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Marcellus Shale Gas Development
A Summary of Marcellus Wastewater Treatment and Disposal
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A Summary of Marcellus Wastewater Treatment and Disposal

Introduction

Perhaps the greatest controversy associated with the development of Marcellus shale gas is “fracking\(^1\)” a practice required to allow the economic recovery of natural gas from the tight Marcellus shale. Fracking injects large quantities (say 4 to 5 million gallons) of water\(^2\) into a newly drilled gas well under very high pressure, in segments of the horizontal portion of the well. The target zone geologic formation fractures (cracks open) and a “proppant” is injected with the water to keep the fractures open\(^3\). When the pressure is released “frac” water flows back out of the well in a volume of about 15 to 30 percent of the water injected into the formation and the well continues to produce “production” water over its operating life.

While ‘frac’ water is the focus of popular interest and has become a popular term representing all the waters flowing from a well, the development of Marcellus Shale gas wells actually produces a variety of liquid and solid wastes, in addition to the aforementioned frac and production water, including those from drilling, grouting, testing, and completion operations, and from pipeline installation. The liquid wastes are collectively known as Marcellus Shale wastewater (MSW) and are frequently mixed at treatment and final disposal sites. All of these wastewaters require some level of treatment prior to reuse, final disposal\(^4\), or discharge. This Summary of Marcellus Wastewater Treatment and Disposal focuses on the facilities that so process the wastewaters produced by Marcellus shale gas development and the practices they employ.

For the purposes of this report, the term “wastewater” means any waste which has not been discharged to the atmosphere and which is not a solid waste. This definition includes wastewaters that are heavily laden with solids materials. During the writing of this report, the distinction between wastewater and

\(^1\) Fracking or frac is short for fracturing.
\(^2\) In Midwestern Canada frac using propane has been demonstrated.
\(^3\) Similar to timbers in a coal mine.
\(^4\) Injection in Class 2 disposal wells may require minimal treatment.
solid waste has migrated to include very high solids containing wastewaters. Also, the distinction between the wastewater and solid waste was clarified by the Pennsylvania Department of Environmental Protection (DEP) which has recently developed a practical definition of solid waste which relates to passing the “paint filter test” required for delivery of solid waste to a landfill. This expands the definition of wastewater to include any wastes that have sufficient free water in them to fail the paint filter test. For treatment facilities operating under the recently revised WMGR 123, the definition also includes wastewater generated from the construction of transmission facilities.

**Marcellus Waste Generation**

Beginning with calendar year 2011 data, the DEP began to publish detailed summaries of the generation and fate of wastes generated by Marcellus well drilling and operation. The more current data were published in April 2012 for the period of the last six months of 2011. That data posted at: https://www.paoilandgasreporting.state.pa.us/publicreports/Modules/DataExports/DataExports.aspx report that seven different types of wastes were generated in thirty-one Pennsylvania counties by 49 gas companies. The wastes were disposed of at 112 different facilities in five states.

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6 The revised WMGR 123 issued March 20, 2012 can be found at: http://files.dep.state.pa.us/Waste/Bureau%20of%20Waste%20Management/WasteMgtPortalFiles/SolidWaste/Residual_Waste/GP/WMGR123.pdf

7 They are: brine, frac fluid, drill cuttings, spent lubricants, flowback fracturing sand, drilling fluids, basic sediment


The data shows that the average daily volumes\textsuperscript{12} of the seven (7) different wastes reported to DEP were as follows:

<table>
<thead>
<tr>
<th>Type of Waste</th>
<th>Daily Volume</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brine</td>
<td>27,622</td>
<td>barrels\textsuperscript{12}</td>
</tr>
<tr>
<td>Frac Fluid</td>
<td>65,298</td>
<td>barrels</td>
</tr>
<tr>
<td>Drill Cuttings</td>
<td>2,612</td>
<td>tons</td>
</tr>
<tr>
<td>Spent Lubricants</td>
<td>8.6</td>
<td>barrels</td>
</tr>
<tr>
<td>Flowback Fracturing Sands</td>
<td>69.8</td>
<td>tons</td>
</tr>
<tr>
<td>Drilling Fluids</td>
<td>28,089</td>
<td>barrels</td>
</tr>
<tr>
<td>Basic Sediment</td>
<td>5.8</td>
<td>barrels</td>
</tr>
</tbody>
</table>

And that the ultimate disposal methods were:

<table>
<thead>
<tr>
<th>Disposal Method</th>
<th>Daily Volume</th>
<th>Units</th>
<th>Number of Facilities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brine or Industrial Wastewater Treatment Facility</td>
<td>77,304 barrels</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Injection Wells</td>
<td>9,994 barrels</td>
<td></td>
<td>42 of which 5 were in WV, 3 in PA, and 34 in Ohio</td>
</tr>
<tr>
<td>Landfill</td>
<td>2,710 tons</td>
<td></td>
<td>32</td>
</tr>
<tr>
<td>Landfill\textsuperscript{14}</td>
<td>8.6 barrels</td>
<td></td>
<td>4</td>
</tr>
<tr>
<td>Publicly Owned Treatment Plant</td>
<td>69.8 tons</td>
<td></td>
<td>2\textsuperscript{15}</td>
</tr>
<tr>
<td>Stored, Ultimate Disposal Method Not Determined\textsuperscript{16}</td>
<td>37.8 barrels</td>
<td></td>
<td>Not Applicable</td>
</tr>
<tr>
<td>Reuse Other Than Spreading\textsuperscript{17}</td>
<td>33,611 barrels</td>
<td></td>
<td>Not Applicable</td>
</tr>
</tbody>
</table>

\textsuperscript{10} And while there are 128 different entries on the list, only 112 appear to be separate and distinct facilities with the difference being explained by inconsistencies in referring to the same facilities and typographic errors.
\textsuperscript{11} Pennsylvania, West Virginia, Ohio, Maryland, and New York.
\textsuperscript{17} Assuming the data covered 182 days. Work day volumes would be 7/5 (no weekend work) or 7/6 (includes Saturday as a work day) of the results reported.
\textsuperscript{13} A barrel is 42 gallons, so multiply Daily Volumes by 42 to convert to gallons/day. For example, 65,298 barrels of Frac Fluid produced/day is 2,742,500 gallons/day.
\textsuperscript{14} It is assumed that all of this material was solidified at the landfill before final disposal, but may be misreported.
\textsuperscript{15} Reynoldsville and Johnstown
\textsuperscript{16} It is not known if any of the materials reported here were subsequently disposed of by another method and so reported.
\textsuperscript{17} Probably for the next frac.
Wastewater Characteristics

MSW varies in characteristic truck by truck, site by site, company by company, by time since the well was drilled and began producing, and geographically. A typical MSW contains widely varying amounts of sand and gravel, oil and grease, dissolved and suspended solids containing multi-valence cations like iron, manganese, thorium, barium, strontium, radium, calcium, and magnesium, and single-valence cations like sodium. A typical range of constituents is set forth below:

Typical Flowback Water Analysis at Marcellus Shale (Source: Blauch, et al., SPE 125740, '09)

<table>
<thead>
<tr>
<th>Constituent</th>
<th>Low</th>
<th>Medium</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>6.22</td>
<td>5.98</td>
<td>5.88</td>
</tr>
<tr>
<td>Alkalinity (HCO3-Only in mg/L of CaCO3)</td>
<td>280</td>
<td>240</td>
<td>200</td>
</tr>
<tr>
<td>Cl-, mg/L</td>
<td>54,000</td>
<td>62,900</td>
<td>67,800</td>
</tr>
<tr>
<td>SO42-, mg/L</td>
<td>31</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>Na+, mg/L</td>
<td>26,220</td>
<td>31,810</td>
<td>35,350</td>
</tr>
<tr>
<td>K+, mg/L</td>
<td>1,119</td>
<td>1,350</td>
<td>1,480</td>
</tr>
<tr>
<td>Ca2+, mg/L</td>
<td>7,160</td>
<td>9,720</td>
<td></td>
</tr>
<tr>
<td>Mg2+, mg/L</td>
<td>341</td>
<td>488</td>
<td>805</td>
</tr>
<tr>
<td>Ba2+, mg/L</td>
<td>28.9</td>
<td>99.6</td>
<td>175.7</td>
</tr>
<tr>
<td>Sr2+, mg/L</td>
<td>1,110</td>
<td>1,513</td>
<td>1,387</td>
</tr>
<tr>
<td>Fe3+, mg/L</td>
<td>0.4</td>
<td>1.1</td>
<td>3.3</td>
</tr>
<tr>
<td>Fe Total, mg/L</td>
<td>63</td>
<td>72</td>
<td>78</td>
</tr>
<tr>
<td>TSS, mg/L</td>
<td>144</td>
<td>498</td>
<td>502</td>
</tr>
<tr>
<td>Langelier Index</td>
<td>1.02</td>
<td>0.72</td>
<td>0.55</td>
</tr>
<tr>
<td>Microbial Count</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
</tr>
</tbody>
</table>

Another data set:

<table>
<thead>
<tr>
<th>Constituent</th>
<th>Low (mg/L)</th>
<th>Medium (mg/L)</th>
<th>High (mg/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ba</td>
<td>2,300</td>
<td>3,310</td>
<td>4,700</td>
</tr>
<tr>
<td>Ca</td>
<td>5,140</td>
<td>14,100</td>
<td>31,300</td>
</tr>
<tr>
<td>Fe</td>
<td>11</td>
<td>52</td>
<td>134</td>
</tr>
<tr>
<td>Mg</td>
<td>438</td>
<td>938</td>
<td>1,630</td>
</tr>
<tr>
<td>Mn</td>
<td>2</td>
<td>5</td>
<td>7</td>
</tr>
<tr>
<td>Sr</td>
<td>1,390</td>
<td>2,100</td>
<td>6,830</td>
</tr>
<tr>
<td>Hardness (as CaCO3)</td>
<td>17,900</td>
<td>49,400</td>
<td>90,337</td>
</tr>
<tr>
<td>Radioactivity</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
</tr>
<tr>
<td>TDS</td>
<td>69,400</td>
<td>175,600</td>
<td>248,000</td>
</tr>
</tbody>
</table>
Any individual sample\textsuperscript{18} might well be within the ranges cited or might not be. A simple summary would be to state that MSW contains oil and grease, other organics, dissolved and colloidal metals, hardness, and salt as well as settleable solids like drill cuttings and mud, sand, and gravel. The contaminants in MSW together with the intended fate of the MSW define, in large part, the treatment steps required.

\textsuperscript{18} Care is required in technique to obtain a representative sample.
Chemicals Used by Hydraulic Fracturing Companies in Pennsylvania

DEP has reported the following chemicals can be added to make a frac water.
<table>
<thead>
<tr>
<th>Chemical</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1,2,4-Trimethylbenzene</td>
<td>Glycol Ethers (includes 2BE)</td>
</tr>
<tr>
<td>1,3,5 Trimethylbenzene</td>
<td>Guar gum</td>
</tr>
<tr>
<td>2,2-Dibromo-3-Nitrilopropionamide</td>
<td>Hemicellulase Enzyme</td>
</tr>
<tr>
<td>2,2-Dibromo-3-Nitrilopropionamide</td>
<td>Hydrochloric Acid</td>
</tr>
<tr>
<td>2-butoxyethanol</td>
<td>Hydrotreated light distillate</td>
</tr>
<tr>
<td>2-Ethylhexanol</td>
<td>Hydrotreated Light Distilled</td>
</tr>
<tr>
<td>2-methyl-4-isothiazolin-3-one</td>
<td>Iron Oxide</td>
</tr>
<tr>
<td>5-chloro-2-methyl-4-isothiazolin-3-one</td>
<td>Isopropanol</td>
</tr>
<tr>
<td>Acetic Acid</td>
<td>Isopropyl Alcohol</td>
</tr>
<tr>
<td>Acetic Anhydride</td>
<td>Kerosine</td>
</tr>
<tr>
<td>Acie Pensurf</td>
<td>Magnesium Nitrate</td>
</tr>
<tr>
<td>Alcohol Ethoxylated</td>
<td>Mesh Sand (Crystalline Silica)</td>
</tr>
<tr>
<td>Alphatic Acid</td>
<td>Methanol</td>
</tr>
<tr>
<td>Alphatic Alcohol Polyglycol Ether</td>
<td>Mineral Spirits</td>
</tr>
<tr>
<td>Aluminum Oxide</td>
<td>Monoethanolamine</td>
</tr>
<tr>
<td>Ammonia Bifluoride</td>
<td>Naphthalene</td>
</tr>
<tr>
<td>Ammonia Bisulfite</td>
<td>Nitrilotriacetamide</td>
</tr>
<tr>
<td>Ammonium chloride</td>
<td>Oil Mist</td>
</tr>
<tr>
<td>Ammonium Salt</td>
<td>Petroleum Distillate Blend</td>
</tr>
<tr>
<td>Ammonia Persulfate</td>
<td>Petroleum Distillates</td>
</tr>
<tr>
<td>Aromatic Hydrocarbon</td>
<td>Petroleum Naphtha</td>
</tr>
<tr>
<td>Aromatic Ketones</td>
<td>Polyethoxylated Alkanol (1)</td>
</tr>
<tr>
<td>Boric Acid</td>
<td>Polyethoxylated Alkanol (2)</td>
</tr>
<tr>
<td>Boric Oxide</td>
<td>Polyethylene Glycol Mixture</td>
</tr>
<tr>
<td>Butan-1-01</td>
<td>Polysaccharide</td>
</tr>
<tr>
<td>Citric Acid</td>
<td>Potassium Carbonate</td>
</tr>
<tr>
<td>Crystalline Silica: Cristobalite</td>
<td>Potassium Chloride</td>
</tr>
<tr>
<td>Crystalline Silica: Quartz</td>
<td>Potassium Hydroxide</td>
</tr>
<tr>
<td>Dazomet</td>
<td>Prop-2-yn-1-01</td>
</tr>
<tr>
<td>Diatomaceous Earth</td>
<td>Propan-2-01</td>
</tr>
<tr>
<td>Diesel (use discontinued)</td>
<td>Propargyl Alcohol</td>
</tr>
<tr>
<td>Diethylbenzene</td>
<td>Propylene</td>
</tr>
<tr>
<td>Doclecybenzene Sulfonic Acid</td>
<td>Sodium Ash</td>
</tr>
<tr>
<td>E B Butyl Cellosolve</td>
<td>Sodium Bicarbonate</td>
</tr>
<tr>
<td>Ethane-1,2-diol</td>
<td>Sodium Chloride</td>
</tr>
<tr>
<td>Ethoxlated Alcohol</td>
<td>Sodium Hydroxide</td>
</tr>
<tr>
<td>Ethoxylated Alcohol</td>
<td>Sucrose</td>
</tr>
<tr>
<td>Ethoxylated Octylphenol</td>
<td>Tetramethylammonium Chloride</td>
</tr>
<tr>
<td>Ethylbenzene</td>
<td>Titanium Oxide</td>
</tr>
<tr>
<td>Ethylene Glycol</td>
<td>Toluene</td>
</tr>
<tr>
<td>Ethylhexanol</td>
<td>Xylene</td>
</tr>
<tr>
<td>Ferrous Sulfate Heptahydrate</td>
<td>Glutaraldehyde</td>
</tr>
<tr>
<td>Formaldehyde</td>
<td></td>
</tr>
</tbody>
</table>
Not all of these chemicals will be added to every frac.

The fate of the chemicals added to make frac water is not well reported\textsuperscript{19}. It can be assumed that the high heat and pressure prevailing in a horizontal Marcellus well together with other physical and chemical factors result in many of the chemicals added to a frac being consumed or converted in the fraccing process or retained in the target formation. Further, because frac water chemicals represent a measurable cost in the development of the well, it is assumed that excessive chemical amounts, amounts more than needed to accomplish the intended purpose, are not routinely added. Further, it is interesting to note that used frac water laboratory analyses are typically expressed as shown in the previous tables on an elemental or wastewater characteristic basis and not in terms of the specific organic chemicals noted above. For example, the presence of ethylene glycol in water returned from a frac job would more likely be reported as chemical oxygen demand (COD) than as ethylene glycol.

**History of MSW Treatment in Pennsylvania**

Pennsylvania has a long history of gas well development. A total of 375,000\textsuperscript{20} gas wells have been drilled in Pennsylvania beginning in the middle of the 19\textsuperscript{th} Century. They all produce varying amounts of water, called produced or production water, during their operating lives. Beginning in the mid-1950’s\textsuperscript{21} fracturing became increasing popular in vertical wells. With the development of horizontal drilling the gas locked in Marcellus shale vertical fractures could be economically produced. The first modern Marcellus well was drilled in 2004, but long before that, when the lower Oriskany Sandstone was being developed in the 1950’s, it was known that the Marcellus contained gas.

For many years the brines produced in Pennsylvania’s vertical\textsuperscript{22} gas wells have been treated at a few Centralized Wastewater Treatment Plants (CWT’s) like those owned by Pa Brine, at Publicly Owned Treatment Works (POTW’s) like the sewage treatment plants in New Castle, Clearfield, and Brockway,

\textsuperscript{19} See \url{http://www.nwri-usa.org/documents/A6Dempsey2011NOM.pdf} for a discussion of organics in the frac flowback.

\textsuperscript{20} Governor’s Marcellus Shale Advisory Commission

\textsuperscript{21} Source: \url{http://geology.com/energy/world-shale-gas/}

\textsuperscript{22} The term “shallow well” is frequently used to identify non-Marcellus wells, but some of the formations tapped by these “shallow wells” are very deep, even deeper than the Marcellus.
and by transport to Class 2 disposal wells in Ohio. By 2008 as gas prices peaked, Marcellus exploration
ramped up and MSW treatment and disposal came to the forefront. Existing treatment disposal options
were initially utilized, but with much well drilling occurring in geographic areas not then currently
producing natural gas, soon new POTW’s like the sewage treatment plant in Jersey Shore began to
accept MSW by truck and numerous proposals for treatment and CWT’s like TerrAqua Resource
Management were developed. Industrial wastewater treatment plants like Sunbury Power began to
accept MSW.

The fall of 2008 was a dry period and as flow decreased in the Monongahela River total dissolved solids
measurements increased to or beyond maximum acceptable limits. Also, at about the same time the
DEP received numerous permit proposals for treatment and discharge CWT’s, particularly on the West
Branch of the Susquehanna. DEP reacted in 2009 by issuing a policy in April which effectively halted
proposals for new treatment and discharge facilities by requiring a very high level of total dissolved
solids (TDS) removal and by adopting new regulations which were enacted in 2010. Finally, in 2011 with
Governor Corbett’s approval, DEP asked treatment plants\(^{23}\) that had been accepting MSW to stop by
May 19\(^{24}\). As of this writing it is reported\(^{25}\) that all have stopped receiving MSW and that only the legacy

\(^{23}\) Clairton City Municipal Authority and McKeesport City Municipal Authority, both in Allegheny County;
Johnstown Redevelopment Authority, Cambria County; Ridgway Borough, Elk County; Franklin Township Sewage
Authority, Greene County; Tunnelton Liquids Co. and Hart Resource Technologies Inc., both in Indiana County;
Brockway Area Sewage Authority, Punxsutawney Borough Municipal Authority and Reynoldsville Borough
Authority, all in Jefferson County; New Castle City Sanitation Authority, Lawrence County; Sunbury Generation,
Snyder County; Franklin Brine Treatment Corp., Venango County; Waste Treatment Corp., Warren County; and the
Kiski Valley Water Pollution Control Authority, Westmoreland County.


\(^{25}\) Email from Thomas Starosta, DEP April 21, 2012
brine treatment and discharge CWT's\textsuperscript{26} continued to accept wastewater from shallow oil and gas wells, not Marcellus wells.

\textbf{Current Treatment and Disposal Options}

There are several options for treatment and disposal of MSW including disposal in Class 2 disposal wells\textsuperscript{27}, recycling with treatment\textsuperscript{28} on site, recycling with treatment off site, distillation and evaporation, and treatment and discharge. Transportation costs as well as treatment costs are important considerations. For example, a rule of thumb is that it costs $0.02 per gallon\textsuperscript{29} ($0.84 per barrel) to transport MSW for one hour, say, 50 miles.

\textbf{A Market Based Treatment Industry}

MSW treatment facilities (MSWTF's) receive MSW via an agreement with either a trucking company or the exploration and production (E&P) gas company. Upon inspection, the MSWTF either accepts the load on a tank truck or rejects it. When accepted, it becomes the MSWTF’s responsibility to treat it.

No MSW received at any MSWTF in Pennsylvania is presently ‘piped’ in, although that is a likely future development. Rather, all MSW is delivered by truck, and perhaps via rail in the future. They can be characterized as CWT’s\textsuperscript{30}.

\textbf{Treatment Requirements}

Three MSW permitting options exist depending the final disposal of MSW provided. In Pennsylvania, facilities that have no liquid discharge are regulated in accordance with residual waste management

\textsuperscript{26} Dannic/Punxsutawney STP; Ridgway Borough STP; AWS/New Castle STP; Reynoldsdale STP; Dannic/Brockway Area STP; Tunnelton CWT; PA Brine –Josephine CWT; Hart Resource –Creekside CWT; PA Brine - Franklin CWT; Waste Treatment Corp. CWT identified from an email from Tom Starosta, DEP April 21, 2012

\textsuperscript{27} Mostly in Ohio.

\textsuperscript{28} Treatment provided varies.

\textsuperscript{29} Assumes a truck with driver rents at $100.00 per hour and can carry 5,000 gallons. $100.00 divided by 5,000 gallons is $0.02. Consideration must also be given to the round trip details of transport.

\textsuperscript{30} CWT’s are defined in U.S. EPA regulations 40 CFR 437.2 (c)
regulations while treatment and discharge facilities are regulated under the Clean Streams Law and NPDES permit regulations. In the third case, Class 2 disposal wells are regulated by the U.S. EPA. Also, it should be noted that Pennsylvania generated MSW that is transported to Ohio or West Virginia (or any other state) will be treated in accordance with that state’s regulations. One major difference is that Ohio has primacy for regulation of its Class 2 disposal wells.

Treatment requirements for MSW vary depending on the purpose desired characteristics of the treated MSW. If the MSW is to be discharged to a POTW or to the surface waters of the Commonwealth, then 25 PA Code 95.10 and related chapters such as 92 apply, but if the MSW is to be treated and then mixed with other waters to be used in the next frac job, then the treatment requirement is established by the gas company that will be using the water. Generally, the standard for reuse of the water is the requirement that downhole problems like scaling or bacterial growth will not occur. If the MSW is to be transported to Class 2 disposal wells in Ohio, then the MSW must be treated to the standards established by those well operators.

The level of treatment provided to MSW is critical not only for achieving the desired water quality, but also for the quality and quantity of the residuals, the sludges, produced. Achieving higher levels of MSW treatment result in the production of ever greater volumes of residuals. Each of the treatment steps described below produce successively more residuals. When MSW dissolved metal removal is practiced, the residuals may well fail landfill radiation protocols, total contaminant leaching procedure (TCLP) limits for barium, and local limits for sodium chloride. Removal of hardness adds considerably to the treatment sludge weight and volume and evaporation and crystallization are likely to produce even more solid waste, as much as one pound of salt per gallon of MSW treated.

**Treatment Steps**

The treatment steps identified below may exist separately or be combined with other steps in a MSWTF. Not all MSWTF’s provide all treatment steps. The treatment processes employed are intended to meet treatment and applicable permit requirements.

**Trucked In Wastewater (TIW) Receiving Facilities**
The first step in MSW treatment is unloading from the tank truck. The unloading occurs in a specially designed area so that any spills will be contained. Card readers and swipes may be used to identify source, truck, driver, and company making the delivery. Samples are taken and retained. Volumes and types of MSW are recorded on a manifest. Samples are taken, sometimes at three locations, tank top, tank bottom, and tank middle, because separation of the tank contents can occur in transit. Trucks dump by gravity or by ejection.

**Oil and Grease, Debris, Grit, Sand, Proppant, and Gravel Separation**

The MSW delivered to a MSWTF is likely to contain heavy settleable solids and floatable oil and grease (O&G). The largest solids are removed by coarse or fine screen, the gravel, grit, proppant, and other settleable solids are removed by gravity settling. O&G can best be removed by gravity flotation or by gravity assisted flotation via diffused or dissolved air flotation. Sometimes the processes employed to remove these contaminants are called “pre-treatment” or “preliminary” treatment.

**Metals Removal**

Metals in solution may precipitate and form scale if MSW is reused. Precipitation of the non-alkali metals dissolved in the MSW typically occurs in one or two stages. Given that the solubility of metals decreases with increasing pH, precipitants are added to raise the pH and to provide an anion or oxyanion to bond to the metal cation. Coagulants may then be added to enhance the flocculation of suspended precipitants for the purposes of increasing the rate of settling or flotation. Polymers may also be utilized to enhance flocculation.

The alkali metals (sodium is the most common) are not easily precipitated and will not be removed during this step. Organic matter which is present from the chemicals added during the frac process, from the drill mud and lubricants, and from the Marcellus itself and other high organic containing geologic strata may be precipitated during this step and the following step if it carries a positive charge. Such removal may be enhanced with the careful selection of precipitants like polyaluminum chlorides and polydadeacos.
**Hardness Removal**

Removal of hardness may be desirable in order to reduce the chance of scale formation in the well and producing formation. Hardness is preferentially defined\(^{32}\) as the sum of the magnesium and calcium cation equivalents dissolved in water. Hardness is most commonly removed by a lime (calcium hydroxide, Ca(OH)\(_2\)) and soda ash (sodium carbonate, Na\(_2\)CO\(_3\)) treatment process. Lime is used to remove chemicals that cause carbonate hardness. Soda ash is used to remove chemicals that cause non-carbonate hardness. Significant hardness removal will result in large volumes of sludge produced because hardness in MSW can be very high frequently in excess of 20,000 mg/l.

The metals and hardness removal steps may be combined in a single treatment step. The products of hardness and metals removal from MSW are sludge(s) and a very clear and very salty water.

**Sodium Chloride Removal**

Sodium chloride removal may be accomplished if it is desired that a solid salt or brine salt product be produced for sale and/or if it is desired to produce a treated water that may be discharged to surface waters or reused with few restrictions.

While the prior mentioned treatment steps may produce large quantities of sludge and may consume considerable amounts of coagulants and coagulant aids, they are relatively not very energy intensive when compared to the steps needed to remove sodium chloride (salt) in Pennsylvania\(^{33}\).

It is difficult and expensive to remove salt from water. Two methods prevail, removal by passing through a membrane and through thermal and/or vacuum evaporation. Desalination, the removal of

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\(^{32}\) By Standard Methods Procedure No. 2340 hardness is preferentially calculated as the sum of the calcium and magnesium cations expressed as milligram equivalents of calcium carbonate (CaCO\(_3\)). Hardness may also be determined by titration with EDTA.

\(^{33}\) Natural options may not exist. Annual rainfall exceeds annual evaporation in Pennsylvania, so evaporation ponds similar to those used to produce natural salt in western U.S. states like Utah would actually gain water in Pennsylvania.
salt from ocean, estuarine, and high TDS ground waters, is typically achieved through treatment processes that incorporate reverse osmosis (R.O.) as a final salt removal step. Reverse osmosis membranes function as physical barriers preventing the migration of the sodium and chloride ions while permitting the movement of water molecules. The result is product water having a total dissolved solids (TDS) of less than 500 mg/l and a brine which typically would have a TDS of over 35,000 mg/l. The membranes operate under high pressure, typically around 1,000 psi depending on the feed water TDS concentration. When employed in a desalination role, the brine reject water is returned to the source water body.

The efficacy of reverse osmosis when applied to treatment of MSW is limited by the typical TDS concentration of the raw, MSW feed water and by the lack of a receiving water to accept the high brine containing R.O. reject water. The current technological limitation on TDS in feed water to an R.O. membrane is around 60,000 to 80,000 mg/l and at those concentrations results in a very high fraction of reject water. Assuming the limit in practice is 60,000 mg/l, the treatment of a 1,000 gallons of 30,000 mg/l TDS water to an R.O. membrane would result in the production of 500 gallons of product water and 500 gallons of reject water containing 60,000 mg/l TDS. If the R.O. membrane is operated in such a way as to allow higher TDS levels in the reject, precipitation occurring on the surface of the R.O. membrane would likely occur leading to perhaps to the membrane’s permanent fouling. Also, the concentrated brine reject resulting from R.O. requires further treatment or final disposal in a disposal well. The TDS in a new surface water discharge would be limited to 500 mg/l.

Continuing the example of the limited efficacy of R.O. membranes in treating MSW, consideration should be given to the fact that many MSW TDS levels exceed 100,000 mg/l well above the technological limit for the use of membranes. Despite the challenges faced, an R.O. MSW treatment facility does operate at Eureka

**Evaporation and Distillation**

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34 25 PA Code 95.10
In nature, evaporation can occur at any temperature and represents the phase change of water from a liquid to a gas. Distillation incorporates the additional step of condensation where the phase change is reversed from a gas back to a liquid. When evaporation occurs under controlled conditions, a nearly saturated, saturated, or supersaturated brine can be produced. The mass of the MSW is reduced by the percentage of water removed. Sometimes the intent is to produce a very highly saturated brine at or near the saturation index, sometimes solid crystals are desired. Distillation is a step that captures the evaporated water. It would be desirable for the distilled water to meet the requirements of it to be “de-wasted” pursuant to DEP residual waste requirements.

**Corrosion and Scaling Problems**

At the high temperatures and high dissolved solids loadings required to achieve efficient evaporation corrosion and scaling can become serious problems. One evaporation treatment plant in Fairmont, West Virginia closed due to the failure of the stainless steel piping and tankage used in the treatment process.

**Sludge Production and Disposal**

The aforementioned MSW treatment steps are all separation steps. At least two flow streams result from treatment. The first is the treated MSW that is either recycled or disposed of. The second is a sludge or sludges. The most common method of sludge separation from MSW gravity settling, but gravity and pressure filtration, centrifuging, cycloning, and air flotation are frequently employed.

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35 In solutions of several liquids, some may evaporate first at a lower temperature than water. In the case of MSW, water is evaporated and a highly concentrated brine (or solid crystals) remains.
36 For example, the complete evaporation of a 20% brine (200,000 mg/l TDS) to dry crystals would result in a reduction in weight of 80%. Evaporation of one ton of such brine would result in 400 pounds of salt (mostly) crystals.
37 The theoretical saturation concentration of salt, NaCl, in water at room temperature is about 350,000 mg/l or ten times the concentration of salt in the oceans.
38 See draft WGMR 128 when and if published by DEP.
39 Communication from Travis Buggey, Venture Engineering, who re-designed the AOP Clearwater facility.
For disposal of the sludge, standards of the receiving facility (ultimately a landfill) must be met. In addition to the paint filter test previously cited, landfills also have standards for radiation, for chlorides, and for total contaminant leaching (TCLP)\(^{40}\).

The volumes of sludge are dependent on the amount of material removed from the MSW plus the amount of treatment chemical added to form the sludge plus the water remaining in the sludge. For example, if sodium sulfate (Na\(_2\)SO\(_4\)) is added to MSW to precipitate metals, the weight of the sludge generated will be the weight of the sulfate added (the sodium will stay in solution) plus the weight of the metals removed plus the water in the sludge. Landfills charge by weight, so dewatering of the sludge to meet the paint filter test also has the desirable effect of reducing the weight of the sludge.

When it is difficult or expensive to sufficiently dewater the sludge to permit passing the paint filter test or when it is possible the sludge will fail radiation or TCLP test limits, sludge bulking can be practiced wherein materials are added to the sludge to reduce the likelihood of test failure. Bulking materials may be sand, sawdust, cement and others. The use of bulking agents adds to the cost of sludge disposal at a landfill.

**Facilities Accepting MSW**

Facilities accepting MSW are reported by DEP in three (3) different lists. The first list is a list generated by DEP from reporting received by Marcellus waste generators that indicates the actual delivery of MSW and other Marcellus wastes to treatment or disposal facilities in Pennsylvania and surrounding states. It has been published at six (6) month summaries beginning in calendar year 2011. The other two lists are of facilities for which permits have been issued or are pending in the DEP regional offices; one list is for residual waste permits and one is for mostly treatment and discharge permits. The three lists will be individually discussed.

**Facilities Reported to be in Operation in 2011**

Beginning with calendar year 2011 data, the DEP began to publish detailed summaries of the generation and fate of wastes generated by Marcellus well drilling and operation. The more current data were

\(^{40}\) EPA Test Method 1311
published in April 2012 for the period of the last six months of 2011. That data posted at:
https://www.paoilandgasreporting.state.pa.us/publicreports/Modules/DataExports/DataExports.aspx

report that that seven different types of wastes\(^{43}\) were generated in thirty-one Pennsylvania counties\(^{42}\) by 50 gas companies\(^{43}\). The wastes were disposed of at 112 different facilities\(^{44}\) in five states\(^{45}\).

This list is probably the best list available for current information on the generation and fate of MSW in Pennsylvania. It should be noted, however, that the data is "oil and gas permittee" data and does not reflect or report on subsequently produced wastes. For example, there is no reporting on this list of sludges generated at MSWTF's. Review of the data leads to the conclusion that the data is unedited\(^{46}\) and is reported by DEP as received from its oil and gas permittees. Confirmation of actual receipt of the waste by the receiving parties is not reported.

For this report, the entire 9,000 row list was converted to Excel format and sorted by type of waste. It is attached as an appendix accessible at:

2011-2 by type of waste w subtotals.xlsx

Facilities reported to have accepted Marcellus wastes and wastewaters in the second half of 2011 are as follows:

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<th>Waste Facility Permit # / Waste Facility Name / Address</th>
<th>Waste Type</th>
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<tr>
<td>1011534 LAUREL HIGHLANDS LANDFILL 260 LAUREL RIDGE ROAD JOHNSTOWN, PA 15909 (814)749-9065</td>
<td>BASIC SEDIMENT</td>
<td>LANDFILL</td>
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</table>

\(^{41}\) They are: brine, frac fluid, drill cuttings, spent lubricants, flowback fracturing sand, drilling fluids, basic sediment

\(^{42}\) See list in Appendix

\(^{43}\) Ibid.

\(^{44}\) Ibid.

\(^{45}\) Pennsylvania, West Virginia, Ohio, Maryland, and New York.

\(^{46}\) Typographic errors and minor misidentification of wastes and receiving facilities. In this report no attempt was made to make corrections.
PA 100081
WASTE MANAGEMENT, INC - SOUTHERN ALLEGHENIES
843 MILLER PICKING ROAD SOMERSET COUNTY DAVIDSVILLE, PA 15928 (814)479-2537
0114
WILCOX #1
5324 TALLMAGE ROAD ROOTSTOWN, OH 44272
0968
ROJ DISPOSAL PO BOX 538
CHESIRE, OH (740)821-1127
1076
BRINE
INJECTION DISPOSAL WELL
1198
MYERS INJECTION WELL
3361 BAIRD AVENUE PARIS, OH 44669 (330)771-3207
1198
LYONS INJECTION WELL
221 1/2 SOUTH 6TH STREET BYEVILLE, OH 43723 (740)685-5169
253723/PA025723
APPALACIAN WATER SERVICES LLC
SHALLENBERGER CONSTRUCTION
195 ENTERPRISE LANE CONNELLSVILLE, PA 15424 (724)583-2081
301333
BRINE
INJECTION DISPOSAL WELL
3192
WASTE RECOVERY SOLUTIONS, INC
343 KING STREET MYERSTOWN, PA 17067 (877)866-9955
3192
DIETRICH # 1, PETROWATER INC
2201 STATE RTE 167
JEFFERSON, OH 44047 (440)904-9089
3192
BRINE
INJECTION DISPOSAL WELL
3192
PETROWATER INC
1972 FOOTVILLE-RICHMOND ROAD
JEFFERSON, OH 44047 (440)563-9475
34-007-20919
B & R INJECTION WELL
6101 LICKING ROAD PIERPOINT, OH 44082
34-007-24523
MONROE PARTNERS, LLC PO BOX 1085
WOOSTER, OH 44691 (412)395-3921
34-009-22704
GINSBURG DISPOSAL WELL LADD BRIDGE ROAD ALBANY, OH 45710 (412)395-3921

* Probably an injection well and misreported to be a waste treatment plant.
34-013-20611
GEORGETOWN MARINE #1 SWIW
1 COUNTY ROAD 214
BELLAIRE, OH 43906 (330)363-0239
BRINE
INJECTION DISPOSAL WELL

34-059-2406
DEVCO INJECTION WELL SWIW #11 (740)585-5168
BRINE
INJECTION DISPOSAL WELL

34-059-24067
DAVID R. HILL DISPOSAL WELL DEVCO UNIT NO. 1
57901 CLAYSVILLE ROAD CAMBRIDGE, OH 43725 (740)638-2068
BRINE
INJECTION DISPOSAL WELL

3405231270000
NORTH STAR BRINE DISPOSAL
1000 OHIO WORKS ROAD MAHoning COUNTY
YOUNGSTOWN, OH 44510 (330)792-9524
BRINE
BRINE OR INDUSTRIAL WASTE TREATMENT PLT

34-115-1899
STONEBRIDGE OPERATING COMPANY-KORTING #1
2130 HARRIS HWYWAY WASHINGTON, WV 26181 (304)481-5824
BRINE
INJECTION DISPOSAL WELL

34-121-2-3995
HUNTERS SWIW #5
P.O. BOX 430
JACKSON TOENSHIP. NOBLE COUNTY REo, OH 45773
(740)375-2940
BRINE
INJECTION DISPOSAL WELL

34-127-6595
JUNCTION CITY DISPOSAL WELL
555 STATE ROUTE 668 SOUTH JUNCTION CITY,
OH 43748 (614)371-0002
BRINE
INJECTION DISPOSAL WELL

34-133-20114-00
SALTY’S DISPOSAL - WILCOX #1
5324 TAILMADGE ROAD ROOTSTOWN, OH 44272 (330)868-2083
BRINE
BRINE OR INDUSTRIAL WASTE TREATMENT PLT

34-133-21076
SALTYS DISPOSAL - MYERS INJECTION WELL
3361 BAIRD AVENUE PARIS, OH 44669
(330)868-2083
BRINE
INJECTION DISPOSAL WELL

34-133-24095
SALTYS DISPOSAL - GROSELLE INJECTION WELL
3361 BAIRD AVENUE PARIS, OH 44669
(330)868-2083
BRINE
INJECTION DISPOSAL WELL

34-151-2-1920
ALBERT CREIGHTON #1
3751 ELSON AT SE MAGNOLIA. OH 44643
(330)886-3558
BRINE
BRINE OR INDUSTRIAL WASTE TREATMENT PLT

34-151-2-2783
NUIMANS
67 POLAND MANOR YOUNGSTOWN, OH 44514
(440)992-0214
BRINE
INJECTION DISPOSAL WELL
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<td>SALTY'S DISPOSAL - MEYERS #2 3204 STATE ROUTE 183 ATWATER, OH 42201 (330)866-2083</td>
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<tr>
<td>34-167-28462</td>
<td>BROAD STREET ENERGY - COLUMBUS 37 WEST BROAD STREET #1100 COLUMBUS, OH 43215 (740)401-0413</td>
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<tr>
<td>34-167-2-8466</td>
<td>BROAD STREET ENERGY BELPRE 3111 BRAUN ROAD BELPRE, OH 45714 (740)551-2070</td>
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<tr>
<td>34-167-29395</td>
<td>WV OIL GATHERING ST MARY'S 157 LOWER EUREKA LANE PLEASANT COUNTY ST. MARY'S, WV 26170 (800)846-6642</td>
<td>BRINE OR INDUSTRIAL WASTE TREATMENT PLT</td>
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<tr>
<td>3420</td>
<td>B &amp; WELL # 2 (BELDEN &amp; BLAKE) 4317 RT 225 DIAMON, OH 44412 (330)654-2501</td>
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<tr>
<td>4096</td>
<td>GROSELLE #2 3361 BAIRD AVENUE PARIS, OH 44569 (330)771-5207</td>
<td>INJECTION DISPOSAL WELL</td>
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<td>4137</td>
<td>ELKHEAD GAS &amp; OIL DISPOSAL 9170 RUTLIDGE ROAD HOWARD, OH 43028 (740)403-9664</td>
<td>INJECTION DISPOSAL WELL</td>
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<tr>
<td>4355</td>
<td>B &amp; B OILFIELD SERVICE, INC. P. O. BOX 367 GARRETSTVILLE, OH 44231 (330)527-5377</td>
<td>INJECTION DISPOSAL WELL</td>
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<tr>
<td>47-085-05151</td>
<td>VIRCO - HARRISVILLE WELL GILLESPIE RUN ROAD WV DEPARTMENT OF ENVIRONMENTAL PROTECTION CARIO, WV 26337 (304)628-3444</td>
<td>INJECTION DISPOSAL WELL</td>
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<td>BLAZEK PUMP AND WELL 5506 ALLYN ROAD HIRAM, OH 44234 (330)274-3553</td>
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<td>7350</td>
<td>LYDIC ENERGY 85C LTD SALTWATER DISPOSAL WELL KENT1  LYDIC ENERGY 85C, LTD P.O. BOX 2635 ZANESVILLE, OH 43702-2635 (740)453-2623</td>
<td>INJECTION DISPOSAL WELL</td>
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<td>BROADSTREET SERVICES BARTLETT 823 STATE RT 550 BARTLETT, OH 45713 (740)551-2070</td>
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C-20
EUREKA RESOURCES
419 SECOND STREET WILLIAMSPORT, PA 17701 (570)971-9978

BRINE

BRINE OR INDUSTRIAL WASTE TREATMENT PLT

EPA ID: 748-183
PATRIOT WATER TREATMENT
2840 SFERRA DRIVE WARREN, OH 44482 (330)222-1274

BRINE

BRINE OR INDUSTRIAL WASTE TREATMENT PLT

FRAC WATER REUSE

REUSE OTHER THAN ROAD SPREADING

OH-34-007-20919
RENSHAW / BRADNAN #1 DISP WELL
ASHTUBULA COUNTY, PIERPONT TOWNSHIP

BRINE

INJECTION DISPOSAL WELL

OH-34-007-22038
PAROBECK WELL-ASHTABULA-NEW LYME. OHIO ASHTUBULA COUNTY, NEW LYME TOWNSHIP
OH-34-007-23262
CLINTON OIL #2 (SWIW #21) P O BOX 367 GARRETTSVILLE OH 44231 (330)221-6681

BRINE

INJECTION DISPOSAL WELL

OH-34-007-24355
B & B OILFIELD SERVICE, INC MILLER & CO #3 6794 STATE ROUTE 85 ASHTABULA COUNTY, WINDSO TOENSHIP GARRETTSVILLE, OH 44231 (330)527-5377

BRINE

BRINE OR INDUSTRIAL WASTE TREATMENT PLT

OH-34-121-23390
CARPER WELL SVC BRYANE SMITH 1 INJ WELL 30745 STATE ROUTE 7 NOBLE COUNTY, NOBLE TOWNSHIP MARIETTA, OH 45750 (740)374-2567

BRINE

BRINE OR INDUSTRIAL WASTE TREATMENT PLT

OH-34-133-22523
MILLER #1 DISP WELL PORTAGE COUNTY, WINDHAM TOWNSHIP

BRINE

INJECTION DISPOSAL WELL

OH-34-155-21893
WOLF #1 DISP WELL TRUMBULL COUNTY, NEWTON TOWNSHIP

BRINE

INJECTION DISPOSAL WELL

OH-34-155-21894
WOLF #2 DISPOSAL WELL TRUMBULL COUNTY, NEWTON TOWNSHIP

BRINE

INJECTION DISPOSAL WELL

OH-34-155-22403
8DB ENERGY D-1 DISP WELL 34-155-22403-00-00 TRUMBULL COUNTY, FOWLER TOWNSHIP

BRINE

INJECTION DISPOSAL WELL

OH-34-155-23584
KOONTZ #1 DISPOSAL WELL 4317 STATE RT 225 TRUMBULL COUNTY, WARREN TOWNSHIP DIAMOND, OH 44412

BRINE

INJECTION DISPOSAL WELL

OH-34-155-23795
PANDER #1 - NEWTON TWP. TRUMBULL COUNTY TRUMBULL COUNTY, NEWTON TOWNSHIP

BRINE

INJECTION DISPOSAL WELL
PA0026034
DORNSICK POINT WATTP
241 ASPHALT RD JOHNSTOWN, PA  15905-1128
BRINE
MUNICIPAL SEWAGE TREATMENT PLANT

PA0028207
REYNOLDSVILLE SEWAGE AUTHORITY STP
BRINE
MUNICIPAL SEWAGE TREATMENT PLANT

PA0095273
PA BRINE TRT INC - JOSEPHINE PLT -INDIANA CO
P O BOX 295 BELLS MILLS ROAD JOSEPHINE, PA  15750
BRINE
BRINE OR INDUSTRIAL WASTE TREATMENT PLT

PA0095443
HART RESOURCE TECHNOLOGIES, INC T
5035 ROUTE 110 WEST P. O. BOX 232
CREEKSIDE, PA  15732 (724)349-8600
BRINE
BRINE OR INDUSTRIAL WASTE TREATMENT PLT

PA0101508
PA BRINE TRT INC - FRANKLIN PLT - VENANGO CO
5148 RT 322
FRANKLIN, PA  16323
BRINE
BRINE OR INDUSTRIAL WASTE TREATMENT PLT

PA0102784
WASTE TREATMENT CORPORATION
341 WEST HARMAR STREET
CITY OF WARREN, WARREN COUNTY
WARREN, PA  16365
(724)228-9674
BRINE
BRINE OR INDUSTRIAL WASTE TREATMENT PLT

PA0264185
RESERVED ENVIRONMENTAL SERVICES
1119 OLD STATE ROUTE 119
HEMPFIELD TOWNSHIP, WESTMORELAND COUNTY
MOUNT PLEASANT, PA  15666 (724)696-4299
BRINE
BRINE OR INDUSTRIAL WASTE TREATMENT PLT

PAR000519462
ADVANCED WASTE SERVICES OF PA (NEW CASTL
1001 SAMPSON STREET
NEW CASTLE, PA  16101-8913 (724)657-8777
BRINE
BRINE OR INDUSTRIAL WASTE TREATMENT PLT

PAS2D05BCLE
IRVIN A SALTWATER DISPOSAL
BRINE
BRINE OR INDUSTRIAL WASTE TREATMENT PLT

PAS2D251BERI
CROSS #2 DISP WELL (049-24388)
BRINE
INJECTION DISPOSAL WELL

PAS2D028CLE-02
SPENCER LAND CO #2 DISP WELL (033-22059)
BRINE
INJECTION DISPOSAL WELL

PAS2D012SOM
CRESSFIELD #F76 DISP WELL (111-29006)
BRINE
INJECTION DISPOSAL WELL

PBR RES
1090 FREEPORT ROAD SUITE 2
PITTSBURGH, PA  15238 (412)784-3399
BRINE
BRINE OR INDUSTRIAL WASTE TREATMENT PLT

PBR
SRI, INC.
1550 SOLDIERS HOME W CAROLTON ROAD
DAYTON, OH  45418
(937)295-8991
BRINE
BRINE OR INDUSTRIAL WASTE TREATMENT PLT

REUSE OF BRINE TO FRAC A WELL
BRINE
REUSE OTHER THAN ROAD SPREADING
REUSED FOR UIC CLASS II (PROVIDE UIC # IN COMMENT)  
BRINE  REUSE OTHER THAN ROAD SPREADING

REUSED IN DRILLING OR PLUGGING JOB  
BRINE  REUSE OTHER THAN ROAD SPREADING

STORAGE PENDING DISPOSAL OR REUSE  
BRINE  NOT DETERMINED

SWMW-45  
FISHBURN DISPOSAL  
5012 STATE ROUTE 229  
MARENGO, OH 43334 (419)253-6031  
BRINE  INJECTION DISPOSAL WELL

TERRAQUA RESOURCE MANAGEMENT  
1000 COMMERCE PARK DRIVE SUITE 201  
WILLAMSPORT, PA  
BRINE  BRINE OR INDUSTRIAL WASTE TREATMENT PLT

TRIAD-DEXTER CITY  
300 SMITHSON AVENUE DEXTER CITY, OH 45727  
BRINE  BRINE OR INDUSTRIAL WASTE TREATMENT PLT

UIC 45  
RAY PANDER TRUCKING INC  
4317 STATE ROUTE 225  
DIAMOND, OH 44412 (330)654-3103  
BRINE  INJECTION DISPOSAL WELL

WMGR123  
HYDRO RECOVERY LP  
7 RIVERSIDE PLAZA P O BOX 38  
BLOOMSBURG, PA 16912 (570)638-0217  
BRINE  BRINE OR INDUSTRIAL WASTE TREATMENT PLT

WMGR123NC001  
ARTHUR CENTRAL TREATMENT FACILITY  
355 DERR ROAD EXT MUNCY, PA 17756  
(888)964-9724  
BRINE  BRINE OR INDUSTRIAL WASTE TREATMENT PLT

WV OIL GATHERING PUMP STATION BELMONT, WV 26134 (304)665-2461  
BRINE  BRINE OR INDUSTRIAL WASTE TREATMENT PLT

#SWF 1032  
WASTER MANAGEMENT MEADOWFILL LANDFILL ROUTE 2. PO BOX 68 DAWSON DRIVE  
WV DEPARTMENT OF ENVIRONMENTAL PROTECTION-BRIDGEMENT. WV 26330 (800)333-0013  
DRILL CUTTINGS  LANDFILL

100172  
ARDEL LANDFILL, INC  
200 RANGOS LANE WASHINGTON, PA 15301  
(724)225-1589  
DRILL CUTTINGS  LANDFILL

100277  
DEP SIT WESTMORELAND WASTE, LLC  
111 CONNER LANE  
BELLE VERNON, PA 15012-4569 (724)929-7694  
DRILL CUTTINGS  LANDFILL

100351  
MCKEAN COUNTY LANDFILL/RUSTICK, LLC  
19 NESS LANE KANE, PA 16735  
DRILL CUTTINGS  LANDFILL

100434  
EVERGREEN LANDFILL, INC  
1310 LUCISBORO RD BLAIRSVILLE, PA 15717  
(724)479-3336  
DRILL CUTTINGS  LANDFILL

100592  
SOUTH HILLS LANDFILL  
3100 HILL ROAD  
SOUTH HILLS, PA 15129 (724)348-7013  
DRILL CUTTINGS  LANDFILL
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<td>MCCUTCHEON ENTERPRISE</td>
<td>250 PARK ROAD</td>
<td>BIOSOLIDS TREATMENT FACILITY APOLLO, PA 15613 (724) 568-3523</td>
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<td>SENECA MEADOWS LANDFILL</td>
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<td>1786 SALC MAN ROAD WATERLOO, NY 13165-9570 (800) 724-7537</td>
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<tr>
<td>WASTE MANAGEMENT - NORTHWESTERN LANDFILL</td>
<td>ROUTE 50 EAST DRY RUN ROAD</td>
<td>PARKERSBURG, WV 26101 (800) 333-9913</td>
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<tr>
<td>THR029</td>
<td>DRILL CUTTINGS</td>
<td>LANDFILL</td>
</tr>
<tr>
<td>TUNNELL HILL RECLAMATION LANDFILL</td>
<td>2500 TR 205 ROUTE 2</td>
<td>EPA PERMIT CID: 272650 NEWLEXINGTON, OH 43754</td>
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<tr>
<td>WAYNE TOWNSHIP LANDFILL</td>
<td>DRILL CUTTINGS</td>
<td>LANDFILL</td>
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<tr>
<td>264 LANDFILL LANE LOCK HAVEN, PA (570) 937-6944</td>
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<tr>
<td>WO2A17</td>
<td>DRILL CUTTINGS</td>
<td>LANDFILL</td>
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<tr>
<td>HYLAND FACILITY ASSOCIATION</td>
<td>6653 HERDMAN RD ANGELICA, NY 14709 (585) 466-7271</td>
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<tr>
<td>34-009-1899</td>
<td>DRILLING</td>
<td>INJECTION DISPOSAL WELL</td>
</tr>
<tr>
<td>STONEBRIDGE OPERATING COMPANY-PAUL HAHN #2</td>
<td>2130 HARRIS HIGHWAY WASHINGTON, WV 25181 (304) 481-5824</td>
<td></td>
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<tr>
<td>34-105-23610</td>
<td>DRILLING</td>
<td>INJECTION DISPOSAL WELL</td>
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<tr>
<td>ROSCOE MILLS</td>
<td>53549 GREAT BEND ROAD PORTLAND MEIGS, OH 45770 (740) 395-3921</td>
<td></td>
</tr>
<tr>
<td>34-167-29359</td>
<td>DRILLING</td>
<td>IDENTIFY METHOD IN COMMENTS</td>
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<tr>
<td>WEST VIRGINIA OIL GATHERING</td>
<td>47550319</td>
<td>CAMP CREEK DISPOSAL SERVICES, INC</td>
</tr>
<tr>
<td>CAMP CREEK ROAD</td>
<td>200 CAMP CREEK ROAD</td>
<td>47-055-00319</td>
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<tr>
<td>CAMP CREEK, WV 25620 (276) 880-2323</td>
<td></td>
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</tr>
<tr>
<td>CLEAN HARBORS OF BALTIMORE, INC</td>
<td>DRILLING</td>
<td>BRINE OR INDUSTRIAL WASTE TREATMENT PLT</td>
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<tr>
<td>1910 RUSSEL STREET BALTIMORE, MD 21230-3144 (410) 244-8200</td>
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<td>NJD91291105</td>
<td>DRILLING</td>
<td>LANDFILL</td>
</tr>
<tr>
<td>CLEAN EARTH OF NORTH JERSEY</td>
<td>115 JACOBUS AVENUE SOUTH KEARNY, NJ 07032 (973) 344-4004</td>
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</table>
PAD04835146  
MAX ENVIRONMENTAL TECHNOLOGIES - 
YUKON FACILITY  
233 MAX LANE YUKON, PA  15598 (724)722-3500

DRILLING  
INJECTION DISPOSAL WELL

PAR014285009  
ARMSTRONG ENVIRONMENTAL SERVICES  
205 GREENFIELD ROAD LANCASTER, PA  
17601 (717)393-2770

DRILLING  
BRINE OR INDUSTRIAL 
WASTE TREATMENT PLT

WMGR119NC001  
CLEAN STREAMS, LLC  
212 COLVIN ROAD WILLIAMSPORT, PA  17701  
(877)518-2880

DRILLING  
BRINE OR INDUSTRIAL 
WASTE TREATMENT PLT

8-4630-00010/00  
HAKES C&D LANDFILL  
4376 MANNING RIDGE ROAD PAINTED POST, 
NY  14870-8402 (607)937-6044

FLOW-BACK FRACTURING 
SAND  
LANDFILL

UIC2D0610317  
GRER A-1 SALTWATER DISPOSAL  
1862 SNAKE HILL ROAD MORGANTOWN, WV  
26508 (304)894-7807

FRAC FLUID  
INJECTION DISPOSAL WELL

**Treatment and Surface Water Discharge Facilities**

For facilities discharging or intending to discharge to surface waters, the following list was provided by DEP. It shows existing and proposed facilities sorted by regional office. For example, SWRO refers to DEP’s Southwest Regional Office. Facilities listed as “pending” are likely to be dormant and will not move toward actual operation. This list does not include any facilities in states other than Pennsylvania, but it does include some non-discharge facilities that are permitted under residual waste management regulations.

The list is provided at:

*Oil_Gas_Wastewater_Facility_List_fr Starosta.pdf*
The third DEP list is of facilities permitted under residual waste management regulations. None of these have a liquid discharge, but all are likely to generate sludges that require further disposal.

<table>
<thead>
<tr>
<th>Facility Name</th>
<th>Facility Location</th>
<th>County</th>
<th>Permit Number</th>
<th>Status</th>
<th>Technology</th>
<th>Capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eureka Resources</td>
<td>2nd Street Facility</td>
<td>Lycoming</td>
<td>WMGR123N C005</td>
<td>In Operation</td>
<td>Chemical Precipitation, and Evaporation/Distillation</td>
<td>820,000 gpd</td>
</tr>
<tr>
<td></td>
<td>City of Williamsport</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TerrAqua</td>
<td>City of Williamsport</td>
<td>Lycoming</td>
<td>WMGR121</td>
<td>In Operation</td>
<td></td>
<td>400,000 gpd</td>
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<tr>
<td>Resource Mgt. LLC</td>
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<tr>
<td>Hydro Recovery LP</td>
<td>Blossburg Borough</td>
<td>Tioga</td>
<td>WMGR123</td>
<td>In Operation</td>
<td>Chemical Precipitation</td>
<td>300,000 gpd</td>
</tr>
<tr>
<td>Waste Management Inc.</td>
<td>Penn Township</td>
<td>Lycoming</td>
<td>WMGR123N C001</td>
<td>In Operation</td>
<td>Chemical Precipitation</td>
<td>576,000 gpd</td>
</tr>
<tr>
<td>EOG Resources Inc.</td>
<td>Lawrence Twp.</td>
<td>Clearfield</td>
<td>WMGR123N C003</td>
<td>In Operation</td>
<td>Blending</td>
<td>3.15 million gpd</td>
</tr>
<tr>
<td>Clean Streams LLC</td>
<td>Old Lycoming Twp.</td>
<td>Lycoming</td>
<td>WMGR123N C006</td>
<td>In Operation</td>
<td>Chemical Precipitation, and Evaporation/Distillation</td>
<td>105,000 gpd</td>
</tr>
<tr>
<td>Chesapeake</td>
<td>Asylum Twp.</td>
<td>Bradford</td>
<td>WMGR123N</td>
<td>In</td>
<td>Chemical</td>
<td>940,000 gpd</td>
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</table>

48 All facilities now operate under the revised WGRM-123 amended March 14, 2012.
<table>
<thead>
<tr>
<th>Energy</th>
<th>C004</th>
<th>Operation</th>
<th>Precipitation</th>
<th>gpd</th>
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</thead>
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<tr>
<td>Reserved Env. Services</td>
<td>119 Old Route (119S)</td>
<td>Westmoreland and</td>
<td>WMGR123S W005</td>
<td>In Operation</td>
</tr>
<tr>
<td>Somerset Regional</td>
<td>4 SR WR 1006</td>
<td>Wyoming</td>
<td>WMGR123N E001</td>
<td>In Operation</td>
</tr>
<tr>
<td>Water Resources</td>
<td>Tunkhannock</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**DEP File Reviews**

In order to gather more information on the disposal of MSW in Pennsylvania, file reviews were conducted in the four (4) DEP regions wherein are located MSW treatment facilities. The file reviews were conducted on those facilities that are on the second and third lists, both provided by DEP as previously reported. Many do not currently receive MSW, but have in the past.

The file materials reviewed were generally those containing permits, recent correspondence, enforcement actions, and operations and performance data.

File review materials are attached as follows:

**Currently Accepting MSW**

All of the following facilities are accepting MSW and are zero liquid discharge (ZLD) facilities:

- Chesapeake Arnold Site
- Clean Streams DEP Docs
- EOG
- Eureka DEP Documents
- Hydro Recovery DEP Docs
- Somerset Resources Tunkhannock
- TARM
- TerrAqua NPDES
- Waste Management Arthur Site
All of the following facilities are listed by DEP as having received MSW. It is believed that MSW is no longer received at these facilities:

Allegheny Clarion Valley Development Corp
Brockway Area Sewer Authority
Clearfield NPDES
Jersey Shore M A NPDES
Lock Haven NPDES
Moshannon Valley ISA NPDES
New Castle
Pennsylvania Brine Treatment
Pine Creek M A NPDES
Punxatawney Borough STP
Reynoldsville Borough STP
Ridgeway Borough
Valley Joint S A NPDES
Williamsport Central NPDES
DRAFT
Marcellus Shale Gas Development
A Summary of Marcellus Wastewater Treatment and Disposal
August 2012

Prepared for:

Ben Franklin Shale Gas Innovation and Commercialization Center
Director, Bill Hall
billhall@psu.edu
814.863.4881
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814.574.6695