1. Flow Peaks: The peaking factor (PF) of more than 3.5 is unusually high for a collection system consisting primarily of pvc pipes and precast concrete manholes. Inflow and Infiltration (I&I) would appear to have a major impact on Lynn Township's wastewater treatment plant (WWTP). The Northern Lehigh School has been mentioned as a key contributor, with peak flows of more than 50,000 gallons per day (gpd) while their average is closer to 10,000 gpd when school is in session. The peak flow rate governs the size of many treatment processes, including the influent screen, influent pump station, all process piping, the clarifiers, flow metering and the disinfection system. Treatment plant upgrade costs would be higher than normal because of the high peaking factor, and these added costs should be weighed against the cost to reduce peak flows.

    a. Surface Water Inflow: During the plant tour we were advised that flows rise soon after rain begins, indicating that the inflow of surface water is the primary source of storm flow, rather than the infiltration of groundwater. Inflow mostly enters through leaking manhole frames and covers, and when roof drains and downspouts are improperly connected to the sanitary sewers. The latter is often the case with schools and commercial buildings if the roof leaders are tied into the sanitary sewers, rather than the storm sewers. This category of flow tends to start very soon after rain starts, and it ends not too long after it stops. Dye testing is often very effective.

    b. Groundwater Infiltration: Infiltration results from groundwater entering the sewers through leaking pipe joints and manholes, so it occurs where the groundwater table is above the sewer. The quantity and timing of infiltration generally follows the depth of the groundwater table, so flows tend to rise more slowly, and remain elevated for longer periods of time. There may be no infiltration during drought periods, such as during the dry summers and hard winters. Buildings (residences, schools, commercial, etc.) contribute infiltration most often through sump pumps and/or foundation drains connected to the sewer.

    c. I&I Repair Costs: Some concern was expressed during the plant tour about political and homeowner concerns if restrictions against inflow and infiltration were more vigorously enforced. Perhaps if the extra costs for the treatment facility were more fully explained, opposition would lessen. Reducing I&I at the source is logical if the costs of the corrective action are less than the costs to expand the plant to handle the excess flows. The benefit of enforcement should also be considered: if customers know the Authority is strict about excess flow sources, they might expect it would also be strict about other prohibited flows, such as industrial cleaners.

    d. Peaking Factors: The peaking factor for new extensions should be considerably lower than what the plant has experienced to date. Maximum daily flows from new sewer systems that are properly constructed normally are less than twice the average daily flow. As the system expands, the peaking factor should decrease even if nothing is done to correct existing I&I. (Bear in mind we strongly advise working to reduce that problem.) The use of plastic sewer lines and precast manholes is the primary reason why new sewers don't leak as badly as older ones do, which emphasizes how unusual it is for Lynn Township to have such severe I&I with a sewer system that was mostly built with modern sewer materials.

2. Existing WWTP Summary: The treatment facility is typical in many respects for its era: Many extended aeration activated sludge treatment plants were constructed, starting in the 1970's and continuing to this day. They often were economically built with many processes and buildings constructed using common wall construction. Lynn Township is a little unusual to have the administration building sandwiched between the two aeration tanks and digesters (which originally were clarifiers.) Concrete was not often used for an extended air plant; most were built of steel, and few of them lasted this long. This is also the first plant the Author has seen with the chlorine contact tanks inside a building, an obvious error; even back then designers understood the negative effect of chlorine on metal. Worse, most of the plant's electrical switchgear is in the same room as the chlorine contact tank. It is remarkable that the electrical components have not all completely corroded apart.

    a. Common Wall Construction: The two aeration tanks share a common wall with the administration building, which houses the generator, chlorine contact tank and electrical room, aeration blowers, and office/lab. Common wall construction saved cost, but all rooms in the building are very cramped.

    b. Headworks: The influent flow metering channel, comminutor, and wetwell share a common structure. Another common arrangement in older treatment plants, peak flows flood out the entire structure.

    c. Structural Condition: The portion of all of the concrete structures that was visible above the water line generally appeared to be sound, such that it looked like it could continue to be used for the life of the proposed expansion.

    d. Plant Hydraulics: The operator reported that the gravity flow piping in the plant, downstream of the aeration tanks, was only 6-inches, which is inadequate, to the point that the clarifier is flooded out during peak flows, whereupon mixed liquor recycles through the scum trough back to the influent pump station. Gravity mains through the expanded plant will possibly need to be 10 inches in diameter.

The plant will next be reviewed by following the wastewater through the liquid flow train, then the sludge processing from generation to ultimate disposal.

3. Planned flows 160,000 vs. 250,000 gpd. We concur with the Supervisors decision to design the plant expansion for an Average Daily Flow (ADF) of 160,000 gpd. This is 60% more than the highest Maximum 3-Month Average flow experienced in the last 5 years, which occurred from October to December 2005.

    a. It would be prudent to design [those treatment processes whose capacity is governed by the peak flow rate] for the peak that would correspond to an average flow of 250,000 gpd. This would include the influent screen, influent pump station, all process piping, clarifiers, flow metering and the disinfection system.

    b. The biological processes, aeration tanks, return and waste sludge pumping, aeration blowers, and sludge handling stages should be designed for the ADF of 160,000 gpd. With two aeration tanks and a proposal for two each aerobic digesters, clarifiers, and reed sludge drying beds, adding a third unit for each process would increase capacity to 240,000 gpd.

4. Influent Flow Meter: The v-notch weir was replaced with a rectangular weir to increase the maximum flow that could be measured to 300,000 gpd. This is less than half the proposed peak flow of 560,000 gpd (3.5 times an average of 160,000 gpd). A new influent flow meter would be needed, in which case one of two alternatives would appear to be the best choice:

    a. Raw Influent: If an exact measurement of the actual influent is needed, a new parshall flume should be installed. It may be possible to modify the existing headworks, but the screen should not be allowed to back up into the flume; if it does, the flow reading becomes meaningless. All incoming sewers would feed upstream of the flume, and all internal recycle flows downstream, so only the raw wastewater is measured. In this case internal recycle flows, which are significant, would need to be estimated.

    b. Reactors Influent: On the other hand, magnetic flow meter could be set on the force main after the influent pump station to provide an exact measurement of the flow to the biological reactors. Magnetic flow meters, properly installed, are much more accurate than parshall flumes. Measuring at this point would identify all flows entering the treatment processes, including internal recycles. As the biological process is upgraded to remove nutrients, a much higher degree of control is needed and accurate flow data of the actual flow to the biological process becomes critical.

    c. Effluent Flow Metering: DEP normally requires both influent and effluent flow metering at design flows above 100,000 gpd. The effluent flow meter should accurately record the actual flows being discharged to Ontelaunee Creek, so it is located after all recycle flows have been drawn off. If an effluent meter is provided, a parshall flume is normally set on the outfall sewer, after disinfection.

5. Influent Screen: Comminutors are inappropriate for wastewater treatment plant headworks because they do not remove any objectionable material; they only grind it into smaller particles. Plant staff regularly have to remove these particles from pumps and other places where they become lodged. The comminutor should be replaced with a fine mesh mechanical filter screen, which has a chain of fine mesh that rotates into the channel, catches all of the larger organics, rags, hygiene products, and other objectionable material. The screen would bring the material up above grade and deposit it into a dumpster. Screens in this climate can be set outdoors, but they are a significant odor source, and are often set in buildings to control odors. It would appear that the existing channel could be modified to use with a new screen.

    a. Mechanical Screens: There are many types of mechanical screen and the selection depends in large part on the type of equipment downstream that screenings would damage or require more maintenance. The finer the screen, the more material it removes, but also the more maintenance it requires. A coarse screen such as a bar rack or a climber screen was commonly matched with trickling filters or older activated sludge plants such as extended air. With coarse bubble or surface aerators fouling by rags was not a major problem. Fine mesh filter screens are well suited for nutrient removal processes that employ anoxic zone mixers, internal recycle pumps and fine-bubble air diffusers. They will minimize propeller fouling and pump plugging. Ultra-fine perforated plate screens are now in vogue because they are necessary with membrane treatment.

6. Influent Pumps: The current arrangement where the operator must set temporary pumps to handle peak flows is untenable. The permanently installed pumps must be able to pump the peak influent flows. They must also be able to pump the average and minimum flows without upsetting or washing solids out of the activated sludge process, which does not respond well to flow variations. The replacement influent pumps would need variable speed drives to match the feed to the treatment process to the influent flow, as close as possible. When the peaking factor is much greater than two, as would be the case here, three influent pumps are recommended, so two can handle the peak flow, in case one is out of service. At normal flows one pump operates, speeding up and down to match the daily flow variations.

    a. Reuse Existing: The existing wetwell may be large enough to fit three larger influent pumps. If the pumps would not fit they could be set in a new pump room; the existing wetwell may have enough volume to continue in use. This would be a wetwell-dry pit pump station layout. Variable-speed pumps minimize the needed wetwell volume.

    b. New Submersible: A second, more expensive option would be to construct a new influent pump station with pumps set in a new wetwell. This may be needed, depending on the mechanical screen's space requirements. The valves could be set in a new underground vault, or possible in an existing structure.

7. Grit Removal: The existing treatment plant does not have an efficient grit removal system, which is not unusual for a plant this size. Grit means sand and gravel, and most grit is very fine sand. It is of concern because of the wear on treatment plant equipment: pumps, pipe, mixers, air diffusers, etc. The expanded plant would be at the size where grit removal is considered, especially with leaking collection systems. Sewers with high peaking factors carry much greater grit loads as the soil surrounding the sewer washes into it. Taking Millville, Columbia County as an example, about a cubic yard of grit is removed every month, with 98% coming during wet weather. The grit system would cost roughly the same as the mechanical filter screen, and if Lynn Township considers grit removal as part of the expansion the cost should be weighed against the operational savings.

8. Reactor Influent Flow Distribution: Raw wastewater is piped from the influent pumps to the two aeration tanks, and a simple tee in the piping splits the flow. The split is never even due to subtle differences in the hydraulics that depend on the flow rate, and this causes the two aeration tanks to operated differently because they do not receive the same feed. This operational difficulty cannot continue once the plant is upgraded to remove nutrients.

    a. Weir Gates: All influent to the reactors, including raw wastewater, return activated sludge and recycle flows should be fed to a reactor influent distribution box equipped with weir gates that would evenly split the flow. Weir gates are the most reliable means to evenly distribute flow; influent flows over top of the weir and if the gates are at the same elevation the flow is evenly split. Raise one gate high enough and all flow goes to the other reactor, so the first can be drained for service. The distribution box should be built with space to add a third weir gate to handle the potential third reactor that may be needed in the future. Adding a gate at a later date and providing a uniform flow split is very difficult.

b. Peak Flow Bypass: The distribution box should incorporate a peak flow bypass with weirs that feed the latter part of the reactors. Activated sludge processes fail at peak flows because the activated sludge biomass washes out of the reactors and into the clarifiers. If the peaks continue long enough, solids are flushed out of the clarifiers into the chlorine contact tank, and then into the stream. Excess peak flows can be bypassed around most of the reactor into the last part, which functions as a contact stabilization process. Biomass does not wash out and the reactor meets the permit limits at higher flows. Because solids are retained the reactors do not need to recover from washout, so treatment efficiency is undiminished. This is similar to the bypass mentioned with the VLR but better because less than 20 percent of the reactor is subject to peak flows, so the washout potential is lower.

9. Nutrient Removal Process: The consulting engineer considered only two alternatives to expand the plant's capacity and upgrade to remove nutrients. US Filter owns the patents to both, meaning that only one company can bid on the equipment during construction. The Envirex division of US Filter holds the patent for the Vertical Loop Reactor (VLR), and US Filter's Jet Tech division holds the patent for their Jet Tech Sequencing Batch Reactor. With a wide variety of other Nutrient Removal Technologies (NRT) available, including several non-proprietary (unpatented) process alternatives that are much better suited for the existing aeration tanks, it is not clear why only these two were evaluated.

a. Nutrient Removal Basics: Conventional activated sludge treatment processes are designed to oxidize Biochemical Oxygen Demand (BOD) and reduce Total Suspended Solids (TSS). Permits written for secondary treatment set limits for BOD, TSS, pH, coliform bacteria, and dissolved oxygen. Some also have seasonal ammonia limits. Nitrogen and phosphorus are nutrients that have become a problem because they feed the growth of plants, and algae is of particular concern in tidal water such as the Delaware Bay because it can deplete the oxygen there, killing off other aquatic species. Nutrient limits are being imposed on wastewater treatment plants all along the eastern seaboard that feed tidal waters.

i. Nitrogen Removal: Nitrogen is removed in two ways: nitrogen removal in the waste sludge and Biological Nitrogen Removal (BNR). About one-third of the influent nitrogen (for plants like Lynn Township) is taken up in cell growth and removed when sludge is wasted. BNR describes how the excess nitrogen is completely removed from the process. BNR occurs in twp steps: nitrification, where ammonia is oxidized to nitrite and nitrate, and denitrification, where nitrite and nitrate are reduced to nitrogen gas and oxygen. Any activated sludge treatment plant with a high enough detention time and enough air will nitrify, including the existing extended aeration process. Anoxic conditions are needed to denitrify, because the microorganisms will not do so if oxygen is present. Once oxygen has been removed the microbes will break down nitrates and nitrite (NO_X) in order to obtain the oxygen they need to survive.

ii. Phosphorus Removal: Phosphorus can be removed chemically with metal salts such as alum or ferric chloride, or biologically through luxury uptake. Biological Phosphorus Removal (BPR) also requires two stages. The first is the anaerobic step, where microbes are stressed by the absence of both oxygen and NO_X. Here, they release phosphorus from their cell mass in order to survive. The second is the aerobic step, where the microbes take back up the phosphorus they released, along with excess from the raw wastewater, into their cell mass. This is called the luxury uptake.

iii. Nutrient Removal Technologies: There are dozens NRT processes used in hundreds, maybe thousands of treatment plants around the world, many patented and a similar number that are not. Some remove nitrogen, others phosphorus, and there are those that remove both. The limits this treatment plant is being subject to are very moderate, and many processes can achieve them without the use of chemicals. This Author designed a number of treatment plants using non-proprietary processes that have been meeting these limits for years. There should be a compelling need for a patented process, which clearly is not the case for Lynn Township, or else it should be the least costly alternative, which does not appear to be the case here.

b. Peak flows have a compounding negative effect on nutrient removal, which will be required under the permit, because peak flows often have elevated oxygen concentrations, and they are normally fairly dilute (low in BOD) and have a low oxygen demand. The nutrient removal process must be carefully designed to minimize this negative effect.

c. Vertical Loop Reactor: The VLR is an oxidation ditch turned on its side. Oxidation ditches are one of the oldest and most common nutrient removal processes, with many patented variations. Originally they were constructed like trapezoidal ditches, with concrete poured on earthen walls, and the name stuck, although construction is different now. The mixed liquor flows in a loop with influent fed at one point and effluent drawn off at another. The VLR is similar to one popular variation on the oxidation ditch process where two ditches operate in series, with the first serving as the anoxic zone and the second as the oxic zone.

i. Hydraulic Detention Time: Oxidation ditches are low-load processes where the influent is completely mixed with the mixed liquor, and as a result the reaction rates are slower than plug-flow processes and more detention time is needed to produce the same effluent quality. Ditches normally have hydraulic detention times (HDT's) of 24 hours or more, based on the average daily flow. The manufacturer indicates the VLR would need 140,000 gallons to treat 160,000 gpd, or a detention time of 21 hours. This seems somewhat aggressive especially given the peak flows are more than 3 times the average, when flows peak the actual HDT would be less than 7 hours.

ii. Anoxic VLR: When two VLR's are operated in series, as is proposed here, the first serves as the anoxic zone. A surface aerator would mix the tank. Minimizing dissolved oxygen in the anoxic zone is critical to denitrification, yet an aerator is proposed to provide mixing, and the Study indicates about 50% of the process oxygen would be fed here. If that much air is fed it is hard to see how this reactor would ever become anoxic, and certainly it will not be anaerobic. Peak flows will compound the difficulty in forming a stable anoxic zone because they normally have high dissolved oxygen levels. The proposal is based on nitrification and denitrification occurring in the same reactor, which is difficult to consistently achieve.

iii. Filamentous Bacteria Control: A critical advantage of a well-designed nutrient removal process is the ability to control filaments and produce a sludge that settles well. The sludge volume index (SVI) measures how well a sludge settles. Filamentous bacteria need either low dissolved oxygen or low loading conditions to out-compete other microorganisms. Filaments cause foaming and bulking sludge that does not settle in the clarifiers, making them very prone to wash-outs during peak flows. Excessive filaments will cause permit violations for TSS and BOD. Oil and grease in the raw wastewater promote filaments, as does I & I. The existing aeration tanks experience foaming problems. Oxidation ditches and SBR's are notorious filament breeders because both are low-load processes that have low DO conditions at some point in their process. Aerating the first VLR while trying to operate in an anoxic mode will encourage the growth of filaments, not control them.

iv. Anoxic and Oxic HDT's: By using one of the two VLR's as the anoxic zone, the anoxic HDT at average flows would be 10.5 hours, which is excessive. The Feasibility Study mentions the possibility of luxury uptake of phosphorus. With the proposed aerator as a mixer, true anaerobic conditions are unlikely, and BPR will be limited to what occurs inside floc particles. The second VLR would be mixed and aerated to serve as the oxic zone. The aerobic HDT of 10.5 hours would be low for a complete-mixed process.

v. Oxygen Transfer: The claims of improve aeration efficiency by the horizontal shelf and air release plate, which purportedly cause coarse bubble aeration to act like fine bubble aeration, are remarkably similar to those made by Innova-Tech about their patented barrier oxidation ditch. The Author had lengthy experience with 4 of their systems. Innova-Tech built a large, deep draft tube (8-foot diameter by 20 feet at the deepest point for Berwick, PA's 4.0-MGD ditch). Coarse bubbles were fed by a sparge ring set beneath a horizontal mixer which pushed the aerated mixed liquor down the draft tube, under a barrier wall and back up the other side. The down-and-up flow path was supposed to double the oxygen transfer efficiency, making it act more like fine-bubble aeration. This of course is nonsense, but exposure to this and other manufacturers' claims over the years have ingrained a healthy skepticism for manufacturer's claims that seem inconsistent with the laws of physics.

vi. Horizontal Shelf Structure: The horizontal shelf is necessary to create the oxidation-ditch effect with mixed liquor flowing across the top of the shelf, down the end wall ,along the bottom of the shelf, and back up the far side through the Air Release Plate. The Author observed the conversion of existing aeration tanks into VLR reactors at Selinsgrove and noted how difficult the construction of the horizontal shelf was. In structural terms the shelf is an elevated floor slab that must be supported by doweling into an existing concrete wall. While the Author is not a structural engineer, he was accompanied by one at Selinsgrove, who said he would be reluctant to design such a structure.

vii. VLR Summary: The Length-to-Width ratio of the existing aeration tanks is low, the proposed detention time appears low and the anticipated oxygen transfer efficiency would seem to be high. The system is complicate with both surface aeration mixers and coarse bubble diffusers, set beneath a horizontal shelf. There are unpatented simpler methods to expand capacity and remove nutrients at Lynn Township.

10. Alternative Treatment Processes: Generally the ideal treatment process to upgrade existing aeration tanks to nutrient removal reactors is that which best utilized the existing tank volume and layout. There are two reactors, each 50 feet long, 15 feet wide and 10 feet deep. The combined volume is 15,000 cubic feet, or 112,000 gallons. The hydraulic detention time at a design ADF of 160,000 gpd would be 16.8 hours. This is more than sufficient for a plug-flow NRT process, so the walls would not need to be raised. The ideal process would be able to achieve the stated effluent goals of 10 mg/l TN and 2.0 mg/l TP without increasing the reactor volume and with minimal modifications to the existing tanks.

    a. Plug-flow treatment processes are ideally suited to the existing rectangular tanks. Plug flow describes a process where influent wastewater and all recycle streams (return sludge, internal recycles, etc. are introduced at one end of the reactor and they flow as a “plug” down the length of the reactor, exiting at the other end. The combined streams flow together along the tank, like a bullet down a barrel. Plug-flow processes produce better effluent quality than complete-mixed, for a given volume, because they operate at higher kinetic rates. This is because all of the food in the raw wastewater is mixed with a relatively small amount of mixed liquor at the head of the plant so the reaction rate is not limited by the amount of food.

    b. The plug-flow processes are nearly identical in appearance, with subtle differences in where wastewater, air, and recycle flows are introduced. Plug-flow processes are most common in larger treatment plants, but the rectangular tank layout is also the most common for package plants such as Lynn Township. The following first describes general modifications needed to upgrade the aeration tanks to biological reactors, and then several simple plug-flow processes that would meet and exceed the proposed effluent limits.

    c. Modifications: Baffle walls would be built across the width of the aeration tanks to divide them into zones and subzones. They would cover 98% of the width, with a small opening at the bottom and the top of the wall would be just below the water surface. Mixers would be needed to maintain solids in suspension in unaerated (anoxic or anaerobic) zones. Fine bubble diffusers would replace the coarse bubble diffusers. With only part of the reactor being aerated (the aerobic, or oxic zone) greater oxygen transfer efficiency would be required. Internal recycle pumps would be needed to convey mixed liquor from one part of the reactor to the other. The secondary clarifier would continue in use, along with the return sludge pumps. The peak flow bypass mentioned earlier should be incorporated to maximize the plant’s peak flow treatment capacity.

    d. Modified Ludzack Ettinger: The MLE process consists of a pre-anoxic zone for denitrification and filamentous control followed by an oxic zone for BOD removal and nitrification. It was invented in the 1950’s and has been used extensively since then, including seven installations by the Author. The anoxic zone would be mixed, but not aerated. It could be separated into two subzones. The abandoned hopper-bottom clarifiers could be readily converted into part of the necessary volume. The oxic zone would be separated into three subzones, with the peak flow bypass fed into the last zone. Internal recycle pumps with a peak capacity of 350% of the ADF would recycle nitrified mixed liquor back to the anoxic zone, for denitrification. Roughly 30 to 40% of the volume would be anoxic, and the remainder oxic. The MLE could reliably produce effluent with TN less than 6 mg/l and TP averaging 1 mg/l without the use of chemicals.

e. Anaerobic-Anoxic-Oxic: The A^2O was patented for its ability to produce a sludge that settles readily, and anoxic conditions were provided for denitrification. The Author has incorporated the A^2O as an option in many treatment plants he has designed. The first zone is anaerobic, with only raw wastewater and RAS fed to an unaerated zone. The second zone is also unaerated but nitrified mixed liquor is fed, making it anoxic. The last, oxic zone functions the same as the MLE. The A^2O enhances BPR, so effluent TP levels would drop to 0.8 mg/l. Effluent TN levels would be a little higher than from the MLE. When both BPR and denitrification are incorporated into the same process they compete for the available carbon from BOD, and so plants with dilute wastewaters (such as Lynn Township in wet weather) may have slower reaction rates. The available detention time is high enough that the effluent limits could easily be met with any of the plug flow processes mentioned.

f. Virginia Initiative Plant: The VIP was patented by a Virginia Tech professor who disliked treatment processes being patented and millions of dollars of royalties being collected. He released the VIP into the public domain, meaning it could be used without charge. The VIP has the same Anaerobic-Anoxic-Oxic configuration as the A^2O, but a second internal pumping system is provided to recycle denitrified mixed liquor from the anoxic zone to the anaerobic zone. This improves the efficiency of both BPR and denitrification, so effluent TP levels at Lynn Township would be 0.5 mg/l and TN would be 5.0 mg/l. The Author has three VIP plants in operation.

g. 4- and 5-Stage Bardenpho, University of Cape Town, University of North Carolina, etc.: Several other more complicated plug-flow processes are available that could further reduce effluent nutrient levels. They add second anoxic and aerobic stages, internal recycles, fermenters, or other enhancements. They are not needed to meet the limits proposed here and they would raise costs, and so they are not discussed in detail.

h. Summary: The MLE is the simplest process that would reliably meet the proposed effluent limits, and it is proposed for implementation here. If the anoxic zone is divided into at least two subzones, operating as the A^2O is as simple as diverting the internal recycle to the second subzone, rather than the first. The VIP can be provided by simply adding the second internal recycle pump, which in a plant this size would be one 60 gpm pump (about one HP) in each reactor. The aeration tanks could be converted to a plug flow BNR process without raising the walls by adding new air diffusers, a few baffles, submersible mixers and internal recycle pumps.

i. Process Guarantees: The value of a guarantee is defined by the reputation and resources of the guarantor, and by one's need for the guarantee, which is a form of insurance. Many short-lived companies have sold process guarantees, and the company was gone by the time the owner realized the process didn't work. US Filter is the largest purveyor of wastewater treatment equipment in the US and it, or its successors (it has been sold twice in the last seven years) can be expected to be in business for many years to come. On the other hand we see no reason to pay for the guarantee for a patented process when there are so many successful installations of unpatented processes that are producing cleaner effluent than you will be required to. Buying a patented process would be like buying insurance you don't need. The Engineer you engage to design this Expansion/Upgrade should be qualified by experience in designing a variety of nutrient removal processes, and his Professional Seal on your design drawings and permit application should be all the guarantee you need.

j. Sequencing Batch Reactor's: The existing aeration tanks are poorly suited for conversion to any SBR process because the tanks are far too shallow. The SBR functions as both a reactor and a clarifier. After the air supply is turned off the mixed liquor is allowed to settle into a sludge blanket, leaving a relatively clear supernatant to be drawn off. When the tank is too shallow not enough separation exists between the blanket and the supernatant, and solids are drawn off along with the effluent, causing permit violations. The tank walls would need to be raised at least five feet to end up with SBR's that might be able to meet the effluent limits. The structure might not be able to support the additional weight and water pressure.

    i. Another problem with SBR's is they are low-load processes prone to filament growth with high sludge volume indexes and effluent TSS violations. They require detention times of 24 hours or more in order to meet nutrient limits.

    ii. SBR's are particularly poor at handling storm flow peaks and excessive I&I, such as what Lynn Township experiences. When flows peak SBR's are adjusted by shortening the Cycle time to as little as 3 hours, decreasing operational efficiency. Nutrient removal ceases at very low cycle times, and while nitrification will resume after flows drop (as long as the biomass has been retained) effluent must be significantly better during dry weather to offset the deficit.

    iii. SBR's produce very thin waste activated sludge at roughly 0.4% solids, compared to 1% or better with clarifiers, so the digester volume must be correspondingly higher. This also increases the hydraulic loading on the sludge drying beds.

11. Gravity Reactor Drains: If the reactors do not have adequate means to drain piping and valves it should be provided that allow rapid draining (overnight) by gravity to facilitate cleaning.

12. Secondary Clarifiers: Lower loading rates are used for secondary clarifiers serving a nutrient removal process than for a conventional activated sludge process because BNR sludge has the potential to settle worse. The Author uses BNR loading rates of 400 gpd/sf at average flows and 800 gpd/sf at peak, so peak rates govern here because peak flows are more than double the average. Using the peak flow from the feasibility study of 560,000 gpd, the secondary clarifiers' surface area would need to be 700 square feet. Two 20-foot clarifiers would provide 628 square feet, so the peak overflow rate would be 890 gpd/sf – a little high, but tolerable. At 800 gpd/sf the peak flow capacity would be 502,000 gpd, a peaking factor of 3.1, which may be more reasonable, for reasons discussed earlier. However, if one of the 2 clarifiers were out of service treatment would be severely compromised.

    a. Two new 20-foot clarifiers would allow the plant to treat the peak flow with one of the three off-line. The flow capacities with three 20-foot clarifiers would be 376,000 gpd at ADF and a peak flow of 753,000 gpd, which would allow for a 3.0 peaking factor on an average daily flow of 250,000 gpd.

b. The Study recommends adding one 30-foot diameter clarifier, which actually would have more capacity and be less expensive than two 20-foot units. The flow capacities with one 20-foot and one 30-foot clarifier would be 408,000 gpd at ADF and a peak flow of 816,000 gpd. Operations would be more complex because different return rates would be needed. However, we have often worked with plants that have two different sized clarifiers and the capital cost savings here may outweigh the difficulties. The main problem with adding one 30-foot clarifier comes when it must be taken out of service. The peak flow capacity of the 20-foot clarifier is 250,000 gpd and any higher flows could cause effluent violations. However, clarifiers do not often break down for extended periods of time, and maintenance normally can be scheduled for dry weather.

13. Clarifier Influent Distribution Box: We would concur with the recommendation for a clarifier influent distribution box using weir gates to control flow. The length of the gate feeding each clarifier would be proportionate to it's percentage of the total flow capacity, so if three 20-foot clarifiers were provided three equal-width gates would be provided. If one 20-foot and one 30-foot were provided, the gate for the 20 would be 4/9ths as wide as the one for the 30-footer.

14. Return and Waste Sludge Pumping: New pump(s) would be needed to serve the new clarifier(s). The existing pumps may need replaced, depending on their age and condition. In most plants this size separate waste sludge pumping is not provided; return sludge is diverted to the sludge processes. All should have variable speed drives, with the option to flow-pace return sludge (increase and decrease the return sludge pump rate to be a constant percentage of the influent).

15. Nitrate Recycle Pumping: The plug flow processes require separate pumps to recycle nitrates from the end of the oxic zone to the head of the anoxic. Submersible pumps are often used, and given the restricted space in the building, probably the best choice here. They also should be powered by variable frequency drives so the pump rate can range up to 350% of the influent flow. Nitrate recycle pumps normally are flow paced except during wet-weather peak flows.

16. Aeration Blowers: Fine bubble air diffusers have at least double the oxygen transfer efficiency of coarse bubble diffusers and surface aerators, including those proposed with the VLR process. At first glance, doubling the efficiency should allow the existing blowers to serve the expanded plant, which would have double the capacity. They probably would not have enough capacity once the demands of nitrification are considered. Additional blower capacity would most likely be needed, but the process calculations would determine that. Depending on their age, the blowers may be due for replacement anyway.

17. Ultraviolet Disinfection: The chlorination system should be replaced with ultraviolet light disinfection, which is safer for the operations staff and effective disinfection. One caution is the operator mentioned the wastewater from the school often causes the influent to be colored. Color is one factor that can interfere with ultraviolet light transmittance, so the manufacturer should be consulted during design. Testing may be needed. While it was a mistake to put the chlorine contact tank inside, we would place the UV system in the building. The chlorine contact tank could be modified and the UV channel set in its place. The channel would be covered by aluminum checker plate to block the light and control humidity. This would make the room safe for continued use housing the electrical supply and controls.

18. Aerobic Digester: We agree that additional aerobic digestion is needed, and new concrete tanks should be built. The size needed would depend on the waste sludge production, which would be determined during design using the BioWin process model. For estimating purposes Millville, a 250,000 gpd WWTP, has 70,000 gallons of aerobic digester volume, so Lynn Township would need 45,000 gallons for the 160,000gpd capacity. Existing tanks are often converted to digesters when they are not well suited for the new process either because they are too small or the wrong shape. Because the existing aeration tanks are generously sized to serve as new plug-flow reactors, and the clarifier would remain in service, constructing new digesters makes the most sense here.

19. Reed Sludge Drying Beds: Insufficient information was provided to evaluate the reed beds. Doubling the capacity would seem logical, given the proposal to double the plants design ADF. We agree that the expanded plant would be the size where mechanical sludge dewatering is considered. For example Millville has a 0.6 meter-wide belt filter press, but then they take in septic tank waste from haulers and leachate, so they have a heavy sludge load.

20. Automated Controls: Nutrient removal requires a finer degree of process control than conventional secondary treatment and so automatic controls would be recommended as part of the plant expansion and upgrade. Programmable Logic Controllers, tied into Personal Computers. A Motor Control Center, the Emergency Generator, and a variety of field instruments, are networked to provide the operator with the ability to instantaneously respond to changing conditions.