Sheldon A. Neeley, Mayor

CITY OF FLINT PROPOSAL NO.21000566

BATTERY B GRIT REMOVAL IMPROVEMENTS – ENGINEERING SERVICES

Date Posted: 10/3/2020

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BATTERY B GRIT REMOVAL IMPROVEMENTS – ENGINEERING SERVICES

On Tuesday, March 10, 2020, Governor Gretchen Whitmer declared a State of Emergency after two individuals were confirmed testing presumptively positive for COVID-19. On Thursday, March 12, 2020, Mayor Sheldon A. Neeley declared a local State of Emergency to exist in the City of Flint as a result of the threat of COVID-19. On Sunday, March 15, 2020, effective March 17, 2020, Mayor Neeley, based on the COVID-19 public health threat, closed City Hall to the public. Residents were asked to take precautionary measures. On March 22, 2020, Mayor Neeley asked residents to participate in a voluntary shelter in place. City Council approved the continuation of the declaration of a State of Emergency.

Based on the White House guidelines issued on March 16, 2020, and these guidelines are still in place. It is recommended that people not gather in groups larger than 10 people in order to "flatten" the curve and slow the spread of the virus. On March 24, 2020, Governor Whitmer instituted Executive Order 2020-21,a temporary requirement to suspend activities that are not necessary to sustain or protect life, prohibiting "in-person" work with exceptions for essential and critical infrastructure workers.

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Finance Department
Division of Purchases & Supplies

Sheldon A. Neeley
Mayor

Joyce A. McClane
Purchasing Manager

REQUEST FOR PROPOSALS AND QUALIFICATIONS

OWNER:
THE CITY OF FLINT
DEPARTMENT OF PURCHASES AND SUPPLIES
1101 S. SAGINAW STREET, ROOM 203
FLINT, MI, 48502

Project Name: BATTERY B GRIT REMOVAL IMPROVEMENTS – ENGINEERING SERVICES

Proposal No.: 210000566

The City of Flint is soliciting Statements of Qualifications (SOQ) from qualified consulting firms to provide consulting services in support of the City's Battery B Grit Removal Improvements**.**

This is a Qualification Based Selection (QBS) process. Cost or billing rates will not be included in the evaluation criteria, so the consultant should exclude any references to these in the SOQ.

If your firm is interested in providing the requested services, please submit one (1) original proposal AND one (1) unbound with all requested information, EXCEPT, the total price of your proposal. Outside of the envelope, the enclosed proposal should clearly identify that the information submitted is the **PROPOSAL ONLY** – With the title of the Proposal and Proposal Number.

In a separate envelope, the **TOTAL PRICE** of the proposal that is submitted must be in a **SEALED ENVELOPE**. The outside of the enclosed **TOTAL PRICE** should clearly identify that the information submitted is the **TOTAL PRICE ONLY** – **With the title of the Proposal and Proposal Number.**

For this project, faxed bids to the Purchasing Department will not be accepted. Bidding Documents shall meet requirements set forth in the Specification. Section 00 10 20, Instructions to Bidders.

A City selection committee will review the SOQ'S received and select the consultants it feels are the most qualified to furnish professional services to the City of Flint; however, the city reserves the right to conduct interviews with a short-list of firms as necessary.

The city reserved the right to reject any and or all SOQ's and waive any informalities therein.
The SOQ is prepared at the consultant's expense and becomes city property, and therefore a public record. Proposal Guarantee shall provide assurance that the bidder will, upon acceptance of the bid, execute the necessary Contract with the City. No bid may be withdrawn for one hundred twenty (120) days after scheduled closing time for receiving bids.

Proposals submitted by Bidders who have been debarred, suspended, or made ineligible by any Federal Agency will be rejected. The project is funded through the State Clean Water Revolving Loan program and requirements of the program are included in the Contract Documents.

Each bidder agrees to waive any claim it has or may have against the Owner, the Architect/Engineer, and their respective employees, arising out of or in connection with the administration, evaluation, or recommendation of any bid.

The City of Flint reserves the right to reject all bids and to waive irregularities in bidding.

All additional bid documents, requirements, addendums, specifications and plans/drawings (if utilized) are available on the Purchasing page of the City of Flint's web site at https://www.cityofflint.com/finance/purchasing/ under "open bids" and the specific bid or proposal number assigned to this notice.

Anticipated Bid Submission Schedule:

Date Released/Bid Posted to City's Website:	**Monday, October 5, 2020**
Bid Advertisement:	**Monday, October 5, 2020**
Final Date for Questions:	**Wednesday, October 14, 2020 at 2:00 PM EST**
Final Addendum:	**Monday, October 19, 2020 by 5:00 PM EST**
Bid Due Date:	**Monday, November 2, 2020 by 2:00 PM EST** **ELECTRONIC BIDS ARE NOT ACCEPTED** **DROP OFF BIDS** **(A MASK MUST BE WORN)**

The dates provided above are estimated dates only and may be subject to change.

Send to: The City of Flint
Department of Purchases and Supplies
1101 S. Saginaw Street, Room 203 Flint, MI 48502

Effective immediately upon release of these Bidding Documents, and until notice of contract award, all official communications from proposers regarding the requirements of this Bid shall be directed to:

Joyce A. McClane
810-766-7340
jmcclane@cityofflint.com

The City, or designee, shall distribute all official changes, modifications, responses to questions or notices relating to the requirements of this Bid. Addendum to this Bid may be developed and shared with all Vendors. Any other information of any kind from any other source shall not be considered official, and proposers relying on other information do so at their own risk.

Sincerely,

Joyce A. McClane, Purchasing Manager

REQUEST FOR PROPOSALS AND QUALIFICATIONS
FOR ENGINEERING SERVICES

BATTERY B GRIT REMOVAL IMPROVEMENTS

Flint Water Pollution Control
G-4652 Beecher Road
Flint, Michigan

INSTRUCTIONS TO BIDDER- SPECIFICATION SECTION 00 10 20

Project Objective

The purpose of the project is to upgrade the grit removal system and install fine screening on Battery B of the process flow at the WPCF. Primary considerations for design are effectiveness, reliability, and efficiency of the grit removal system. It is anticipated that the entire grit removal process will be replaced with a newer technology process.

Existing conditions

Preliminary physical treatment at the Flint WPCF consists of ¾ inch bar screens at all three influent pump stations (Northwest, East, and 3rd Avenue) and aerated grit removal in Battery A and B. Screenings are collected then proceed to washers to recycle the organics back to the raw wastewater stream. They are then compacted for disposal. The aerated grit removal system uses diffused air to create a helical flow pattern of water, reducing the axial velocity of the grit particles to influence settling. The grit is then collected in a submerged concrete channel and transferred to a grit collection sump using a spiral conveyor. Battery B currently removes the collected grit with chain and bucket elevators and belt conveyors.

The existing grit removal equipment in the Grit B building has surpassed its useful life. The chain and bucket elevator system is maintenance intensive to operate and the aerated grit process is not as efficient as newer technology. Additional fine screening prior to grit removal will reduce the screenings building up in downstream equipment, tanks, and digesters. This would improve plant operations and reduce maintenance requirements.

Proposed Improvements

The complete upgrade of the grit removal system with the addition of fine screening in Battery B would require demolition of old equipment and reconfiguration of the grit tanks and building. As stated above, effectiveness, efficiency, and reliability are the desired outcome. The new system would provide protection of downstream equipment and processes from grit and debris carryover not currently captured by screening and the grit removal system, while reducing maintenance repair expenses and labor.

The preferred grit removal system is the Hydro-International Headcell with the Slurry Cup grit washer and the Grit Snail dewatering escalator. Grit tank modifications will be required. Other systems may be considered. The addition of fine screening for Battery B prior to grit removal must include a screenings washer and compactor. All of these upgrades will require reconfiguration of the Battery B grit building and load-out garage. Other upgrades include replacement of the Influent water pipe and Magmeter, evaluation and recommendations for repair or replacement of all process piping, gates, and valves. Concrete evaluation and repairs should also be included.

Consideration of the hydraulic profile for the upgraded grit removal and fine screening is paramount. The current plant is rated at 50 MGD average dry weather flow and must be able to sustain a wet weather flow of 75 MGD with Battery A and Battery B in service. Battery B grit removal must maintain a maximum flow capacity of 40+ MGD, and ideally 50 MGD. Head loss calculations for both the fine screen and the grit system are required.

A final design consideration is ease of operation and control and equipment access for maintenance and repair. The grit building currently has an overhead crane for equipment removal but an additional crane or modification of the existing rail may be desirable.

Scope of Services - The Engineering Consultant shall perform the following services:

A. Design

The Consultant shall prepare Design and Construction documents consisting of Civil, Structural, Architectural, Mechanical, Electrical, and Instrumentation drawing sheets and specifications. The Construction Documents shall be developed for the purpose of bidding the construction of the facilities and acquiring a MDEQ Part 41 Construction Permit for the above improvements. Upon MDEQ approval, and receipt of the Permit, the documents shall be used to competitively bid the project for construction. The Consultant shall ensure that the Construction Documents result in a complete and operational system as described above. The design shall incorporate the following project elements:

1. Specifications for concrete repairs where required including walkways.
2. Provide specifications and design for the new grit system including the components for grit removal, washing and dewatering.
3. Provide specifications and design for dewatered grit conveyance to a collection dumpster for landfill disposal.
4. Design and specifications for the new fine bar screen, screening washer, compactor and delivery to the grit dumpster.
5. Specifications and design, including necessary demolition, for the grit building modifications. The load-out area should be included in this design.
6. Specifications for the replacement of the Influent sewer pipe and Magmeter, evaluation and specifications for repair or replacement of all process piping, gates, and valves.
7. Provide the hydraulic profile and head loss calculations for both the fine screen and the grit removal system.
8. Evaluate the need for an additional overhead crane or modification of the existing rail system, and provide specifications if additions are needed.

B. Bidding Support Services

The Consultant shall prepare appropriate bid documents, conduct a prebid meeting with potential contractors, respond to questions during the bidding process, and prepare addenda as required during the course of bidding. The Consultant shall distribute minutes and responses to questions raised at the meeting. The Consultant shall assist in the review of the bids and make a recommendation for award of the Contract. The work is to be coordinated with the Battery A-Grit Improvements Project.

C. Construction Services - The Consultant shall perform the following services during construction:

1. Respond to Construction Contractor Requests for Information (RFIs).

2. Attend regularly scheduled construction meetings during the course of construction. Take meeting minutes and provide copies to all attendees.

3. Insure that charges and costs are consistent with the Consultant's submitted bid and project schedule.

4. Resolve field engineering issues and provide supervision during construction. The Consultant shall include in the Proposal an anticipated level of resident engineering and onsite inspections.

5. Insure that the Construction Contractor is in compliance with all EPA and EGLE requirements for a CWSRF project. Ex. Review of Davis-Bacon payroll requirements

6. Update and correct the design drawings to produce project record drawings depicting the as-built conditions.

D. Start-up Services

The Consultant shall assist the Contractor and Owner's staff during the start-up period and shall provide oversight and engineering during the start-up period. The Consultant shall include in the Proposal an anticipated level of office engineering, inspections, and onsite start-up services.

E. Deliverables - The Consultant shall provide the following:

1. Pre-design draft report, five copies for review.
2. Final pre-design report, five copies.
3. 50% design submittals, five copies.
4. Specification documents and drawings. Drawings shall be in AutoCAD format.
5. 90% design submittals, five hard copies and specifications.
6. 100% design submittals, five hard copies and specifications.
7. Bid drawing sets, five hard copies, 24" X 36" drawings, five copies of 11" X 17" drawings, and specifications.
8. Record Drawing Set - one hard copy, 24" X 36" drawings and one electronic AutoCAD copy.

F. Contents of the Proposal The proposal shall be issued in the following format:

1. **Project Team-** Provide an organizational chart with a listing of the Consultant's project team members. Resumes of key project team members shall be attached to the proposal. Sub-consultant resumes shall be included. Consultants shall agree not to substitute key members without written authorization of the City.
2. **Approach and Design Concept-** Describe the Consultant's proposed approach to the pre-design and design of the facilities.
3. **Scope of Services-** Provide a detailed list of all task items to be performed in the conformance with the Scope of Services work herein.
4. **Project Schedule**- Provide a detailed project schedule listing pre-design, design, bidding, and anticipated construction period.

5. **References**- Provide references for any previous projects of this nature or for demonstration of the efficacy of the design concept.

6. **Insurance**- State the insurance types and limits to be maintained by the Consultant during the course of the project.

G. General Bid and Proposal Requirements

The formal detailed proposal is being solicited to provide engineering design and construction management services. Proposal statements must include the following:

1. The name, address, telephone number, and fax number of the consulting engineering firm.

2. The name, telephone number, and e-mail address of the primary contact person for the proposal.

3. Composition of the team proposed to provide the consulting engineering firm's design and construction services, including any subcontractors. The team description should include:

    a. Specific discipline covered by each team member; that is, mechanical, process, structural, electrical, instrumentation and controls, etc.

    b. Resumes demonstrating related work experience.

    c. Indication of the current workload of specific team members, and hours available for this project. Please note that subsequent substitution of proposed team members without City concurrence may result in rejection of the firm for this project.

4. A description of the qualifications of the project manager proposed to lead this project.

5. Ability of the consulting engineering firm and any sub consultants to dedicate proposed project team members to provide the necessary services. Subsequent substitution of proposed team members without City concurrence may result in rejection of the firm for this project.

6. A summary statement indicating the vendor's understanding of the project, its goals and purposes, and the constraints or limitations that must be observed while achieving them.

7. A listing of equipment the consultant envisions needing to obtain the project goals.

8. The design concept and approach to be used to achieve a successful and cost effective project.

9. A detailed Project Scope of Services. References to related experiences on previous projects may be included.

10. A schedule providing milestone dates after a “Notice To Proceed”, and expected completion for each phase of the services to be provided.

Detailed responses to the RFP shall be submitted to the City Purchasing Department on or before the deadline date and time specified.

Failure to supply all requested information and documentation listed under proposal statements shall result in bid disqualification.

List any value-added considerations or alternate proposal on a separate sheet of paper.

The proposals will be rated to determine the best value for the City. Ratings will be based on the following factors:

- Qualifications of the firm and the team members to be dedicated to this project, including project-related experience
- Qualifications of the project manager to be dedicated to this project.
- Ability of the firm and dedicated personnel to provide the services.
- Understanding of the project, its goals, purposes, and related constraints.
- Quality of the design, design concept, and the potential for achieving project goals.
- Quality of the proposal, including level of detail and presentation.

These items are not of equal importance. Responding firms will be scored on each category, and a composite rating calculated based on the rating form below. The City reserves the right to reject any and all proposal submittals.

Proposal Statement Evaluation Form			
Item	Score	Weight (%)	Rating
1. Qualifications of firm, project manager, and personnel to be dedicated for provision of services		25	
2. Ability of the firm and dedicated personnel to provide the services (workload)		10	
3. Understanding of the project and its goals		30	
4. Design concept		30	
5. Quality of the proposal, including level of detail and presentation		5	
Total		*100*	

A Characterization of Municipal Grit for the City of Flint, Michigan

Study Conducted by Grit Solutions
2402 E. 2659th Rd.
Marseilles, IL 61341

Study Prepared for
Fishbeck, Thompson, Carr & Huber, Inc.

June 13, 2009

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Definitions/Abbreviations

gpm - gallons per minute.

Grit – A settleable inorganic kernel with attached organics larger than 50 microns and characterized by physical size and settling velocity.

Grit Concentration – the amount of grit present in the wastestream based on the fixed solids measurements

Grit Fixed Solids (FS) – also expressed as "**fixed solids**" - the inorganic portion of sample remaining after organics are removed by ashing in a muffle furnace at 550°C.

lbs./MG – Pounds per Million Gallons

MG - Million Gallons

MGD – Million Gallons per Day

NR1 – the Reynolds number for the trial SES

NR2 – the Revised Reynolds number

SAA – Surface Active Agents – material affixed to the grit particle, such as organics, fats, oils, and greases that may affect the settling velocity of municipal grit.

Sample – All material accumulated in the bottom of the grit settler which includes settleable organics.

Sand Equivalent Size (SES) - The sand particle size, measured in microns, having the same settling velocity as the selected grit particle.

Sed h, cm – The height of water in the Imhoff cone through which the sediment passed to reach the surface of accumulated material during SES determination

Sed Time, sec – The time required for sediment to reach the recorded volume during SES determination

Sed vel, cm/s – the settling velocity (v) of the sediment reaching a particular settled volume

Sed. Vol., cc – Sedimentation Volume (cc or ml) – The amount of material that settles in the Imhoff Cone during SES determinations

SES, d1, u – Trial Sand Equivalent Size, in microns

Definitions/Abbreviations Continued

SES, d2, u – Revised Reynolds Number based on NR2 and d1

VIS – Vertically Integrated Sampler

Vol Frac, % - the cumulative sedimentation percentage occurring during SES determination

WPCP – Water Pollution Control Plant

Introduction

The City of Flint, Michigan is evaluating the characteristics and volumes of grit entering the Water Pollution Control Plant (WPCP). This information will be used to design and select new headworks equipment.

In removal system design, grit has commonly been treated as clean sand with a specific gravity of 2.65. Metcalf and Eddy's Wastewater Engineering: Treatment and Reuse says "Grit consists of sand, gravel, cinders, or other heavy materials that have specific gravities or settling velocities considerably greater than those of organic particles". These inorganics are often associated with Surface Active Agents (SAA) that include fats, oils, greases, and other organic materials can lower the specific gravity to 1.3 (Tchobanoglous, 2003). The shape and composition of grit may also affect settling velocities.

When determining quantities of grit during this study, grit will be defined as settleable inorganic material larger than 50 microns. However, settling velocities, attached organics and SAA will be considered during the on-site laboratory analyses. The settling velocity is expressed as the Sand Equivalent Size (SES), which is the sand particle size having the same settling velocity as the more buoyant grit particle. Materials less than 50 microns are considered silt or clay and will be excluded from the data.

Downstream deposition of grit can be prevented by removing grit 100 microns and larger. Knowing the volumes and characteristics of grit entering the wastewater treatment facilities will help determine the level of protection required and aid in selecting the appropriate removal method and equipment.

Study Objectives

The purpose of this study is to determine the amounts and characteristics of grit entering the Flint, Michigan Wastewater Treatment Plant.

Methods/Materials

Obtaining Representative Grit Fixed Solids (FS) Sample

The volume and characteristics of grit received at wastewater treatment facilities can vary widely depending on the characteristics of the collection system, weather conditions, septic waste haulers, and industrial activities. The analytical procedures used in compiling these data take into account and compensate for the non-homogeneity of the grit.

Samples were collected from the Battery "B" influent wastestream after screening. During the influent grit characterization, the wastestream was sampled by placing a Vertically Integrated Sampler (VIS) in the influent channel before the introduction of facility recycle flows (See Figures 1 and 2). A VIS is constructed from a section of six-inch diameter PVC pipe with a sealed bottom and a slot cut along the length of the pipe. The VIS is secured in the middle of the wastestream and the suction end of a trash pump is placed inside the pipe two-inches from the bottom. The VIS is designed to collect sample from the entire height of the water column. The slot width is determined by the velocity present in the channel during maximum flows. Since the pump rate and the channel depth are known, it is possible to calculate the width of slot required to match the velocity across the slot with the velocity in the wastestream. If a slot is too wide, the slow velocity may create a non-isokinetic condition that may cause a grit particle to go around the VIS and avoid being sampled. A slot that is too thin can always be widened or, if the pump is starving, reduce the speed of the pump. During the start of the sampling event, the trash pump will often remove wastewater at a rate higher than can flow through the slot; therefore the pump speed is lowered until the plant flow increases. The pump is plumbed into the side of a 50-micron settler (See Figure 3) and equipped with a 90° elbow to divert the incoming sample laterally and slow the velocity.

The 50-micron grit settlers are constructed from 50-gallon plastic storage tanks with an influent port and a discharge weir (See Figure 4). Flow enters the tank and is diverted to the side to reduce the velocity. Grit settles to the bottom, and wastewater exits over the weir. In order to settle 50-micron grit with a specific gravity of 2.65, the overflow rate must be less than three-gallons/ft^2 of surface area. Each settler has a diameter of 24-inches, or a surface area of 3.14 ft^2. At ten-gpm, the overflow rate is 3.18 gallons/ft^2. The settler feed velocity is adjusted to less than eight-gpm to insure settling of fine grit and checked by timing the overflow rate of the settler. This is repeated every 30 minutes to insure stability. The excess flow provided by the pump is bypassed back into the wastestream. Excess flow from the sample pump is bypassed.

At the end of the sampling period, the settler contents are allowed to settle for 20 minutes. The supernatant is discarded and grit that has accumulated in the bottom of the settler is rinsed into buckets. The liquid portions of the grit samples are gradually poured off until the remaining grit/sludge samples are thick enough to obtain a homogenous mixture without grit settling out of the slurry. The entire volume of each sample is recorded before being split for analysis. Since bacteria will reduce the organics that are attached to the grit particles, it's important to perform the analyses on fresh grit immediately after collection. If immediate analysis is not possible, samples may be stored at $4^{O}C$ for no longer than 12 hrs.

Determination of Grit Particle Distribution

The collected grit sample was immediately sieved through a series of screens listed below in Table 1.

Table 1. Sieve Size Equivalents

		Opening	
U.S. Sieve Size	Tyler Equivalent	microns	inches
1/4	3.25 mesh	6300	0.2500
1/8	6.5 mesh	3180	0.1250
#12	10 mesh	1680	0.0661
#20	20 mesh	841	0.0331
#50	48 mesh	297	0.0117
#70	65 mesh	210	0.0083
#100	100 mesh	149	0.0059
#140	150 mesh	105	0.0041
#200	200 mesh	74	0.0029
#270	270 mesh	53	0.0021

Determination of Sand Equivalent Size (SES) distribution

Settling tests were conducted immediately on solids passing the U.S. #20 sieve and sequentially retained on the #50, #70, #100, #150, #200, and #270 sieves. Large organics often interfere with the settling of grit on screens larger than #50. A portion of the retained material is placed into a modified Imhoff cone filled with water (See Figure 5). The column is inverted and as the grit settles in the cone corresponding time and volume measurements are recorded. The objective of these measurements is to determine the size of a sand sphere having the same settling velocity as the collected grit fraction.

The weight measurements of the grit particles retained on each of the ten sieves were determined according to methods 2540B and 2540G as outlined in Standard Methods for the Examination of Water and Wastewater, 1998 APHA, AWWA, WEF, 20th edition. Fixed solids fractions were arranged into fractional and cumulative distributions. From this data a cumulative curve factoring physical size and weight of fixed solids is generated.

Data from the settling tests are entered into a spreadsheet for each size fraction that converts the settling velocities and volumes into Sand Equivalent Size. The SES value generated is plotted against the corresponding volume fraction to generate a series of SES charts. Each chart is divided into 20-micron SES intervals and the percentages of grit falling within each interval are entered into a spreadsheet for analysis. From this data, a cumulative curve factoring SES and weight of fixed solids per size fraction is generated. By comparing the "SES" curve with the "Physical Size" curve, we can determine the amount of grit that can bypass a grit removal system designed around a known sand particle size. The SES charts are also used to compare the average SES within a sieve fraction with the average physical size of clean, round silica sand for that same sieve fraction.

To calculate the concentration of grit present in the sewer during normal flow conditions, the volume of wastewater sampled each day is compared to the measured volume of wastewater passing through the sewer during the sampling periods. The total amount of grit collected during each sampling period is applied to the total volume of wastewater to determine the lbs/MG of grit present in the sewer.

Discussion of Results

The sampling setup can be seen in Figure 6. A high flow event was simulated on May 20th by allowing a wet well to fill and releasing the collected wastewater. Hourly flows for the simulated event peaked at 29.0 MGD, while the average flow remained similar to those occurring on May 18 and 19. Sampling conditions are presented below in Table 2 "Flint, MI WPCP Sampling Period".

Table 2. Flint, MI WPCP Sampling Period

Date	Average Flow During Sampling (MGD)	Start Time	Finish Time	Hours
May 18, 2009	25.600	9:00	15:15	6.25
May 19, 2009	25.500	7:30	13:30	6.00
May 20, 2009	26.200	7:35	13:35	6.00

Table 3 below summarizes the amount of Grit Fixed Solids (FS) obtained from the influent sampling location.

Table 3. Amounts of Grit Fixed Solids Entering the Flint WPCP

Date	Settler Feed Rate (gpm)	Total Grit FS Entering Channel During Sampling (lbs.)	Grit FS Concentration (lbs./MG)
May 18, 2009	8.08	51.3	7.7
May 19, 2009	7.44	11.3	1.8
May 20, 2009	7.59	157.8	24.1

According to Figure 7, between 14.6% and 37.7% of grit was larger than 297-microns physical size. Grit smaller than 297-microns accounted for 62.3% to 85.4% of the total amount of grit collected. Figure 8 charts the fractional amounts of grit FS collected from the influent channel. At peak daily flows, the concentration of grit present in the sewer was between 1.8 and 7.7 lbs/MG. On May 20, a simulated high flow event produced 24.1 lbs/MG. The concentrations of grit entering the facility on May 18 and 19 were extremely low, while the simulated high flow event produced slightly higher concentrations. Facility staff report that the plant becomes inundated with grit during high flow events, particularly snow thaw. It is likely that a large amount of grit is accumulating in the collection system. The simulated high flow event only flushed the portion of sewer between the wet well and the facility and did not affect the rest of the collection system.

Sand Equivalent Size (SES) vs. Physical Size plots can be used to determine grit removal system design parameters. The following table lists theoretical removal efficiencies for a system designed to remove grit based on the SES data collected from the influent sampling site.

Table 4. Predicted Removal Efficiencies (%) of a System Designed to Remove Grit of a Specific SES at the Flint WPCP				
Sample Date	300-micron SES Design	150-micron SES Design	100-micron SES Design	75-micron SES Design
May 18, 2009	6.5	63.5	93.5	99.0
May 19, 2009	28.5	53.0	82.6	97.5
May 20, 2009	11.7	58.0	90.8	98.5

Efficiencies listed in Table 4 are found in Figure 9, 10, and 11. These figures also demonstrate the differences in Physical Size and Sand Equivalent Size. For example, from Figure 10, 150-micron **Physical Size** grit comprises 50.3% of the physical size distribution. From the corresponding Sand Equivalent Size (SES) line, 150-micron **Sand Equivalent Size** grit comprises 63.5% of the distribution. By subtracting the % SES from the % Physical size, the resulting 13.2% is the estimated amount of grit that may bypass a Grit Removal System if the physical size distribution is used for design. Figure 12 compares the difference in settling velocity between the influent grit collected during the study and clean sand with a specific gravity of 2.65.

Conclusions

1. Between 14.6% and 37.7% of grit was larger than 297-microns physical size. Grit smaller than 297-microns accounted for 62.3 to 85.4% of the total amount. (See Figure 7).

2. The concentration of grit FS entering the WPCP was between 1.8 and 7.7 lbs/MG on May 18 and 19. On May 20, a simulated high flow event produced 24.1 lbs/MG (Table 3, Figure 8).

3. A Grit Removal System design based on 150-micron Sand Equivalent Size would collect between 53.0 and 63.5% of influent grit while a 100-micron SES system would improve to between 82.6 and 93.5% efficiency. A 75-micron SES system would collect from 97.5 to 98.5% of influent grit (See Table 4; Figures 9 through 11).

4. When designing a new grit removal system, the large quantities of grit that enter the facility during high flow events needs to be accounted for.

Figure 1 – Vertically Integrated Sampler

Figure 2 – Vertically Integrated Sampler Installed

Figure 3 - 50-Micron Grit Settler

Figure 4 - Discharge Weir

Figure 5 – Modified Imhoff Cone for SES Measurements

Figure 6 – Sampling Setup

Figure 7. Fractional Distribution of Influent Grit Fixed Solids Entering the City of Flint WPCP

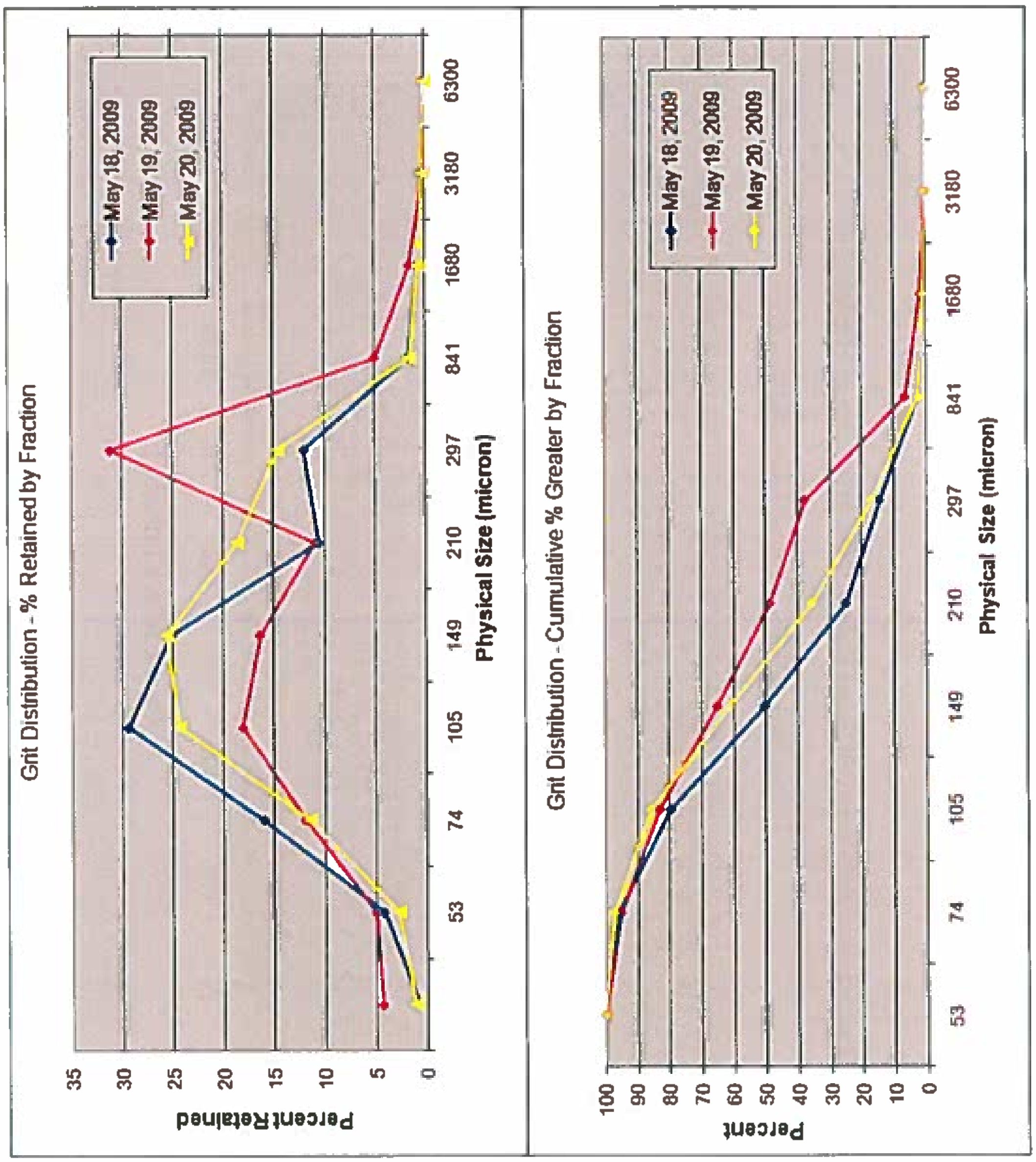


Figure 8. Concentration of Influent Grit Fixed Solids Entering the City of Flint WPCP

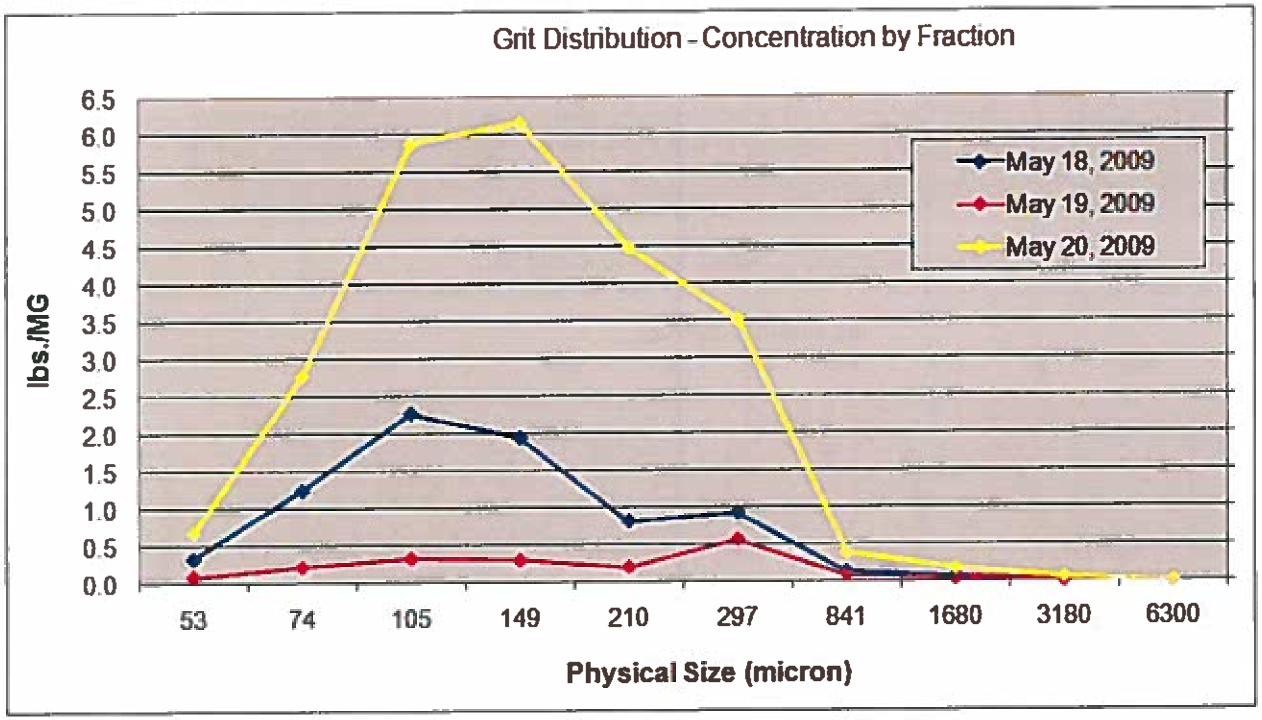


Figure 9. Comparison of the City of Flint WPCP Influent Grit Physical Size and Sand Equivalent Size on May 18, 2009

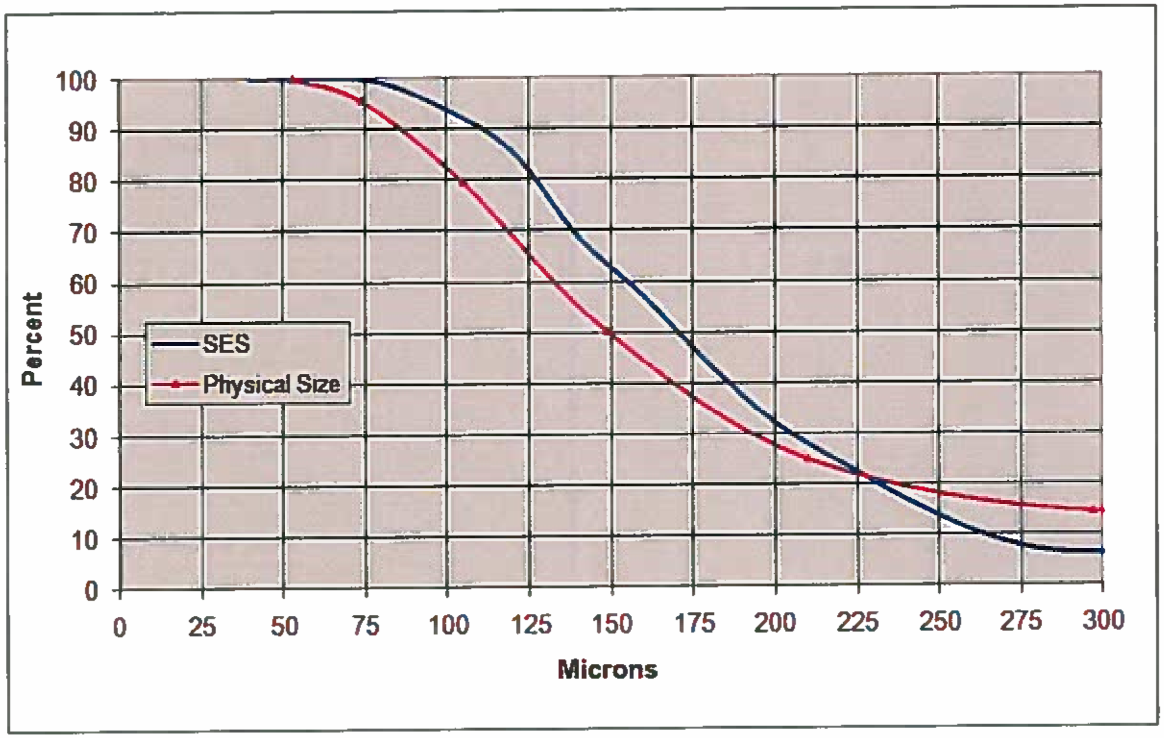


Figure 10. Comparison of the City of Flint WPCP Influent Grit Physical Size and Sand Equivalent Size on May 19, 2009

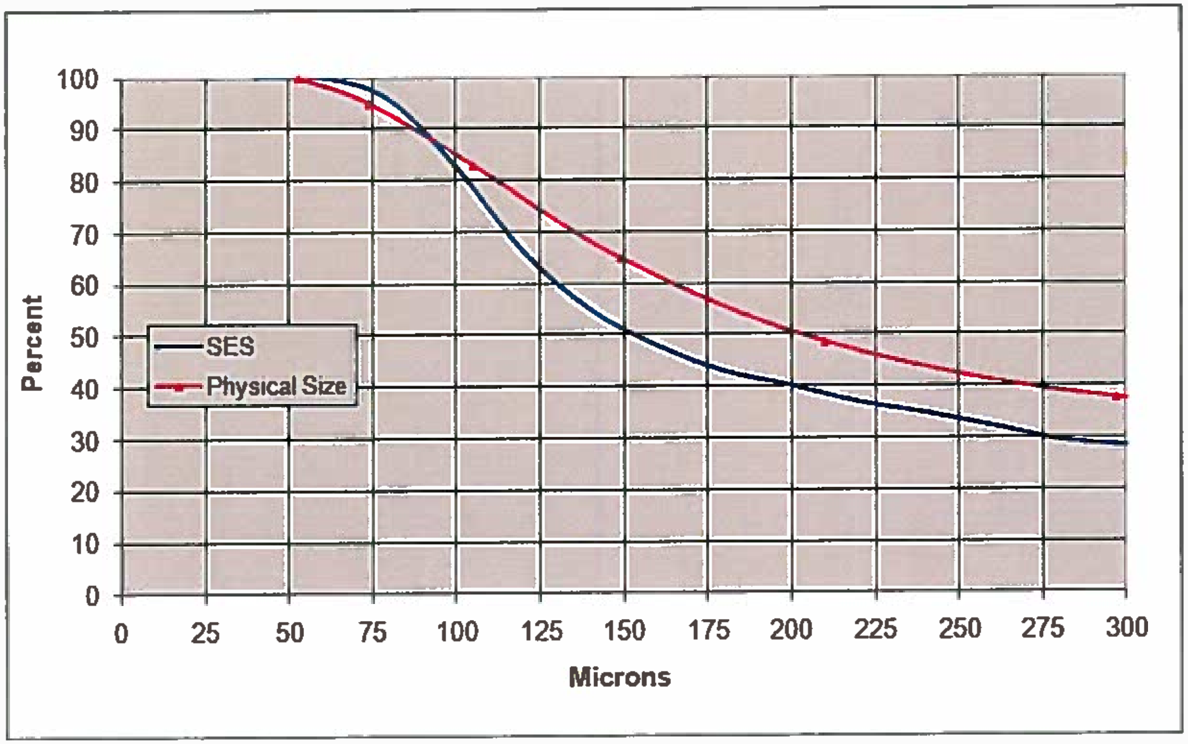


Figure 11. Comparison of the City of Flint WPCP Influent Grit Physical Size and Sand Equivalent Size on May 20, 2009

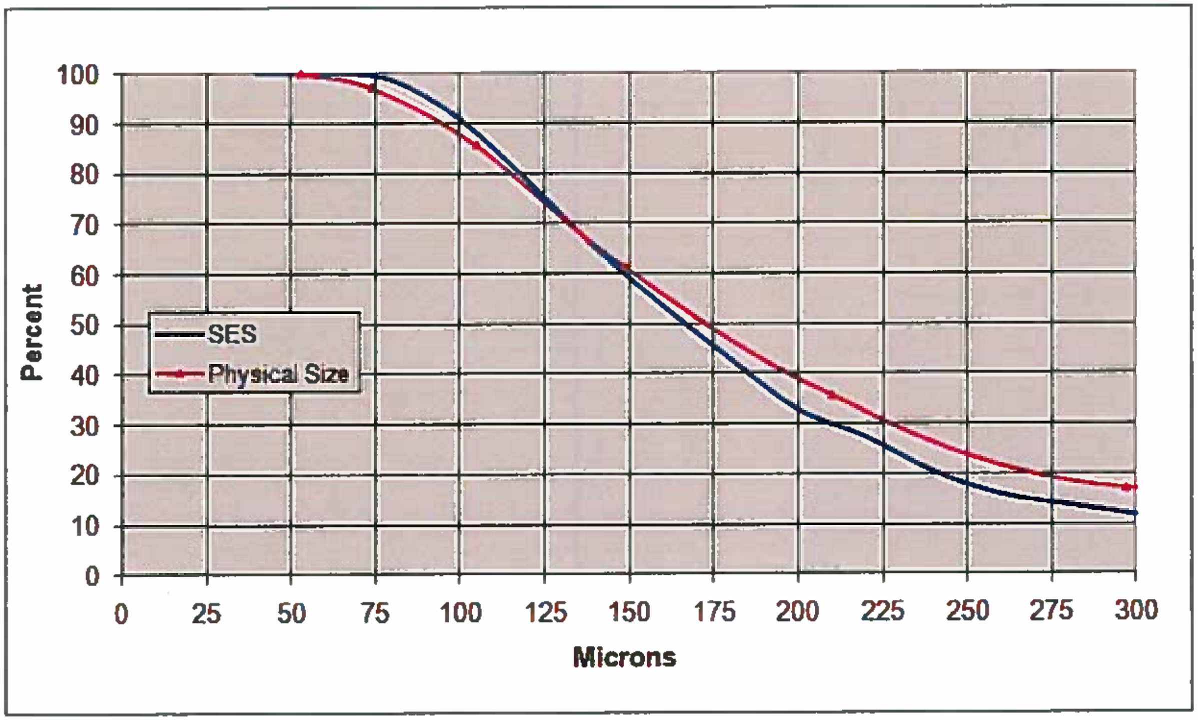
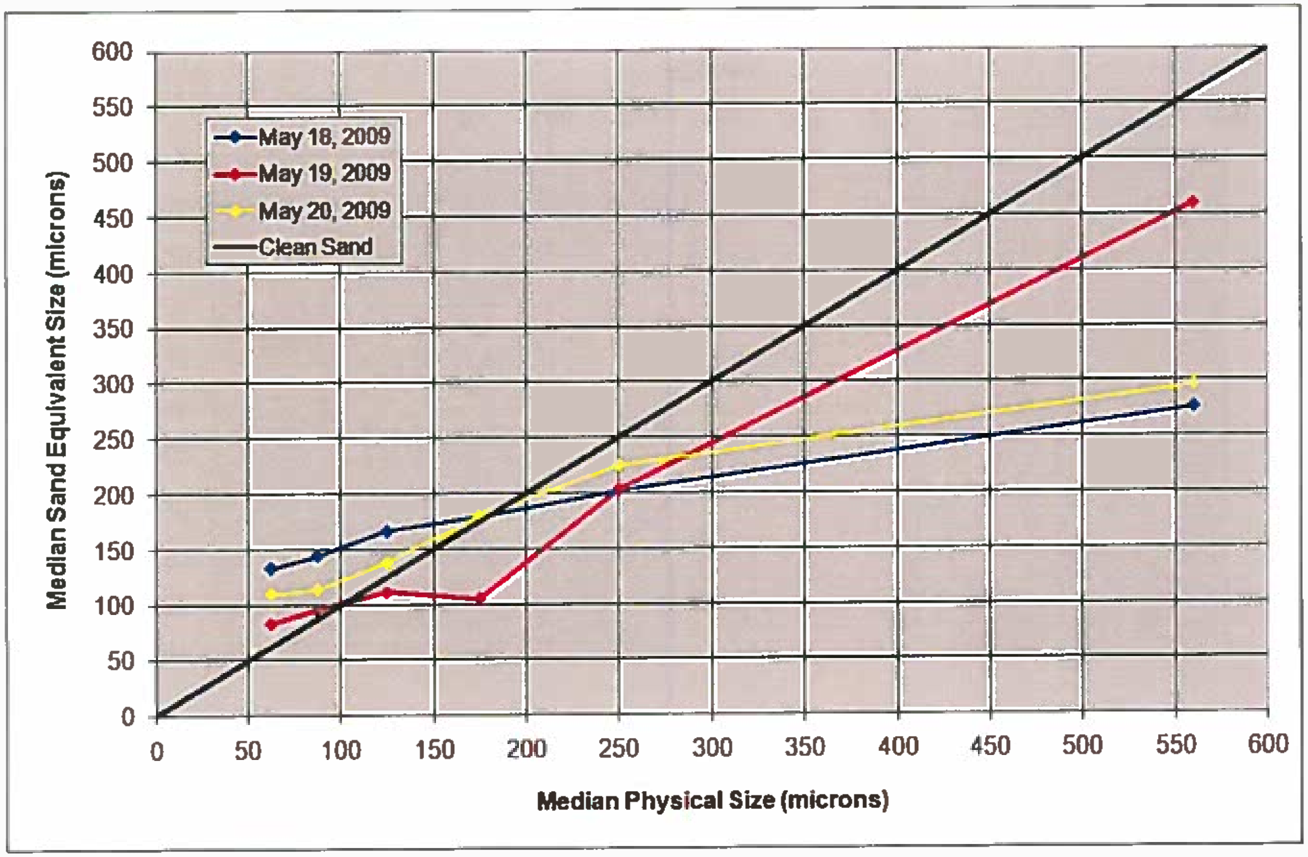


Figure 12. Median Size Distribution of Grit Entering the City of Flint WPCP vs. Clean Sand Distribution



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Appendix A – Raw Data

A-1 Volume Correction Spreadsheet

Volume Correction Spreadsheet - Flint, MI - May 18 -20, 2008

Sample Date	Start Time	End Time	Sampling Time (hrs.)	Settler Feed Rate (gpm)	Flow (MGD)	Amount of Flow During Sampling Period (MG)	Gallons Sampled	Total Grit Collected (grams)
May 18, 2009	9 00	15 15	6 25	8 08	25 600	6.67	3030	10 58
May 19, 2009	7 30	13 30	6 00	7.44	25 500	6 38	2678	2 14
May 20, 2009	7 35	13 35	6 00	7.59	26 200	6 55	2732	29 86

Sample Date	Total Sample Volume (ml)	Total Sample Volume (gal)	Volume of Sample Put in Wet Sieve (ml)	Weight of Sample Put in Wet Sieve (gm)	Total FS Weight (gm)	Total Grit FS Collected (pounds)	Total Grit Entering Channel During Sampling (pounds)	Pounds of Grit per MG
May 18, 2009	1	0 0003	1	1	10 58	0 0233	51 3	7 7
May 19, 2009	1	0 0003	1	1	2 14	0 0047	11 3	1 8
May 20, 2009	1	0 0003	1	1 000	29 86	0 0658	157 8	24 1

A-2 Solids Analysis Bench Sheets

Fixed Solids Weights - Flint, MI

Fixed Solids Sample Weight (grams)				
		Sample		
Micron	US Sieve	May 18, 2009	May 19, 2009	May 20, 2009
6300	1/4	0.00	0 00	0 00
3180	1/8	0 02	0 00	0 06
1680	#12	0.08	0 03	0 21
841	#20	0 17	0 10	0 47
297	#50	1.26	0 64	4 31
210	#70	1.11	0 22	5 49
149	#100	2.64	0 34	7.55
105	#140	3 09	0 37	7.20
74	#200	1.68	0.25	3 40
53	#270	0 45	0 10	0 84
	pan	0 08	0 09	0 33
Total FS Weight (gm)		10 58	2 14	29 86

Fixed Solids Sample Percent Retained				
		Sample		
Micron	US Sieve	May 18, 2009	May 19, 2009	May 20, 2009
6300	1/4	0 00	0 00	0 00
3180	1/8	0 22	0 04	0 20
1680	#12	0 75	1 54	0 70
841	#20	1 64	4 97	1 59
297	#50	11 97	31 13	14 60
210	#70	10 55	10 91	18 60
149	#100	25 16	16 40	25.56
105	#140	29 41	18 08	24 38
74	#200	16 03	11 96	11 53
53	#270	4 27	4 98	2 84
	pan	0 79	4 37	1 13
Total (minus pan)		100 00	100 00	100.00

Fixed Solids Sample Cumulative %>				
		Date		
Micron	US Sieve	May 18, 2009	May 19, 2009	May 20, 2009
53	#270	100	100	100
74	#200	95 73	95 02	97 16
105	#140	79 70	83 06	85 63
149	#100	50.29	64 98	61.25
210	#70	25 13	48 58	35 69
297	#50	14 57	37.68	17.09
841	#20	2 60	6 55	2 49
1680	#12	0 96	1.58	0 90
3180	1/8	0.22	0 04	0 20
6300	1/4	0 00	0 00	0 00

A-3 Fractional Grit Concentration Calculation Bench Sheet

Micron	US Sieve	May 18, 2009 %	lbs/MG	May 19, 2009 %	lbs/MG	May 20, 2009 %	lbs/MG
6300	0.25	0.00	0.00	0.00	0.00	0.00	0.00
3180	0.125	0.22	0.02	0.04	0.00	0.20	0.05
1680	#12	0.75	0.06	1.54	0.03	0.70	0.17
841	#20	1.64	0.13	4.97	0.09	1.59	0.38
297	#50	11.97	0.92	31.13	0.56	14.60	3.52
210	#70	10.55	0.81	10.91	0.20	18.60	4.48
149	#100	25.16	1.94	16.40	0.30	25.56	6.16
105	#140	29.41	2.26	18.08	0.33	24.38	5.88
74	#200	16.03	1.23	11.96	0.22	11.53	2.78
53	#270	4.27	0.33	4.98	0.09	2.84	0.68
	Total (lbs)	7.70	7.70	1.80	1.80	24.10	24.10

A-4 SES Data Analysis

							Flint, MI - Influent - May 18, 2009			
sed vol, cc	vol frac, %	sed time, sec	sed h, cm	sed vel, cm/s	d1, μ	NR1	NR2	SES, μ	SES, μ	vol frac, %≥
20M - 50M, 300μ - 820μ										
0.5	25	8	52.4	6.55E+00	379.4	24.9	24.9	379.4	379.4	25
1.0	50	12	51.4	4.29E+00	275.9	11.8	11.8	275.9	275.9	50
1.5	75	19	50.7	2.67E+00	201.4	5.4	5.4	201.4	201.4	75
2.0	100	67	50.2	7.49E-01	96.4	0.7	0.7	96.4	96.4	100
50M - 70M, 200μ - 300μ										
0.50	36	17	52.4	3.08E+00	220.9	6.8	6.8	220.9	220.9	36
1.0	71	26	51.4	1.98E+00	167.4	3.3	3.3	167.4	167.4	71
1.3	93	57	51.0	8.95E-01	106.3	1.0	1.0	106.3	106.3	93
1.4	100	86	50.9	5.91E-01	84.9	0.5	0.5	84.9	84.9	100
70M - 100M, 150μ - 200μ										
0.50	17	15	52.4	3.50E+00	239.9	8.4	8.4	239.9	239.9	17
1.0	33	19	51.4	2.71E+00	203.2	5.5	5.5	203.2	203.2	33
1.5	50	23	50.7	2.21E+00	178.9	3.9	3.9	178.9	178.9	50
2.0	67	29	50.2	1.73E+00	154.6	2.7	2.7	154.6	154.6	67
2.5	83	51	49.7	9.75E-01	111.4	1.1	1.1	111.4	111.4	83
3.0	100	111	49.3	4.44E-01	72.9	0.3	0.3	72.9	72.9	100
100M - 140M, 100μ - 150μ										
0.50	17	18	52.4	2.91E+00	212.9	6.2	6.2	212.9	212.9	17
1.0	33	23	51.4	2.24E+00	180.4	4.0	4.0	180.4	180.4	33
1.5	50	26	50.7	1.95E+00	166.1	3.2	3.2	166.1	166.1	50
2.0	67	38	50.2	1.32E+00	132.2	1.7	1.7	132.2	132.2	67
2.5	83	48	49.7	1.04E+00	115.3	1.2	1.2	115.3	115.3	83
3.0	100	78	49.3	6.32E-01	88.0	0.6	0.6	88.0	88.0	100
140M - 200M, 75μ - 100μ										
0.10	10	23	54.0	2.35E+00	185.9	4.4	4.4	185.9	185.9	10
0.5	50	34	52.4	1.54E+00	144.5	2.2	2.2	144.5	144.5	50
1.0	100	48	51.4	1.07E+00	117.5	1.3	1.3	117.5	117.5	100
200M - 270M, 50μ - 75μ										
0.01	1	33	55.4	1.68E+00	151.9	2.6	2.6	151.9	151.9	1
0.3	60	42	53.0	1.26E+00	128.8	1.6	1.6	128.8	128.8	60
0.5	100	47	52.4	1.12E+00	120.1	1.3	1.3	120.1	120.1	100

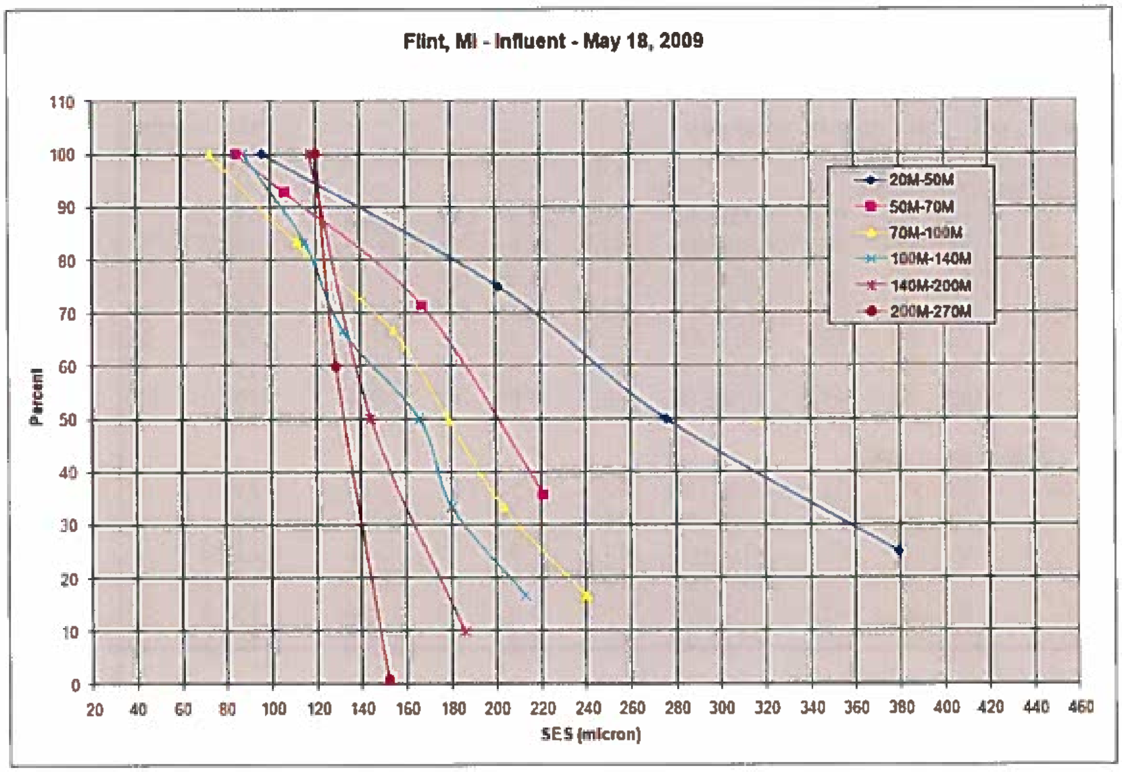
A-4 SES Data Analysis

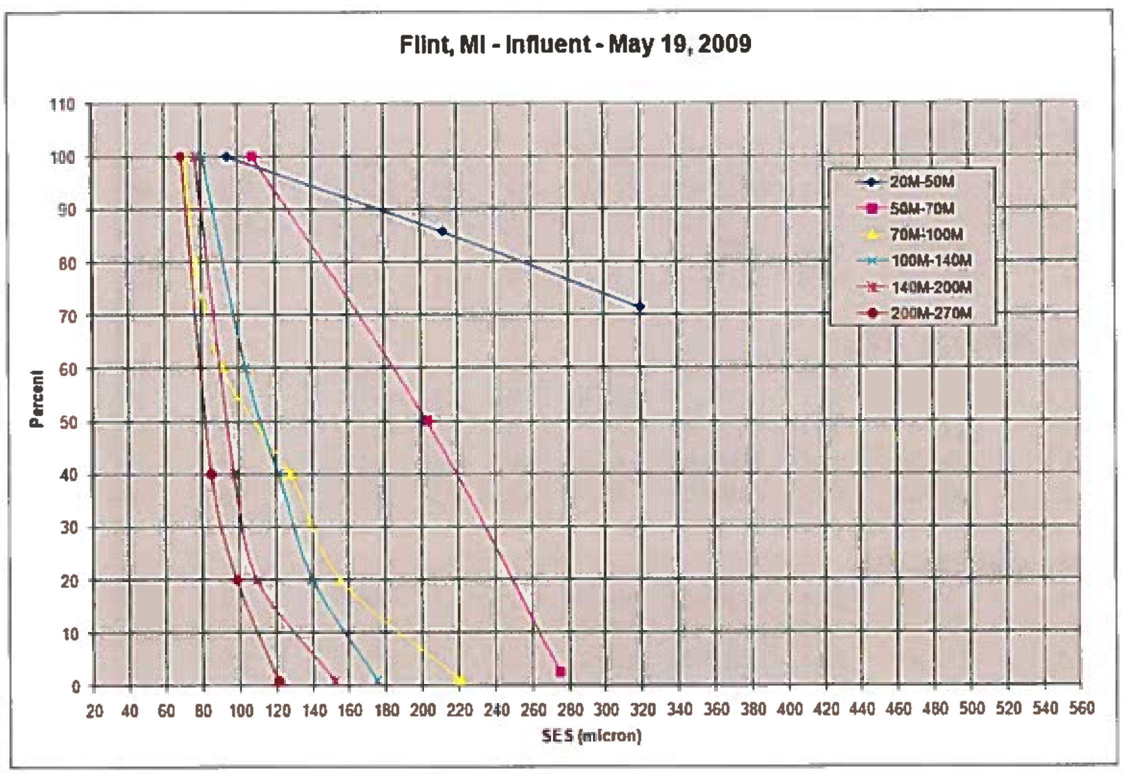
								Flint, MI - Influent - May 19, 2009			
sed vol, cc	vol frac, %	sed time, sec	sed h, cm	sed vel, cm/s	d1, µ	NR1	NR2	SES, µ		SES, µ	vol frac, %≥
20M - 50M, 300µ - 820µ											
0.5	71	10	52.4	5.24E+00	319.3	16.7	16.7	319.3		319.3	71
0.6	86	18	52.2	2.90E+00	212.3	6.2	6.2	212.3		212.3	86
0.7	100	72	52.0	7.22E-01	94.5	0.7	0.7	94.5		94.5	100
50M - 70M, 200µ - 300µ											
0.01	3	13	55.4	4.26E+00	274.9	11.7	11.7	274.9		274.9	3
0.1	50	20	54.0	2.70E+00	202.9	5.5	5.5	202.9		202.9	50
0.2	100	58	53.4	9.21E-01	108.0	1.0	1.0	108.0		108.0	100
70M - 100M, 150µ - 200µ											
0.01	1	18	55.4	3.08E+00	220.7	6.8	6.8	220.7		220.7	1
0.1	20	31	54.0	1.74E+00	155.2	2.7	2.7	155.2		155.2	20
0.2	40	43	53.4	1.24E+00	127.7	1.6	1.6	127.7		127.7	40
0.3	60	79	53.0	6.71E-01	90.9	0.6	0.6	90.9		90.9	60
0.4	80	107	52.7	4.93E-01	77.0	0.4	0.4	77.0		77.0	80
0.5	100	125	52.4	4.19E-01	70.7	0.3	0.3	70.7		70.7	100
100M - 140M, 100µ - 150µ											
0.01	1	26	55.4	2.13E+00	175.2	3.7	3.7	175.2		175.2	1
0.1	20	37	54.0	1.46E+00	140.0	2.0	2.0	140.0		140.0	20
0.2	40	47	53.4	1.14E+00	121.4	1.4	1.4	121.4		121.4	40
0.3	60	62	53.0	8.55E-01	103.7	0.9	0.9	103.7		103.7	60
0.5	100	98	52.4	5.35E-01	80.5	0.4	0.4	80.5		80.5	100
140M - 200M, 75µ - 100µ											
0.01	1	33	55.4	1.68E+00	151.9	2.6	2.6	151.9		151.9	1
0.1	20	57	54.0	9.48E-01	109.7	1.0	1.0	109.7		109.7	20
0.2	40	70	53.4	7.63E-01	97.4	0.7	0.7	97.4		97.4	40
0.5	100	107	52.4	4.90E-01	76.8	0.4	0.4	76.8		76.8	100
200M - 270M, 50µ - 75µ											
0.01	1	49	55.4	1.13E+00	121.1	1.4	1.4	121.1		121.1	1.0
0.1	20	69	54.0	7.83E-01	98.8	0.8	0.8	98.8		98.8	20.0
0.2	40	90	53.4	5.94E-01	85.1	0.5	0.5	85.1		85.1	40.0
0.5	100	130	52.4	4.03E-01	69.3	0.3	0.3	69.3		69.3	100.0

A-4 SES Data Analysis

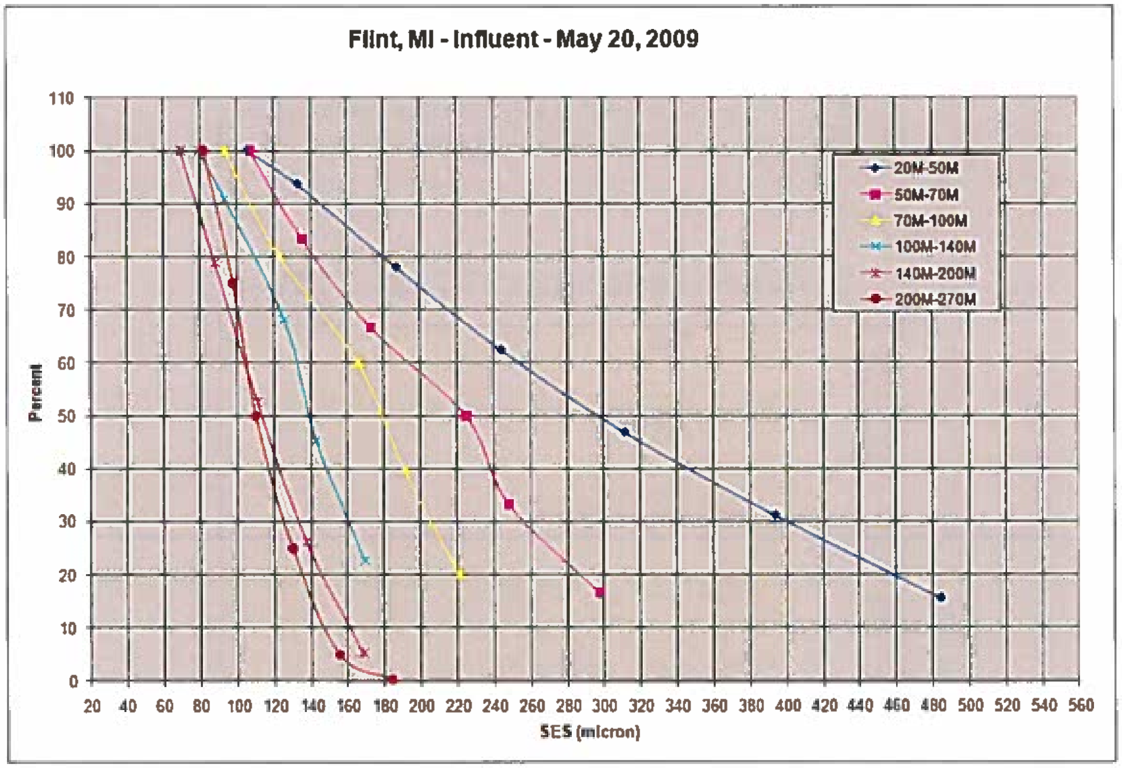
								Flint, MI - Influent - May 20, 2009			
sed vol, cc	vol frac, %	time, sec	sed h, cm	sed vel, cm/s	d1, μ	NR1	NR2	SES, μ		SES, μ	vol frac, %≥
20M - 50M, 300μ - 820μ											
0.5	16	6	52.4	8.74E+00	484.2	42.3	42.3	484.2		484.2	16
1.0	31	7.5	51.4	6.86E+00	393.7	27.0	27.0	393.7		393.7	31
1.5	47	10	50.7	5.07E+00	311.6	15.8	15.8	311.6		311.6	47
2.0	63	14	50.2	3.58E+00	244.0	8.7	8.7	244.0		244.0	63
2.5	78	21	49.7	2.37E+00	186.8	4.4	4.4	186.8		186.8	78
3.0	94	37	49.3	1.33E+00	132.9	1.8	1.8	132.9		132.9	94
3.2	100	55	49.2	8.94E-01	106.2	0.9	0.9	106.2		106.2	100
50M - 70M, 200μ - 300μ											
0.50	17	11	52.4	4.77E+00	297.7	14.2	14.2	297.7		297.7	17
1.0	33	14	51.4	3.67E+00	248.1	9.1	9.1	248.1		248.1	33
1.5	50	16	50.7	3.17E+00	224.9	7.1	7.1	224.9		224.9	50
2.0	67	24	50.2	2.09E+00	173.1	3.6	3.6	173.1		173.1	67
2.5	83	36	49.7	1.38E+00	135.6	1.9	1.9	135.6		135.6	83
3.0	100	54	49.3	9.13E-01	107.5	1.0	1.0	107.5		107.5	100
70M - 100M, 150μ - 200μ											
0.50	20	17	52.4	3.08E+00	220.9	6.8	6.8	220.9		220.9	20
1.0	40	21	51.4	2.45E+00	190.8	4.7	4.7	190.8		190.8	40
1.5	60	26	50.7	1.95E+00	166.1	3.2	3.2	166.1		166.1	60
2.0	80	43	50.2	1.17E+00	123.2	1.4	1.4	123.2		123.2	80
2.5	100	70	49.7	7.10E-01	93.7	0.7	0.7	93.7		93.7	100
100M - 140M, 100μ - 150μ											
0.50	23	26	52.4	2.02E+00	169.4	3.4	3.4	169.4		169.4	23
1.0	45	34	51.4	1.51E+00	142.9	2.2	2.2	142.9		142.9	45
1.5	68	42	50.7	1.21E+00	125.7	1.5	1.5	125.7		125.7	68
2.0	91	71	50.2	7.07E-01	93.4	0.7	0.7	93.4		93.4	91
2.2	100	96	50.0	5.21E-01	79.3	0.4	0.4	79.3		79.3	100
140M - 200M, 75μ - 100μ											
0.10	5	27	54.0	2.00E+00	168.6	3.4	3.4	168.6		168.6	5
0.5	26	37	52.4	1.42E+00	137.6	2.0	2.0	137.6		137.6	26
1.0	53	53	51.4	9.70E-01	111.2	1.1	1.1	111.2		111.2	53
1.5	79	80	50.7	6.34E-01	88.1	0.6	0.6	88.1		88.1	79
1.9	100	124	50.3	4.06E-01	69.5	0.3	0.3	69.5		69.5	100
200M - 270M, 50μ - 75μ											
0.01	0	24	55.4	2.31E+00	184.0	4.2	4.2	184.0		184.0	0.3
0.10	5	31	54.0	1.74E+00	155.2	2.7	2.7	155.2		155.2	5.0
0.50	25	41	52.4	1.28E+00	129.8	1.7	1.7	129.8		129.8	25.0
1.00	50	54	51.4	9.53E-01	110.0	1.0	1.0	110.0		110.0	50.0
1.50	75	66	50.7	7.69E-01	97.8	0.8	0.8	97.8		97.8	75.0
2.0	100	91	50.2	5.51E-01	81.8	0.5	0.5	81.8		81.8	100.0

A-5 SES Charts





A-5 SES Charts



A-6 SES Chart Analysis

Flint, MI - Influent - May 18, 2009

Sieve Size >	1/4	1/8	#12	#20	#50	#70	#100	#140	#200	#270
fxd solids fraction	0.00	0.22	0.75	1.64	11.97	10.55	25.16	29.41	16.03	4.27
SES Interval	% in each interval									
40-60										
60-80							3.0			
80-100					2.0	5.0	9.0	8.0		
100-120				2.0	3.0	7.0	8.0	15.0	4.0	
120-140			2.0	3.0	5.0	6.0	7.0	15.0	39.0	70.0
140-160		2.0	3.0	5.0	5.0	7.0	9.0	10.0	24.0	30.0
160-180	2.0	3.0	5.0	5.0	5.0	11.0	13.0	19.0	17.0	
180-200	3.0	5.0	5.0	5.0	5.0	14.0	15.0	10.0	16.0	
200-220	5.0	5.0	5.0	5.0	6.0	14.0	10.0	10.0		
220-240	5.0	5.0	5.0	6.0	7.0	14.0	9.0	9.0		
240-260	5.0	5.0	6.0	7.0	7.0	15.0	9.0	4.0		
260-280	5.0	6.0	7.0	7.0	7.0	7.0	8.0			
280-300	6.0	7.0	7.0	7.0	5.0					
300-320	7.0	7.0	7.0	5.0	5.0					
320-340	7.0	7.0	5.0	5.0	5.0					
340-360	7.0	5.0	5.0	5.0	5.0					
360-380	5.0	5.0	5.0	5.0	5.0					
380-400	5.0	5.0	5.0	5.0	5.0					
400-420	5.0	5.0	5.0	5.0	5.0					
420-440	5.0	5.0	5.0	5.0	5.0					
440-460	5.0	5.0	5.0	5.0	5.0					
460-480	5.0	5.0	5.0	5.0	3.0					
>480	18.0	13.0	8.0	3.0						
TOTAL	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

% Total in SES Range			
SES (micron)	% Percent	Cumulative % Retained	% >
40			100
60	0	0	100
80	1	1	99
100	5	6	94
120	8	14	86
140	17	31	69
160	12	43	57
180	13	56	44
200	11	68	32
220	8	76	24
240	7	83	17
260	6	89	11
280	4	93	7
300	1	94	6
320	1	94	6
340	1	95	5
360	1	96	4
380	1	96	4
400	1	97	3
420	1	98	2
440	1	99	1
460	1	99	1
480	0	100	0
<480	0	100	0
	100		

A-6 SES Chart Analysis

Flint, MI - Influent - May 18, 2009

Sieve Size >	1/4	1/8	#12	#20	#50	#70	#100	#140	#200	#270
fxd solids fraction	0.00	0.04	1.54	4.97	31.13	10.91	16.40	18.08	11.96	4.98
SES Int										
40-60										
60-80							26.0			
80-100					2.0		20.0	34.0	8.0	42.0
100-120				2.0	2.0	6.0	10.0	24.0	58.0	40.0
120-140			2.0	2.0	2.0	10.0	14.0	22.0	20.0	16.0
140-160		2.0	2.0	2.0	2.0	10.0	12.0	12.0	8.0	2.0
160-180	2.0	2.0	2.0	2.0	2.0	10.0	6.0	8.0	6.0	
180-200	2.0	2.0	2.0	2.0	2.0	11.0	5.0			
200-220	2.0	2.0	2.0	2.0	2.0	12.0	7.0			
220-240	2.0	2.0	2.0	2.0	2.0	13.0				
240-260	2.0	2.0	2.0	2.0	3.0	13.0				
260-280	2.0	2.0	2.0	3.0	3.0	15.0				
280-300	2.0	2.0	3.0	3.0	3.0					
300-320	2.0	3.0	3.0	3.0	3.0					
320-340	3.0	3.0	3.0	3.0	3.0					
340-360	3.0	3.0	3.0	3.0	3.0					
360-380	3.0	3.0	3.0	3.0	3.0					
380-400	3.0	3.0	3.0	3.0	3.0					
400-420	3.0	3.0	3.0	3.0	4.0					
420-440	3.0	3.0	3.0	4.0	4.0					
440-460	3.0	3.0	4.0	4.0	4.0					
460-480	3.0	4.0	4.0	4.0	4.0					
480-500	4.0	4.0	4.0	4.0	4.0					
500-520	4.0	4.0	4.0	4.0	4.0					
520-540	4.0	4.0	4.0	4.0	4.0					
540-560	4.0	4.0	4.0	4.0	4.0					
560-580	4.0	4.0	4.0	4.0	4.0					
>580	40.0	36.0	32.0	28.0	24.0					
	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

% Total in SES Range			
SES	fractional		cumulative
40			100
60	0	0	100
80	4	4	96
100	13	17	83
120	16	34	66
140	11	45	55
160	7	52	48
180	5	57	43
200	3	60	40
220	3	63	37
240	2	65	35
260	2	68	32
280	3	70	30
300	1	71	29
320	1	73	27
340	1	74	26
360	1	75	25
380	1	76	24
400	1	77	23
420	1	79	21
440	1	80	20
460	2	82	18
480	2	83	17
500	2	85	15
520	2	86	14
540	2	88	12
560	2	89	11
580	2	91	9
>580	9	100	0
	100		

A-6 SES Chart Analysis

Flint, MI - Influent - May 18, 2009

Sieve Size >	1/4	1/8	#12	#20	#50	#70	#100	#140	#200	#270
fxd solids fraction	0.00	0.20	0.70	1.59	14.60	18.60	25.56	24.38	11.53	2.84
SES Int										
40-60										
60-80									12.0	
80-100							5.0	13.0	22.0	28.0
100-120					3.0	8.0	13.0	14.0	23.0	36.0
120-140				3.0	5.0	9.0	10.0	23.0	18.0	21.0
140-160			3.0	5.0	5.0	9.0	9.0	20.0	14.0	11.0
160-180		3.0	5.0	5.0	5.0	7.0	14.0	15.0	11.0	3.0
180-200	3.0	5.0	5.0	5.0	6.0	7.0	16.0	15.0		1.0
200-220	5.0	5.0	5.0	6.0	6.0	6.0	13.0			
220-240	5.0	5.0	6.0	6.0	6.0	14.0	13.0			
240-260	5.0	6.0	6.0	6.0	5.0	10.0	7.0			
260-280	6.0	6.0	6.0	5.0	5.0	7.0				
280-300	6.0	6.0	5.0	5.0	5.0	6.0				
300-320	6.0	5.0	5.0	5.0	4.0	6.0				
320-340	5.0	5.0	5.0	4.0	4.0	6.0				
340-360	5.0	5.0	4.0	4.0	4.0	5.0				
360-380	5.0	4.0	4.0	4.0	4.0					
380-400	4.0	4.0	4.0	4.0	4.0					
400-420	4.0	4.0	4.0	4.0	4.0					
420-440	4.0	4.0	4.0	4.0	4.0					
440-460	4.0	4.0	4.0	4.0	3.0					
460-480	4.0	4.0	4.0	3.0	3.0					
480-500	4.0	4.0	3.0	3.0	3.0					
500-520	4.0	3.0	3.0	3.0	3.0					
520-540	3.0	3.0	3.0	3.0	3.0					
540-560	3.0	3.0	3.0	3.0	3.0					
560-580	3.0	3.0	3.0	3.0	3.0					
>580	12.0	9.0	6.0	3.0						
	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

% Total in SES Range

SES	fractional		cumulative
40			100
60	0	0	100
80	1	1	99
100	8	9	91
120	12	21	79
140	13	35	65
160	12	46	54
180	11	57	43
200	10	67	33
220	5	73	27
240	7	80	20
260	5	84	16
280	2	86	14
300	2	88	12
320	2	90	10
340	2	92	8
360	2	94	6
380	1	94	6
400	1	95	5
420	1	96	4
440	1	96	4
460	1	97	3
480	1	97	3
500	1	98	2
520	1	98	2
540	1	99	1
560	1	99	1
580	1	100	0
>580	0	100	0
	100		

A-7 Median SES versus Median Physical Size

Median Size (microns)	Size Range (microns)		May 18, 2009	May 19, 2009	May 20, 2009
62.5	50	75	133	83	110
87.5	75	100	144	95	114
125	100	150	166	111	138
175	150	200	179	105	180
250	200	300	202	203	225
560	300	820	276	460	296

Appendix F – Calculations

Drag Coefficient (C_d)

$24/N_R + 3/\text{sqrt } N_R + 0.34$

Reynolds number (N_R)

(settling velocity of particle)(diameter of particle)/kinematic viscosity

Stoke's Law

Settling velocity (m/s) = $g(sg_p - 1)d^2{}_p/18v$

Where g = acceleration due to gravity (9.81 m/s^2)
sg_p = specific gravity of particle
d_p = diameter of particle
v = kinematic viscosity (m^2/s)

% Total Solids

(grams dry weight/grams wet weight)*100

% Total Volatile Solids

[(grams dry weight - grams ash weight)/ grams dry weight]*100