2028	0	0	0	0	0	1054287	1096632	96.14%	75	94	75.73	3.20	29.92	13.85	1,468,558	1,468,558
2029	119462	267265872	278174683	178177248	1602523	1096632	1096632	100.00%	85	94	85.00	1.76	31.45	13.85	1,608,540	3,211,063
2030	0	0	0	0	0	1096632	1096632	100.00%	80	94	80.00	2.50	30.66	13.85	1,535,847	1,535,847

Table 4. Total Flow

	SW Cell		SE Cell		N Cell		Tot. Prec.	Tot. Pore	Total Q	
Year	Q Prec. (cf)	Q Pore (cf)	Q Prec. (cf)	Q Pore (cf)	Q Prec. (cf)	Q Pore (cf)	(cf)	(cf)	(cf)	(gpd)
1998	2,314,592	2,098,792	2,545,620	0	2,246,301	0	7,106,513	2,098,792	9,205,305	188,646
1999	2,221,406	0	2,389,876	2,165,945	2,110,472	1,886,642	6,721,754	4,052,588	10,774,341	220,800
2000	2,309,504	2,165,409	2,293,707	0	2,026,702	0	6,629,913	2,165,409	8,795,321	180,244
2001	2,212,836	0	2,384,596	2,235,070	2,105,294	1,954,305	6,702,726	4,189,375	10,892,101	223,213
2002	2,304,318	2,233,031	2,284,815	0	**2,017,989**	0	6,607,122	2,233,031	**8,840,154**	**181,163**
2003		0	2,379,215	2,305,161			6,683,311	**4,328,484**	**11,011,795**	225,666
				0		0		2,301,566	8,885,415	182,090
								4,469,376	**11,132,910**	**228,148**
		0	2,266,477	0	1,999,980	0	6,348,124	0	6,348,124	130,093
						0	6,256,676	**2,371,013**	8,627,689	176,809
		0	**2,280,189**	**2,448,160**				2,448,160	8,746,942	179,252
							5,929,275	2,163,826	8,093,100	165,853
2010	2,025,894	0	2,089,646	0	1,637,194	0	5,752,734	0	5,752,734	117,892
2011	2,205,793	2,057,596	2,089,646	0	1,552,562	0	5,848,001	2,057,596	7,905,598	162,011
2012			2,275,032	2,121,181	1,552,562	0	5,941,219	2,121,181	8,062,401	165,224
2013	2,013,552	0	2,180,014	0	1,922,505	1,769,493	6,116,071	1,769,493	7,885,565	161,600
2014	2,013,552	0	2,076,850	0	1,843,178	**0**	**5,933,580**	0	5,933,580	121,598
2015	2,200,735	2,130,384		0	1,757,126	0		2,130,384	8,165,094	167,329
		0	2,269,787	**2,196,530**	**1,757,126**	0		2,196,530	8,328,527	170,678
2017				0	1,917,418	1,841,677		1,841,677	**7,931,179**	**162,535**
					1,834,593	0		0	5,899,279	**120,895**
					1,744,445	0		2,197,282	8,201,068	168,066
		0	2,264,444	2,265,910	1,744,445	0	6,105,249	2,265,910	8,371,160	171,551
			2,162,109	0	1,912,233	1,909,017	6,062,334	1,909,017	7,971,352	163,358
			2,050,343	0	1,825,815	0	5,864,150	0	5,864,150	120,175
			2,050,343	**0**	1,731,433	0		2,016,602	7,769,486	159,221
		0	2,029,003	2,076,873	1,731,433	0		**2,076,873**	7,722,931	158,267
			1,941,030	0	1,613,365	1,679,777	5,346,944	1,679,777	7,026,721	144,000
			1,845,251	0	1,544,014	0	5,181,814	0	**5,181,814**	106,192
					1,468,558	0	5,280,054	1,966,069	**7,246,123**	**148,496**
		0	2,023,963	**2,023,322**		0		2,023,322	7,393,230	151,511
				0	1,608,540	1,602,523	5,321,375	1,602,523	6,923,898	141,892
2030	1,780,338	0	1,832,599	0	1,535,847	0	5,148,785	0	5,148,785	105,515
									max	228,148
									avg.	162,727
									min	105,515

Pore water conc.= 0.0019 mg/L
unox. runoff conc. (unfil)= 0.0002 mg/L
ox. runoff conc. (unfil)= 0.0002 mg/L
GW Conc.= 0.0037 mg/L

GW Pumpage (1st yr)= 2,517,986 CF
GW Pumpage (other yrs)= 30,635 CF

Year	SW Cell pore (cf)	SE Cell pore (cf)	N Cell pore (cf)	SW Cell Q precp. (cf)	SE Cell Q precp. (cf)	N Cell Q precp. (cf)	SW Cell Mass in PW	SE Cell Mass in PW	N Cell Mass in PW	SW Cell Mass in RO	SE Cell Mass in RO	N Cell Mass in RO	Mass in GW	Pore Conc. (ug/L)	RO Conc. (ug/L)	GW Conc. (ug/L)	Total Conc. (ug/L)
1997	0	0	0														
1998	2,098,792	0	0	2,314,592	2,545,620	2,246,301	112,932			13,110	0	0	263,845	1.90	0.065	3.700	1.17
1999	0	2,165,945	1,886,642	2,221,406	2,389,876	2,110,472	0	116,545	101,516	12,582	13,536	11,954	3,210	1.90	0.200	3.700	0.85
2000	2,165,409	0	0	2,309,504	2,293,707	2,026,702	116,516	0	0	13,081	12,992	11,479	3,210	1.90	0.200	3.700	0.63
2001	0	2,235,070	1,954,305	2,212,836	2,384,596	2,105,294	0	120,265	105,157	12,534	13,506	11,924	3,210	1.90	0.200	3.700	0.86
2002	2,233,031	0	0	2,304,318	2,284,815	2,017,989	120,155	0	0	13,052	12,941	11,430	3,210	1.90	0.200	3.700	0.64
2003	0	2,305,161	2,023,322	2,204,080	2,379,215	2,100,016	0	124,036	108,871	12,484	13,476	11,894	3,210	1.90	0.200	3.700	0.88
2004	2,301,566	0	0	2,299,040	2,275,729	2,009,081	123,843	0	0	13,022	12,890	11,379	3,210	1.90	0.200	3.700	0.65
2005	0	2,376,231	2,093,145	2,195,142	2,373,751	2,094,641	0	127,860	112,628	12,433	13,445	11,864	3,210	1.90	0.200	3.700	0.89
2006	0	0	0	2,081,667	2,266,477	1,999,980	0	0	0	11,791	12,837	11,328	3,210		0.200	3.700	0.22
2007	2,371,013	0	0	2,210,766	2,149,315	1,896,595	127,579	0	0	12,522	12,174	10,742	3,210	1.90	0.200	3.700	0.68
2008	0	2,448,160	0	2,121,999	2,280,189	1,896,595	0	131,731	0	12,019	12,915	10,742	3,210	1.90	0.200	3.700	0.69
2009	0	0	2,163,826	2,025,894	2,188,697	1,714,684	0	0	116,431	11,475	12,397	9,712	3,210	1.90	0.200	3.700	0.67
2010	0	0	0	2,025,894	2,089,646	1,637,194	0	0	0	11,475	11,836	9,273	3,210		0.200	3.700	0.22
2011	2,057,596	0	0	2,205,793	2,089,646	1,552,562	110,715	0	0	12,494	11,836	8,794	3,210	1.90	0.200	3.700	0.65
2012	0	2,121,181	0	2,113,625	2,275,032	1,552,562	0	114,137	0	11,972	12,886	8,794	3,210	1.90	0.200	3.700	0.66
2013	0	0	1,769,493	2,013,552	2,180,014	1,922,505	0	0	95,213	11,405	12,348	10,889	3,210	1.90	0.200	3.700	0.59
2014	0	0	0	2,013,552	2,076,850	1,843,178	0	0	0	11,405	11,763	10,440	3,210		0.200	3.700	0.22
2015	2,130,384	0	0	2,200,735	2,076,850	1,757,126	114,632	0	0	12,465	11,763	9,952	3,210	1.90	0.200	3.700	0.65
2016	0	2,196,530	0	2,105,084	2,269,787	1,757,126	0	118,191	0	11,923	12,856	9,952	3,210	1.90	0.200	3.700	0.66
2017	0	0	1,841,677	2,000,928	2,171,157	1,917,418	0	0	99,097	11,333	12,297	10,860	3,210	1.90	0.200	3.700	0.61
2018	0	0	0	2,000,928	2,063,758	1,834,593	0	0	0	11,333	11,689	10,391	3,210		0.200	3.700	0.22
2019	2,197,282	0	0	2,195,583	2,063,758	1,744,445	118,231	0	0	12,436	11,689	9,881	3,210	1.90	0.200	3.700	0.67
2020	0	2,265,910	0	2,096,361	2,264,444	1,744,445	0	121,924	0	11,874	12,826	9,881	3,210	1.90	0.200	3.700	0.67
2021	0	0	1,909,017	1,987,993	2,162,109	1,912,233	0	0	102,720	11,260	12,246	10,831	3,210	1.90	0.200	3.700	0.62
2022	0	0	0	1,987,993	2,050,343	1,825,815	0	0	0	11,260	11,613	10,341	3,210		0.200	3.700	0.22
2023	2,016,602	0	0	1,971,109	2,050,343	1,731,433	108,509	0	0	11,164	11,613	9,807	3,210	1.90	0.200	3.700	0.65
2024	0	2,076,873	0	1,885,622	2,029,003	1,731,433	0	111,752	0	10,680	11,492	9,807	3,210	1.90	0.200	3.700	0.67
2025	0	0	1,679,777	1,792,549	1,941,030	1,613,365	0	0	90,385	10,153	10,994	9,138	3,210	1.90	0.200	3.700	0.62
2026	0	0	0	1,792,549	1,845,251	1,544,014	0	0	0	10,153	10,452	8,745	3,210		0.200	3.700	0.22
2027	1,966,069	0	0	1,966,245	1,845,251	1,468,558	105,790	0	0	11,137	10,452	8,318	3,210	1.90	0.200	3.700	0.67
2028	0	2,023,322	0	1,877,386	2,023,963	1,468,558	0	108,871	0	10,634	11,464	8,318	3,210	1.90	0.200	3.700	0.68
2029	0	0	1,602,523	1,780,338	1,932,496	1,608,540	0	0	86,229	10,084	10,946	9,111	3,210	1.90	0.200	3.700	0.61
2030	0	0	0	1,780,338	1,832,599	1,535,847	0	0	0	10,084	10,380	8,699	3,210		0.200	3.700	0.22

max	1.17
min	0.22
avg.	0.60

Table 6. Water Quality PAHs

Pore water conc.= 0.9437 mg/L
unox. runoff conc. (unfil)= 18.03 mg/L
ox. runoff conc. (unfil)= 0.0877 mg/L
GW conc.= 5.2 mg/L

GW Pumpage (1st yr)= 2,517,986 CF
GW Pumpage (other yrs)= 30,635 CF

Year	SW Cell pore (cf)	SE Cell pore (cf)	N Cell pore (cf)	SW Cell Q precp. (cf)	SE Cell Q precp. (cf)	N Cell Q precp. (cf)	SW Cell Mass in PW	SE Cell Mass in PW	N Cell Mass in PW	SW Cell Mass in RO	SE Cell Mass in RO	N Cell Mass in RO	Mass in GW	Pore Conc. (mg/L)	RO Conc. (mg/L)	GW Conc. (mg/L)	Total Conc. (mg/L)
1997	0	0	0														
1998	2,098,792	0	0	2,314,592	2,545,620	2,246,301	56,091,453			1,181,853,001	0	0	370,808,633	0.94	5.87	5.20	4.85
1999	0	2,165,945	1,886,642	2,221,406	2,389,876	2,110,472	0	57,886,156	50,421,612	5,517,227	1,220,293,502	1,077,627,184	4,511,505	0.94	12.10	5.20	7.90
2000	2,165,409	0	0	2,309,504	2,293,707	2,026,702	57,871,816	0	0	1,179,254,685	5,696,798	5,033,647	4,511,505	0.94	6.34	5.20	5.01
2001	0	2,235,070	1,954,305	2,212,836	2,384,596	2,105,294	0	59,733,560	52,229,938	5,495,942	1,217,597,487	1,074,983,262	4,511,505	0.94	12.11	5.20	7.81
2002	2,233,031	0	0	2,304,318	2,284,815	2,017,989	59,679,066	0	0	1,176,607,054	5,674,713	5,012,006	4,511,505	0.94	6.35	5.20	4.96
2003	0	2,306,161	2,023,322	2,204,080	2,379,215	2,100,016	0	61,606,776	54,074,474	5,474,195	1,214,849,932	1,072,288,372	4,511,505	0.94	12.11	5.20	7.72
2004	2,301,566	0	0	2,299,040	2,275,729	2,009,081	61,510,696	0	0	1,173,911,689	5,652,146	4,989,881	4,511,505	0.94	6.35	5.20	4.95
2005	0	2,376,231	2,093,145	2,195,142	2,373,751	2,094,641	0	63,506,164	55,940,520	5,451,994	1,212,060,090	1,069,543,778	4,511,505	0.94	12.12	5.20	7.83
2006	0	0	0	2,081,667	2,266,477	1,999,980	0	0	0	5,170,163	5,629,167	4,967,279	4,511,505		0.09	5.20	0.11
2007	2,371,013	0	0	2,210,766	2,149,315	1,896,595	63,366,704	0	0	1,128,838,515	5,338,176	4,710,504	4,511,505	0.94	6.43	5.20	4.92
2008	0	2,448,160	0	2,121,999	2,280,189	1,896,595	0	65,428,497	0	5,270,333	1,164,286,477	4,710,504	4,511,505	0.94	6.58	5.20	5.01
2009	0	0	2,163,826	2,025,894	2,188,697	1,714,684	0	0	57,829,511	5,031,640	5,435,967	875,534,055	4,511,505	0.94	5.28	5.20	4.12
2010	0	0	0	2,025,894	2,089,646	1,637,194	0	0	0	5,031,640	5,189,978	4,066,240	4,511,505		0.09	5.20	0.11
2011	2,057,596	0	0	2,205,793	2,089,646	1,552,562	54,990,468	0	0	1,126,299,165	5,189,978	3,856,043	4,511,505	0.94	6.86	5.20	5.32
2012	0	2,121,181	0	2,113,625	2,275,032	1,552,562	0	56,689,807	0	5,249,534	1,161,653,422	3,856,043	4,511,505	0.94	6.96	5.20	5.38
2013	0	0	1,769,493	2,013,552	2,180,014	1,922,505	0	0	47,290,741	5,000,988	5,414,422	981,649,566	4,511,505	0.94	5.73	5.20	4.66
2014	0	0	0	2,013,552	2,076,850	1,843,178	0	0	0	5,000,988	5,158,197	4,577,834	4,511,505		0.09	5.20	0.11
2015	2,130,384	0	0	2,200,735	2,076,850	1,757,126	56,935,745	0	0	1,123,716,482	5,158,197	4,364,110	4,511,505	0.94	6.63	5.20	5.15
2016	0	2,196,530	0	2,105,084	2,269,787	1,757,126	0	58,703,560	0	5,228,322	1,158,975,043	4,364,110	4,511,505	0.94	6.73	5.20	5.20
2017	0	0	1,841,677	2,000,928	2,171,157	1,917,418	0	0	49,219,885	4,969,632	5,392,424	979,051,907	4,511,505	0.94	5.74	5.20	4.63
2018	0	0	0	2,000,928	2,063,758	1,834,593	0	0	0	4,969,632	5,125,681	4,556,513	4,511,505		0.09	5.20	0.11
2019	2,197,282	0	0	2,195,583	2,063,758	1,744,445	58,723,636	0	0	1,121,085,873	5,125,681	4,332,616	4,511,505	0.94	6.65	5.20	5.12
2020	0	2,265,910	0	2,096,361	2,264,444	1,744,445	0	60,557,775	0	5,206,655	1,156,246,662	4,332,616	4,511,505	0.94	6.74	5.20	5.17
2021	0	0	1,909,017	1,987,993	2,162,109	1,912,233	0	0	51,019,607	4,937,506	5,369,953	976,404,312	4,511,505	0.94	5.75	5.20	4.60
2022	0	0	0	1,987,993	2,050,343	1,825,815	0	0	0	4,937,506	5,092,362	4,534,711	4,511,505		0.09	5.20	0.11
2023	2,016,602	0	0	1,971,109	2,050,343	1,731,433	53,894,860	0	0	1,006,467,118	5,092,362	4,300,297	4,511,505	0.94	6.24	5.20	4.86
2024	0	2,076,873	0	1,885,622	2,029,003	1,731,433	0	55,505,647	0	4,683,252	1,036,028,509	4,300,297	4,511,505	0.94	6.54	5.20	5.03
2025	0	0	1,679,777	1,792,549	1,941,030	1,613,365	0	0	44,893,024	4,452,089	4,820,866	823,799,833	4,511,505	0.94	5.50	5.20	4.42
2026	0	0	0	1,792,549	1,845,251	1,544,014	0	0	0	4,452,089	4,582,984	3,834,813	4,511,505		0.09	5.20	0.12
2027	1,966,069	0	0	1,966,245	1,845,251	1,468,558	52,544,352	0	0	1,003,983,354	4,582,984	3,647,406	4,511,505	0.94	6.77	5.20	5.19
2028	0	2,023,322	0	1,877,386	2,023,963	1,468,558	0	54,074,474	0	4,662,797	1,033,455,025	3,647,406	4,511,505	0.94	6.85	5.20	5.23
2029	0	0	1,602,523	1,780,338	1,932,496	1,608,540	0	0	42,828,363	4,421,781	4,799,672	821,338,140	4,511,505	0.94	5.51	5.20	4.46
2030	0	0	0	1,780,338	1,832,599	1,535,847	0	0	0	4,421,781	4,551,561	3,814,529	4,511,505		0.09	5.20	0.12
														max	12.12		7.90
														min	0.09		0.11
														avg.	5.68		4.25

Table 7. Wat[illegible] ality Arsenic

Pore water conc.= 0.025 mg/L
unox. runoff conc. (unfil)= 0.232 mg/L
ox. runoff conc. (unfil)= 0.005 mg/L

Year	SW Cell pore (cf)	SE Cell pore (cf)	N Cell pore (cf)	SW Cell Q precp. (cf)	SE Cell Q precp. (cf)	N Cell Q precp. (cf)	SW Cell Mass PCBs	SE Cell Mass Con.	N Cell Mass Con.	SW Cell Mass Con.	SE Cell Mass Con.	N Cell Mass Con.	Pore Conc. (mg/L)	RO Conc. (mg/L)	Total Conc. (mg/L)
1997	0	0	0												
1998	2,098,792	0	0	2,314,592	2,545,620	2,246,301	1,485,945			15,207,426	0	0	0.03	0.08	0.06
1999	0	2,165,945	1,886,642	2,221,406	2,389,876	2,110,472	0	1,533,489	1,335,743	314,551	15,702,057	13,866,307	0.03	0.16	0.11
2000	2,165,409	0	0	2,309,504	2,293,707	2,026,702	1,533,109	0	0	15,173,993	324,789	286,981	0.03	0.08	0.07
2001	0	2,235,070	1,954,305	2,212,836	2,384,596	2,105,294	0	1,582,430	1,383,648	313,338	15,667,366	13,832,286	0.03	0.16	0.11
2002	2,233,031	0	0	2,304,318	2,284,815	2,017,989	1,580,986	0	0	15,139,924	323,530	285,747	0.03	0.08	0.07
2003	0	2,305,161	2,023,322	2,204,080	2,379,215	2,100,016	0	1,632,054	1,432,512	312,098	15,632,012	13,797,610	0.03	0.16	0.11
2004	2,301,566	0	0	2,299,040	2,275,729	2,009,081	1,629,509	0	0	15,105,242	322,243	284,486	0.03	0.08	0.07
2005	0	2,376,231	2,093,145	2,195,142	2,373,751	2,094,641	0	1,682,372	1,481,947	310,832	15,596,114	13,762,294	0.03	0.16	0.10
2006	0	0	0	2,081,667	2,266,477	1,999,980	0	0	0	294,764	320,933	283,197		0.01	0.01
2007	2,371,013	0	0	2,210,766	2,149,315	1,896,595	1,678,677	0	0	14,525,265	304,343	268,558	0.03	0.09	0.07
2008	0	2,448,160	0	2,121,999	2,280,189	1,896,595	0	1,733,297	0	300,475	14,981,390	268,558	0.03	0.09	0.07
2009	0	0	2,163,826	2,025,894	2,188,697	1,714,684	0	0	1,531,989	286,867	309,919	11,265,885	0.03	0.07	0.06
2010	0	0	0	2,025,894	2,089,646	1,637,194	0	0	0	286,867	295,894	231,827		0.01	0.01
2011	2,057,596	0	0	2,205,793	2,089,646	1,552,562	1,456,778	0	0	14,492,590	295,894	219,843	0.03	0.09	0.07
2012	0	2,121,181	0	2,113,625	2,275,032	1,552,562	0	1,501,796	0	299,289	14,947,509	219,843	0.03	0.09	0.07
2013	0	0	1,769,493	2,013,552	2,180,014	1,922,505	0	0	1,252,801	285,119	308,690	12,631,320	0.03	0.08	0.06
2014	0	0	0	2,013,552	2,076,850	1,843,178	0	0	0	285,119	294,082	260,994		0.01	0.01
2015	2,130,384	0	0	2,200,735	2,076,850	1,757,126	1,508,312	0	0	14,459,358	294,082	248,809	0.03	0.09	0.07
2016	0	2,196,530	0	2,105,084	2,269,787	1,757,126	0	1,555,144	0	298,080	14,913,045	248,809	0.03	0.09	0.07
2017	0	0	1,841,677	2,000,928	2,171,157	1,917,418	0	0	1,303,907	283,331	307,436	12,597,895	0.03	0.08	0.06
2018	0	0	0	2,000,928	2,063,758	1,834,593	0	0	0	283,331	292,228	259,778		0.01	0.01
2019	2,197,282	0	0	2,195,583	2,063,758	1,744,445	1,555,675	0	0	14,425,509	292,228	247,013	0.03	0.09	0.07
2020	0	2,265,910	0	2,096,361	2,264,444	1,744,445	0	1,604,264	0	296,845	14,877,938	247,013	0.03	0.09	0.07
2021	0	0	1,909,017	1,987,993	2,162,109	1,912,233	0	0	1,351,584	281,500	306,155	12,563,827	0.03	0.08	0.06
2022	0	0	0	1,987,993	2,050,343	1,825,815	0	0	0	281,500	290,329	258,535		0.01	0.01
2023	2,016,602	0	0	1,971,109	2,050,343	1,731,433	1,427,754	0	0	12,950,658	290,329	245,171	0.03	0.08	0.07
2024	0	2,076,873	0	1,885,622	2,029,003	1,731,433	0	1,470,426	0	267,004	13,331,038	245,171	0.03	0.09	0.07
2025	0	0	1,679,777	1,792,549	1,941,030	1,613,365	0	0	1,189,282	253,825	274,850	10,600,198	0.03	0.07	0.06
2026	0	0	0	1,792,549	1,845,251	1,544,014	0	0	0	253,825	261,288	218,632		0.01	0.01
2027	1,966,069	0	0	1,966,245	1,845,251	1,468,558	1,391,977	0	0	12,918,699	261,288	207,948	0.03	0.09	0.07
2028	0	2,023,322	0	1,877,386	2,023,963	1,468,558	0	1,432,512	0	265,838	13,297,924	207,948	0.03	0.09	0.07
2029	0	0	1,602,523	1,780,338	1,932,496	1,608,540	0	0	1,134,586	252,096	273,641	10,568,496	0.03	0.07	0.06
2030	0	0	0	1,780,338	1,832,599	1,535,847	0	0	0	252,096	259,496	217,476		0.01	0.01
													max	0.16	0.11
													min	0.01	0.01
													avg.	0.08	0.06

Table 8. Water Quality Lead

Pore water conc.=	0.2125 mg/L		
unox. runoff conc. (unfil)=	6.8 mg/L	GW Pumpage (1sst yr)=	2,517,986
ox. runoff conc. (unfil)=	0.032 mg/L	GW Pumpage (other yrs)=	30,635
GW Conc.=	0.7706 mg/L		

Year	SW Cell pore (cf)	SE Cell pore (cf)	N Cell pore (cf)	SW Cell Q precp. (cf)	SE Cell Q precp. (cf)	N Cell Q precp. (cf)	SW Cell Mass in PW	SE Cell Mass in PW	N Cell Mass in PW	SW Cell Mass in RO	SE Cell Mass in RO	N Cell Mass in RO	Masss in GW	Pore Conc. (mg/L)	RO Conc. (mg/L)	GW Conc. (mg/L)	Total Conc. (mg/L)
1997	0	0	0														
1998	2,098,792	0	0	2,314,592	2,545,620	2,246,301	12,630,533			445,734,909	0	0	54,950,996	0.21	2.21	0.77	1.55
1999	0	2,165,945	1,886,642	2,221,406	2,389,876	2,110,472	0	13,034,659	11,353,812	2,013,127	460,232,713	406,426,226	668,560	0.21	4.56	0.77	2.92
2000	2,165,409	0	0	2,309,504	2,293,707	2,026,702	13,031,430	0	0	444,754,956	2,078,649	1,836,678	668,560	0.21	2.39	0.77	1.85
2001	0	2,235,070	1,954,305	2,212,836	2,384,596	2,105,294	0	13,450,653	11,761,007	2,005,361	459,215,913	405,429,073	668,560	0.21	4.57	0.77	2.89
2002	2,233,031	0	0	2,304,318	2,284,815	2,017,989	13,438,383	0	0	443,756,404	2,070,591	1,828,782	668,560	0.21	2.39	0.77	1.84
2003	0	2,305,161	2,023,322	2,204,080	2,379,215	2,100,016	0	13,872,459	12,176,355	1,997,426	458,179,675	404,412,697	668,560	0.21	4.57	0.77	2.85
2004	2,301,566	0	0	2,299,040	2,275,729	2,009,081	13,850,824	0	0	442,739,850	2,062,356	1,820,709	668,560	0.21	2.40	0.77	1.83
2005	0	2,376,231	2,093,145	2,195,142	2,373,751	2,094,641	0	14,300,159	12,596,546	1,989,325	457,127,488	403,377,576	668,560	0.21	4.57	0.77	2.82
2006	0	0	0	2,081,667	2,266,477	1,999,980	0	0	0	1,886,490	2,053,972	1,812,462	668,560		0.03	0.77	0.04
2007	2,371,013	0	0	2,210,766	2,149,315	1,896,595	14,268,755	0	0	425,740,538	1,947,795	1,718,770	668,560	0.21	2.42	0.77	1.81
2008	0	2,448,160	0	2,121,999	2,280,189	1,896,595	0	14,733,025	0	1,923,040	439,109,709	1,718,770	668,560	0.21	2.48	0.77	1.84
2009	0	0	2,163,826	2,025,894	2,188,697	1,714,684	0	0	13,021,904	1,835,946	1,983,484	330,206,965	668,560	0.21	1.99	0.77	1.51
2010	0	0	0	2,025,894	2,089,646	1,637,194	0	0	0	1,835,946	1,893,721	1,483,691	668,560		0.03	0.77	0.04
2011	2,057,596	0	0	2,205,793	2,089,646	1,552,562	12,382,616	0	0	424,782,824	1,893,721	1,406,994	668,560	0.21	2.58	0.77	1.96
2012	0	2,121,181	0	2,113,625	2,275,032	1,552,562	0	12,765,269	0	1,915,451	438,116,654	1,406,994	668,560	0.21	2.62	0.77	1.98
2013	0	0	1,769,493	2,013,552	2,180,014	1,922,505	0	0	10,648,811	1,824,762	1,975,616	370,228,340	668,560	0.21	2.16	0.77	1.72
2014	0	0	0	2,013,552	2,076,850	1,843,178	0	0	0	1,824,762	1,882,124	1,670,361	668,560		0.03	0.77	0.04
2015	2,130,384	0	0	2,200,735	2,076,850	1,757,126	12,820,648	0	0	423,808,768	1,882,124	1,592,378	668,560	0.21	2.50	0.77	1.90
2016	0	2,196,530	0	2,105,084	2,269,787	1,757,126	0	13,218,720	0	1,907,712	437,106,506	1,592,378	668,560	0.21	2.54	0.77	1.92
2017	0	0	1,841,677	2,000,928	2,171,157	1,917,418	0	0	11,083,210	1,813,321	1,967,589	369,248,639	668,560	0.21	2.16	0.77	1.71
2018	0	0	0	2,000,928	2,063,758	1,834,593	0	0	0	1,813,321	1,870,260	1,662,582	668,560		0.03	0.77	0.04
2019	2,197,282	0	0	2,195,583	2,063,758	1,744,445	13,223,241	0	0	422,816,635	1,870,260	1,580,886	668,560	0.21	2.51	0.77	1.89
2020	0	2,265,910	0	2,096,361	2,264,444	1,744,445	0	13,636,248	0	1,899,806	436,077,499	1,580,886	668,560	0.21	2.54	0.77	1.91
2021	0	0	1,909,017	1,987,993	2,162,109	1,912,233	0	0	11,488,467	1,801,599	1,959,390	368,250,101	668,560	0.21	2.17	0.77	1.70
2022	0	0	0	1,987,993	2,050,343	1,825,815	0	0	0	1,801,599	1,858,102	1,654,627	668,560		0.03	0.77	0.04
2023	2,016,602	0	0	1,971,109	2,050,343	1,731,433	12,135,910	0	0	379,588,264	1,858,102	1,569,094	668,560	0.21	2.35	0.77	1.79
2024	0	2,076,873	0	1,885,622	2,029,003	1,731,433	0	12,498,623	0	1,708,826	390,737,319	1,569,094	668,560	0.21	2.46	0.77	1.85
2025	0	0	1,679,777	1,792,549	1,941,030	1,613,365	0	0	10,108,899	1,624,479	1,759,039	310,695,445	668,560	0.21	2.07	0.77	1.63
2026	0	0	0	1,792,549	1,845,251	1,544,014	0	0	0	1,624,479	1,672,240	1,399,247	668,560		0.03	0.77	0.04
2027	1,966,069	0	0	1,966,245	1,845,251	1,468,558	11,831,805	0	0	378,651,515	1,672,240	1,330,866	668,560	0.21	2.55	0.77	1.91
2028	0	2,023,322	0	1,877,386	2,023,963	1,468,558	0	12,176,355	0	1,701,382	389,766,732	1,330,866	668,560	0.21	2.58	0.77	1.93
2029	0	0	1,602,523	1,780,338	1,932,496	1,608,540	0	0	9,643,983	1,613,413	1,751,306	309,766,265	668,560	0.21	2.08	0.77	1.64
2030	0	0	0	1,780,338	1,832,599	1,535,847	0	0	0	1,613,413	1,660,775	1,391,846	668,560		0.03	0.77	0.04
														max	4.57		2.92
														min	0.03		0.04
														avg.	2.14		1.56

Pore water conc.=	0.0543 mg/L		
unox. runoff conc. (unfil)=	0.154 mg/L	GW Pumpage (1st yr)=	2,517,986 CF
ox. runoff conc. (unfil)=	0.0011 mg/L	GW Pumpage (other yrs)=	30,635 CF
GW Conc.=	0.0063 mg/L		

Year	SW Cell pore (cf)	SE Cell pore (cf)	N Cell pore (cf)	SW Cell Q precp. (cf)	SE Cell Q precp. (cf)	N Cell Q precp. (cf)	SW Cell Mass in PW	SE Cell Mass in PW	N Cell Mass in PW	SW Cell Mass in RO	SE Cell Mass in RO	N Cell Mass in RO	Mass in GW	Pore Conc. (mg/L)	RO Conc. (mg/L)	GW Conc. (mg/L)	Total Conc. (mg/L)
1997	0	0	0														
1998	2,098,792	0	0	2,314,592	2,545,620	2,246,301	3,227,473			10,094,585	0	0	449,249	0.05	0.05	0.006	0.04
1999	0	2,165,945	1,886,642	2,221,406	2,389,876	2,110,472	0	3,330,739	2,901,233	69,201	10,422,917	9,204,359	5,466	0.05	0.10	0.006	0.08
2000	2,165,409	0	0	2,309,504	2,293,707	2,026,702	3,329,914	0	0	10,072,392	71,454	63,136	5,466	0.05	0.05	0.006	0.05
2001	0	2,235,070	1,954,305	2,212,836	2,384,596	2,105,294	0	3,437,038	3,005,283	68,934	10,399,890	9,181,776	5,466	0.05	0.10	0.006	0.08
2002	2,233,031	0	0	2,304,318	2,284,815	2,017,989	3,433,902	0	0	10,049,777	71,177	62,864	5,466	0.05	0.05	0.006	0.05
2003	0	2,305,161	2,023,322	2,204,080	2,379,215	2,100,016	0	3,544,821	3,111,417	68,662	10,376,422	9,158,758	5,466	0.05	0.10	0.006	0.08
2004	2,301,566	0	0	2,299,040	2,275,729	2,009,081	3,539,293	0	0	10,026,755	70,894	62,587	5,466	0.05	0.05	0.006	0.05
2005	0	2,376,231	2,093,145	2,195,142	2,373,751	2,094,641	0	3,654,111	3,218,788	68,383	10,352,593	9,135,316	5,466	0.05	0.10	0.006	0.08
2006	0	0	0	2,081,667	2,266,477	1,999,980	0	0	0	64,848	70,605	62,303	5,466		0.00	0.006	0.00
2007	2,371,013	0	0	2,210,766	2,149,315	1,896,595	3,646,087	0	0	9,641,771	66,955	59,083	5,466	0.05	0.06	0.006	0.05
2008	0	2,448,160	0	2,121,999	2,280,189	1,896,595	0	3,764,721	0	66,105	9,944,543	59,083	5,466	0.05	0.06	0.006	0.06
2009	0	0	2,163,826	2,025,894	2,188,697	1,714,684	0	0	3,327,480	63,111	68,182	7,478,217	5,466	0.05	0.05	0.006	0.05
2010	0	0	0	2,025,894	2,089,646	1,637,194	0	0	0	63,111	65,097	51,002	5,466		0.00	0.006	0.00
2011	2,057,596	0	0	2,205,793	2,089,646	1,552,562	3,164,123	0	0	9,620,082	65,097	48,365	5,466	0.05	0.06	0.006	0.06
2012	0	2,121,181	0	2,113,625	2,275,032	1,552,562	0	3,261,902	0	65,844	9,922,054	48,365	5,466	0.05	0.06	0.006	0.06
2013	0	0	1,769,493	2,013,552	2,180,014	1,922,505	0	0	2,721,084	62,726	67,912	8,384,583	5,466	0.05	0.05	0.006	0.05
2014	0	0	0	2,013,552	2,076,850	1,843,178	0	0	0	62,726	64,698	57,419	5,466		0.00	0.006	0.00
2015	2,130,384	0	0	2,200,735	2,076,850	1,757,126	3,276,053	0	0	9,598,022	64,698	54,738	5,466	0.05	0.06	0.006	0.06
2016	0	2,196,530	0	2,105,084	2,269,787	1,757,126	0	3,377,772	0	65,578	9,899,177	54,738	5,466	0.05	0.06	0.006	0.06
2017	0	0	1,841,677	2,000,928	2,171,157	1,917,418	0	0	2,832,086	62,333	67,636	8,362,396	5,466	0.05	0.05	0.006	0.05
2018	0	0	0	2,000,928	2,063,758	1,834,593	0	0	0	62,333	64,290	57,151	5,466		0.00	0.006	0.00
2019	2,197,282	0	0	2,195,583	2,063,758	1,744,445	3,378,927	0	0	9,575,553	64,290	54,343	5,466	0.05	0.06	0.006	0.06
2020	0	2,265,910	0	2,096,361	2,264,444	1,744,445	0	3,484,462	0	65,306	9,875,873	54,343	5,466	0.05	0.06	0.006	0.06
2021	0	0	1,909,017	1,987,993	2,162,109	1,912,233	0	0	2,935,641	61,930	67,354	8,339,782	5,466	0.05	0.05	0.006	0.05
2022	0	0	0	1,987,993	2,050,343	1,825,815	0	0	0	61,930	63,872	56,878	5,466		0.00	0.006	0.00
2023	2,016,602	0	0	1,971,109	2,050,343	1,731,433	3,101,082	0	0	8,596,558	63,872	53,938	5,466	0.05	0.05	0.006	0.05
2024	0	2,076,873	0	1,885,622	2,029,003	1,731,433	0	3,193,766	0	58,741	8,849,051	53,938	5,466	0.05	0.06	0.006	0.06
2025	0	0	1,679,777	1,792,549	1,941,030	1,613,365	0	0	2,583,121	55,841	60,467	7,036,338	5,466	0.05	0.05	0.006	0.05
2026	0	0	0	1,792,549	1,845,251	1,544,014	0	0	0	55,841	57,483	48,099	5,466		0.00	0.006	0.00
2027	1,966,069	0	0	1,966,245	1,845,251	1,468,558	3,023,374	0	0	8,575,343	57,483	45,749	5,466	0.05	0.06	0.006	0.06
2028	0	2,023,322	0	1,877,386	2,023,963	1,468,558	0	3,111,417	0	58,484	8,827,070	45,749	5,466	0.05	0.06	0.006	0.06
2029	0	0	1,602,523	1,780,338	1,932,496	1,608,540	0	0	2,464,321	55,461	60,201	7,015,295	5,466	0.05	0.05	0.006	0.05
2030	0	0	0	1,780,338	1,832,599	1,535,847	0	0	0	55,461	57,089	47,845	5,466		0.00	0.006	0.00
														max	0.10		0.08
														min	0.00		0.00
														avg.	0.05		0.05

Pore water conc.= 0.104 mg/L
unox. runoff conc. (unfil)= 4.06 mg/L
ox. runoff conc. (unfil)= 0.027 mg/L
GW Conc.= 0.078 mg/L

GW Pumpage (1st yr)= 2,517,986
GW Pumpage (other yrs)= 30,635

Year	SW Cell pore (cf)	SE Cell pore (cf)	N Cell pore (cf)	SW Cell Q precp. (cf)	SE Cell Q precp. (cf)	N Cell Q precp. (cf)	SW Cell Mass in PW	SE Cell Mass in PW	N Cell Mass in PW	SW Cell Mass in RO	SE Cell Mass in RO	N Cell Mass in RO	Mass in GW	Pore Conc. (mg/L)	RO Conc. (mg/L)	GW Conc. (mg/L)	Total Conc. (mg/L)
1997	0	0	0														
1998	2,098,792	0	0	2,314,592	2,545,620	2,246,301	6,181,531			266,129,960	0	0	5,562,130	0.10	1.32	0.08	0.84
1999	0	2,165,945	1,886,642	2,221,406	2,389,876	2,110,472	0	6,379,316	5,556,689	1,698,576	274,786,002	242,660,364	67,671	0.10	2.73	0.08	1.74
2000	2,165,409	0	0	2,309,504	2,293,707	2,026,702	6,377,735	0	0	265,544,871	1,753,860	1,549,697	67,671	0.10	1.43	0.08	1.10
2001	0	2,235,070	1,954,305	2,212,836	2,384,596	2,105,294	0	6,582,908	5,755,975	1,692,023	274,178,913	242,065,005	67,671	0.10	2.73	0.08	1.71
2002	2,233,031	0	0	2,304,318	2,284,815	2,017,989	6,576,903	0	0	264,948,677	1,747,061	1,543,035	67,671	0.10	1.43	0.08	1.09
2003	0	2,305,161	2,023,322	2,204,080	2,379,215	2,100,016	0	6,789,345	5,959,251	1,685,328	273,560,218	241,458,169	67,671	0.10	2.73	0.08	1.69
2004	2,301,566	0	0	2,299,040	2,275,729	2,009,081	6,778,756	0	0	264,341,734	1,740,113	1,536,223	67,671	0.10	1.44	0.08	1.09
2005	0	2,376,231	2,093,145	2,195,142	2,373,751	2,094,641	0	6,998,666	6,164,898	1,678,493	272,932,000	240,840,141	67,671	0.10	2.73	0.08	1.67
2006	0	0	0	2,081,667	2,266,477	1,999,980	0	0	0	1,591,726	1,733,039	1,529,265	67,671		0.03	0.08	0.03
2007	2,371,013	0	0	2,210,766	2,149,315	1,896,595	6,983,297	0	0	254,192,145	1,643,452	1,450,212	67,671	0.10	1.45	0.08	1.08
2008	0	2,448,160	0	2,121,999	2,280,189	1,896,595	0	7,210,516	0	1,622,565	262,174,326	1,450,212	67,671	0.10	1.49	0.08	1.10
2009	0	0	2,163,826	2,025,894	2,188,697	1,714,684	0	0	6,373,073	1,549,080	1,673,565	197,152,982	67,671	0.10	1.19	0.08	0.90
2010	0	0	0	2,025,894	2,089,646	1,637,194	0	0	0	1,549,080	1,597,827	1,251,864	67,671		0.03	0.08	0.03
2011	2,057,596	0	0	2,205,793	2,089,646	1,552,562	6,060,198	0	0	253,620,333	1,597,827	1,187,151	67,671	0.10	1.55	0.08	1.17
2012	0	2,121,181	0	2,113,625	2,275,032	1,552,562	0	6,247,473	0	1,616,162	281,581,414	1,187,151	67,671	0.10	1.57	0.08	1.18
2013	0	0	1,769,493	2,013,552	2,180,014	1,922,505	0	0	5,211,653	1,539,643	1,666,926	221,048,097	67,671	0.10	1.29	0.08	1.02
2014	0	0	0	2,013,552	2,076,850	1,843,178	0	0	0	1,539,643	1,588,042	1,409,367	67,671		0.03	0.08	0.03
2015	2,130,384	0	0	2,200,735	2,076,850	1,757,126	6,274,576	0	0	253,038,764	1,588,042	1,343,569	67,671	0.10	1.50	0.08	1.13
2016	0	2,196,530	0	2,105,084	2,269,787	1,757,126	0	6,469,397	0	1,609,632	260,978,296	1,343,569	67,671	0.10	1.52	0.08	1.14
2017	0	0	1,841,677	2,000,928	2,171,157	1,917,418	0	0	5,424,254	1,529,989	1,660,153	220,463,158	67,671	0.10	1.30	0.08	1.02
2018	0	0	0	2,000,928	2,063,758	1,834,593	0	0	0	1,529,989	1,578,032	1,402,803	67,671		0.03	0.08	0.03
2019	2,197,282	0	0	2,195,583	2,063,758	1,744,445	6,471,610	0	0	252,446,403	1,578,032	1,333,873	67,671	0.10	1.50	0.08	1.12
2020	0	2,265,910	0	2,096,361	2,264,444	1,744,445	0	6,673,740	0	1,602,961	260,363,918	1,333,873	67,671	0.10	1.52	0.08	1.13
2021	0	0	1,909,017	1,987,993	2,162,109	1,912,233	0	0	5,622,591	1,520,099	1,653,235	219,866,972	67,671	0.10	1.30	0.08	1.01
2022	0	0	0	1,987,993	2,050,343	1,825,815	0	0	0	1,520,099	1,567,774	1,396,091	67,671		0.03	0.08	0.03
2023	2,016,602	0	0	1,971,109	2,050,343	1,731,433	5,939,457	0	0	226,636,522	1,567,774	1,323,923	67,671	0.10	1.41	0.08	1.07
2024	0	2,076,873	0	1,885,622	2,029,003	1,731,433	0	6,116,973	0	1,441,822	233,293,164	1,323,923	67,671	0.10	1.48	0.08	1.10
2025	0	0	1,679,777	1,792,549	1,941,030	1,613,365	0	0	4,947,414	1,370,655	1,484,189	185,503,457	67,671	0.10	1.24	0.08	0.97
2026	0	0	0	1,792,549	1,845,251	1,544,014	0	0	0	1,370,655	1,410,953	1,180,615	67,671		0.03	0.08	0.03
2027	1,966,069	0	0	1,966,245	1,845,251	1,468,558	5,790,625	0	0	226,077,228	1,410,953	1,122,919	67,671	0.10	1.53	0.08	1.14
2028	0	2,023,322	0	1,877,386	2,023,963	1,468,558	0	5,959,251	0	1,435,525	232,713,666	1,122,919	67,671	0.10	1.55	0.08	1.15
2029	0	0	1,602,523	1,780,338	1,932,496	1,608,540	0	0	4,719,879	1,361,318	1,477,664	184,948,681	67,671	0.10	1.25	0.08	0.98
2030	0	0	0	1,780,338	1,832,599	1,535,847	0	0	0	1,361,318	1,401,279	1,174,370	67,671		0.03	0.08	0.03
														max	2.73		1.74
														min	0.03		0.03
														avg.	1.28		0.93

Table We

Pore water conc.=	305	mg/L
unox. runoff conc. (unfil)=	56.5	mg/L
ox. runoff conc. (unfil)=	56.5	mg/L
GW Conc.=	10.0000	mg/L

GW Pumpage (1st yr)=	2,517,986
GW Pumpage (other yrs)=	30,635

Year	SW Cell pore (cf)	SE Cell pore (cf)	N Cell pore (cf)	SW Cell Q precp. (cf)	SE Cell Q precp. (cf)	N Cell Q precp. (cf)	SW Cell Mass in PW	SE Cell Mass in PW	N Cell Mass in PW	SW Cell Mass in RO	SE Cell Mass in RO	N Cell Mass in RO	Mass in GW	Pore Conc. (mg/L)	RO Conc. (mg/L)	GW Conc. (mg/L)	Total Conc. (mg/L)
1997	0	0	0														
1998	2,098,792	0	0	2,314,592	2,545,620	2,246,301	18,128,529,463			3,703,532,699	0	0	713,093,635	305.00	18.40	10.00	67.91
1999	0	2,165,945	1,886,642	2,221,406	2,389,876	2,110,472	0	18,708,570,104	16,296,059,881	3,554,427,835	3,823,992,393	3,376,923,787	8,675,832	305.00	56.50	10.00	149.57
2000	2,165,409	0	0	2,309,504	2,293,707	2,026,702	18,703,935,340	0	0	3,695,390,443	3,670,114,811	3,242,885,295	8,675,832	305.00	56.50	10.00	117.31
2001	0	2,235,070	1,954,305	2,212,836	2,384,596	2,105,294	0	19,305,643,500	16,880,503,546	3,540,715,398	3,815,543,984	3,368,638,620	8,675,832	305.00	56.50	10.00	151.68
2002	2,233,031	0	0	2,304,318	2,284,815	2,017,989	19,288,031,399	0	0	3,687,093,653	3,655,887,169	3,228,943,389	8,675,832	305.00	56.50	10.00	118.89
2003	0	2,305,161	2,023,322	2,204,080	2,379,215	2,100,016	0	19,911,059,470	17,476,649,990	3,526,704,817	3,806,934,064	3,360,193,734	8,675,832	305.00	56.50	10.00	153.78
2004	2,301,566	0	0	2,299,040	2,275,729	2,009,081	19,880,006,555	0	0	3,678,647,280	3,641,348,013	3,214,689,674	8,675,832	305.00	56.50	10.00	120.49
2005	0	2,376,231	2,093,145	2,195,142	2,373,751	2,094,641	0	20,524,933,883	18,079,748,578	3,512,402,192	3,798,191,628	3,351,593,094	8,675,832	305.00	56.50	10.00	155.86
2006	0	0	0	2,081,667	2,266,477	1,999,980	0	0	0	3,330,834,471	3,626,544,104	3,200,128,209	8,675,832		56.50	10.00	56.28
2007	2,371,013	0	0	2,210,766	2,149,315	1,896,595	20,479,860,809	0	0	3,537,403,001	3,439,076,009	3,034,702,966	8,675,832	305.00	56.50	10.00	124.39
2008	0	2,448,160	0	2,121,999	2,280,189	1,896,595	0	21,146,223,918	0	3,395,368,183	3,648,485,079	3,034,702,966	8,675,832	305.00	56.50	10.00	125.65
2009	0	0	2,163,826	2,025,894	2,188,697	1,714,684	0	0	18,690,262,788	3,241,592,529	3,502,089,624	2,743,631,398	8,675,832	305.00	56.50	10.00	122.51
2010	0	0	0	2,025,894	2,089,646	1,637,194	0	0	0	3,241,592,529	3,343,600,474	2,619,641,462	8,675,832		56.50	10.00	56.25
2011	2,057,596	0	0	2,205,793	2,089,646	1,552,562	17,772,695,502	0	0	3,529,445,524	3,343,600,474	2,484,223,505	8,675,832	305.00	56.50	10.00	120.75
2012	0	2,121,181	0	2,113,625	2,275,032	1,552,562	0	18,321,914,966	0	3,381,968,957	3,640,233,962	2,484,223,505	8,675,832	305.00	56.50	10.00	121.46
2013	0	0	1,769,493	2,013,552	2,180,014	1,922,505	0	0	15,284,175,160	3,221,845,076	3,488,196,488	3,076,161,944	8,675,832	305.00	56.50	10.00	111.87
2014	0	0	0	2,013,552	2,076,850	1,843,178	0	0	0	3,221,845,076	3,323,125,967	2,949,231,681	8,675,832		56.50	10.00	56.26
2015	2,130,384	0	0	2,200,735	2,076,850	1,757,126	18,401,401,159	0	0	3,521,352,260	3,323,125,967	2,811,541,594	8,675,832	305.00	56.50	10.00	120.92
2016	0	2,196,530	0	2,105,084	2,269,787	1,757,126	0	18,972,751,618	0	3,368,303,301	3,631,840,818	2,811,541,594	8,675,832	305.00	56.50	10.00	121.63
2017	0	0	1,841,677	2,000,928	2,171,157	1,917,418	0	0	15,907,666,707	3,201,644,466	3,474,024,815	3,068,021,781	8,675,832	305.00	56.50	10.00	113.80
2018	0	0	0	2,000,928	2,063,758	1,834,593	0	0	0	3,201,644,466	3,302,177,900	2,935,495,887	8,675,832		56.50	10.00	56.26
2019	2,197,282	0	0	2,195,583	2,063,758	1,744,445	18,979,240,287	0	0	3,513,108,809	3,302,177,900	2,791,251,800	8,675,832	305.00	56.50	10.00	122.66
2020	0	2,265,910	0	2,096,361	2,264,444	1,744,445	0	19,572,026,527	0	3,354,344,721	3,623,290,983	2,791,251,800	8,675,832	305.00	56.50	10.00	123.35
2021	0	0	1,909,017	1,987,993	2,162,109	1,912,233	0	0	16,489,329,515	3,180,947,515	3,459,547,552	3,059,725,103	8,675,832	305.00	56.50	10.00	115.61
2022	0	0	0	1,987,993	2,050,343	1,825,815	0	0	0	3,180,947,515	3,280,712,062	2,921,450,290	8,675,832		56.50	10.00	56.26
2023	2,016,602	0	0	1,971,109	2,050,343	1,731,433	17,418,599,578	0	0	3,153,931,899	3,280,712,062	2,770,430,833	8,675,832	305.00	56.50	10.00	120.56
2024	0	2,076,873	0	1,885,622	2,029,003	1,731,433	0	17,939,199,378	0	3,017,146,522	3,246,567,431	2,770,430,833	8,675,832	305.00	56.50	10.00	122.88
2025	0	0	1,679,777	1,792,549	1,941,030	1,613,365	0	0	14,509,242,718	2,868,221,533	3,105,803,135	2,581,513,620	8,675,832	305.00	56.50	10.00	115.45
2026	0	0	0	1,792,549	1,845,251	1,544,014	0	0	0	2,868,221,533	2,952,549,256	2,470,546,312	8,675,832		56.50	10.00	56.23
2027	1,966,069	0	0	1,966,245	1,845,251	1,468,558	16,982,120,734	0	0	3,146,148,614	2,952,549,256	2,349,811,070	8,675,832	305.00	56.50	10.00	123.45
2028	0	2,023,322	0	1,877,386	2,023,963	1,468,558	0	17,476,649,990	0	3,003,968,158	3,238,502,990	2,349,811,070	8,675,832	305.00	56.50	10.00	124.04
2029	0	0	1,602,523	1,780,338	1,932,496	1,608,540	0	0	13,841,952,656	2,848,683,078	3,092,148,863	2,573,793,227	8,675,832	305.00	56.50	10.00	113.56
2030	0	0	0	1,780,338	1,832,599	1,535,847	0	0	0	2,848,683,078	2,932,305,430	2,457,478,602	8,675,832		56.50	10.00	56.22
														max	56.50		155.86
														min	18.40		56.22
														vg.	55.35		108.90

Table Zinc

Pore water conc.=	0.862	mg/L
unox. runoff conc. (unfil)=	30.9	mg/L
ox. runoff conc. (unfil)=	0.34	mg/L
GW Conc.=	0.2750	mg/L

GW Pumpage (1st yr)=	2,517,986
GW Pumpage (other yrs)=	30,635

Year	SW Cell pore (cf)	SE Cell pore (cf)	N Cell pore (cf)	SW Cell Q precp. (cf)	SE Cell Q precp. (cf)	N Cell Q precp. (cf)	SW Cell Mass in PW	SE Cell Mass in PW	N Cell Mass in PW	SW Cell Mass in RO	SE Cell Mass in RO	N Cell Mass in RO	Mass in GW	Pore Conc. (mg/L)	RO Conc. (mg/L)	GW Conc. (mg/L)	Total Conc. (mg/L)
1997	0	0	0														
1998	2,098,792	0	0	2,314,592	2,545,620	2,246,301	51,235,385			2,025,471,865	0	0	19,610,075	0.86	10.06	0.28	6.31
1999	0	2,165,945	1,886,642	2,221,406	2,389,876	2,110,472	0	52,874,713	46,056,405	21,389,477	2,091,351,592	1,846,848,584	238,585	0.86	20.80	0.28	13.26
2000	2,165,409	0	0	2,309,504	2,293,707	2,026,702	52,861,614	0	0	2,021,018,844	22,085,647	19,514,708	238,585	0.86	10.99	0.28	8.46
2001	0	2,235,070	1,954,305	2,212,836	2,384,596	2,105,294	0	54,562,179	47,708,177	21,306,960	2,086,731,135	1,842,317,405	238,585	0.86	20.81	0.28	13.10
2002	2,233,031	0	0	2,304,318	2,284,815	2,017,989	54,512,403	0	0	2,016,481,308	22,000,029	19,430,810	238,585	0.86	11.00	0.28	8.41
2003	0	2,305,161	2,023,322	2,204,080	2,379,215	2,100,016	0	56,273,224	49,393,024	21,222,648	2,082,022,347	1,837,698,874	238,585	0.86	20.82	0.28	12.94
2004	2,301,566	0	0	2,299,040	2,275,729	2,009,081	56,185,461	0	0	2,011,861,964	21,912,537	19,345,035	238,585	0.86	11.01	0.28	8.35
2005	0	2,376,231	2,093,145	2,195,142	2,373,751	2,094,641	0	58,008,174	51,097,519	21,136,580	2,077,241,085	1,832,995,161	238,585	0.86	20.83	0.28	12.78
2006	0	0	0	2,081,667	2,266,477	1,999,980	0	0	0	20,043,960	21,823,451	19,257,409	238,585		0.34	0.28	0.34
2007	2,371,013	0	0	2,210,766	2,149,315	1,896,595	57,880,787	0	0	1,934,615,092	20,695,325	18,261,929	238,585	0.86	11.14	0.28	8.29
2008	0	2,448,160	0	2,121,999	2,280,189	1,896,595	0	59,764,082	0	20,432,304	1,995,366,176	18,261,929	238,585	0.86	11.40	0.28	8.42
2009	0	0	2,163,826	2,025,894	2,188,697	1,714,684	0	0	52,822,972	19,506,928	21,074,522	1,500,499,296	238,585	0.86	9.18	0.28	6.93
2010	0	0	0	2,025,894	2,089,646	1,637,194	0	0	0	19,506,928	20,120,782	15,764,214	238,585		0.34	0.28	0.34
2011	2,057,596	0	0	2,205,793	2,089,646	1,552,562	50,229,716	0	0	1,930,263,127	20,120,782	14,949,310	238,585	0.86	11.87	0.28	8.97
2012	0	2,121,181	0	2,113,625	2,275,032	1,552,562	0	51,781,937	0	20,351,672	1,990,853,618	14,949,310	238,585	0.86	12.04	0.28	9.07
2013	0	0	1,769,493	2,013,552	2,180,014	1,922,505	0	0	43,196,587	19,388,094	20,990,917	1,682,361,134	238,585	0.86	9:95	0.28	7.88
2014	0	0	0	2,013,552	2,076,850	1,843,178	0	0	0	19,388,094	19,997,572	17,747,589	238,585		0.34	0.28	0.34
2015	2,130,384	0	0	2,200,735	2,076,850	1,757,126	52,006,583	0	0	1,925,836,900	19,997,572	16,919,011	238,585	0.86	11.48	0.28	8.68
2016	0	2,196,530	0	2,105,084	2,269,787	1,757,126	0	53,621,350	0	20,269,436	1,986,263,386	16,919,011	238,585	0.86	11.65	0.28	8.77
2017	0	0	1,841,677	2,000,928	2,171,157	1,917,418	0	0	44,958,717	19,266,533	20,905,636	1,677,909,257	238,585	0.86	9.96	0.28	7.82
2018	0	0	0	2,000,928	2,063,758	1,834,593	0	0	0	19,266,533	19,871,513	17,664,931	238,585		0.34	0.28	0.34
2019	2,197,282	0	0	2,195,583	2,063,758	1,744,445	53,639,689	0	0	1,921,328,535	19,871,513	16,796,913	238,585	0.86	11.52	0.28	8.63
2020	0	2,265,910	0	2,096,361	2,264,444	1,744,445	0	55,315,039	0	20,185,437	1,981,587,458	16,796,913	238,585	0.86	11.67	0.28	8.72
2021	0	0	1,909,017	1,987,993	2,162,109	1,912,233	0	0	46,602,630	19,141,985	20,818,516	1,673,371,782	238,585	0.86	9.98	0.28	7.77
2022	0	0	0	1,987,993	2,050,343	1,825,815	0	0	0	19,141,985	19,742,338	17,580,409	238,585		0.34	0.28	0.34
2023	2,016,602	0	0	1,971,109	2,050,343	1,731,433	49,228,960	0	0	1,724,893,729	19,742,338	16,671,619	238,585	0.86	10.81	0.28	8.20
2024	0	2,076,873	0	1,885,622	2,029,003	1,731,433	0	50,700,295	0	18,156,280	1,775,556,347	16,671,619	238,585	0.86	11.32	0.28	8.48
2025	0	0	1,679,777	1,792,549	1,941,030	1,613,365	0	0	41,006,450	17,260,094	18,689,789	1,411,836,652	238,585	0.86	9.56	0.28	7.45
2026	0	0	0	1,792,549	1,845,251	1,544,014	0	0	0	17,260,094	17,767,553	14,867,004	238,585		0.34	0.28	0.34
2027	1,966,069	0	0	1,966,245	1,845,251	1,468,558	47,995,371	0	0	1,720,637,030	17,767,553	14,140,456	238,585	0.86	11.72	0.28	8.74
2028	0	2,023,322	0	1,877,386	2,023,963	1,468,558	0	49,393,024	0	18,076,977	1,771,145,883	14,140,456	238,585	0.86	11.86	0.28	8.81
2029	0	0	1,602,523	1,780,338	1,932,496	1,608,540	0	0	39,120,535	17,142,518	18,607,621	1,407,614,349	238,585	0.86	9.58	0.28	7.53
2030	0	0	0	1,780,338	1,832,599	1,535,847	0	0	0	17,142,518	17,645,732	14,788,367	238,585		0.34	0.28	0.34
														max	20.83		13.26
															0.34		0.34
															9.86		7.13

Water Quality Concentrations for Selected Parameters

		PCBs			PAHs (tot.)			Arsenic			Lead			Cadmium			Chromium			Zinc		
		tot.	filtered	CAC	tot.	filtered	FAV	tot.	filtered	FAV	tot.	filtered	FAV	tot.	filtered	FAV	tot.	filtered	FAV	tot.	filtered	FAV
Pore Water	max	3.20	0.048	0.014	1,820	27.300	-	34	5.1	720	370	55.5	274	99.5	14.93	12	195.0	29.3	4,840	1,270	190.5	330
	avg.	1.90	0.029	0.014	944	14.156	-	25	3.8	720	213	31.9	274	54.3	8.15	12	104.0	15.6	4,840	862	129.3	330
	min	0.50	0.008	0.014	67	1.011	-	16	2.4	720	55	8.3	274	9.0	1.35	12	13.0	2.0	4,840	454	68.1	330
Runoff	max			0.014	12,119	181.790	-	157	23.6	720	4,570	685.6	274	103.6	15.54	12	2731.4	409.7	4,840	20,833	3124.9	330
	avg.	<0.2		0.014	*5,680*	85.195	-	*76*	11.4	720	*2,141*	321.2	274	*48.7*	7.31	12	*1283.8*	192.6	4,840	*9,861*	1479.1	330
	min			0.014	88	1.316	-	5	0.8	720	32	4.8	274	1.1	0.17	12	27.0	4.1	4,840	340	51.0	330
Ground Water	max			0.014			-	-		720	4,700	705.0	274	10.0	1.50	12	260.0	39.0	4,840	2,600	390.0	330
	avg.	<1.16		0.014	5,200	78.000	-	-		720	436	65.4	274	6.3	0.95	12	61.0	9.2	4,840	243	36.4	330
	min			0.014			-	-		720	5	0.8	274	5.0	0.75	12	9.2	1.4	4,840	3	0.4	330
Total Combined Flow	max	*1.17*	0.013	0.014	*7,896*	118.445	-	*107*	16.1	720	*2,921*	438.0	274	*84.8*	12.71	12	*1735.8*	12.7	4,840	*13,264*	1989.6	330
	avg.	*0.60*	0.009	0.014	*4,245*	63.680	-	*59*	8.9	720	*1,557*	233.1	274	*46.0*	6.90	12	*925.1*	6.9	4,840	*7,126*	1068.8	330
	min	*0.22*	0.003	0.014	*112*	1.684	-	*5*	0.8	720	*36*	5.1	274	*1.1*	0.17	12	*27.2*	0.2	4,840	*340*	50.9	330

Notes:

1 - All units are ug/L. Total values represent unfiltered concentrations.

2 - Italicized values were calculated from the tables.

3 - Ground water values are max, average, and min from the all the data in the ECI Site GW quality Database. For calculation of the average and min, non-detect data was asssumed to be equal to the stated reporting limits.

4 - Pore water data and Runoff max and min concentrations are from WES Report EL-87-9.

5 - Filtered organics assume removal of 85% of contaminant mass via sand filtration followed by removal of 90% of the remaining mass by activated carbon. Filtered inorganic concentrations assume 85% removal of contaminant mass via sand filtration only.

6 - FAV = Final Acute Value, Indiana water quality standard applicable to the discharge (not counting mixing zone), 327 IAC 2-1-6.

7 - CAC = Chronic Aquatic Criteria, Indiana water quality standard applicable outside the mixing zone, 327 IAC 2-1-6. For PCBs and PAHs no FAV was listed.

ATTACHMENT D-2

STORM VOLUMES AND FLOWRATES

CELRC-ED-HH

JUL 22 1999

MEMORANDUM FOR CELRC-ED-HE

SUBJECT: Indiana Harbor & Canal CDF, Storm Volumes

1. References:

a. Huff, Floyd A., and Angel, James R., Rainfall Frequency Atlas of the Midwest, Illinois State Water Survey Bulletin 71, Champaign Illinois, 1992

b. EPA; Guide to Technical Resources for the Design of Land Disposal Facilities; EPA/625/6-88/018

2. The following memorandum provides support to ED-HE in design of the treatment plant capacity. ED-HH performed two tasks for ED-HE. (1) Review the previous calculations for the average annual volumes. This was limited to reviewing the precipitation and evaporation calculations. (2) Provide a table of volumes of water due to storm events for different frequency and duration of events.

3. Task 1. Review of previous ED-HE spreadsheets calculating the average annual volumes of flow requiring treatment. The calculations accounted for the pore water, precipitation, and ground water. ED-HH only reviewed the precipitation and evaporation numbers given in the spreadsheet. The precipitation and evaporation numbers in the spreadsheet are from the National Oceanic and Atmospheric Administration (NOAA) Climatological Data publication for Indiana. To estimate run-off the Soil Conservation Service (SCS) curve number method was used. The amount of evaporation was estimated by using the lowest evaporation month multiplied by the number of months with evaporation. This is a conservative approach to estimating evaporation. The total runoff was calculated by subtracting the evaporation from the precipitation. The methodology of the spreadsheet assumes that the average annual rainfall is a one-year long event falling continuously. Given the assumptions and level of study the numbers provide an approximation of the average annual runoff volumes to the treatment plant.

4. Task 2. The rest of the memorandum addresses task 2, which provides a table of storm volumes for different frequency and duration of events.

5. Table 1 provides the precipitation amounts for different frequencies and durations from reference (a). Reference (a) only provides durations up to 10 days. Since the expected duration of ponded storm water will exceed 10 days, the 30-day duration precipitation amounts were calculated by extrapolation from the given values. The following calculations utilize the rainfall in Table 1 with no losses and to simplify calculations the volume is entered at the beginning of the duration period.

Table 1: Rainfall in inches for a given recurrence interval and duration.

Duration	Recurrence Interval				
	1-year	2-year	10-year	25-year	100-year
24-hour	2.42	2.89	4.22	5.22	7.12
10-day	4.23	4.84	6.67	8.03	10.58
30-day*	5.40	6.40	8.50	10.05	13.00

* Extrapolated values.

9. Point of contact is Mark Werner.

Thomas J Fogarty

Thomas J. Fogarty, P.E.
Chief, Hydraulic and Environmental
Engineering Branch

Table 2: Rainfall-Runoff Storage Requirements

Scenario	Cumulative Required Storage Volume (acre-feet) (1)														
	1 year			2 year			10 year			25 year			100 year		
	1 day	10 day	30 day	1 day	10 day	30 day	1 day	10 day	30 day	1 day	10 day	30 day	1 day	10 day	30 day
No pumping	25.4	44.4	56.7	30.3	50.8	67.2	44.3	70.0	89.3	54.8	84.3	105.5	74.8	111.1	136.5
100 gpm	25	40	43	30	46	54	44	66	76	54	80	92	74	107	123
200 gpm	25	36	30	29	42	41	43	61	63	54	75	79	74	102	110
500 gpm	23	22	0 (2)	28	29	1	42	48	23	53	62	39	73	89	70
1,000 gpm	21	0	0 (2)	26	7	0 (2)	40	26	0 (2)	50	40	0 (2)	70	67	4

(1) Table does not account for evaporation.

(2) Pump out occurs by end of duration.

Table 3: Duration of Ponding (days)

Scenario	Duration of Ponded Water (days) (1), (2)														
	1 year			2 year			10 year			25 year			100 year		
	1 day	10 day	30 day	1 day	10 day	30 day	1 day	10 day	30 day	1 day	10 day	30 day	1 day	10 day	30 day
100 gpm	45.0	73.0	89.0	53.0	81.0	103.0	73.0	106.0	130.0	87.0	124.0	149.0	112.0	155.0	183.0
200 gpm	26.0	43.0	53.0	31.0	48.0	62.0	43.0	64.0	80.0	52.0	76.0	92.0	68.0	96.0	115.0
500 gpm	12.0	20.0	25.0	14.0	23.0	29.0	20.0	30.0	38.0	24.0	36.0	44.0	32.0	46.0	55.0
1,000 gpm	7.0	11.0	14.0	8.0	12.0	16.0	11.0	17.0	21.0	13.0	19.0	24.0	18.0	25.0	30.0

(1) Accounts for evaporation.

(2) Volume of precipitation is entered at the beginning of the duration period to simplify calculations.

CELRC-ED-HH

MEMORANDUM FOR CELRC-ED-HE

JUL 27 1999

SUBJECT: Indiana Harbor & Canal CDF, Storm Volumes

1. Reference:

a. CELRC-ED-HH, MEMORANDUM FOR CELRC-ED-HE, SUBJECT: Indiana Harbor & Canal CDF, Storm Volumes, Dated July 22, 1999

2. The following memorandum provides an additional table to the memorandum listed in reference (a). ED-HE requested the additional table. The three tables provided in reference (a) listed the rainfall, storage requirements, and duration of ponding for the Indiana CDF. The additional table (Table 4) is attached. Table 4 calculates the maximum amount of surface area inundated for the precipitation amounts listed in Table 1 of reference (a).

3. Point of contact is Mark Werner.

Thomas J. Fogarty, P.E.
Chief, Hydraulic and Environmental
Engineering Branch

Table 4: Maximum Surface Area Inundation (1), (2), (3), (4)

Scenario	Maximum Amount of Surface Area Inundated (%)														
	1 year			2 year			10 year			25 year			100 year		
	1 day	10 day	30 day	1 day	10 day	30 day	1 day	10 day	30 day	1 day	10 day	30 day	1 day	10 day	30 day
No pumping	22	29	32	25	31	35	30	37	40	33	40	44	38	46	50
100 gpm	22	28	28	25	30	31	30	36	37	33	39	41	38	45	48
200 gpm	22	26	23	25	29	27	30	34	34	33	38	38	38	45	45
500 gpm	22	21	6	25	24	7	30	31	20	33	35	27	38	42	36
1,000 gpm	22	9	6	25	14	7	30	24	8	33	29	8	38	37	10

Assumptions:

(1) Based on the subcells graded to a 1 % slope.

(2) Duration of 1-day rainfall occurs over one day.

Duration of 10-day rainfall is equally distributed over ten days.

Duration of 30-day rainfall is equally distributed over thirty days.

(3) All CDF subcells are pumped out simultaneously.

(4) During events the majority of the treatment capacity will be utilized for the removal of water due to precipitation.