GROUNDWATER SAMPLING AND ANALYSIS PROGRAM

FOR

GRAND RIVER DAM AUTHORITY LANDFILL
GRAND RIVER ENERGY CENTER

MAYES COUNTY, OKLAHOMA

SOLID WASTE PERMIT NO. 3549012

PREPARED FOR:

GRAND RIVER DAM AUTHORITY
VINITA, OKLAHOMA

ORIGINAL: OCTOBER 16, 2017
UPDATED: JANUARY 3, 2018

A&M PROJECT NO. 1986-023

PREPARED BY:

A&M ENGINEERING AND ENVIRONMENTAL SERVICES, INC.
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A & M Engineering and
Environmental Services, Inc.
Consulting - Design - Construction - Remediation

January 3, 2018

Ms. Hillary Young, P.E.
Chief Engineer
Land Protection Division
Oklahoma Department of Environmental Quality
707 North Robinson
P.O. Box 1677
Oklahoma City, Oklahoma 73101-1677

RE: Updated Groundwater Sampling and Analysis Program
Grand River Dam Authority
Grand River Energy Center
Choteau, Oklahoma
A&M Engineering Project No. 1986-023

Dear Ms. Young:

On behalf of our Client, the Grand River Dam Authority (GRDA), A&M Engineering and Environmental Services, Inc. (A&M Engineering) is pleased to submit the attached Updated Groundwater Sampling and Analysis Program for the Coal Combustion Residuals (CCR) Landfill at the above referenced GRDA Facility. Updates have been made to the document in response to your letter of November 29, 2017 and include modifying the regulation citations from the Federal Coal Combustion Residual Regulations as contained in 40 CFR §257 to the State of Oklahoma Regulations as found in OAC 252:517. As required by OAC 252:517, a copy of this updated document will be posted on the GRDA CCR Webpage.

In addition, and per your letter request, a schedule has been prepared for monitoring of OAC 252:517 Appendix A and Appendix B parameters in order to obtain the minimum eight (8) background samples necessary for statistical analysis of the groundwater data. Please note that historical detection monitoring of groundwater at the facility typically included the majority of Appendix A constituents. Boron and fluoride analysis had previously been added to the list of parameters for which detection monitoring was being conducted and a sufficient background subset for these two parameters has already been acquired. Statistical evaluation of groundwater data from the most recent semi-annual sampling event is being completed and will include evaluation of inter-well and intra-well comparisons for the facility's permit required detection monitoring parameters as well as for boron and fluoride.

Your letter indicated that background monitoring should be conducted on a quarterly basis. With DEQ approval, GRDA would like to accelerate the sampling schedule for the Appendix B parameters to gather the 8 background samples over the next six months. The Appendix B parameters primarily address metals concentrations in the groundwater. Studies have shown that

concentrations of metals in groundwater tend to be higher during periods of increased or higher precipitation. With one precipitation peak for the Chouteau, OK area occurring in late spring/early summer and one in the fall, gathering the background data for the Appendix B parameters over the next six months would likely result in data consistent with temporal changes that may be observed over a two year (eight quarter) period since periods of both high and low precipitation would be encountered. For your review the proposed accelerated schedule of monitoring for the Appendix B parameters is attached as Figure 1.

Please review the Updated Groundwater Sampling and Analysis Program and proposed schedule for monitoring of the Appendix B parameters and consider the request to accelerate the Appendix B parameter monitoring. If you have any questions on this matter, or if you require any additional information, please do not hesitate to call.

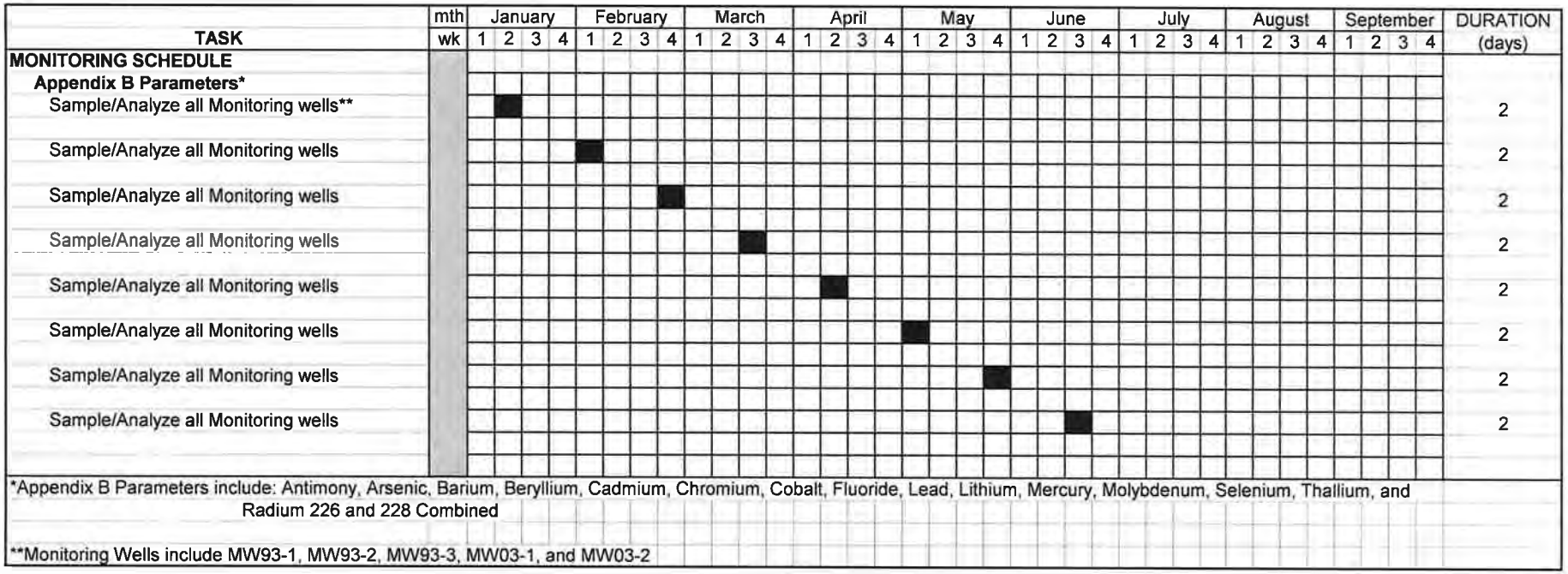
Sincerely,
A & M Engineering and Environmental Services, Inc.

Thomas A. Trebonik, P.G.
Senior Project Manager

Cc: Mike Bednar, GRDA
John Roberts, A&M

Figure 1

Grand River Dam Authority
Estimated Time Line for Sampling/Analysis of
Appendix B Parameters



SCOTT A. THOMPSON
Executive Director

OKLAHOMA DEPARTMENT OF ENVIRONMENTAL QUALITY

MARY FALLIN
Governor

November 29, 2017

CERTIFIED MAIL RETURN RECEIPT REQUESTED

Mr. Michael Bednar, Environmental Compliance Superintendent
Grand River Dam Authority
P.O. Box 70
Langley, OK 74350

Re: Groundwater Sampling and Analysis Program Plan
Grand River Dam Authority (GRDA)
Permit Number 3549012
Mayes County

NOTICE OF DEFICIENCY

Dear Mr. Bednar:

On October 18, 2017 the Department of Environmental Quality (DEQ) received the proposed "Groundwater Sampling and Analysis Program" Plan dated October 18, 2017, A&M Engineering and Environmental Services (A&M) submitted for GRDA. The Plan was submitted in accordance with OAC 252:517-9-1(b)(1)(B).

DEQ has reviewed the Plan and has the following comments:

1. References to 40 CFR §257 are made throughout the Plan. Please update the Plan to reference OAC 252:517 instead.
2. Please include in the Plan a quarterly monitoring schedule for OAC 252:517 Appendix A and B parameters to obtain the minimum eight (8) background samples necessary for detection monitoring per OAC 252:517-9-5(b).

If you have any questions, please contact Martha Grafton of my staff at (405) 702-5144.

Sincerely,

Hillary Young, P.E.
Chief Engineer
Land Protection Division

HY/mg

cc: Tom Trebonik, A&M Engineering

GROUNDWATER SAMPLING AND ANALYSIS PROGRAM
GRAND RIVER DAM AUTHORITY LANDFILL
GRAND RIVER ENERGY CENTER
MAYES COUNTY, OKLAHOMA

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CERTIFICATION STATEMENT

I certify that this Groundwater Sampling and Analysis Program was prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information for the GRDA Landfill located within the Grand River Energy Center complex in Mayes County, Oklahoma. Based on the information reviewed the groundwater monitoring system for the existing Coal Combustion Residuals (CCR) landfill has been designed and constructed to meet the requirements of OAC 252:517-9-2, 252:517-9-4, and252:517-9-5; and the selected statistical method is appropriate for evaluating the groundwater monitoring data for the CCR management area. Documentation of the information reviewed supporting this determination and a narrative description of the statistical method selected to evaluate the groundwater monitoring data are attached. This report is to the best of my knowledge and belief, true, accurate and complete.

A&M ENGINEERING AND ENVIRONMENTAL SERVICES, INC.

John H. Roberts, P.E.
Oklahoma Registration No. 12485

January 4, 2018
Date

GROUNDWATER SAMPLING AND ANALYSIS PROGRAM
GRAND RIVER DAM AUTHORITY LANDFILL
GRAND RIVER ENERGY CENTER
MAYES COUNTY, OKLAHOMA

1.0 INTRODUCTION

The Grand River Dam Authority (GRDA) owns and operates the Grand River Energy Center (GREC) electric generating facility located approximately three (3) miles east of the City of Chouteau in Mayes County, Oklahoma. Two (2) coal fired boilers are operated at GREC which produce Coal Combustion Residuals (CCRs) consisting of fly ash and bottom ash. Fly ash comprises greater than 80% of CCRs generated at the facility and is largely sold for beneficial use purposes. Excess fly ash and bottom ash is disposed within a permitted coal ash landfill, herein referred to as the GRDA Landfill, located within the GREC complex.

On June 9, 2016, the Governor of the State of Oklahoma approved by Declaration a final rule for the Disposal of CCRs from Electric Utilities. The new rule regulates the disposal of CCRs under OAC 252:517 Sections 1 through 19. The rule applies both to new and existing CCR landfills and surface impoundments at coal burning electric utility sites.

OAC 252:517-9-1(b)(1) requires existing CCR landfill facilities to:

"*No Later than October 17, 2017, the owner or operator of the CCR unit must be in compliance with the following groundwater monitoring requirements:*

(i) Install the groundwater monitoring system as required by OAC 252:517-9-2;

(ii) Develop the groundwater sampling and analysis program to include selection of the statistical procedures to be used for evaluating groundwater monitoring data as required by OAC 252:517-9-4;

(iii) Initiate the detection monitoring program to include obtaining a minimum of eight independent samples for each background and downgradient well as required by 252:517-9-5(b);

(iv) Begin evaluating the groundwater monitoring data for statistically significant increases over background levels for the constituents listed in Appendix A of this Chapter as required by OAC 252:517-9-5."

This Groundwater Sampling and Analysis Program has been prepared to satisfy the requirements of OAC 252:517-9-1(b)(1).

2.0 LANDFILL INFORMATION

The GRDA Landfill is permitted by the Oklahoma Department of Environmental Quality (DEQ) as a Non-Hazardous Industrial Waste Landfill that is allowed to accept fly ash, bottom ash and spent powdered activated carbon used to control flue gas emissions, generated at the GREC (DEQ, 2015). The GRDA Landfill is situated south of the coal-fired boiler units within the GREC complex, as shown in **Figure 1**, and has been in operation since 1981. The total landfill permit area consists of approximately 116 acres, of which only 47 acres have been utilized for CCR disposal. The GRDA Landfill remains active to date.

The landfill is bordered by surface impoundments to the west and south. The surface impoundments to the south were created during construction of US Highway 412 by using the area for borrow material. These impoundments hold water continuously throughout the year and are connected to the groundwater, as is shown below. The water level in these impoundments fluctuates from 592 to 596 feet above mean sea level (MSL). **Figure 2** shows the landfill, the monitoring wells and the impoundments.

3.0 SITE HYDROGEOLOGY

The landfill is underlain by an unconsolidated clay, silt, sand and gravel layers ranging in total thickness from 9 feet to about 25 feet. The unconsolidated section is underlain by Pennsylvanian sandstone/limestone bedrock.

The uppermost aquifer is in the unconsolidated section and is monitored on-site by five monitoring wells, one (1) upgradient well and four (4) downgradient wells as is shown in **Figure 2**. MW93-1 is the upgradient well and MW93-2, MW93-3, MW03-1 and MW03-2 are the downgradient wells. **Appendix A** contains the boring logs and available well completion data for the monitoring wells.

Historical groundwater maps covering the time range from July, 2012 to June, 2017 show the fluctuations of the groundwater levels at each monitoring well (**Appendix B**). The maps were compiled semi-annually and give the height of the groundwater at each well, interpolated contours of the top of groundwater elevation across the site, and the direction of flow. For each monitoring well, **Table 1** shows the surface and bedrock elevations, the average top of groundwater elevations, and the saturated thickness of the aquifer in the well.

The average top of groundwater varies from a high point of 609.8 feet at MW93-01 to a low point of 591.2 feet at MW03-02, for a total elevation change of 18.6 feet. The top of groundwater elevation varies uniformly between the wells. This shows that the groundwater is connected to the surface impoundments. The aquifer saturated thickness varies from 5.6 feet at MW93-01 to 21.2 feet at MW03-02, although the thickness variation is not uniform across the site.

The groundwater in the uppermost aquifer flows from the west-northwest to the east-southeast, following the surface terrain. The groundwater velocity was calculated to be 3.39×10^{-6} cm/sec or 3.5 ft/year. This calculation and assumed values are included in **Appendix C**. The aquifer has a low hydraulic conductivity and yield, and the flow rate indicates that it will take several years for MW03-01 and MW03-02 to show an impact not detected at monitoring wells MW93-2 and MW93-3 located adjacent to and immediately downgradient from the CCR unit. Therefore, it can be concluded that the length of time the wells have been in place and the locations of MW03-01 and MW03-02 are adequate to ensure detection of groundwater contamination in the uppermost aquifer at the downgradient boundary of the GREC complex.

4.0 MONITOR WELL CONSTRUCTION

The monitoring well borings were drilled with a 4 inch hollow stem auger to a depth just above the top of bedrock elevation. The monitor wells consist of a 2 inch diameter PVC casing centered in a 4 inch diameter boring. The bottom portion of the PVC monitoring well is perforated to create a screen, the annular space filled with coarse sand to an elevation one foot above the top of the screen. The sand pack is capped with 3/8 inch bentonite chips to within two feet of the top of the boring. The remaining two feet of annular space is sealed with cementitious grout. A&M Engineering has reviewed the construction details and monitoring well completion reports that are contained in **Appendix A**.

5.0 SAMPLING AND ANALYSIS

Sampling and analysis of groundwater at the GRDA landfill facility is an on-going activity that has been conducted for at least 20-years. Three of the five groundwater monitoring wells currently used in the monitoring activities (upgradient well MW93-1, down-gradient well MW93-2, and down-gradient well MW93-3) have analytical data sets that extend back to December 1994. The two remaining down-gradient wells (MW03-1 and MW03-2) were installed in 2004 and have analytical data sets extending back to June 2004. As such, a sufficient number of analyses are available from the upgradient well to establish background water quality for each of the constituents required for detection monitoring.

Groundwater monitoring of the five monitoring wells is currently conducted semi-annually; with the results of laboratory analysis and statistical evaluation reported to DEQ on a semi-annual basis. It is anticipated at this time that groundwater monitoring and reporting activities will continue on a semi-annual basis with a separate annual groundwater monitoring and corrective action report compiled and posted to the GRDA CCR Website in accordance with OAC 252:517-9-1(e). Sampling and analysis methods to be employed in conducting the groundwater monitoring activities are addressed below.

5.1 Sample Collection

Only qualified, experienced field personnel will conduct the sampling activities at the GRDA Landfill. All groundwater-sampling activities will be conducted using appropriate safety equipment. All personnel participating in the sampling activities will be required to utilize the personal protective equipment normally required for work at the facility (hard hat, safety glasses, steel-toed shoes/boots, and high visibility vest/clothing) as well as disposable nitrile gloves. All consumables generated during sampling (e.g., nitrile gloves, paper towel, etc.) will be containerized and properly disposed after each sampling event.

5.2 Equipment Preparation

Equipment to be used for water level measurement and/or purging the wells will be operated and maintained according to the manufacturer's instructions. Prior to gauging or purging the wells, any equipment that is not single use and disposable will be decontaminated with an Alconox soap solution and rinsed with distilled water. Appropriate precautions will be taken to ensure that the water used is contaminant free.

5.3 Well Gauging

Prior to purging and sampling, the static water level of each groundwater monitoring well will be measured and recorded. The water levels in the monitoring wells will be measured starting with the least potentially contaminated wells (as determined by gradient position) and progressing from least to the most potentially contaminated. A Heron Dipper-T water level indicator (or equivalent electric tape) will be used in gauging. The electric tape will be decontaminated with an Alconox® soap solution and rinsed with distilled water prior to measuring the first well and between each subsequent well. Water levels will be measured and recorded to the nearest one-hundredth of a foot from the designated measuring point at the top of the well casing. Water level data gathered will be utilized to evaluate the groundwater elevation and flow direction across the site and for calculation of groundwater gradient.

5.4 Well Purging

Depending on equipment availability on the day of sampling, the monitoring wells will be purged (either pumped or bailed) to ensure the groundwater samples collected are fresh and representative of the shallow groundwater system. If a pump is used to purge the wells, a small diameter electric pump suitable for use in 2-inch diameter monitoring wells (e.g., Grundfos Ready- Flo2 environmental sampling pump or equivalent) will be used. If hand bailed, new disposable Teflon® bailers will be used to purge the monitoring wells. A new bailer will be used for each well.

Removal of three well volumes of groundwater is typically considered adequate to ensure all stagnant water has been removed from the well. A well volume is the amount of water contained in the well casing immediately prior to purging and is calculated using the following formula:

Well volume (in gallons) = [(TWD – DTW)*0.163]

where: TWD = Total Well Depth

DTW = Depth to Water

0.163 = factor for conversion of feet of water to gallons in a 2" diameter well casing

The total purge volume for a well is then calculated by multiplying the calculated well volume by three (3) and rounding up to the nearest gallon when necessary. Wells that do not yield three well volumes will be purged until dry and allowed to recover a minimum of 24-hours prior to sampling. Experience has shown that monitoring wells on the facility are slow to recharge and that allowing 24-hours for recovery is desirable to ensure sufficient water to conduct sampling activities. Purge volumes will be monitored to ensure adequate water removal.

5.5 Sample Collection

After the 24-hour recovery period, each monitoring well will be sampled by slowly lowering a new disposable bailer into the well until the water surface is contacted. The bailer will be allowed to slowly sink below the surface and fill with water. The bailer will then be slowly

raised to the surface and the sample water gently discharged into the laboratory prepared sample containers. Groundwater samples collected from the monitoring wells will not be field filtered. This will allow for measurement of total recoverable metals which captures both the particulate fraction and the dissolved fraction of metals within the groundwater.

This process will be repeated until all laboratory prepared bottles/vials are filled. Once the individual sample containers are full and properly labeled, they will be placed into an ice chest containing sufficient ice to cool and maintain sample temperature at 4°C during transportation to the laboratory (See **Section 5.6** for sample preservation and shipping information).

An alternate method of well purging and sample collection is currently being contemplated for implementation at the GREC Complex. The method, Low Flow Purging and Sampling, utilizes a low flow pump to both purge and sample the wells. Under this method, a Pegasus Low-Flow peristaltic pump (or equivalent) with an attached flow-through-cell is used to collect groundwater samples. New low density polyethylene (LDPE) intake tubing is used for each individual well. The tubing is lowered into the well casing until the intake is within the screen interval of the well, at a depth that will remain under water at all times. Pumping is then initiated at a low-flow rate (approximately 100 mL/min) while indicator field parameters are monitored using the flow-through-cell device.

Stabilization of field parameters is used to indicate that conditions are suitable for sampling to begin. The field parameters typically monitored include: Temperature, Specific Conductance, pH, Oxidation Reduction Potential, Dissolved Oxygen, and Turbidity. The field parameters are recorded approximately every three minutes while pumping. When the parameters ensuing recordings falls within a prescribed range, the field parameters are considered stabilized and the well suitable for immediate sampling. All data generated during the event is typically recorded on Low-Flow Groundwater Sampling Field Sheets which become part of the sampling event permanent record.

One of the advantages of Low Flow Purging and Sampling is that the technique eliminates the need to remove significant volumes of water from each well while allowing for collection of representative formation water in the immediate area of the well screen without disturbing stagnant water which may be above or below the screened interval. Once samples are collected into the laboratory prepared containers, the flow-through-cell is thoroughly cleaned and decontaminated prior to moving to the next monitoring well.

In the event the Low Flow Purging and Sampling technique is implemented at the GREC Complex, the Annual Groundwater and Corrective Action Report required under OAC 252:517-9-1(e) will include a detailed description of the procedures used and all data generated during the sampling activities.

5.6 Sample Preservation and shipment

Each sample for analysis will be collected into laboratory supplied pre-cleaned bottles or vials. The glass or plastic bottles/vials will contain the appropriate preservative for the individual parameters to be analyzed. The sample bottles/vials will be appropriately labeled by the laboratory indicating the preservative being used.

Each collected sample will then be packaged and transported appropriately as described in the following protocol:

- Collect samples into appropriate laboratory supplied containers containing the required preservative.
- Print the following information clearly in waterproof ink on the label for each sample container: the sample number, the project number (if required), the initials of the sample collector, and the date and time the sample was collected.
- Fill out Chain-of-Custody record.
- Prepare and package samples for shipping.
- Place samples into a cooler containing sufficient ice to cool and maintain sample temperature at 4°C during transportation to the laboratory.

- Ship the samples together with the Chain-of-Custody form to the laboratory.

Because the laboratory utilized for the analysis is located within driving distance of the facility, samples will be hand delivered directly to the laboratory by the sampling personnel. Third party shipping will not be required.

5.7 Analytical Procedures

Analysis of groundwater samples will generally be performed by a third party, State of Oklahoma Certified Laboratory. However, those constituents for which the GREC Complex Laboratory is approved for analysis, may on occasion and at the option of GRDA, be conducted at the facility. Laboratory analysis of the groundwater samples will, at a minimum, include those constituents listed in Appendix A to Section 9 of OAC 252:517, "Constituents for Detection Monitoring". However, the existing Landfill Permit issued by DEQ requires additional constituents and general water quality parameters to be analyzed on a semi-annual basis. The complete list of groundwater constituents anticipated to be analyzed on a semi-annual basis is provided in **Table 2.** In the event the list of groundwater constituents is modified by DEQ, this Sampling and Analysis Program will be updated to reflect any changes made. Those parameters typically recorded in the field (pH, temperature, Specific Conductance, etc.) will be appropriately recorded on the chain-of-custody form at the time of sampling.

Methods to be utilized in analysis of the groundwater will vary based on the constituent being quantified. However, Certified Laboratories typically utilize standard published methodologies for analysis of groundwater. The standard methodologies to be used during analysis of the groundwater from the GRDA monitoring wells include:

40 CFR Parts 136, 141, and 261.

Methods for Chemical Analysis of Water and Wastes, EPA-600/4-79-020, March 1983.

Test Methods for Evaluating Solid Wastes, SW-846, Final Update III. Standard Methods 1998 (20th Edition).

Standard Methods 2005 (21st Edition) and Standard Methods 2011 (22nd Edition) for the

Examination of Water and Wastewater.

5.8 Sample Chain-of-Custody

Sample custody procedures will be followed through sample collections, transfer, analysis and ultimate disposal. The purpose of these procedures is to assure that the integrity of samples is maintained during their collection, transportation and storage prior to analysis and any remaining sample material is properly disposed of after analysis. Sample custody begins with the shipment/receipt of the laboratory prepared sample containers. Sample containers are generally shipped from the laboratory in sealed coolers or cartons with appropriate seals and custody documentation or they can be picked up at the laboratory by sampling personnel. Sample quantities, constituents for analysis, sample containers, appropriate preservatives, sample media types, and sample locations will be determined before any field work commences.

The sampling personnel will be responsible for the care and custody of the samples until properly transferred to the laboratory for analysis. Custody transfer will be documented on a properly completed Chain-of-Custody Form. An example of the Chain-of-Custody form currently used in groundwater monitoring for the GRDA Landfill is included as **Appendix D** at the end of this document.

At the chemical laboratory, a designated sample custodian will accept custody of the delivered samples and verify that the information on the sample label matches that on the Chain-of-Custody form(s). Pertinent information such as sample condition, shipment, pickup, and courier will also be checked on the Chain-of-Custody form(s). Information on the date and time of receipt, method of shipment, and sample condition will be recorded on this form. The custodian will then enter the appropriate data into the laboratory sample tracking system. The laboratory custodian will use the sample number on the sample label as well as assign a unique laboratory number to each sample. The custodian will then transfer the sample(s) to the proper analyst(s) or store the sample(s) in an appropriate area according to **Table 3**.

Laboratory personnel will be responsible for the care and custody of samples from the time they are received and are responsible for sample disposal. Data sheets and laboratory records will be retained as part of the Quality Assurance Records for a period of at least 5 years. Samples are typically retained by the analytical laboratory for up to 30 days after the data is reported by the laboratory. Unless notified otherwise, excess or unused samples are disposed of by the laboratory in a manner consistent with appropriate government regulations.

5.9 Quality Assurance and Quality Control

Quality assurance / quality control (QA/QC) sample collection and analysis activities are discussed in the following paragraphs. Laboratory QC requirements are contained within the laboratory's Quality Assurance Manual and are available directly from the laboratory.

5.9.1 Field Duplicate Samples

Duplicate samples will be collected and prepared at a frequency of one (1) duplicate per sampling event. The monitoring well from which the duplicate sample will be collected will be randomly chosen by sampling personnel at the time of sample collection. The duplicate sample will be collected by filling a laboratory supplied sample bottle containing appropriate preservative with groundwater from the chosen monitoring well. Sampling personnel will keep a separate record of the sampling time and from which well the duplicate sample was collected. The duplicate sample will be included on the Chain-of-Custody and will only be analyzed for the Appendix A constituents. The analytical laboratory will not be informed from which well the duplicate sample was collected.

5.9.2 Trip Blanks

Trip blanks are used to document contamination attributable to shipping and field handling procedures. One trip blank will be included in each cooler which will hold samples to be analyzed. The Trip Blanks will be prepared by the laboratory and will consist of analyte-free water taken from the laboratory to the sampling site and returned to the laboratory unopened. The trip blank will be analyzed for Appendix A Constituents only.

6.0 STATISTICAL ANALYSIS METHOD

Statistical evaluation of the analytical results of the groundwater will be conducted utilizing a tolerance or prediction interval procedure. Under this procedure, an interval for each constituent determined from laboratory analysis is established from the background data gathered from the upgradient monitoring well and the level of each constituent in the downgradient (compliance) wells is compared to the upper tolerance or prediction limit.

The Shapiro-Francia Test of Normality, Levene's Test for Equal Variance and Prediction Limit Interval tests for inter-well analyses will be utilized in the statistical evaluation of the parameters. In the event that inter-well statistical evaluation indicates the presence of an elevated parameter in the downgradient wells compared to historical data of the upgradient or background wells, an Intra-well Prediction Limit Interval test will also be conducted on the specific well or wells of interest. These intra-well comparisons will then be utilized to determine whether a significant increase had occurred within a specific well in question. This method of statistical evaluation is consistent with OAC 252:517-9-4(g)(3) and is the method currently used by the GREC Complex in statistical analysis of groundwater data.

7.0 DETECTION MONITORING REQUIREMENTS

In accordance with OAC 252:517-9-5, GRDA must conduct detection monitoring at all groundwater MWs for the constituents listed in Appendix A of the CCR regulations. At a minimum the following parameters shall be monitored on a semi-annual basis:

Boron
Calcium
Chloride
Fluoride
pH
Sulfate
Total Dissolved Solids

Groundwater data on the additional groundwater constituents required by DEQ to be analyzed on a semi-annual basis (and as discussed above in Section 5.7) will also be determined as part of the detection monitoring procedures.

OAC 252:517-9-5 (b) states that a minimum of eight (8) independent samples from each background and downgradient well must be collected and analyzed for the constituents listed in Appendix A and B of the CCR regulations. Therefore, in addition to the parameters listed above for the normal detection monitoring regimen, the following parameters shall also be monitored on a semi-annual basis for the first eight (8) testing cycles:

Antimony
Arsenic
Barium
Beryllium
Cadmium
Chromium
Cobalt
Fluoride
Lead
Lithium
Mercury
Molybdenum
Selenium
Thallium
Radium 226 and 228 Combined

Historically, semi-annual frequency of monitoring has occurred on the sixth and twelfth months of the year (June and December). Upon review of the hydrogeological data for the past five years (**Table 1**), these testing intervals have shown to be adequate regarding the presence of sufficient groundwater flow necessary for the sampling of each well. Only one well was reported dry during these sampling periods (MW03-01 in December, 2012), and the ground water level in the well rebounded by the next sampling period.

GRDA will maintain the current sampling schedule, unless the need arises to alter the current monitoring frequency. If it is determined that the monitoring frequency is to be varied, GRDA

will provide documentation as to the reason, considering the following factors according to OAC 252-517-9-5(d)(1):

A. Lithology of the aquifer and unsaturated zone,

B. Hydraulic conductivity of the aquifer and unsaturated zone, and

C. Groundwater flow rates.

Additionally, the documentation shall show that the alternative frequency proposed will not be less effective in ensuring that any CCR leakage will be undiscovered within a timeframe necessary to take corrective measures, according to OAC 252-517-9-5 (d)(2).

Should GRDA need to alter the frequency of the detection monitoring program, a certification by a professional engineer will be provided stating that the new monitoring program meets the requirements of OAC 252:517-9-1(e).

According to OAC 252-517-9-5 (e), if it is determined, for wells located at the waste boundary, that there is a statistically significant increase over background levels in the constituents listed in Appendix A, a corrective action procedure shall be established.

8.0 CORRECTIVE MEASURES

According to OAC 252-517-9-5 (e)(1), GRDA must *"within 90 days of detecting a statistically significant increase over background levels for any constituent, establish an assessment monitoring program meeting the requirements of OAC 252:517-9-6."* A notification stating that an assessment monitoring program has been established is required to be placed in the facility's operating record.

Alternatively, GRDA can attempt to demonstrate that a source other than the CCR unit caused the significant increase, or that the increase in constituent levels were caused by error in sampling, analysis, statistical evaluation, or natural variation in groundwater quality. A demonstration report, certified by a professional engineer, is required to be completed within 90

days of the detection occurrence. If successful demonstration is shown, GRDA may continue with the detection monitoring program already in place.

9.0 RECORDKEEPING REQUIREMENTS

In accordance with OAC 252:517-19-1(h), GRDA must maintain the facility operating record with the following information, OAC 252:517-19-1(h)(2-5):

- Documentation of the design, installation, development, and decommissioning of any monitoring wells, piezometers and other measurement, sampling, and analytical devices as required by OAC 252:517-9-2(e)(1).
- The groundwater monitoring system certification as required by OAC 252:517-9-2(f).
- The selection of a statistical method certification as required by OAC 252:517-9-4(f)(6).
- Within 30 days of establishing an assessment monitoring program, the notification as required by OAC 252:517-9-5(e)(3).

Placement of the Groundwater Sampling and Analysis Program into the facility's operating record will satisfied the above requirement. Unless specified otherwise, each file must be retained for at least five (5) years following the date of each occurrence, measurement, maintenance, corrective action, report, record, or study.

10.0 NOTIFICATION REQUIREMENTS

In accordance with OAC 252:517-19-2(g), the DEQ Land Protection Division must be notified when this document or any subsequent amendments or revisions to this document are placed in the operating record and on the publicly accessible internet site.

11.0 CCR WEBSITE REQUIREMENTS

In accordance with OAC 252:517-19-3(h), GRDA must maintain this Groundwater Sampling and Analysis Program on the corporate "CCR Rule Compliance Data and Information" webpage. Unless otherwise required, the information required to be posted to the CCR Website must be

made available to the public for at least five (5) years following the date on which the information was first posted.

12.0 REFERENCES

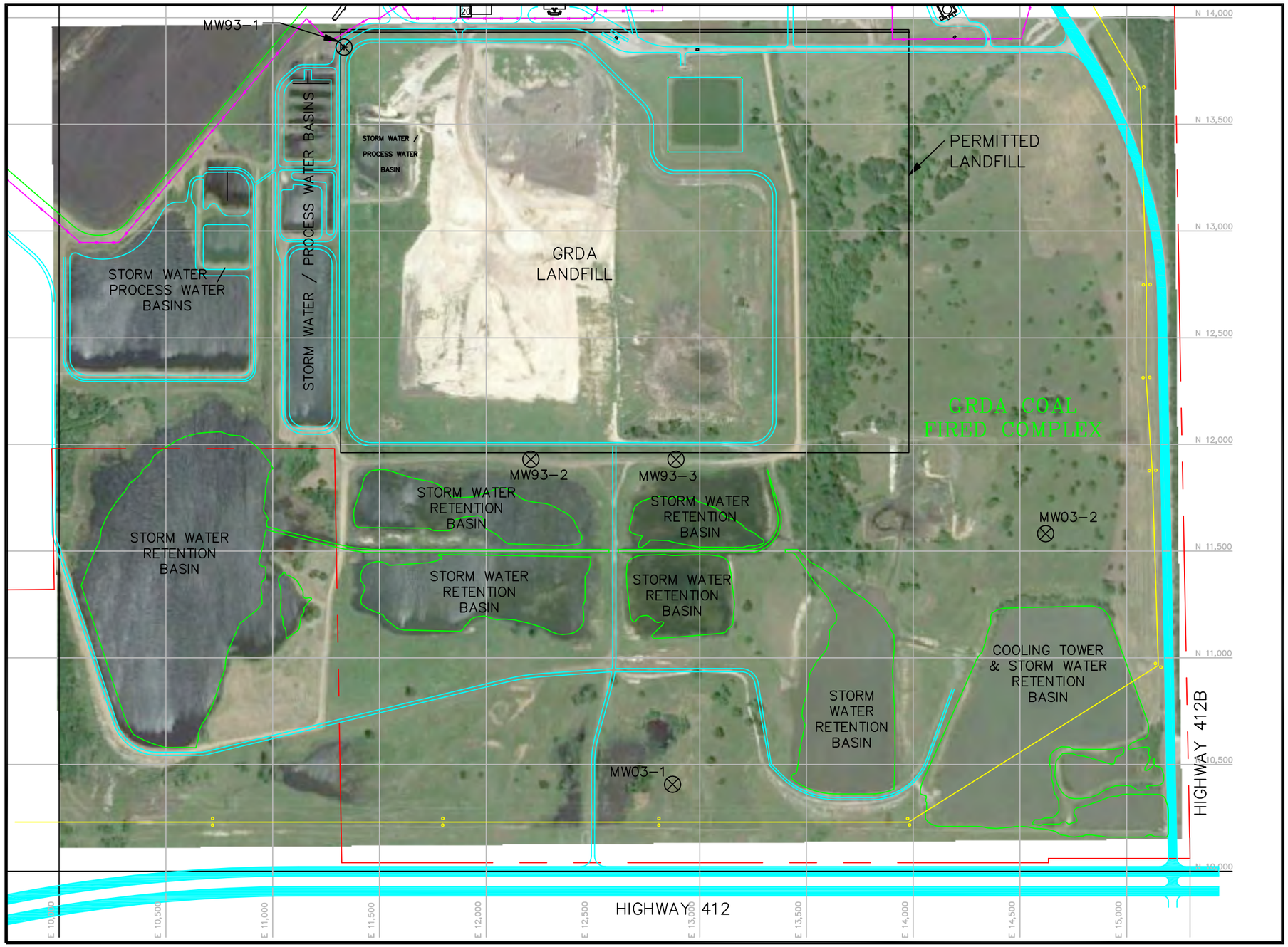
Holway-United, *Grand River Dam Authority 490-MW Coal-Fired Generating Station Ash Disposal Site Permit Application, Chouteau, Oklahoma.* August 22, 1979.

Oklahoma State Department of Health (OSDH), Permit for a *Coal Ash Disposal Site*. January 13, 1981.

Oklahoma Department of Environmental Quality (DEQ), *Permit Modification to add an additional Solid Waste Stream, Grand River Dam Authority, Mayes County, Permit 3549012.* February 20, 2015.

Oklahoma Department of Environmental Quality (DEQ), *OAC 252:517.* September 15, 2016.

FIGURES



NORTH

SCALE

0 500′ 1000′

DJR 4/13/06

GENERAL NOTES

1) BASE MAP PROVIDED BY GRDA.
2) AERIAL PHOTO PROVIDED BY GOOGLE EARTH, DATED JUNE 10, 2013.

REVISIONS

NO.	DESCRIPTION	BY	CHECKED	DATE	NO.	DESCRIPTION	BY	CHECKED	DATE

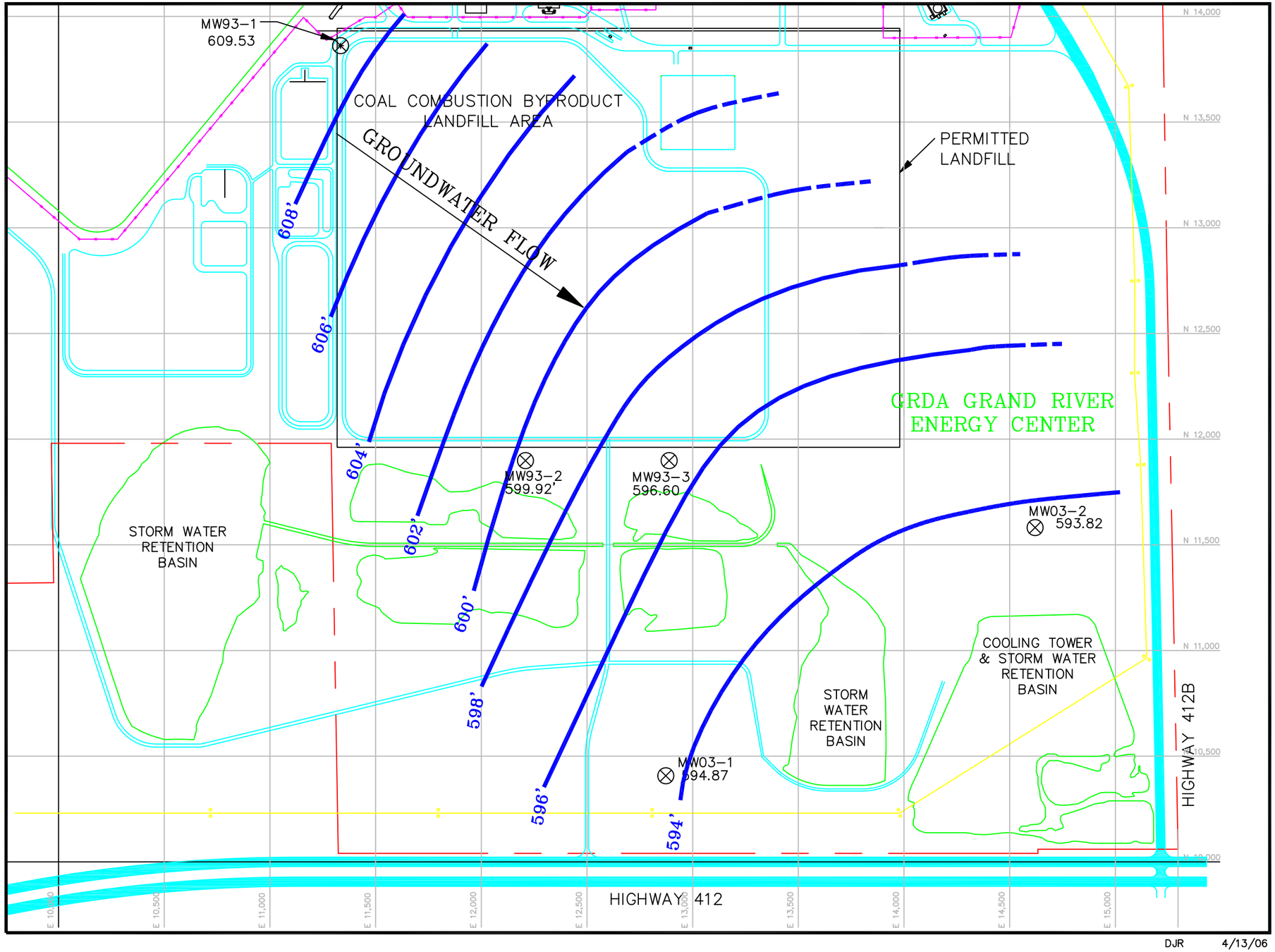
A & M ENGINEERING AND ENVIRONMENTAL SERVICES, INC.
ENGINEERING – ENVIRONMENTAL – CONSTRUCTION

DRAWN:	CHECKED BY:	MATERIALS BY:	ENGINEER:
DME	DME		
DATE: 10/10/2016	DATE: 10/10/2016	DATE:	DATE:

SITE MAP

GRAND RIVER DAM AUTHORITY LANDFILL
CHOUTEAU, OKLAHOMA

APPROVED BY:	SCALE:	PROJECT NUMBER:	DRAWING NUMBER:	REV.:
DME	AS SHOWN	1986-016	FIGURE 1	
DATE: 10/10/2016				



NORTH

SCALE

0 500' 1000'

DJR 4/13/06

GENERAL NOTES

1) GROUNDWATER ELEVATIONS MEASURED ON JUNE 6, 2017.

REVISIONS

NO.	DESCRIPTION	BY	CHECKED	DATE	NO.	DESCRIPTION	BY	CHECKED	DATE

A & M ENGINEERING AND ENVIRONMENTAL SERVICES, INC.

ENGINEERING – ENVIRONMENTAL – CONSTRUCTION

GROUNDWATER CONTOUR MAP
JUNE 6, 2017
GRAND RIVER DAM AUTHORITY LANDFILL
CHOUTEAU, OK

DRAWN:	CHECKED BY:	MATERIALS BY:	ENGINEER:	APPROVED BY:	SCALE:	PROJECT NUMBER:	DRAWING NUMBER:	REV.:
BAG	DME			DME	AS SHOWN	1986-002	FIGURE 1	
DATE: 7/18/2017	DATE: 7/18/2017	DATE:	DATE:	DATE: 7/21/2017				

TABLES

TABLE 1 SATURATED AQUIFER THICKNESS

Uppermost Aquifer Thickness						
		MW93-1	**MW93-2**	**MW93-3**	**MW03-1**	**MW03-2**
T.O. Grade Elev. (ft)		617.7	605.0	605.4	595.6	595.0
Depth to Bedrock (ft)		13.5	23.0	25.0	9.3	25.0
T.O. GW Elev. (ft)	**Jul-12**	610.1	599.4	594.8	592.7	591.1
	Dec-12	609.1	599.3	594.0	DRY	590.4
	Jun-13	610.9	599.8	594.9	595.3	592.0
	Dec-13	609.6	598.9	594.7	593.5	590.8
	Jun-14	611.3	599.5	595.3	595.6	592.1
	Dec-14	609.7	599.4	594.7	593.5	591.1
	Jun-15	610.0	599.5	596.6	594.8	593.2
	Dec-15	610.3	599.7	598.3	595.6	592.3
	Jun-16	608.5	599.8	594.8	594.0	595.0
	Dec-16	608.4	599.3	594.2	591.1	580.9
	Jun-17	609.5	599.9	596.6	594.9	593.8
Avg. GW Elev. (ft)		609.8	599.5	595.4	594.1	591.2
T.O. Bedrock (ft)		604.2	582.0	580.4	586.4	570.0
SaturatedAquifer Thickness (ft)		**5.6**	**17.5**	**15.0**	**7.8**	**21.2**

Elevations shown are relative to MSL

TABLE 2 SEMI-ANNUAL GROUNDWATER CONSTITUENT LIST

Field Temperature (°C)	Arsenic* (mg/L)
Field pH* (Std. Units)	Barium (mg/L)
Specific Conductivity (µmhos/cm)	Boron* (mg/L)
ORP (mv)	Calcium* (mg/L)
Alkalinity (mg/L)	Chloride* (mg/L)
Sulfate* (mg/L)	Copper (mg/L)
Hardness (mg/L)	Fluoride* (mg/L)
Nitrate-Nitrogen (mg/L)	Iron (mg/L)
Total Residue (mg/L)	Phosphorous (mg/L)
Total Dissolved Solids* (mg/L)	Potassium (mg/L)
Chemical Oxygen Demand (mg/L)	Selenium (mg/L)
Total Organic Carbon (mg/L)	Sodium (mg/L)

*Appendix III Constituent

TABLE 3 CONSTITUENT PRESERVATION, STORAGE, AND HOLDING TIME

Analysis	**Container Type**	**Preservation/Storage**	**Maximum Holding Time**
Field Temp	N/A	N/A	Field
Field pH	N/A	N/A	Field
Specific Conductivity	Plastic/Glass	4° C	28 Days
ORP	N/A	N/A	Field
Alkalinity	Plastic/Glass	4°C	14 Days
Sulfate	Plastic/Glass	4°C	28 Days
Hardness	Plastic/Glass	HNO_3 - pH below 2	6 Months
Nitrate-Nitrogen	Plastic/Glass	4°C	48 Hours
Total Residue	Plastic/Glass	4°C	7 Days
Total Dissolved Solids	Plastic/Glass	4°C	6 Months
Chemical Oxygen Demand	Plastic/Glass	4°C	28 Days
Total Organic Carbon	Plastic/Glass	4°C, H2SO4/HCl/H3PO4 - pH below 2	28 Days
Arsenic	Plastic/Glass	HNO_3 - pH below 2	6 Months
Barium	Plastic/Glass	HNO_3 - pH below 2	6 Months
Boron	Plastic/Glass	HNO_3 - pH below 2	6 Months
Calcium	Plastic/Glass	HNO_3 - pH below 2	6 Months
Chloride	Plastic/Glass	N/A	28 Days
Copper	Plastic/Glass	HNO_3 - pH below 2	6 Months
Fluoride	Plastic/Glass	N/A	28 Days
Iron	Plastic/Glass	HNO_3 - pH below 2	6 Months
Phosphorous	Plastic/Glass	4°C, H_2SO_4 - pH below 2	28 Days
Potassium	Plastic/Glass	HNO_3 - pH below 2	6 Months
Selenium	Plastic/Glass	HNO_3 - pH below 2	6 Months
Sodium	Plastic/Glass	HNO_3 - pH below 2	6 Months

APPENDIX A

BENTLEY ENVIRONMENTAL ENGINEERING, INC.

LOG OF TEST BORING NO.: MW93-1 (was TB93-9) Page 1 of 1

CLIENT: GRDA
PROJECT: ASH DISPOSAL CELL
PROJECT NUMBER: 9350
LOCATION: ~25' S OF NW DIKE CORNER

SURFACE ELEVATION: 617.7
BORING DEPTH: 13.5'
DATE: 09/01/93

DEPTH FRM LAND SURF	SAMP DEPTH INTERVAL	SAMP TYPE	SAM #	N	RECV ft	DESCRIPTION OF MATERIAL	SOIL CLASS	LAB. OR FIELD TESTS	OVA ppm	DRILLING AND SAMPLING NOTES
-	0 - 5'	CS			5'	4" dark brown silty loam, loose, roots, sli moist, orange brown, gravelley lean CLAY, sli moist, cohesive, semiplastic sandy fill has tilled appearance & no color grading	TOPSOIL / CL-FILL			
--2.5										
-	3'		1							
--5.0	5 - 10'	CS			5'	dark olive brown silty lean CLAY, cohesive, stiff, v. sli moist	CL			
-						med olive br. v. gravelley lean CLAY, sli moist, color grades downward to olive orange brown to orange brown	CL-GW			
--7.5										
-	9'		2			3" cherty gravel, moist not wet w/ 50% CLAY	GW-CL			
--10.0	10 - 13.5'	CS			6"	cherty gravel w/ clay, v. moist to wet (drilled off 1' to 13' - probably water bearing gravel)	CL-GW / GW			
--12.5										
--15.0						EOB 13.5' @ 8:20	BEDROCK CHERT			
--17.5						Set well to 13.5' w/ 5' screen				
--20.0										
--22.5										
--25.0										
--27.5										
--30.0										

DRILLING DATA

START DATE: 09/01/93
COMPLETION DATE: 09/01/93
LOGGED BY: GKM
DRILLING METHOD: HOLLOW STEM AUGER 7" OD
DRILLING CONTRACTOR: PSI

S.A.A.= Same As Above
SS= Split Spoon Sampler
CS= Continuous Sampler
EOB= End of Boring
BDL= Below Detection Limit
TOC= Top of Casing
N/A= Not Applicable

WATER LEVEL INFORMATION (Datum = SURF)

DEPTH AT COMPLETION: 13.0'
LATER TIME/DEPTH:
LATER TIME/DEPTH:
CAVE IN DEPTH: N/A
DRILLING LOSSES: None

935014.ML

BENTLEY ENVIRONMENTAL ENGINEERING, INC.

LOG OF TEST BORING NO.: MW93-2 Page 1 of 1

CLIENT: GRDA
PROJECT: ASH DISPOSAL CELL
PROJECT NUMBER: 9350
LOCATION: ~ 200 YDS EAST OF SW DIKE CORNER ON S SIDE OF S DIKE

SURFACE ELEVATION: 605.0
BORING DEPTH: 23'
DATE: 09/01/93

DEPTH FRM LAND SURF	SAMP DEPTH INTERVAL	SAMP TYPE	SAM #	N	RECV ft	DESCRIPTION OF MATERIAL	SOIL CLASS	LAB. OR FIELD TESTS	OVA ppm	DRILLING AND SAMPLING NOTES
-	0 - 5'	CS			2.5'	dark brown clayey LOAM, roots, cohesive, sli moist to dry	TOPSOIL			
-						gravel-clay mixed FILL	FILL			
-	2'		1			dark brown clayey LOAM, roots, cohesive, sandy increases in gravel downward, sli moist	TOPSOIL			
--2.5										
--5.0	5 - 10'	CS			2'	yellow brown clayey, sandy gravel, well graded, v. fn to crs. loose, v. moist,	GW			
-	5.5'		2			orange brown, v. clayey gravel to a v. gravelly CLAY, sli cohesive, v. moist	GW-CL			
--7.5										
--10.0	10 - 15	CS			1.5'	lt orange brown wet v. clayey gravel, sli cohesive	GW			
-	11'		3			grey brown v. gravelly CLAY, v. moist, cohesive, v. moist	GW-CL			
--12.5										
--15.0	15 - 20'	CS			2'	olive brown interbedded sandy gravel loose,	GW			
-	15.5'		4			water bearing w/ cohesive, very clayey gravel & v. gravelly CLAY, 6" to 12" beds	GW-CL			
--17.5										
--20.0	20 - 23'	CS			2.5'	lt. greenish blue clayey pasty-coated w/ pure white pasty blebs about the consistency of thick water based paint (~ 6 pictures)				
-	21'		5							
-	22'		6							
--22.5										
						EOB @ 23' @ 8:24	BEDROCK			
--25.0						install well @ 19.5'				
--27.5										
--30.0										

DRILLING DATA

START DATE: 09/01/93
COMPLETION DATE: 09/01/93
LOGGED BY: GKM
DRILLING METHOD: HOLLOW STEM AUGER 7" OD
DRILLING CONTRACTOR: PSI

S.A.A.= Same As Above
SS= Split Spoon Sampler
CS= Continuous Sampler
EOB= End of Boring
BDL= Below Detection Limit
TOC= Top of Casing
N/A= Not Applicable

WATER LEVEL INFORMATION (Datum = SURF)

DEPTH AT COMPLETION: 15.0
LATER TIME/DEPTH:
LATER TIME/DEPTH:
CAVE IN DEPTH: N/A
DRILLING LOSSES: None

935011.ml

BENTLEY ENVIRONMENTAL ENGINEERING, INC.

LOG OF TEST BORING NO.: MW93-3 Page 1 of 1

CLIENT: GRDA
PROJECT: ASH DISPOSAL CELL
PROJECT NUMBER: 9350
LOCATION: ~ 150 YDS WEST OF SE DIKE CORNER ON S SIDE OF SOUTH DIKE

SURFACE ELEVATION: 605.4
BORING DEPTH: 25'
DATE: 08/31/93

DEPTH FRM LAND SURF	SAMP DEPTH INTERVAL	SAMP TYPE	SAM #	N	RECV ft	DESCRIPTION OF MATERIAL	SOIL CLASS	LAB. OR FIELD TESTS	OVA ppm	DRILLING AND SAMPLING NOTES
-	0 - 5'	CS			3'	dark brown clayey LOAM, roots, sli moist	TOPSOIL			
-						tan-brown gravelly sandy-clay FILL non-cohesive-gravel, clay mix	FILL			
--2.5						dark brown clayey LOAM, tr. organic, silty sli moist, sli cohesive	TOPSOIL			
-	3'		1							
--5.0	5 - 10'	CS			5'	brown grey silty lean CLAY, cohesive, sli moist, tr. sand, tr. gravel, grey - yel-brwn mottling, stiff	CL			
--7.5	7.5'		2			orange grey brown mottled gravelly lean CLAY (sand gravel 20%) cohesive, stiff, sli moist Fe stain tr. lignite frags				
--10.0	10 - 15'	CS			5'	lt orange-brown v. gravelly CLAY to v. clayey GRAVEL (close to 50-50) sli moist to moist (gravel is L.S. chert, flint)	CL-GW			
--12.5										
-	14.5'		3							
--15.0	15 - 20'	CS			3'	red brown sandy, silty v. clayey GRAVEL, v. fn. to v. crse, moist, (not wet to v. moist) sli cohesive	GW	-		
-	16.5'		4							
--17.5						orange brown v. gravelly CLAY, cohesive, v. moist, v. fn. to crse gravel	CL-GW			
--20.0	20 - 25'	CS			6"	water bearing angular GRAVEL, tr. sand, clay	GW			
--22.5										
--25.0						Bedrock @ 25'	BEDROCK			
						EOB 16:53 @25' Install well w/ 10' screen				
--27.5										
--30.0										

DRILLING DATA

START DATE: 08/31/93
COMPLETION DATE: 08/31/93
LOGGED BY: GKM
DRILLING METHOD: HOLLOW STEM AUGER 3 1/4" ID
DRILLING CONTRACTOR: PSI

S.A.A.= Same As Above
SS= Split Spoon Sampler
CS= Continuous Sampler
EOB= End of Boring
BDL= Below Detection Limit
TOC= Top of Casing
N/A= Not Applicable

WATER LEVEL INFORMATION (Datum = SURF)

DEPTH AT COMPLETION: 20.0'
LATER TIME/DEPTH:
LATER TIME/DEPTH:
CAVE IN DEPTH: N/A
DRILLING LOSSES: None

LOG OF DRILLING OPERATIONS

Boring No: **MW03-A**

Project: GRDA Well Installation — Location: Grand River Dam Authority, Chouteau, OK

Total Depth: 10.0 ft. — Start Date: 04/27/04 — Finish Date: 04/27/04

Geologist: Jeff Brammer — Instrument/Units: NA – no hydrocarbons present

Drilling Company: AEI — License: DPC-0269 — Driller: Chuck Clark

Drilling Method: Hollow Stem Auger (HSA) — Rig Type: Failing SS-10

Drill Bit Type and Size: HSA/8.25"

Boring Location (Street Address or Description): South of the SE surface water pond, near HWY 412

Depth Below Surface (ft)	Sample Interval	Core Run / Recovery	Field Sample ID	BH/BZ	Soil Core PID (ppm)	Time (military)	Drilling Notes	Lithology	Depth Below Surface (ft)
0							Clayey silt, dark brown, moist, rootlets, soft	ML	0
1									1
2		5.0	None		NA		Silty clay, light brown, mottled gray, firm, moist, low to medium plasticity	CL	2
3							Gravelly clay, reddish brown, gravels include calcite and sandstone, angular, moist, soft	GL	3
4	5.0					08:55			4
5									5
6			None		NA				6
7		5.0					Wet – apparent water level at time of drilling		7
8									8
9									9
10	10.0					09:05	Limestone, gray, hard, dry		10

TD – 10 feet

WELL CONSTRUCTION DETAILS

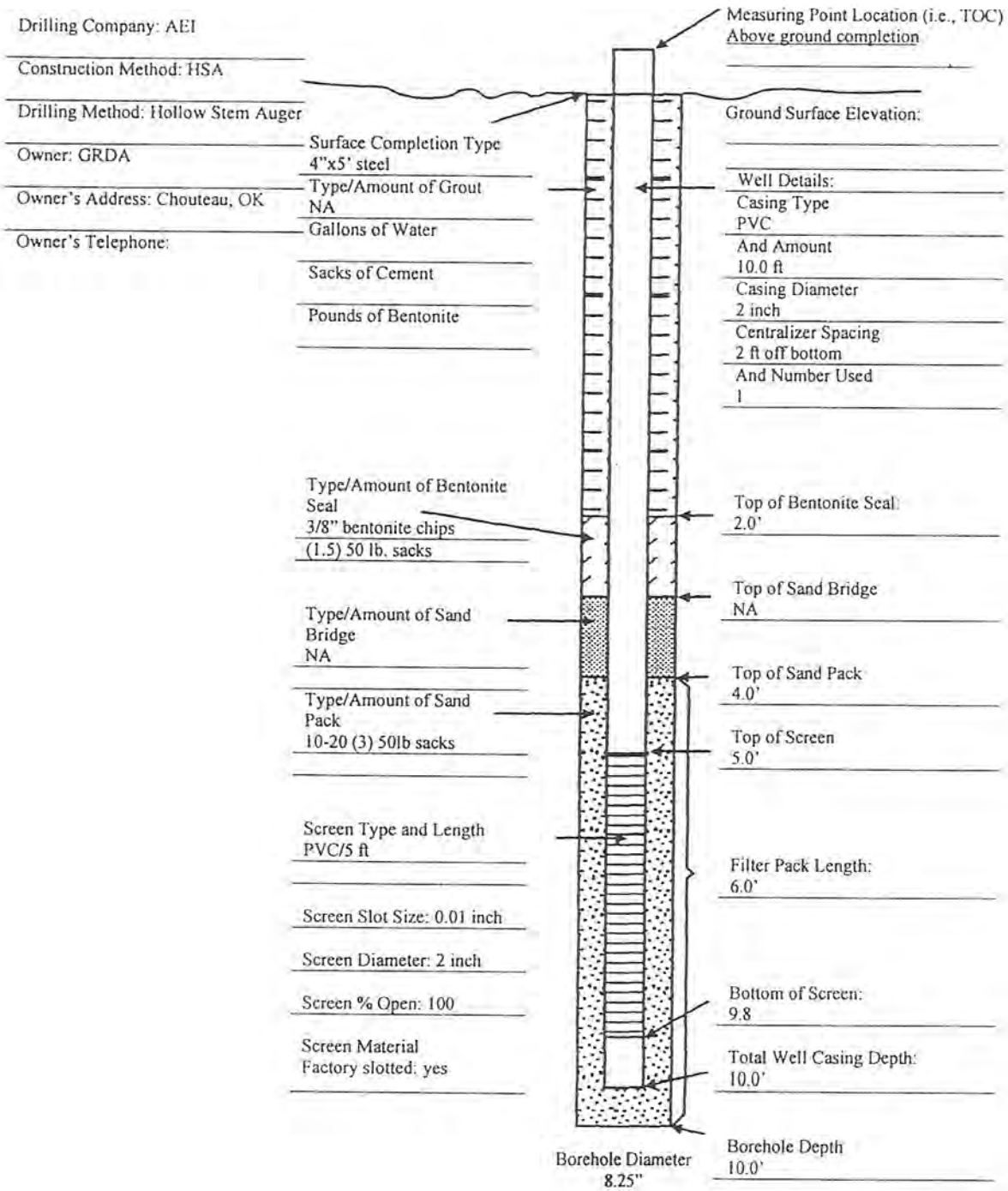
Well Name: **MW03-A**
Supervised by: Jeff Brammer
Well Type: GWMW

Boring No: MW03-A

Location Description: S of SE surface water pond

Installation Date: 04/27/04

Project: Grand River Dam Authority



LOG OF DRILLING OPERATIONS

Boring No: **MW03-B**

Project: GRDA Well Installation

Location: Grand River Dam Authority, Chouteau, OK

Total Depth: 25.0 ft.

Start Date: 04/27/04

Finish Date: 04/27/04

Geologist: Jeff Brammer

Instrument/Units: NA – no hydrocarbons present

Drilling Company: AEI

License: DPC-0269

Driller: Chuck Clark

Drilling Method: Hollow Stem Auger (HSA)

Rig Type: Failing SS-10

Drill Bit Type and Size: HSA/8.25"

Boring Location (Street Address or Description): East of the SE corner of the Ash Landfill

Depth Below Surface (ft)	Sample Interval	Core Run / Recovery	Field Sample ID	BH/BZ	Soil Core PID (ppm)	Time (military)	Drilling Notes	Lithology	Depth Below Surface (ft)
0							Clayey silt, dark brown, soft, moist, rootlets, transitional lower boundary	ML	0
1									1
2		5.0	None		NA		Silty clay, brown, mottled dark red, moist, firm, low plasticity	CL	2
3							Silty clay, brown, mottled gray, moist, firm, low plasticity	CL	3
4	5.0					10:40	Silty clay, gray, mottled brown, Mn nodules	CL	4
5									5
6									6
7		5.0	None		NA				7
8							Increased brown mottling at 8.0 feet		8
9	10.0					10:45			9
10									10

LOG OF DRILLING OPERATIONS

Boring No: **MW03-B**

Start Date: 04/27/04

Geologist: Jeff Brammer

Depth Below Surface (ft)	Sample Interval	Core Run / Recovery	Field Sample ID	BH/BZ	Soil Core PID (ppm)	Time (military)	Drilling Notes	Lithology	Depth Below Surface (ft)
10									10
11								CL	11
12		5.0	None		NA		Less mottling at 12.0 feet and down, gray and becomes greenish gray		12
13							Wet – apparent water level at time of drilling		13
14	15.0					10:50			14
15									15
16									16
17		5.0	None		NA				17
18									18
19	20.0					11:00	Silty clay, brown, mottled gray, moist, firm, low plasticity	CL	19
20									20

LOG OF DRILLING OPERATIONS

Boring No: **MW03-B**

Start Date: 04/27/04

Geologist: Jeff Brammer

Depth Below Surface (ft)	Sample Interval	Core Run / Recovery	Field Sample ID	BH/BZ	Soil Core PID (ppm)	Time (military)	Drilling Notes	Lithology	Depth Below Surface (ft)
20							(continued from above)		20
							Gravel at 20.5 to 22.5 feet		
21								CL	21
22		5.0	None		NA				22
23									23
24									24
	25.0					11:20	Sandstone, brown, wet	SS	
25							TD – 25.0 feet		25
26									26
27									27
28									28
29									29
30									30

WELL CONSTRUCTION DETAILS

Well Name: **MW03-B**
Supervised by: Jeff Brammer
Well Type: GWMW

Boring No: MW03-B

Location Description: E of SE corner of Ash Landfill

Installation Date: 04/27/04

Project: Grand River Dam Authority

Drilling Company: AEI

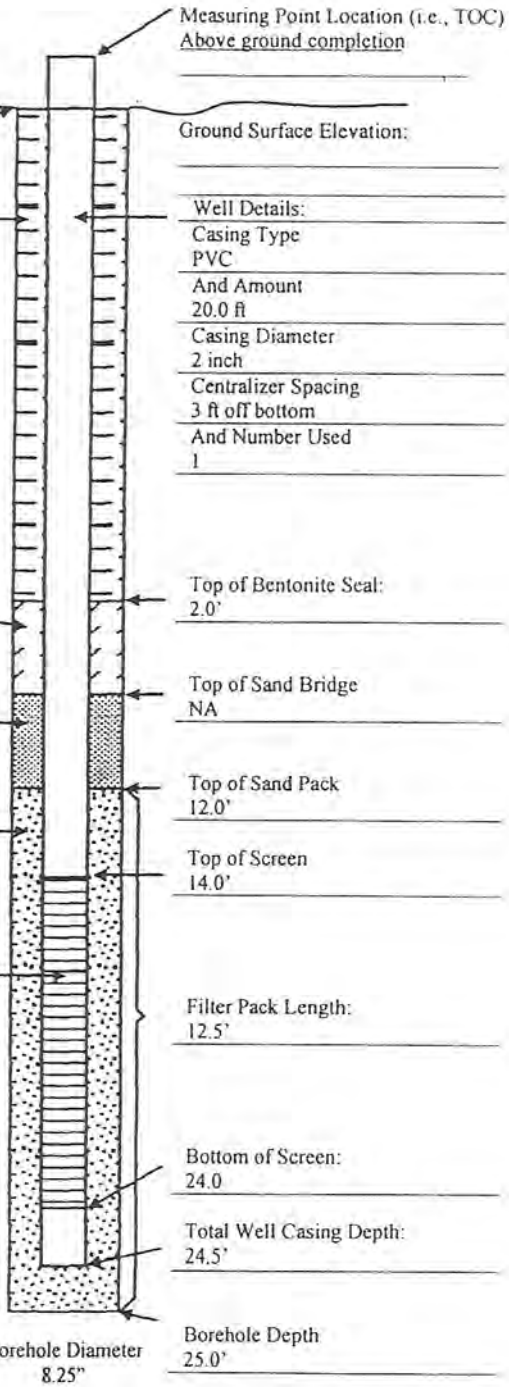
Construction Method: HSA

Drilling Method: Hollow Stem Auger

Owner: GRDA

Owner's Address: Chouteau, OK

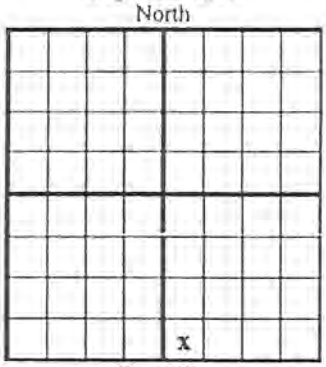
Owner's Telephone:



MULTI-PURPOSE WELL COMPLETION & PLUGGING REPORT

Oklahoma Water Resources Board
3800 North Classen Boulevard
Oklahoma City, OK 73118
Telephone (405) 530-8800

Legal Location



Each square is 10-acres

WELL ID NUMBER: 86183

Quarters SW-SW-SE Section 28 Township 20N Range 19EI

Latitude 36.177546 Longitude -95.286773

Date collected(latitude and longitude), if different from date the well was drilled: 05/05/2004

Method latitude and longitude was collected: Mathematical conversion program

County Mayes Variance Request No. (if applicable) n/a

WELL OWNER - NAME AND ADDRESS

Well Owner Grand River Dam Authority Phone (918) 476-5840

Address/City/State PO Box 609 Chouteau OK Zip 74337

Finding Location I-44 through Tulsa to Hwy 412, east past Chouteau, go over the Grand River, the next left go north to GRDA facility.

Well Name MW03-A Water Rights #: __

TYPE OF WORK: Monitoring Well USE OF WELL: Site Assessment

NEW WELL CONSTRUCTION DATA

Date Well or Boring Was Completed 04/27/2004

Number of wells or borings represented by this log 1

* (Borings are within the same 10 acre-tract and with the same general depths and lithologies)

Hole Diameter 8.75 inches to a depth of 10 ft.

CASING INFORMATION *Note: If surface casing is used please indicate that on the appropriate well casing information line.

Surface Pipe Material: __ Surface Pipe Diameter __ inches Surface Pipe From __ ft to __ ft

1) Well Casing Material PVC Casing Diameter 2 inches Casing From 0 ft to 5 ft

SCREEN OR PERFORATION INFORMATION

Type of Screen: PVC Type of Slots or Openings: Factory Slotted - 10 slot (0.010 inch) From 5 ft to 10 ft.

FILTER PACK INFORMATION

Filter Pack Material: Sand 10-20 (coarse)

Filter Pack Interval: From 4 ft to 10

WELL SEAL INFORMATION

Type of Surface Seal Cement Grout

Type of Annular Seal n/a

Filter Pack Seal Material Bentonite/Cement Grout

Surface Seal Interval: From 0 ft to 2 ft

Annular Seal Interval: From n/a ft to n/a ft

Filter Pack Seal Interval: From 2 ft to 4 ft

TYPE OF COMPLETION: Above Ground

HYDROLOGIC INFORMATION

Depth to water at time of drilling __ ft

Estimated yield of well __ gpm

First water zone 7 ft

LITHOLOGY DESCRIPTION

MATERIAL	ENCOUNTERED FROM (ft.)	ENCOUNTERED TO (ft.)	SATURATED
Gravely Clay	0	9.5	Y
Limestone	9.5	10	N

WELL LOCATION TO POTENTIAL SOURCES OF POLLUTION

Has this well been disinfected after completion of work? n/a

Are than any potential sources of pollution or wastewater lagoons within 300 ft. of the well? n/a

Distance of Well is n/a from possible source. Type of possible source: n/a

PLUGGING INFORMATION

Date Well or Boring Was Plugged n/a

Total Depth of well being plugged __ ft.

Was the well contaminated or was it plugged as though it was contaminated? n/a

If the well or boring was plugged as if it was contaminated, was the casing removed or perforated? n/a

Was the grout tremied? n/a

Backfilled with n/a

Backfilled from __ ft. to __ ft.

Grouted with n/a

Grouted from __ ft. to __ ft.

Grouted with Cement

Grouted from __ ft. to __ ft.

Firm Name Associated Environmental Industries, Corp.

D/PC No. DPC-0269

Operator Name CLARK, CHARLES

OP No. OP-1210

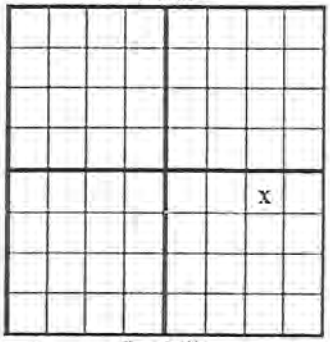
Date 05/05/2004

Comments: Our client was Surbec Environmental PO Box 1757 Norman, OK 73070 (405) 364-9728.

MULTI-PURPOSE WELL COMPLETION & PLUGGING REPORT

Oklahoma Water Resources Board
3800 North Classen Boulevard
Oklahoma City, OK 73118
Telephone (405) 530-8800

Legal Location
North



Each square is 10-acres

WELL ID NUMBER: 86184

Quarters NW-NE-SE Section 28 Township 20N Range 19EI

Latitude 36.182968 Longitude -95.282295

Date collected(latitude and longitude), if different from date the well was drilled: 05/05/2004

Method latitude and longitude was collected: Mathematical conversion program

County Mayes Variance Request No. (if applicable) n/a

WELL OWNER - NAME AND ADDRESS

Well Owner Grand River Dam Authority Phone (918) 476-5840

Address/City/State PO Box 609 Chouteau OK Zip 74337

Finding Location I-44 through Tulsa to Hwy 412, east past Chouteau, go over the Grand River, the next left go north to GRDA facility.

Well Name MW93-3 Water Rights #: ___

TYPE OF WORK: Monitoring Well USE OF WELL: Site Assessment

NEW WELL CONSTRUCTION DATA

Date Well or Boring Was Completed 04/27/2004

Number of wells or borings represented by this log 1

* (Borings are within the same 10 acre-tract and with the same general depths and lithologies)

Hole Diameter 8.75 inches to a depth of 25 ft.

CASING INFORMATION *Note: If surface casing is used please indicate that on the appropriate well casing information line.

Surface Pipe Material: __ Surface Pipe Diameter __ inches Surface Pipe From __ ft to __ ft

1) Well Casing Material PVC Casing Diameter 2 inches Casing From 0 ft to 15 ft

SCREEN OR PERFORATION INFORMATION

Type of Screen: PVC Type of Slots or Openings: Factory Slotted - 10 slot (0.010 inch) From 15 ft to 25 ft.

FILTER PACK INFORMATION

Filter Pack Material: Sand 10-20 (coarse)

Filter Pack Interval: From 13 ft to 25

WELL SEAL INFORMATION

Type of Surface Seal Cement Grout

Type of Annular Seal n/a

Filter Pack Seal Material Bentonite - Hole Plug

Surface Seal Interval: From 0 ft to 2 ft

Annular Seal Interval: From n/a ft to n/a ft

Filter Pack Seal Interval: From 2 ft to 13 ft

TYPE OF COMPLETION: Above Ground

HYDROLOGIC INFORMATION

Depth to water at time of drilling __ ft

Estimated yield of well __ gpm

First water zone 17 ft

LITHOLOGY DESCRIPTION

MATERIAL	ENCOUNTERED FROM (ft.)	ENCOUNTERED TO (ft.)	SATURATED
Silty Clay	0	14	N
Gravely Clay	14	24.5	Y
Limeston	24.5	25	N

WELL LOCATION TO POTENTIAL SOURCES OF POLLUTION

Has this well been disinfected after completion of work? n/a

Are than any potential sources of pollution or wastewater lagoons within 300 ft. of the well? n/a

Distance of Well is n/a from possible source. Type of possible source: n/a

PLUGGING INFORMATION

Date Well or Boring Was Plugged n/a

Total Depth of well being plugged __ ft.

Was the well contaminated or was it plugged as though it was contaminated? n/a

If the well or boring was plugged as if it was contaminated, was the casing removed or perforated? n/a

Was the grout tremied? n/a

Backfilled with n/a

Backfilled from __ ft. to __ ft.

Grouted with n/a

Grouted from __ ft. to __ ft.

Grouted with Cement

Grouted from __ ft. to __ ft.

Firm Name Associated Environmental Industries, Corp.

D/PC No. DPC-0269

Operator Name CLARK, CHARLES

OP No. OP-1210

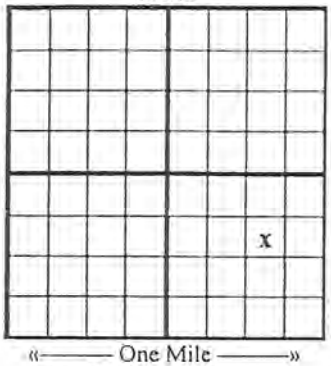
Date 05/05/2004

Comments: Our client was Surbec Environmental PO Box 1757 Norman, OK 73070 (405) 364-9726.

MULTI-PURPOSE WELL COMPLETION & PLUGGING REPORT

Oklahoma Water Resources Board
3800 North Classen Boulevard
Oklahoma City, OK 73118
Telephone (405) 530-8800

Legal Location
North



Each square is 10-acres

WELL ID NUMBER: 86185

Quarters SW-NE-SE Section 28 Township 20N Range 19EI

Latitude 36.181161 Longitude -95.282295

Date collected(latitude and longitude), if different from date the well was drilled: 05/05/2004

Method latitude and longitude was collected: Mathematical conversion program

County Mayes Variance Request No. (if applicable) n/a

WELL OWNER - NAME AND ADDRESS

Well Owner Grand River Dam Authority Phone (918) 476-5840

Address/City/State PO Box 609 Chouteau OK Zip 74337

Finding Location I-44 through Tulsa to Hwy 412, east past Chouteau, go over the Grand River, the next left go north to GRDA facility.

Well Name MW03-B Water Rights #: __

TYPE OF WORK: Monitoring Well **USE OF WELL:** Site Assessment

NEW WELL CONSTRUCTION DATA

Date Well or Boring Was Completed 04/27/2004

Number of wells or borings represented by this log 1

* (Borings are within the same 10 acre-tract and with the same general depths and lithologies)

Hole Diameter 8.75 inches to a depth of 24 ft.

CASING INFORMATION *Note: If surface casing is used please indicate that on the appropriate well casing information line.

Surface Pipe Material: __ Surface Pipe Diameter __ inches Surface Pipe From __ ft to __ ft

1) Well Casing Material PVC Casing Diameter 2 inches Casing From 0 ft to 14 ft

SCREEN OR PERFORATION INFORMATION

Type of Screen: PVC Type of Slots or Openings: Factory Slotted - 10 slot (0.010 inch) From 14 ft to 24 ft.

FILTER PACK INFORMATION

Filter Pack Material: Sand 10-20 (coarse)

Filter Pack Interval: From 12 ft to 24

WELL SEAL INFORMATION

Type of Surface Seal Cement Grout

Type of Annular Seal n/a

Filter Pack Seal Material Bentonite - Hole Plug

Surface Seal Interval: From 0 ft to 2 ft

Annular Seal Interval: From n/a ft to n/a ft

Filter Pack Seal Interval: From 2 ft to 12 ft

TYPE OF COMPLETION: Above Ground

HYDROLOGIC INFORMATION

Depth to water at time of drilling __ ft

Estimated yield of well __ gpm

First water zone 20 ft

LITHOLOGY DESCRIPTION

MATERIAL	ENCOUNTERED		SATURATED
	FROM (ft.)	TO (ft.)	
Silty Clay	0	22	N
Gravely Clay	22	23	Y
Brown Sand Stone	23	24	N

WELL LOCATION TO POTENTIAL SOURCES OF POLLUTION

Has this well been disinfected after completion of work? n/a

Are than any potential sources of pollution or wastewater lagoons within 300 ft. of the well? n/a

Distance of Well is n/a from possible source. Type of possible source: n/a

PLUGGING INFORMATION

Date Well or Boring Was Plugged n/a

Total Depth of well being plugged __ ft.

Was the well contaminated or was it plugged as though it was contaminated? n/a

If the well or boring was plugged as if it was contaminated, was the casing removed or perforated? n/a

Was the grout tremied? n/a

Backfilled with n/a

Backfilled from __ ft. to __ ft.

Grouted with n/a

Grouted from __ ft. to __ ft.

Grouted with Cement

Grouted from __ ft. to __ ft.

Firm Name Associated Environmental Industries, Corp.

D/PC No. DPC-0269

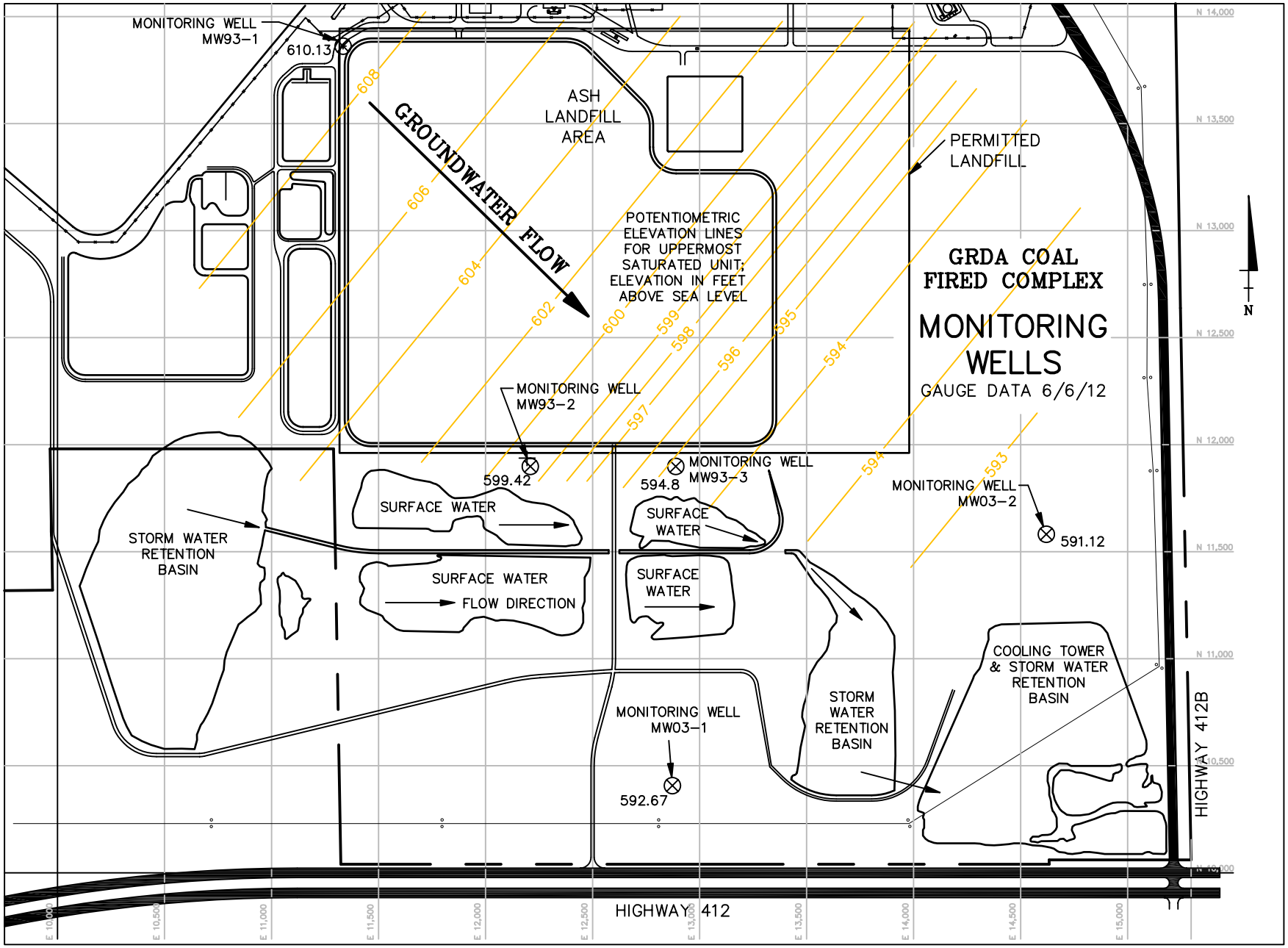
Operator Name CLARK, CHARLES

OP No. OP-1210

Date 05/05/2004

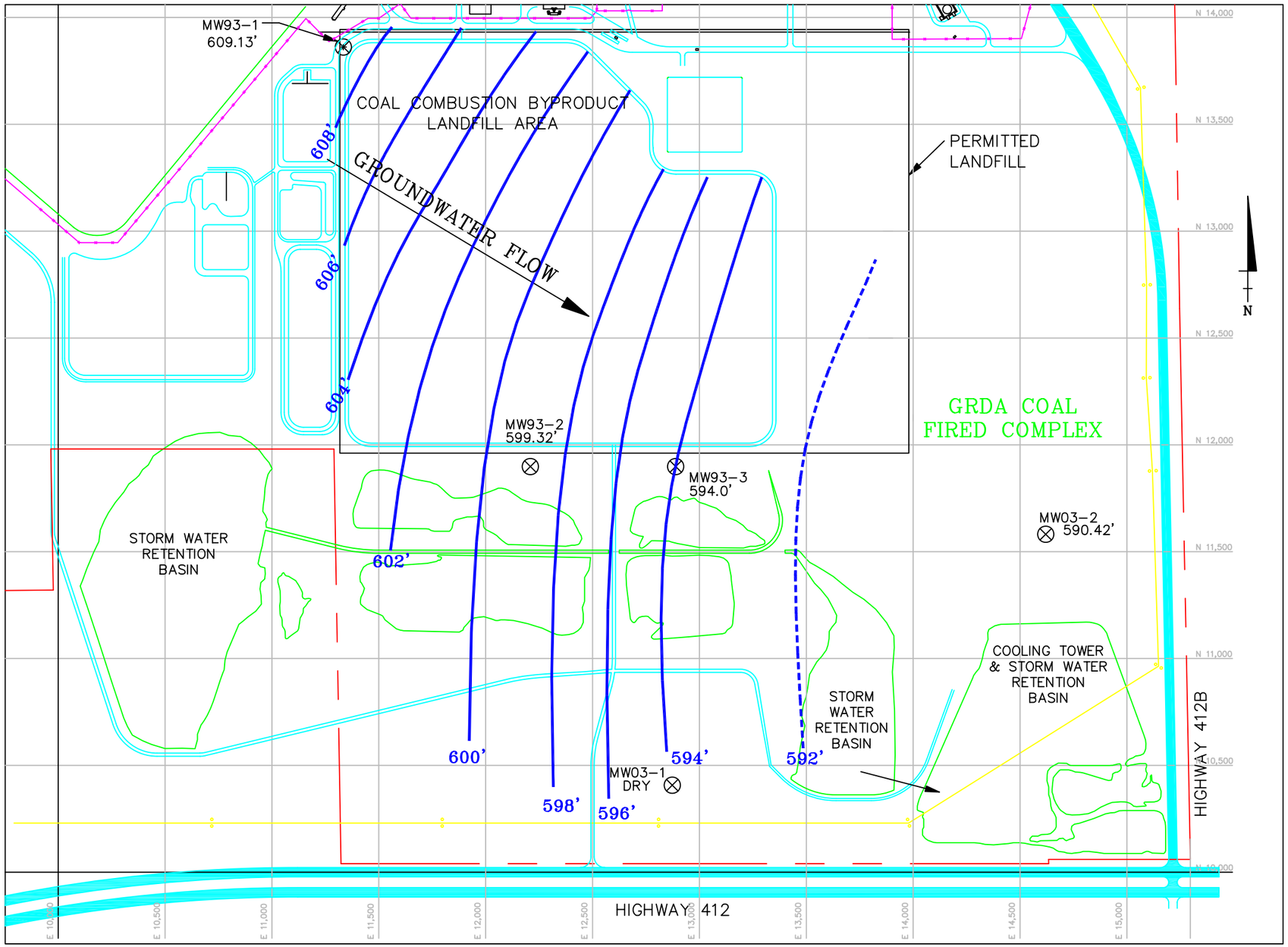
Comments: Our client is Surbec Environmental PO Box 1757 Norman, OK 73070 (405) 364-9726.

APPENDIX B



DJR 7/9/12 CADFILE: MONWELLS

FIGURE 1



SCALE

0 1000'

DJR 4/13/06

GENERAL NOTES

REVISIONS

NO.	DESCRIPTION	BY	CHECKED	DATE	NO.	DESCRIPTION	BY	CHECKED	DATE

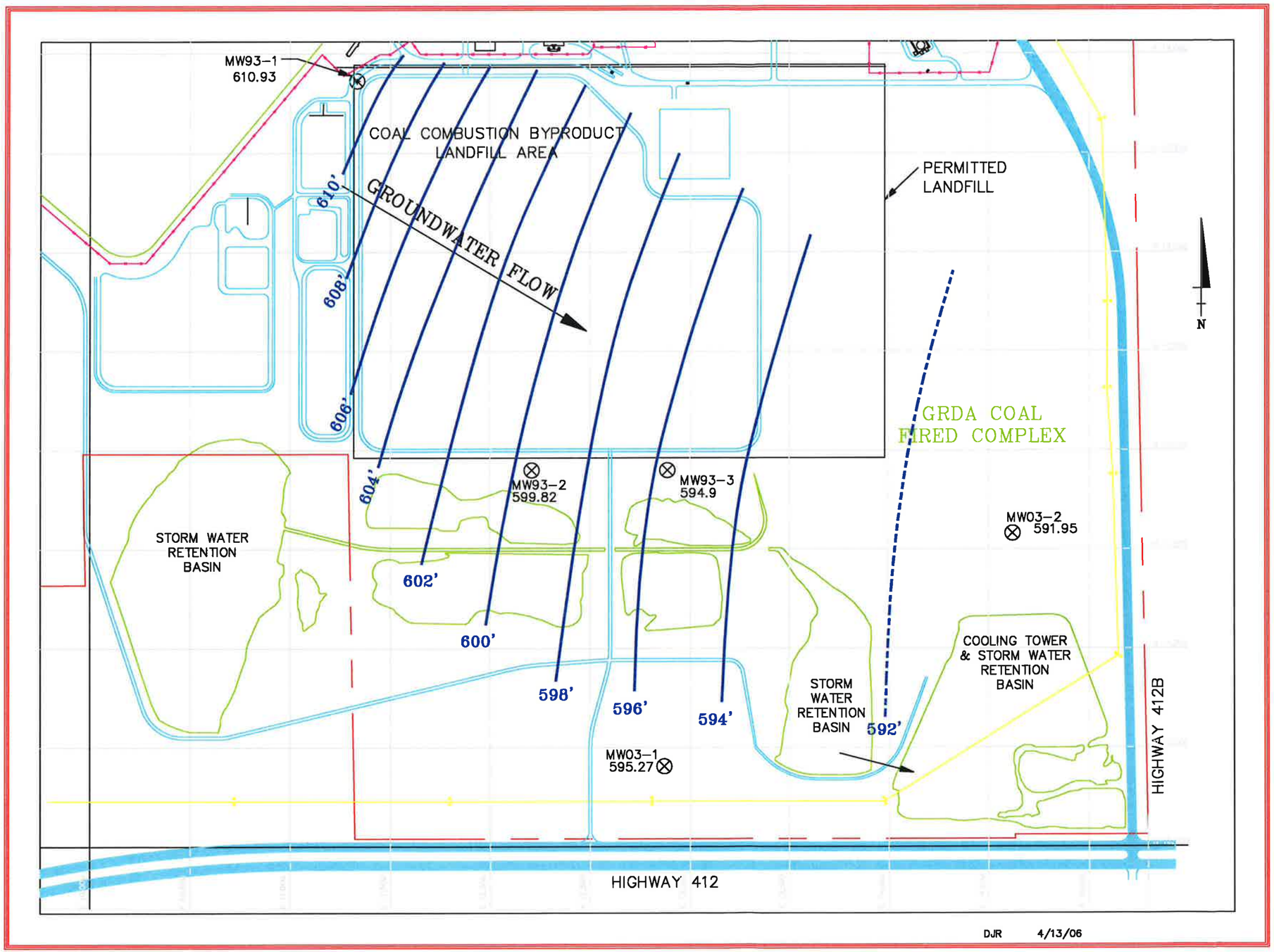
A & M ENGINEERING AND ENVIRONMENTAL SERVICES, INC.

ENGINEERING – ENVIRONMENTAL – CONSTRUCTION

DRAWN:	CHECKED BY:	MATERIALS BY:	ENGINEER:
DATE:	DATE:	DATE:	DATE:

GROUNDWATER CONTOUR MAP
12-12-2012
GRAND RIVER DAM AUTHORITY LANDFILL
CHOUTEAU, OK

APPROVED BY: GJJ	SCALE:	PROJECT NUMBER:	DRAWING NUMBER:	REV.:
DATE: 1/8/2013	AS	1986-002	FIGURE 1	X



SCALE

0 1000'

GENERAL NOTES

REVISIONS

NO.	DESCRIPTION	BY	CHECKED	DATE	NO.	DESCRIPTION	BY	CHECKED	DATE

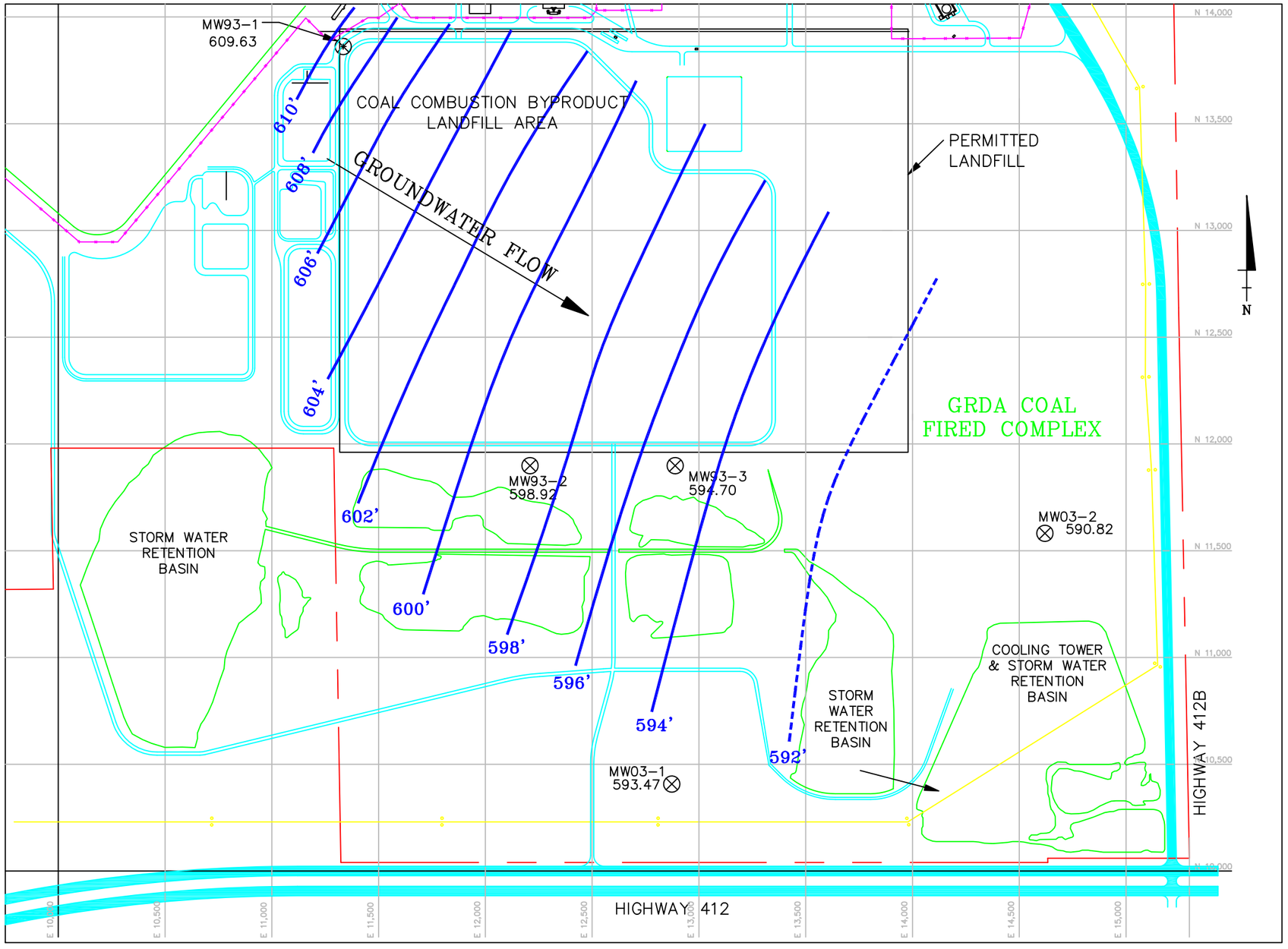
A & M ENGINEERING AND ENVIRONMENTAL SERVICES, INC.

ENGINEERING – ENVIRONMENTAL – CONSTRUCTION

DRAWN:	CHECKED BY:	MATERIALS BY:	ENGINEER:
DATE:	DATE:	DATE:	DATE:

GROUNDWATER CONTOUR MAP
JUNE 19, 2013
GRAND RIVER DAM AUTHORITY LANDFILL
CHOUTEAU, OK

APPROVED BY: GJJ	SCALE:	PROJECT NUMBER:	DRAWING NUMBER:	REV.:
DATE: 7/25/2013	AS	1986-002	FIGURE 1	X



SCALE

0 1000'

DJR 4/13/06

GENERAL NOTES

REVISIONS

NO.	DESCRIPTION	BY	CHECKED	DATE	NO.	DESCRIPTION	BY	CHECKED	DATE

A & M ENGINEERING AND ENVIRONMENTAL SERVICES, INC.

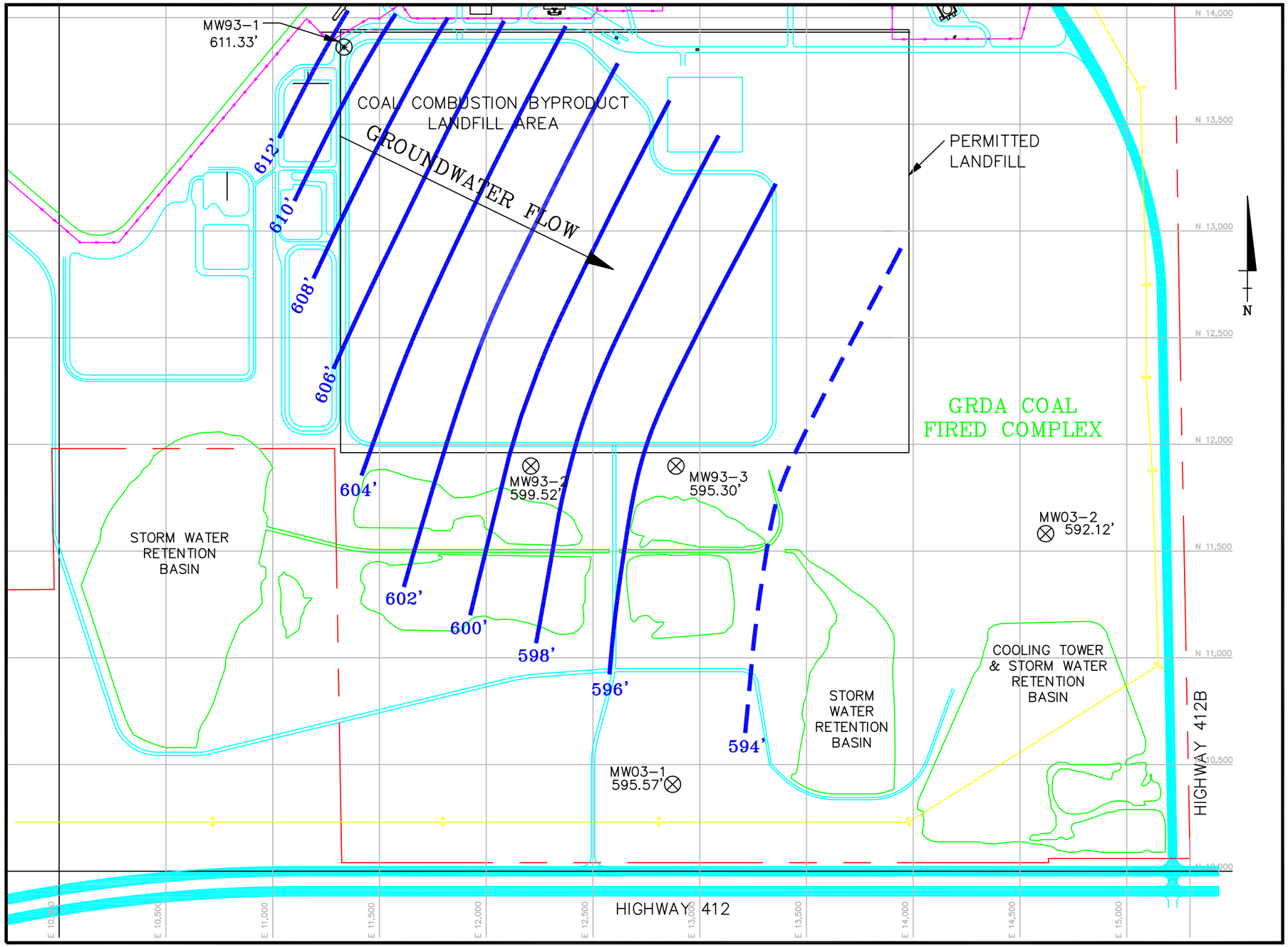
ENGINEERING – ENVIRONMENTAL – CONSTRUCTION

DRAWN:	CHECKED BY:	MATERIALS BY:	ENGINEER:
DATE:	DATE:	DATE:	DATE:

GROUNDWATER CONTOUR MAP DECEMBER 11, 2013

GRAND RIVER DAM AUTHORITY LANDFILL CHOUTEAU, OK

APPROVED BY: GJJ	SCALE:	PROJECT NUMBER:	DRAWING NUMBER:	REV.:
DATE: 12-30-2013	AS	1986-002	FIGURE 1	X



SCALE

0 500' 1000'

DJR 4/13/06

GENERAL NOTES

1) GROUNDWATER ELEVATIONS MEASURED ON JUNE 11, 2014.

REVISIONS

NO.	DESCRIPTION	BY	CHECKED	DATE	NO.	DESCRIPTION	BY	CHECKED	DATE

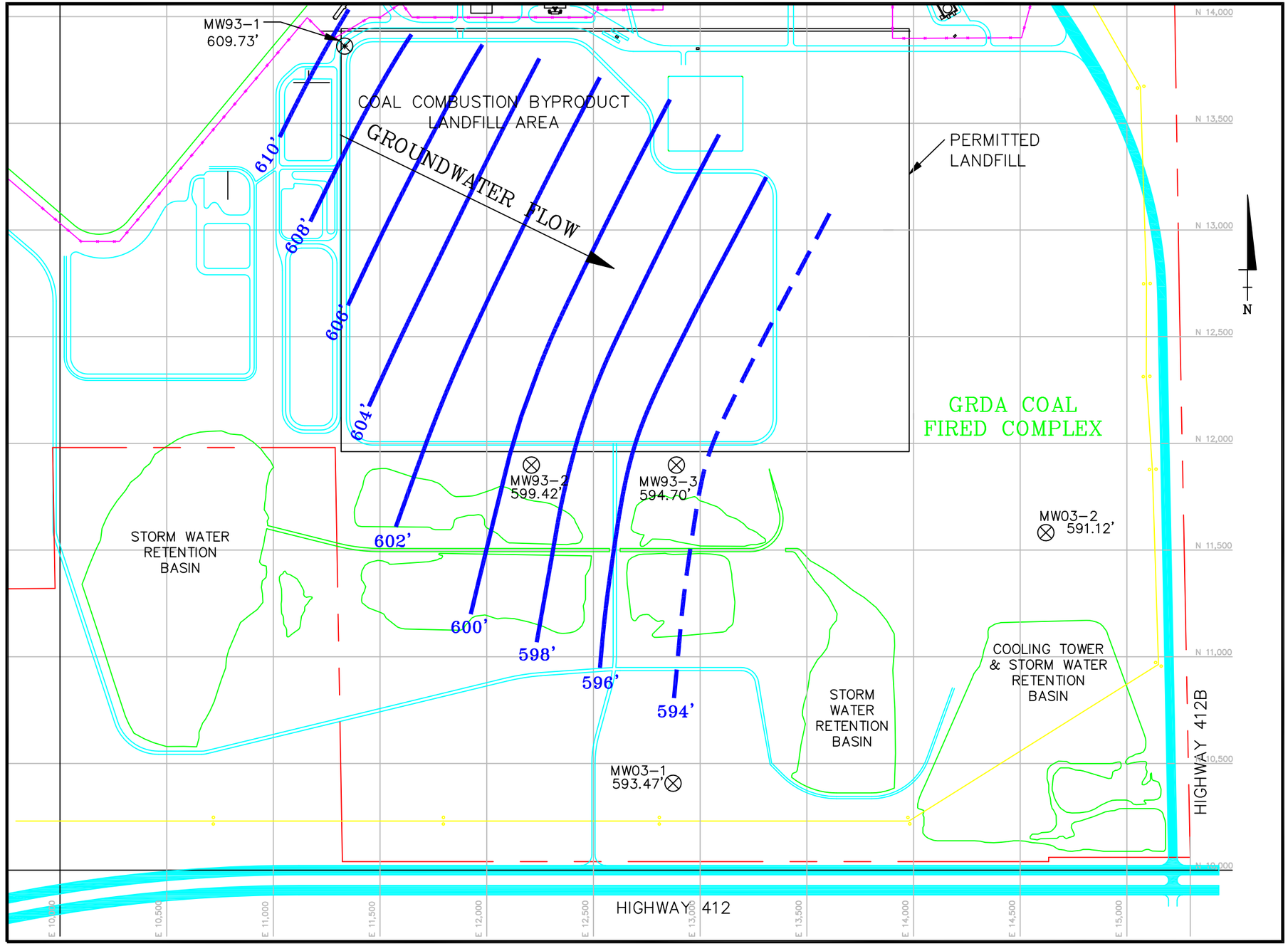
A & M ENGINEERING AND ENVIRONMENTAL SERVICES, INC.

ENGINEERING – ENVIRONMENTAL – CONSTRUCTION

DRAWN: DME	CHECKED BY:	MATERIALS BY:	ENGINEER:
DATE: 7/7/2014	DATE:	DATE:	DATE:

GROUNDWATER CONTOUR MAP
JUNE 11, 2014
GRAND RIVER DAM AUTHORITY LANDFILL
CHOUTEAU, OK

APPROVED BY: DME	SCALE:	PROJECT NUMBER:	DRAWING NUMBER:	REV.:
DATE: 7/7/2014	AS SHOWN	1986-002	FIGURE 1	



NORTH

SCALE

0 500' 1000'

DJR 4/13/06

GENERAL NOTES

1) GROUNDWATER ELEVATIONS MEASURED ON DECEMBER 3, 2014.

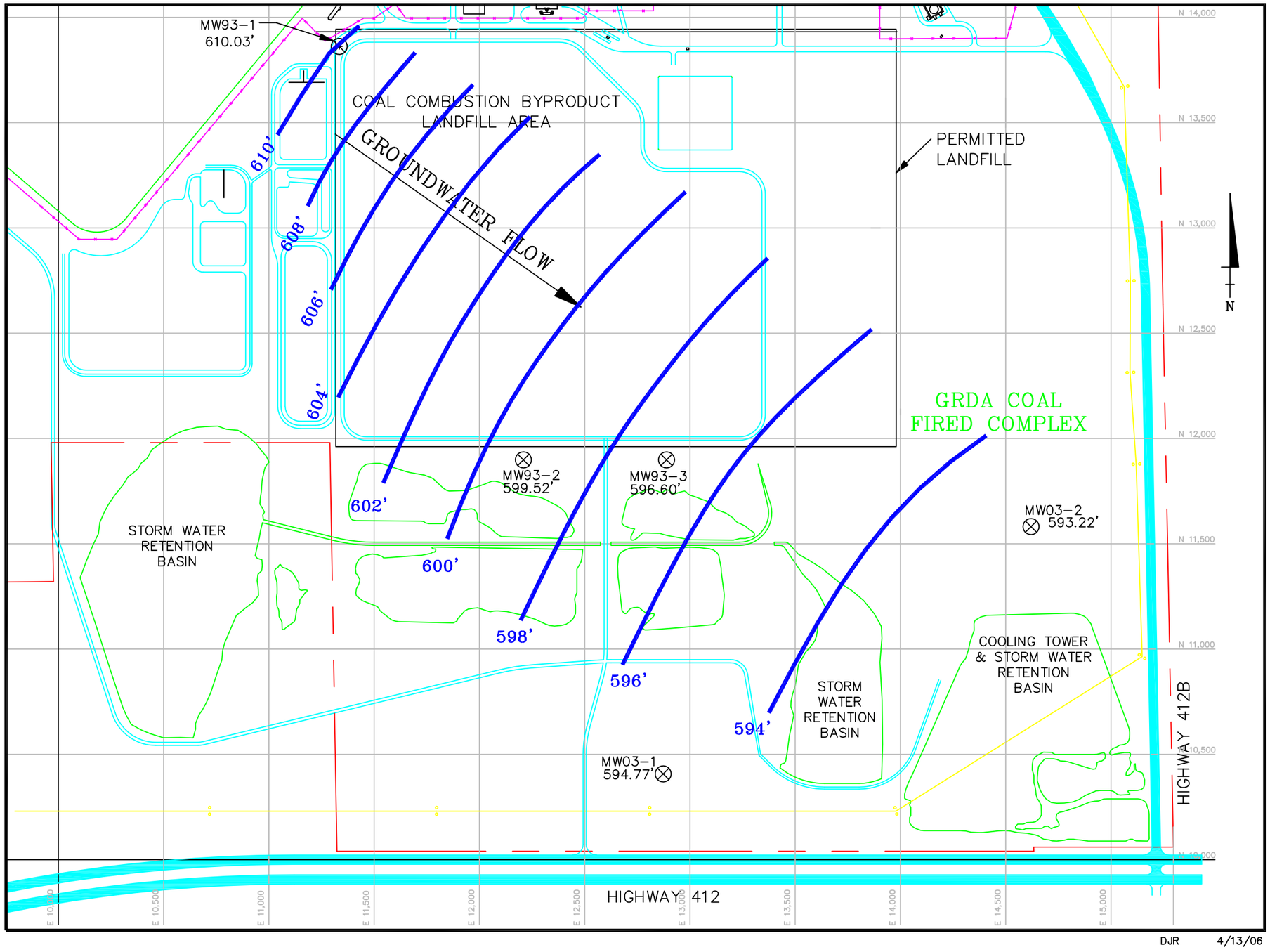
REVISIONS

NO.	DESCRIPTION	BY	CHECKED	DATE	NO.	DESCRIPTION	BY	CHECKED	DATE

A & M ENGINEERING AND ENVIRONMENTAL SERVICES, INC.
ENGINEERING – ENVIRONMENTAL – CONSTRUCTION

GROUNDWATER CONTOUR MAP
DECEMBER 3, 2014
GRAND RIVER DAM AUTHORITY LANDFILL
CHOUTEAU, OK

DRAWN:	CHECKED BY:	MATERIALS BY:	ENGINEER:	APPROVED BY:	SCALE:	PROJECT NUMBER:	DRAWING NUMBER:	REV.:
MJH				DME	AS SHOWN	1986-002	FIGURE 1	
DATE: 1/14/2015	DATE:	DATE:	DATE:	DATE: 1/14/2015				



SCALE

0 500′ 1000′

DJR 4/13/06

GENERAL NOTES

1) GROUNDWATER ELEVATIONS MEASURED ON JUNE 17, 2015.

REVISIONS

NO.	DESCRIPTION	BY	CHECKED	DATE	NO.	DESCRIPTION	BY	CHECKED	DATE

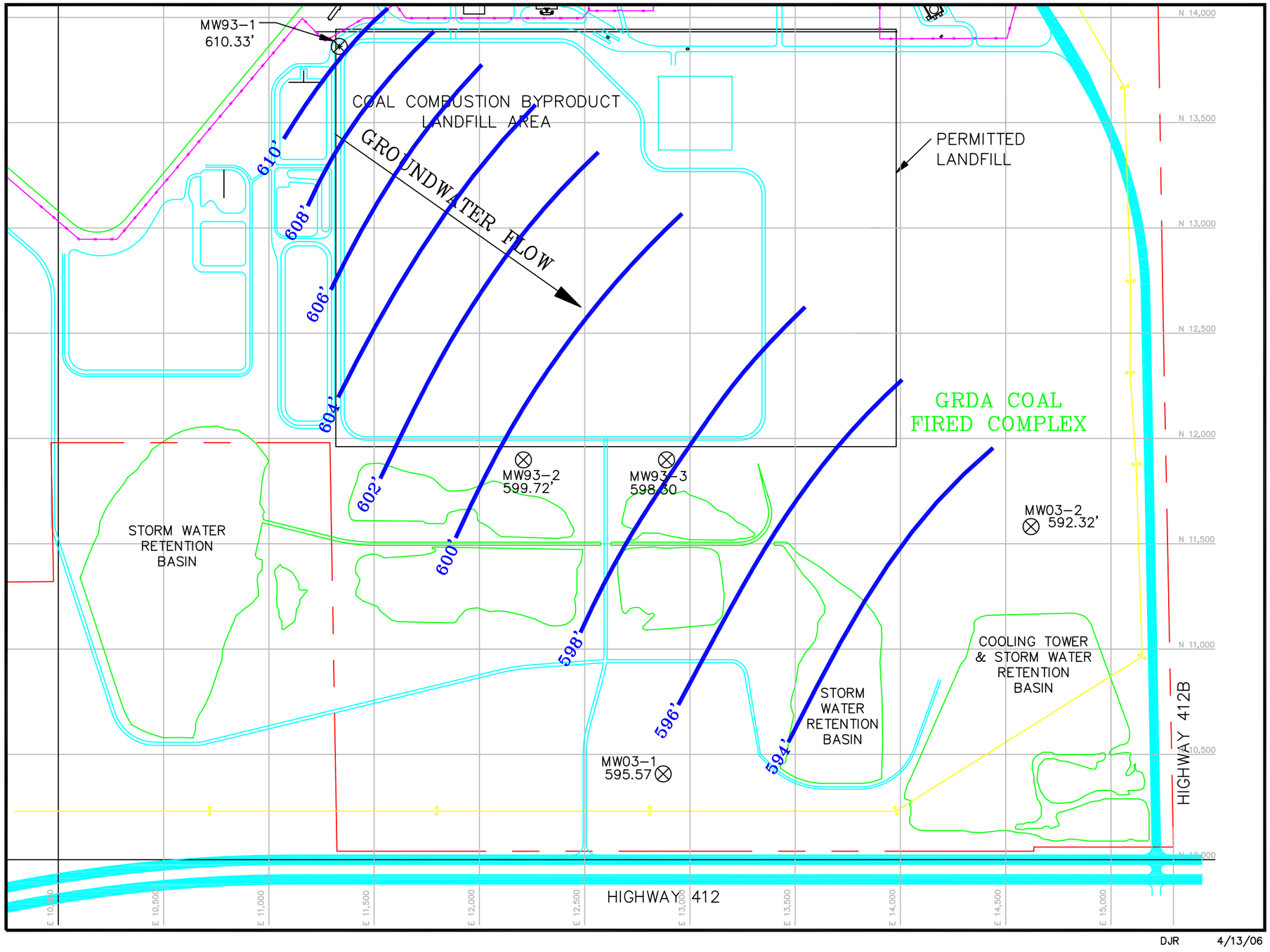
A & M ENGINEERING AND ENVIRONMENTAL SERVICES, INC.

ENGINEERING – ENVIRONMENTAL – CONSTRUCTION

DRAWN: BOC	CHECKED BY:	MATERIALS BY:	ENGINEER:
DATE: 7/22/2015	DATE:	DATE:	DATE:

GROUNDWATER CONTOUR MAP
JUNE 17, 2015
GRAND RIVER DAM AUTHORITY LANDFILL
CHOUTEAU, OK

APPROVED BY: DME	SCALE: AS SHOWN	PROJECT NUMBER: 1986-002	DRAWING NUMBER: FIGURE 1	REV.:
DATE: 7/22/2015				



SCALE

0 500′ 1000′

DJR 4/13/06

GENERAL NOTES

1) GROUNDWATER ELEVATIONS MEASURED ON DECEMBER 1, 2015.

REVISIONS

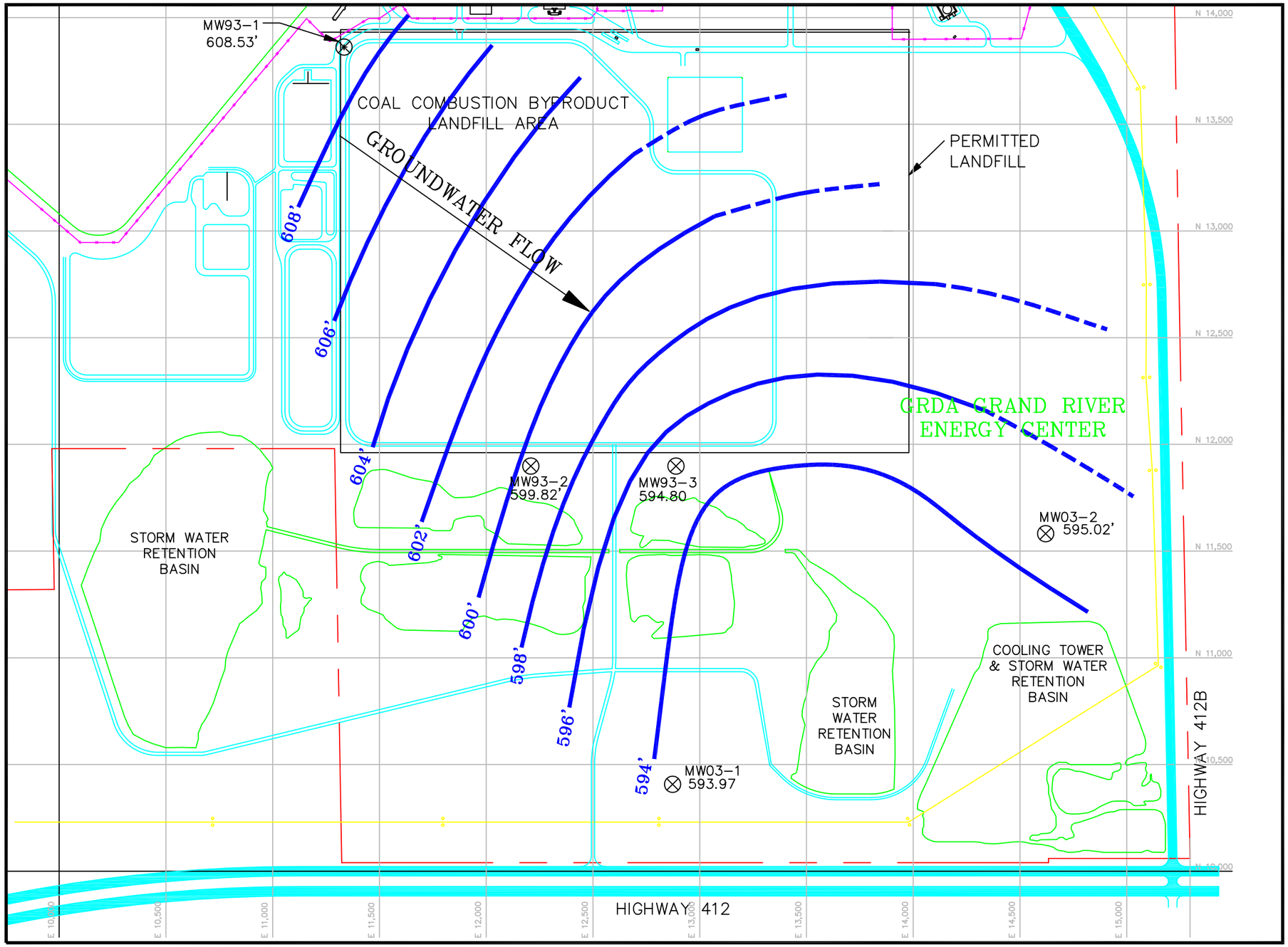
NO.	DESCRIPTION	BY	CHECKED	DATE	NO.	DESCRIPTION	BY	CHECKED	DATE

A & M ENGINEERING AND ENVIRONMENTAL SERVICES, INC.

ENGINEERING – ENVIRONMENTAL – CONSTRUCTION

GROUNDWATER CONTOUR MAP
DECEMBER 1, 2015
GRAND RIVER DAM AUTHORITY LANDFILL
CHOUTEAU, OK

DRAWN:	CHECKED BY:	MATERIALS BY:	ENGINEER:	APPROVED BY:	SCALE:	PROJECT NUMBER:	DRAWING NUMBER:	REV.:
OPC	DME			DME	AS SHOWN	1986-002	FIGURE 1	
DATE: 1/21/2016	DATE: 1/21/2016	DATE:	DATE:	DATE: 1/21/2016				



SCALE

0 500' 1000'

DJR 4/13/06

GENERAL NOTES

1) GROUNDWATER ELEVATIONS MEASURED ON JUNE 22, 2016.

REVISIONS

NO.	DESCRIPTION	BY	CHECKED	DATE	NO.	DESCRIPTION	BY	CHECKED	DATE

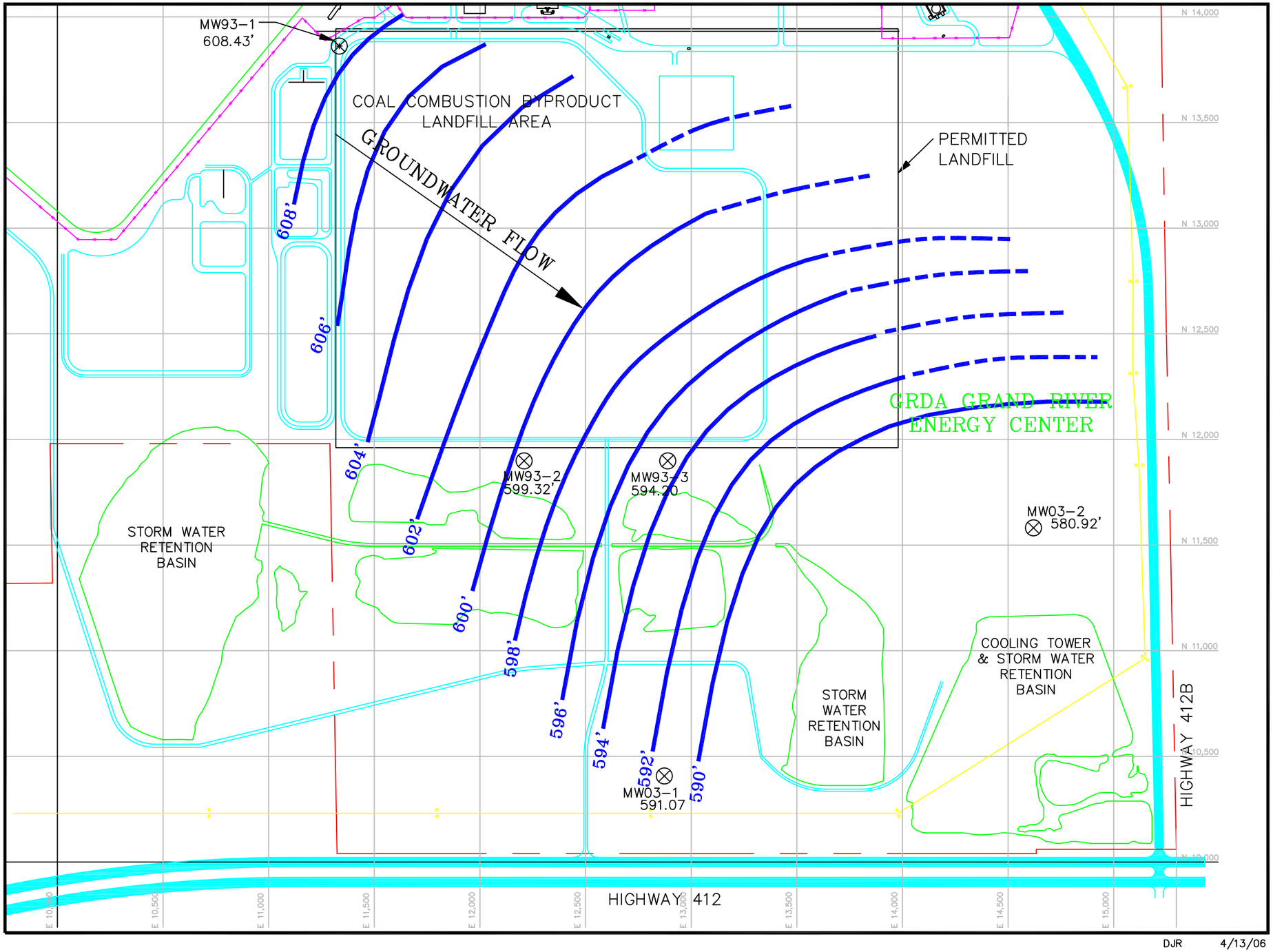
A & M ENGINEERING AND ENVIRONMENTAL SERVICES, INC.

ENGINEERING – ENVIRONMENTAL – CONSTRUCTION

DRAWN:	CHECKED BY:	MATERIALS BY:	ENGINEER:
OPC	DME		
DATE: 8/11/2016	DATE: 8/11/2016	DATE:	DATE:

GROUNDWATER CONTOUR MAP
JUNE 22, 2016
GRAND RIVER DAM AUTHORITY LANDFILL
CHOUTEAU, OK

APPROVED BY:	SCALE:	PROJECT NUMBER:	DRAWING NUMBER:	REV.:
DME	AS SHOWN	1986-002	FIGURE 1	
DATE: 8/11/2016				



SCALE

0 500' 1000'

DJR 4/13/06

GENERAL NOTES

1) GROUNDWATER ELEVATIONS MEASURED ON JUNE 22, 2016.

REVISIONS

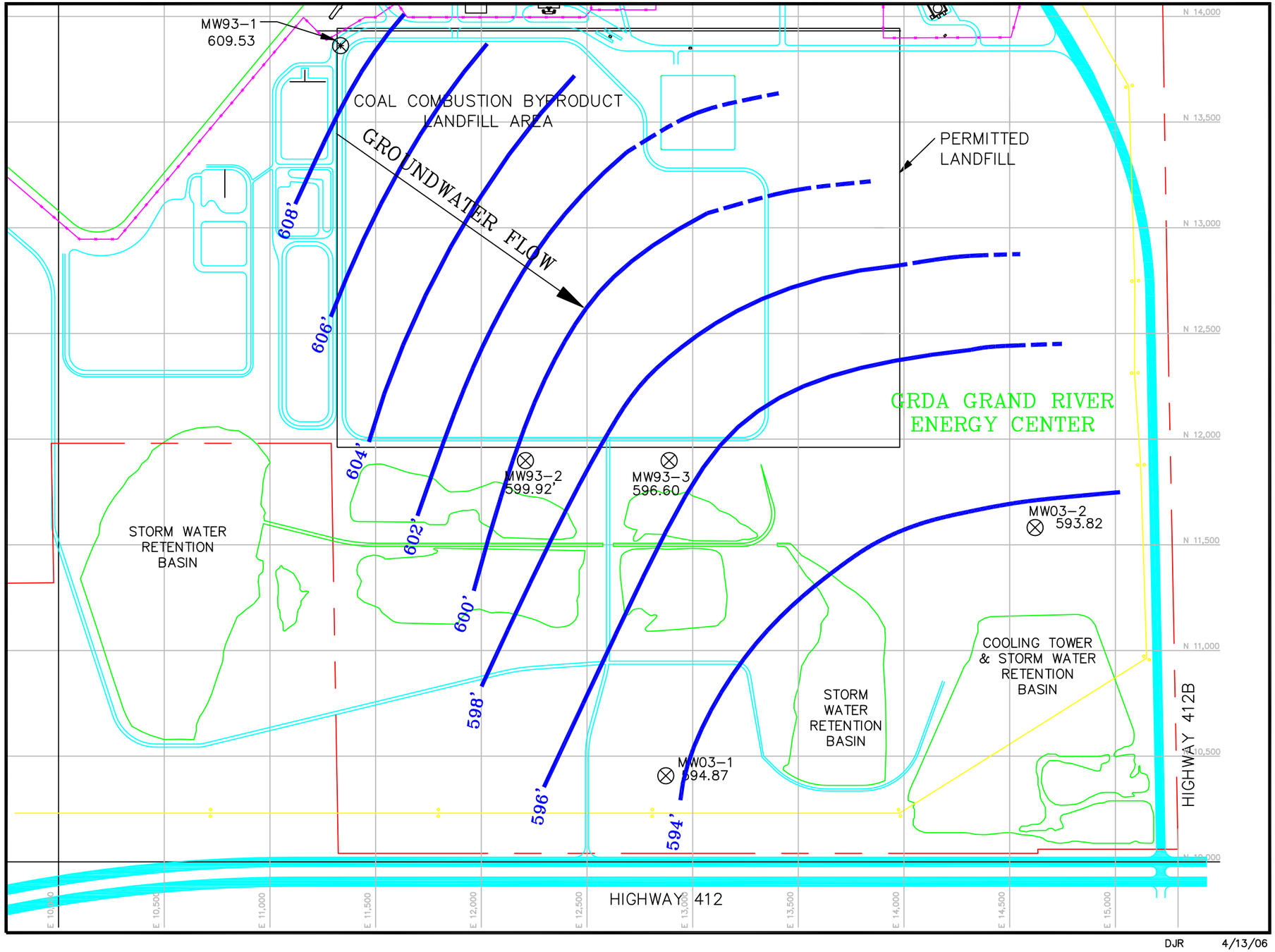
NO.	DESCRIPTION	BY	CHECKED	DATE	NO.	DESCRIPTION	BY	CHECKED	DATE

A & M ENGINEERING AND ENVIRONMENTAL SERVICES, INC.

ENGINEERING – ENVIRONMENTAL – CONSTRUCTION

GROUNDWATER CONTOUR MAP
DECEMBER 20, 2016
GRAND RIVER DAM AUTHORITY LANDFILL
CHOUTEAU, OK

DRAWN:	CHECKED BY:	MATERIALS BY:	ENGINEER:	APPROVED BY:	SCALE:	PROJECT NUMBER:	DRAWING NUMBER:	REV.:
BEN	DME			DME	AS SHOWN	1986-002	FIGURE 1	
DATE: 1/16/2017	DATE: 1/16/2017	DATE:	DATE:	DATE: 1/16/2017				



NORTH

SCALE

0 500' 1000'

DJR 4/13/06

GENERAL NOTES

1) GROUNDWATER ELEVATIONS MEASURED ON JUNE 6, 2017.

REVISIONS

NO.	DESCRIPTION	BY	CHECKED	DATE	NO.	DESCRIPTION	BY	CHECKED	DATE

A & M ENGINEERING AND ENVIRONMENTAL SERVICES, INC.

ENGINEERING – ENVIRONMENTAL – CONSTRUCTION

GROUNDWATER CONTOUR MAP
JUNE 6, 2017
GRAND RIVER DAM AUTHORITY LANDFILL
CHOUTEAU, OK

DRAWN:	CHECKED BY:	MATERIALS BY:	ENGINEER:	APPROVED BY:	SCALE:	PROJECT NUMBER:	DRAWING NUMBER:	REV.:
BAG	DME			DME	AS SHOWN	1986-002	FIGURE 1	
DATE: 7/18/2017	DATE: 7/18/2017	DATE:	DATE:	DATE: 7/21/2017				

APPENDIX C

Groundwater Flow Calculation

$V=(Ki/\Phi)$ where:

V = velocity

K = hydraulic conductivity (Assume $1.0x10^{-4}$ cm/sec)

i = gradient

Φ = effective porosity (Assume 20% or 0.2)

Then the velocity is

$V=(Ki/\Phi)$

$V= (1.0x10^{-4}cm/sec)(0.00678\ ft/ft)/(0.2)$

$V= 3.39\ x10^{-6}$ cm/sec = 107 cm/year = 3.5 ft/year

APPENDIX D

*** Complete Entire COC to be in Compliance***

☐ **RUSH** Due Date _____

Chain of Custody

Accurate Environmental Labs

Client Name-

Project Name-

Accurate Work Order #	Date Sample Taken	Time Sample Taken	Matrix or Source (Refer. below)	Grab (G) or Comp (C)	Client I.D. / Sample Location or DEQ / EPA Location Code	Field Results (pH, Temp, Chlorine, …) (note analysis & units)			Sample Preserv. & Container →	Analysis Requested →							
										# of Container ↓							

On-Site Info Raw **Alkalinity** (TOC Raw)= _____ mg/L **Turbidity** (E.Coli)= _____ ntu

Matrix Codes **DW** = Drinking water ; **WW** = Wastewater ; **SL** = Sludge ; **O** = Other_____

E.Coli Source- **GWUDI-FS**= Groundwater under direct influence of Flowing Stream **GWUDI-RL**= Groundwater under direct influence of Reservoir/Lake

Field Instrument Calibration -

Meter Type	Standards	Final Read.	Date , Time	Initials

Comments

WebCOC

-- All samples are scheduled to be disposed of in 4 weeks of receipt at Accurate.--

Certification by Company Official: I hereby certify that the above sampling occurred during a period such that the sample(s) is/are representative of a typical operating day discharge for the above facility.

Signature :

Date/Time

Sampled By:

Company:

Sample Method:

Relinquished By:	Date/Time	Received By:		Date/Time
☐ Relinquished to Lab By: ☐ Relq'd to Log-In Fridge By:	Date/Time	Received at Lab By:	Rec'd °C	Date/Time

Reporting Requirements (standard 10-15 working days)		**Compliance** Reporting?	Yes or No (DMR, PWS,)	Oklahoma **PWS ID #**		**RUSH** Request (if available)	_____ (Working Days)

Mail Report To:

Address

Phone #: Fax #:

Email:

Mail Invoice To:

Address:

Bid # -

PO # -

Phone #: Fax #:

www.accuratelabs.com (800) 516-5227

505 South Lowry Street, **Stillwater, OK** 74074 — Phone: (405) 372-5300, Fax: (405) 372-5396

6558 E. 40th Street, **Tulsa, OK** 74145 — Phone: (918) 663-5400, Fax: (918) 663-6300

12036 N. Pennsylvania, **Oklahoma City, OK** 73120 — Phone: (405) 751-3132, Fax: (405) 751-3108