DATA MANAGEMENT FOR BIOSOLIDS LAND APPLICATION.
THE PHILADELPHIA WATER DEPARTMENT EXPERIENCE

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ABSTRACT

The need for electronically-assisted data management for biosolids generators and land appliers is increasing at a rapid rate. Regulatory reporting requirements are more demanding, beneficial use programs are scrutinized by an ever-growing community of stakeholders, and time demands are driving the data management pressure cooker. This responsibility is most daunting for large land application programs containing many farms and fields.

The Philadelphia water Department (PWD) “Class B” biosolids recycling program contains 58 farms with more than 700 individual fields. Managing the data for this sizeable program is a considerable challenge. This presentation will review the evolution of data management strategies used by PWD to prescribe appropriate land application rates, document biosolids quality and field operations, and prepare required regulatory reports over the past 10+ years. Reports to the state environmental agencies will also be described.

KEYWORDS

data management, biosolids, land application, regulation, reporting, database, spreadsheet

BACKGROUND

The Philadelphia Water Department (PWD) manages a portion of their biosolids through an agricultural utilization beneficial use land application program. While this is one of several management methods, agricultural utilization remains an important outlet for PWD Class B biosolids cake. Other management outlets include producing a Class A compost for marketing and distribution, landfill disposal, and mine land reclamation. PWD places the greatest priority on those outlets classified as beneficial use.

Established for more than 30 years, agricultural use in Pennsylvania has always been a cornerstone of the PWD Class B biosolids management program. In addition to nutrient and organic matter recycling for soil quality enhancement and crop production, this program has been PWD’s most cost-effective. For example, today’s, land application is roughly one-third of the cost of landfill disposal in eastern Pennsylvania. In all, PWD currently land applies approximately 68,000 wet tons of biosolids cake (31% solids) annually to agricultural lands.
Agricultural land application recycling accounts for approximately 35% of all solids processed at the PWD Biosolids Recycling Center (BRC). The BRC solids from three wastewater treatment facilities with a combined total average daily flow of 450 MGD. The PWD is keenly sensitive to farmer concerns and needs and therefore keeps an agronomist on staff to oversee the activities of its land application contractor, who has responsibility for data management and reporting functions within the program.

**BIOSOLIDS REGULATORY EVOLUTION IN PENNSYLVANIA**

The Pennsylvania Department of Environmental Protection (DEP) has primary regulatory responsibility and oversight for biosolids management in Pennsylvania. Over the life of the biosolids land application program, the DEP regulations governing its conduct have changed considerably.

Pennsylvania’s first regulation, Title 25, Chapter 75 became effective in 1977 and required a site-specific operating permit, but no annual operations report. That regulation remained in effect until 1988 when a more stringent set of regulations, Chapter 275, was promulgated.

Chapter 275 required a site-specific permit and an Annual Operating Report describing application activities at each site. Chapter 275 was modified in July of 1994 in response to 40 CFR Part 503 to incorporate the concepts of Cumulative Pollutant Loading Rate (CPLR) for Class B biosolids and residual nitrogen carryover from previous biosolids applications. Site-specific permits for biosolids land application issued by DEP until 1997 had a ten-year maximum permit life. During the period spanning 1994 through 1997 Pennsylvania biosolids generators/land appliers were required to comply with both state (Chapter 275) and federal (Part 503) regulations.

Finally, Chapter 271 SubChapter J took effect in 1997 and launched Pennsylvania’s statewide General Permit program changing the focus of the permitting process from being site-specific to a focus on the material proposed for recycling (i.e. biosolids quality). Under this approach, land application sites for Class B biosolids need only be “qualified” (approved by DEP but not formally permitted) as being suitable to receive biosolids. In addition, public notice was required 30 days in advance of any application activity providing an opportunity for public comment. Although most land application sites are operating under Chapter 271 today, a few site-specific permits issued under Chapter 275 are in effect and will not all expire until 2007, at which time generators/appliers will be required to comply with the newer Chapter 271 regulations.

The PWD biosolids land application program is large in the range of industry programs. The management of the program however is made more complicated since available land application farm sites are largely small family-operated farms typically comprised of several small fields. In addition, animal agriculture is prevalent in the area making it common for farm operators to land apply animal residuals. In these cases, it is a particular challenge to make “room” for biosolids nutrients where an excess of plant nutrients may already exist on the farm.
The following graph shows the relative importance of the five major outlets for PWD’s total biosolids production that account for 89 to 97 percent of production, depending upon the fiscal year. For the past three years, Pennsylvania agricultural land application sites have provided the second largest outlet, following landfill disposal.

As of the end of fiscal year 2004, the PWD maintained 57 agricultural land application sites (individual farms) in Pennsylvania. Seventeen of the sites were operated under Chapter 275 site-specific permits, with the remaining 40 operated under the PWD Chapter 271 General Permit. The 57 farms represent nearly 4,100 acres of arable land with an average qualified cropland area of between 70 and 80 acres per farm. Notably, the average qualified individual field acreage on these farms is just over 4 acres. Accordingly, the PWD land application program under Chapter 271 includes over 700 individual fields.

REGULATORY REQUIREMENTS

Regulations governing the use and disposal of biosolids developed steadily beginning in the mid-70s. Chapter 75 took effect in 1977 although no permits were actually issued until 1980. This rule required an operating permit but did not require any kind of annual operating report. In order to demonstrate compliance with the Lifetime Loading Rate for cadmium, (which was limited to 3 pounds per acre or 3.37 kilograms per hectare), field level records detailing application rate and analytical data measuring the concentration of cadmium in biosolids was required. Nutrient application to fields receiving biosolids was not reported.

Chapter 275 imposed much more comprehensive analytical and reporting requirements. An Annual Operating Report was required detailing biosolids analytical results for the
calendar year (regulated pollutants and nutrients), Lifetime Loading Rate (essentially a precursor to and the same as CPLR) status of each field receiving biosolids (1988 to 1993) for six metal pollutants and agronomic loading rate based on total nitrogen content and an assumed biosolids nitrogen availability coefficient of 0.4 (1988 to 1993). (That is, 40% of the total nitrogen applied was assumed to be available for crop uptake). No additional nitrogen was assumed to be released from biosolids in subsequent years. Chapter 275 also focused on the actual metals measured in the soils and limits were established for soil metals. As a result, several PWD farm fields with background metal levels above the limits established by DEP were excluded from land application programs irrespective of the Lifetime Loading Rate status. It is important to understand that that the farm fields excluded had naturally occurring high levels of certain metals, particularly chromium derived from the soils parent material. In fact, about 60 years ago, chromium was mined in the area.

Table 1. Pennsylvania Biosolids Regulation and Regulated Pollutant Monitoring Requirement

<table>
<thead>
<tr>
<th></th>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Arsenic</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Cadmium</td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Chromium</td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Copper</td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Lead</td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Mercury</td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Molybdenum</td>
<td></td>
<td></td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Nickel</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Selenium</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Zinc</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>PCB</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
</tbody>
</table>

In July of 1994, Chapter 275 Guidance language was revised to bring regulatory terminology and a number of other requirements in line with the 40 CFR Part 503 regulation. Lifetime Loading Rate became the now familiar CPLR and the concept of residual nitrogen availability from biosolids applications entered the rule. To the dismay of many, DEP now required generators to keep CPLR records that would (for the first time) now include arsenic, mercury and selenium.

In some instances, assumptions based on then current and prior analytical reports had to be made concerning the concentrations of those metals to make the calculations. Importantly, the concept defined the requirement to calculate nitrogen availability contributions for two years beyond the year biosolids were actually applied. In addition, the residual nitrogen provision also carried with it a sub-concept of Crop Year for agronomic loading rate calculation as opposed to calendar year for pollutant application tracking and reporting. With this time juxtaposing provision, all biosolids applied in a calendar year were assumed to contribute to CPLR for that calendar year. However, some biosolids applications made in any calendar year were considered to be supplying...
nutrients for the subsequent Crop Year. In southeastern Pennsylvania, a Crop Year generally runs from August of the prior year through July of the current year.

An example is in order. A biosolids application made in March of 2005 for a corn crop to be planted in May of 2005 would have it’s pollutants reported in the 2005 DEP Annual Operating Report. Nutrient calculations would assume first year nitrogen availability be for calendar year 2005 and residual nitrogen for Crop Years 2006 and 2007. For a biosolids application made in November of 2005 for a corn crop to be planted in May of 2006 would have its pollutants reported in the 2005 DEP Annual Operating Report. For nutrient calculations, however, first year nitrogen availability would be considered to be during Crop Year 2006 and residual nitrogen for Crop Years 2007 and 2008. This accounting process confounds the DEP Annual Operating Report requirements and undoubtedly leads to reporting errors.

Chapter 271, effective in 1997, follows the essential requirements of Chapter 275, including pollutant calendar year reporting and Crop Year nutrient calculation reporting requirements, with one important exception. Under Chapter 271, measured soil baseline metal content would be considered to be a component of CPLR, a provision that actually ran contrary to 503. Chapter 271 also requires that CPLR be calculated for all Class B biosolids (also called “non-EQ”), unlike Part 503. This requirement applies even if biosolids meet the Table 3 pollutant limit standards in §271.914(b)(3) (the same as 503’s Table 3 for EQ biosolids).

Table 2. Summary of permitting and reporting requirements for Pennsylvania biosolids regulations 1977 to present

<table>
<thead>
<tr>
<th>Regulatory/Reporting Requirement</th>
<th>Chapter 75</th>
<th>Chapter 275</th>
<th>Chapter 271 SubChapter J.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operating Permit</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>Site Specific</td>
<td>Product Oriented</td>
<td></td>
</tr>
<tr>
<td>Annual Operating Report</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Lifetime Loading Rate</td>
<td>X¹</td>
<td>X²</td>
<td></td>
</tr>
<tr>
<td>Cumulative Pollutant Loading Rate (CPLR)</td>
<td>X³,4,5</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Nutrients</td>
<td>X⁶</td>
<td>X⁶</td>
<td></td>
</tr>
<tr>
<td>Crop Year Calculations</td>
<td>X⁷</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>PCB</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
</tbody>
</table>

1 For cadmium only.
2 For cadmium, chromium, copper, lead, nickel, and zinc
3 For cadmium, chromium, copper, lead, nickel, and zinc (1988 – 1993)
4 For arsenic, cadmium, chromium, copper, lead, mercury, nickel, selenium, and zinc (1994 – present)
5 In 2000, CPLR required to be updated retroactively beginning in 1980
Total nitrogen, organic nitrogen and ammonium nitrogen
For years beginning in 1993

PWD PAPER AND SPREADSHEET BASED SYSTEMS

The PWD data tracking and reporting system under Chapter 75 was paper-based and, given the reporting requirements, was comparatively simple and straight-forward although a bit tedious. In Bob Cratchit ledger-fashion, biosolids application detail to each farm field was maintained showing wet tons, biosolids moisture content and cadmium concentration, and the calculated cadmium loading rate in pounds per acre. It also showed the rolling calculation updating the Lifetime Loading Rate (LLR) for cadmium for each field at the end of each calendar year. Though the volume of information recorded by hand was substantial, this system could accurately track and maintain DEP required information.

With the advent of Chapter 275 requirements in 1988, it became apparent early on that the additional metal pollutants that needed to be tracked and calculations for nitrogen availability to meet calculated crop requirements made the already cumbersome paper-based system even more tedious. The volume of information required to be tracked increased by nearly an order of magnitude and any changes or errors rippled through the system like additional income in a federal income tax return. In addition, DEP now required an Annual Operating Report necessitating manual transfer of information from the ledger to approved DEP forms, yet another tedious process prone to error. In 1998, the PWD began using the spreadsheet-based system ‘BioArc’ developed by the engineering firm, Gannett Fleming, Inc., to address the more demanding data handling and reporting requirements. This system could clearly manage more easily and accurately the increased volume of information and greatly simplified information reporting to DEP. However, it soon became clear that this spreadsheet system would become a data ‘monster,’ as it did not have the ability to automatically store and retrieve data from year to year, making set-up for each new Crop Year a cumbersome process. The BioArc system was also limited in the number of fields it could handle (100 fields). Hence multiple copies of the application had to be maintained for each crop year due to the number of fields in the PWD program. Generation of annual regulatory reports from the multiple BioArc files made this process an organizational challenge.

With the demand to calculate and consider biosolids residual nitrogen on a Crop Year basis and the need to reconcile applied biosolids amounts with a parallel land application contractor spreadsheet system, the PWD spreadsheet system had met its Waterloo. Biosolids land application data had to be considered on both calendar year and Crop Year bases, a task that required a high degree of organization and proficiency with the Bio-Arc spreadsheet application.

In 2000, PWD elected to separate its biosolids land application data tracking and storage into two spreadsheet systems. Its land application contractor maintained data for calculation of agronomic loading rate on all farm fields from a Crop Year perspective using a custom-developed spreadsheet system. The PWD maintained BioArc for the purpose of tracking CPLR using application event data provided by the land application contractor from a calendar year basis. It was the contractor’s job to manually sort Crop
Year application event data into calendar year application event data for CPLR tracking. As might be expected, with the manual nature of some of the data handling procedures and the volume of data being handled, all in the context of having to meet a DEP Annual Operating Report deadline (March 15 of the year following the year being reported), errors in data entry were a problem. Identifying errors during or after the reporting operation was difficult due to the unlinked, unreferenced and manual data entry operations involved.

The information in Table 3 is intended to provide an estimate of the relative volumes of data tracked and required for regulatory reporting over time and under the three Pennsylvania regulations in force since 1977. The same data points have to be referenced or tracked for each program field (e.g. residual nutrients for the two previous years). Based on the number of data points tracked or referenced and the number of fields utilized by the program in any given year, the number of individual data points referenced or captured can be estimated as shown below.

**Table 3. Annual biosolids data points referenced or captured over time.**

<table>
<thead>
<tr>
<th>(1) Regulation</th>
<th>(2) Nutrients</th>
<th>(3) Residual nutrient years</th>
<th>(4) APLR</th>
<th>(5) LLR or CPLR</th>
<th>(6) Fields Used</th>
<th>(7) Data points referenced or captured annually</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chapter 77 (1977)</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>125</td>
<td>250</td>
</tr>
<tr>
<td>Chapter 275 (1988)</td>
<td>1</td>
<td>0</td>
<td>6</td>
<td>6</td>
<td>170</td>
<td>2,210</td>
</tr>
<tr>
<td>Chapter 275 (1994)</td>
<td>2</td>
<td>2</td>
<td>9</td>
<td>6</td>
<td>230</td>
<td>4,370</td>
</tr>
<tr>
<td>Chapter 271 (1997)</td>
<td>2</td>
<td>2</td>
<td>9</td>
<td>9</td>
<td>500</td>
<td>9,500</td>
</tr>
</tbody>
</table>

1 Calculated by summing columns 2 to 5 and multiplying by the value in column 6. Does not include other nutrient sources data.

To further complicate data handling matters, the PWD had a policy of using a 12-month moving average for calculating agronomic loading rates and pollutant application rates. Updating the analytical data referenced for specific application events involved routine manual changes in spreadsheet formulas/calculations. Once those changes were implemented, going ‘back’ to look at historical calculations required another manual operation to reestablish the data references made in the earlier calculations. The potential for operator error when making such changes are clear and understandable.

As noted earlier, data was being entered and stored in parallel spreadsheet systems to accommodate Crop Year calculations and calendar year reporting. For the purposes of reporting data accurately, the amounts of biosolids contained in both spreadsheet systems had also to be reconciled. Reconciliation turned out to be a very difficult operation and one where errors or disparities were difficult to accurately identify and rectify.
SPREADSHEET DATA MANAGEMENT SYSTEM LIMITATIONS

Spreadsheets are not intended or designed to handle or store large volumes of data. They are intended to perform repetitive calculations using (compared to today’s relational database platforms) limited sheet:cell linkage and referencing. With that perspective and the benefit of specific PWD experience in using the parallel spreadsheet systems for biosolids data management, the following data management issues were identified:

1. Spreadsheets are essentially ‘flat file’ systems that cannot readily take advantage of complex data relationships and references. This limitation is the fundamental reason for having to enter the same data repetitively and having to store data in cells used for referenced calculations and data value referencing. This feature is also the reason why spreadsheets become large quickly and can expand beyond the normal ‘view’ of users. The requirement to enter data repetitively also makes producing data/information reports cumbersome and time-consuming. Using pull-down lists and spreadsheet Lookup functions mitigates this issue to some degree, but if changes need to be made lists or Lookups, specialized assistance may be required.

2. Because data from the same recordset source has to be referenced for calendar year CPLR and Crop Year residual nitrogen considerations, referencing by single application event date becomes complex.

3. Looking at historical data becomes difficult because of the need to ‘reuse’ data cells once the time capacity of the spreadsheet system is reached. To archive data electronically for later viewing requires storing whole spreadsheet systems in separate files. If this approach is taken, data entry cells have to be manually ‘refreshed’ to begin a new reporting time period and references have to be established to out-of-time-range data contained in separate files for residual nitrogen. CPLR has to be brought forward manually into the new system.

4. If an individual field is inactive (no biosolids applications) beyond the time capacity of the spreadsheet system, a manual review and operation is required to carry its CPLR values forward to a new system.

5. When fields are subdivided, a complete new recordset for the new fields must be entered and provisions for the new smaller fields starting residual nitrogen and CPLR accommodated.

6. While not necessarily the case for PWD, multiple sources with different characteristics, produced by different processes vastly complicates the nitrogen availability and residual nitrogen calculations. Accommodations must be made manually to capture the metals applications/calculations from more than one source on the same field.

7. Handling changing cropping input data for agronomic rate calculations is cumbersome and may require manual changes to analytical data references and formulas for calculations as a function of the date the change is being made.
8. Changing regulatory calculation protocols requires modifications to formulas and references in several locations. The changes must be made to each location manually and in the BioArc system, the number of changes required were numerous.

9. The limited flexibility and structure of the spreadsheet system makes developing a system to present information to the public, especially over the internet, nearly impossible. Report formatting limits exacerbates this function.

DATA MANAGEMENT FOR COMPLEX SYSTEMS; THE RELATIONAL DATABASE SOLUTION

The issues associated with the spreadsheet system, especially with the forced requirement for the parallel systems in 1994, resulted in PWD seeking out an alternative approach to data management. The interest in an alternative increased with each year of frustration with systems operations and concerns over data integrity, the potential for human error, reporting issues, and data archiving/historical concerns. In 2004, PWD identified a relational database (RDBMS) application, Material Manager™, specifically designed for biosolids data management and regulatory reporting. The database was developed on a Microsoft Access platform and coded using Visual Basic for Applications (VBA). Coding with VBA enhances basic Access system error handling and notification while increasing its calculation and reporting functions.

The Material Manager™ system has addressed each of the spreadsheet system limitations and is designed to be user-friendly and, for biosolids managers, an intuitive and comprehensive biosolids program data management tool.

1. The massive ‘flat table’ or complex spreadsheet referencing and linkage structure is eliminated. Data is stored in several linked data tables and then ‘called’ for during calculations and reporting through a querying process that selects (filters and sorts) only that data required for the calculation or report. This feature is the essential difference between spreadsheet and RDBMS systems and is the source of RDBMS data management power and flexibility. Data that is common and/or essentially unchanging over time is entered into the system only once and then may be used for multiple reports/calculations for any time period from that one entry point. Utilizing a separate data table system also helps greatly to keep data storage relatively small. As an illustration, once Farm and Field Information is entered into Material Manager™, it is used for all functions and, if modification is necessary (e. g. address or owner changes), the record is easily and quickly presented in a data entry form for editing. Essentially no additional information has been stored. PWD no longer has to set up a new tracking and reporting system for each new reporting year nor does it have to manually carry CPLR and carryover nitrogen values forward to a new system.

2. Data is easily labeled and referenced in multiple ways for use in different calculations and reports. For example, a biosolids application event occurring on November 29, 2005 can be labeled as being a 2006 Crop Year event for nutrient calculations and as a 2005 event for calendar year CPLR reporting. The temporal reporting function that is quite complex for spreadsheet systems is easily and simply addressed by a
RDBMS. The same principle applies allowing biosolids managers to apply more than one biosolids source to a field in any given Crop Year and still accurately calculate and track that field’s CPLR and residual nitrogen status. **PWD no longer has to reconcile a CPLR spreadsheet system and a residual nitrogen spreadsheet system.**

3. Data selection queries, calculations and report templates are created only once for the system and exist separately from the data tables. Formulas and other functions are entered only once and may be referenced by any report from within the system. Uniformity and accuracy are ensured and the effort required to change formulas, functions and report templates is greatly simplified. Material Manager™ also greatly simplifies the entry of variables required for calculations and functions. For example, when agronomic loading rates are calculated and other nutrient sources will be applied to the same field (e.g. animal manure or chemical fertilizer), values for those other sources is easily collected by the agronomic loading rate data entry form and included in calculations. In addition, the RDBMS also ‘remembers’ which set of analyticals (in PWD’s case, which set of twelve analyticals comprise the average pollutant and nutrient values) used in calculations for current year nutrient availability calculation, residual nutrient calculation and to accurately track and update each field’s CPLR. **PWD can reference any time period for any tracked information without having to switch among archived spreadsheet systems.**

4. The instance where a field is inactive for more than the time capacity of the spreadsheet for CPLR, the Material Manager™ RDBMS has no such constraint. This is again a function of storing data separately in linked data tables and then having the system reference data based upon an identifier (e.g. ‘Event Date’) rather than a physical location (cell) within a spreadsheet. **When PWD ‘reactivates’ a field for biosolids application, it no longer has to search through archived spreadsheet systems to find the last CPLR value calculated.**

5. When fields are subdivided, an RDBMS system easily handles the change requiring the user only to enter new subunit field information (field 1 becomes fields 1A and 1B) and referencing field 1 CPLR and residual nitrogen as starting values for the two ‘new’ fields. The original field is then effectively ‘closed’ as will no longer referenced for future calculations or report but can be referenced for historical data review when required. In the PWD data management system, fields are ‘closed’ and sub-field units created numerous times each year. **PWD no longer has to reformat the structure of their spreadsheet system to add rows, formulas and references to accommodate the addition of new or divided fields.**

6. Material Manager™ provides near-real time information describing the nutrient and pollutant status of each farm field. As soon as a biosolids application event is entered into the system, reports can be generated to show status that includes all application events in the system. This feature greatly reduces the chance that an over-application of either nutrients or pollutants will occur. While over-applications were not necessarily common or egregious under the old data management system, any over-application event in Pennsylvania is subject to a DEP-issued Notice of Violation. **By entering its application event information in one form, PWD can receive an instant update of CPLR and field Crop Year nutrient status for any and all fields.**
7. Finally, with the increasing importance of EMS among biosolids agencies, the Material Manager℠ RDBMS provides an easy interface with web-enabled applications designed to provide a public view of selected information. The nature of data selection in an RDBMS ensures that it will always present the most current data and provides for any number of ‘canned’ data views the public may want to see and, at the same time, controls outside viewer access to data. Should PWD choose, they have a ready mechanism to establish a system to share information with the public or regulatory agencies without the need for PWD staff intervention.

THE MATERIAL MANAGER℠ SYSTEM OPERATION

The PWD implemented the Material Manager℠ system in June 2004 by contracting with Material Matters, Inc. to provide data management services. Material Matters collected all required data to setup the system from the PWD and its land application contractor, Mobile Dredging & Pumping. Some data was available in electronic format but most had to be transcribed from paper. To collect, confirm and enter all the data required, dating back to calendar and Crop Year 2003, took Material Matters almost 4 months.

The Material Manager℠ system is housed on a personal computer at the PWD Biosolids Recycling Center, is maintained by Material Matters and is accessible via the internet or the PWD Extranet by all interested parties (with network permission) regardless of physical location and on a 24/7 basis. System updates and maintenance are performed remotely by Material Matters. Software and hardware requirements are nominal.

Samples of the types of reports that the Material Manager℠ system provides are shown in several figures at the end of this discussion. Figures 2 and 3 show the main system and agronomic loading rate control forms, respectively. These figures illustrate the ‘point and click’ functionality of the Material Manager℠ system. Figures 4 provide a sample illustration of the most commonly generated report, the agronomic loading rate calculation (Material Manager℠ system ‘Prescription’) and the detail provided that has proven to be useful to both managers and field operations personnel. Figure 5 shows an example of the CPLR calculation detail report that is required in the Pennsylvania Annual Operating Report for Class B biosolids under the PAG-08 General Permit.

Material Manager℠ system reports are generated at will for information viewing but may also be archived electronically for reference by those not having Microsoft Access software or as another means of preserving data. Electronic archiving may be accomplished by publishing the reports in Microsoft Word, pdf, or Microsoft SnapShot file formats. Most users archiving reports electronically will use one the two latter file formats since they are ‘image’ files whose text cannot be altered once published.

CONCLUSION

The PWD operates a large and complex biosolids management system utilizing several outlets for wastewater treatment solids. The complexities of the management system and regulatory data tracking and reporting requirements quickly overwhelmed even sophisticated spreadsheet-based data management systems.
The myriad of issues the PWD faced with the spreadsheet-based system have all been addressed by the RDBMS system Material Manager\textsuperscript{sm} giving the PWD greater confidence in its reported data and information. Beyond having a more robust data management system, the PWD also saves a significant amount of time in calculating agronomic loading rates and CPLR. What had been at least a part-time but two-person data management system using the spreadsheet system is now a reduced part-time one-person operation. Reporting information has become a matter of a ‘click of a button’ for the DEP Annual Operating Report and perhaps represents the greatest time savings and produces reports that are error-free.

The following is a summary of operational and data handling benefits the PWD has realized using the Material Manager\textsuperscript{sm} system:

1) entity or event data is entered only once – ever. Once data is entered it can be referenced by any Material Manager\textsuperscript{sm} system function from any point in time.
2) One comprehensive system handles information, calculations and reports for PWD solids production, monthly disposal/utilization, and land application management and reporting. All reports are produced at the click of a button.
3) All users are able to customize the data or information that is viewed using Material Manager\textsuperscript{sm} system advanced data selection, sorting and filtering capabilities. All selection criteria are chosen from pull-down menus and assist users to focus on the data or information issue of immediate interest.
4) Complex carryover nitrogen and CPLR calculations and tracking are now entirely automated.
5) Several custom reports have been added to the Material Manager\textsuperscript{sm} system enhancing its information value to the PWD. Information not previously available is now viewable by several users on a near real-time basis.

In addition to the PWD experience described above, Material Manager\textsuperscript{sm} has recently added monthly solids production and solids end use (DMR) ‘one-button click’ reporting. It also now has the capability of storing and presenting farm (application site) map images for reference while viewing farm and field information.
Figure 2. The main Material Manager™ information management control panel.

Figure 3. The Material Manager™ loading rate calculation ‘Prescription’ control panel
Figure 4. Material Manager™ sample loading rate calculation ‘Prescription’ report.

Biosolids Annual Agronomic Loading Rate
Land Applier’s Report (N)

<table>
<thead>
<tr>
<th>Field</th>
<th>Crop Year</th>
<th>Size</th>
<th>Crop 1</th>
<th>Crop 2</th>
<th>Yield Goal</th>
<th>Yield Goal</th>
</tr>
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<tbody>
<tr>
<td>A1</td>
<td>2005</td>
<td>5.2 acre</td>
<td>Wheat, grain</td>
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<td>75 bu/A</td>
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<td>Ankrum</td>
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<td></td>
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<td>Source</td>
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<tr>
<td>P:</td>
<td>2.42%</td>
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</table>

The P Index has not been evaluated for this field/crop/year. Current regulations specify N-based nutrient management.

NH4N: 0.38%
OrgN: 3.40%
K: 0.16%

1. Total crop nitrogen
   lb/acre
   1  75.0

2. Nitrogen provided from other sources either added to or mineralized in the soil
   a. Nitrogen contributions from previous years' activities
      1 N from previous legume crop
         lb/acre
         0.0
      2 Estimate of available N from previous biosolids applications
         lb/acre
         12.3
      3 Estimate of available N from historical manure applications
         lb/acre
         0.0
      Greater of either a.1. or (a.2. + a.3.)
      OR:
      Sum of (a.1. + a.2. + a.3.)
      (If previous legume crop was alfalfa, red clover, trefoil, or other forage legume)
      2a  12.3
      lb/acre
   b. Nitrogen contributions from current years' activities
      1 Estimate of available N from current manure application
         lb/acre
         0.0
      2 N from chemical fertilizers
         lb/acre
         0.0
      3 N from other sources (ex. food processing waste)
         lb/acre
         0.0
      4 N from biosolids applications this crop year
         lb/acre
         41.2
      Sum of (b.1. + b.2. + b.3. + b.4.)
      lb/acre
      2b  41.2
      lb/acre
      Sum of (2a. + 2b.)
      lb/acre
      2  53.5

3. Adjusted nitrogen requirement (Subtract 2 from 1)
   lb/acre
   3  21.5

4. Total available Nitrogen from biosolids (based on biosolids analysis)
   a. NH4-N
      lb/ton NH4-N
      4a  3.6
   b. Org-N
      lb/ton Org-N
      4b  13.6
   Total plant available nitrogen (PAN) from biosolids (4a. + 4b.)
   lb/ton PAN
   4  17.2

5. Calculate the agronomic rate for biosolids application (Divide 3 by 4)
   DT/acre
   5  1.3

6. Calculate amount of biosolids to be applied
   WT/acre
   6  4.1

7. P2O5 and K2O fertilizer equivalent in biosolids
   a. P2O5
      lb/ton
      110.8
   b. K2O
      lb/ton
      3.8

% TS (Predictive) used to generate this agronomic loading rate:
(Enter this in the Biosolids Application Log under %TS (Predictive)).

30.52 %
### Cumulative Pollutant Loading Rate Summary Worksheet

The average of 12 analyses is used for metals calculations.

**Farm Name:**

**Calendar Year:** 2005

<table>
<thead>
<tr>
<th>Field</th>
<th>Acre</th>
<th>DT/A</th>
<th>Limit (lbs/A):</th>
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<tbody>
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<tr>
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<tr>
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<tr>
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<tr>
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<table>
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<tr>
<th>Appl. Rate</th>
<th>As (lb/A)</th>
<th>Cd (lb/A)</th>
<th>Cr (lb/A)</th>
<th>Cu (lb/A)</th>
<th>Pb (lb/A)</th>
<th>Hg (lb/A)</th>
<th>Mo (lb/A)</th>
<th>Ni (lb/A)</th>
<th>Se (lb/A)</th>
<th>Zn (lb/A)</th>
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NR = Not Require