Managing Water Permits with GIS at Questa Mine

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Abstract The Chevron Questa Mine site (formerly known as the Molycorp, Inc.), situated in northeastern New Mexico includes an operational underground mine, mill and tailing disposal facility. Questa Mine has a rich mining legacy that dates back to the mid 1800s and has been a cornerstone of Taos County and two small local municipalities (Red River and Questa). Due to that legacy, Questa Mine has numerous regulatory benchmarks; therefore the facility implemented a comprehensive Environmental Geographic Information System (GIS) to assist in managing these obligations. This paper will provide insight into how the system was implemented as well as the working components of the system.

Keywords GIS, water quality permits, regulatory, USEPA, NMED, mining

Introduction

Due to Questa Mine's legacy mining impacts, on March 7, 2012, the United States Environmental Protection Agency (USEPA) Superfund Division Director and Chevron Mining Inc. (CMI) President, jointly signed an Administrative Order on Consent that set in motion removal actions to address the historic environmental impacts. As a result, the site was listed on the National Priorities List and the facility is currently engaged in the active remediation of the site.

However, while the remediation is occurring, the mine also complies with five prescriptive New Mexico Environmental Department (NMED) and USEPA water quality permits that have over 180 compliance benchmarks that are monitored and reported to both agencies. Specifically, the mine has four (4) NMED groundwater discharge permits and one (1) USEPA National Pollutant Discharge Elimination System (NPDES) permit. Within these permits, there are daily, weekly, monthly, quarterly, semi-annual and annual compliance benchmarks that are reported to state and federal agencies in accordance with the respective permit. To assist in managing the numerous regulatory benchmarks, Questa Mine focused on implementing a GIS system, that was specific to the mine's environmental themes.

As a result, in June of 2011, Questa Mine conducted a comprehensive compliance inventory of all water quality permit requirements, in an effort to categorize and convert this information to a collection of geographic datasets. The compliance monitoring categories that were developed during the assessment consisted of compiling the following:

- Groundwater Monitoring Wells
- Surface Water Monitoring Sites
- Spring and Seep Monitoring Sites
- Storm Water Monitoring Sites
- Outfall Monitoring Sites
- Domestic Waste Water Monitoring Sites
- Spill and Release Monitoring
- Physical Inspections and Monitoring Sites

In addition, efforts were made to acquire historical datasets that were developed from various Questa Mine departments as well as consultants. The datasets that were discovered internally consisted of numerous hard copy maps; AutoCAD files and individual GIS shape files developed by consultants.

Methods

At the completion of compiling the historical data, the datasets were indexed and a “needs assessment” was compiled to determine the Environmental Department’s needs and prioritize the most important datasets. The assessment included identifying datasets that were not discovered in the historic research, but could be acquired from outside agencies and services, such as ArcGIS online, United States Forest Service, Taos County GIS Department, and the New Mexico Resource Geographic Information System. At the completion of the needs assessment, the following dataset were identified as being essential to the system:

- Township Parcels
- Carson National Forest Boundary
- Road and Highway Overlay
- Jurisdictional Waters and Wetlands Boundaries
- County Boundaries
- Section, Township, Range

It should be emphasized; that the needs assessment was a very important component to the development of Questa Mine’s Environmental GIS, since it identified essential datasets and also created the frame work for the geodatabase that was created in ArcCatalog. Fig. 1 represents the geodatabase structure and the individual feature classes, within the database that were created after the assessment.

While framing the database structure, priority was given to setting up the datasets that would make up the administrative data within the geodatabase. The “administrative” feature class consisted of property boundaries, roads, buildings, township parcels, municipal boundaries, utilities, and pipelines. The datasets came from active AutoCAD DWG files and were based on local Questa Mine survey coordinates and not the North American Datum of 1983 (NAD83). Therefore, the datasets did not align when adding DWG files to the ArcGIS online aerial. To correct this issue, a custom projection (prj) file was created and saved with the

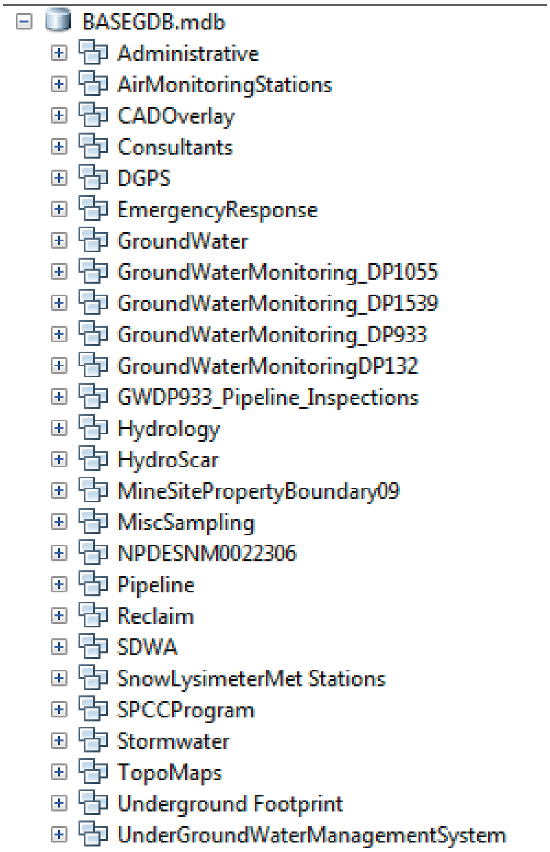

Fig. 1 *Geodatabase Structure and Feature Datasets*

DWG files, which facilitated in the aligning files to the base aerial and assisted with creating the GIS datasets. Fig. 2 represents the Administrative Dataset display.

Another method that was used was the georeferencing tool that is available in ESRI ArcMap toolbox suite. Since the research discovered many hard copy maps that contained historical information, these documents were scanned and indexed. Afterwards, the georeference tool was employed to reference the scanned image file, by selecting control points on the actual image that corresponded with the aerial, which then assigned real-world coordinates for those selected points. An added advantage to this method is once the image is rectified, the same coordinates as the base aerial are assigned to the scanned image. This is done by the image being assigned a world file, which allows the file to be brought into other

Fig. 2 *Administrative Dataset display.*

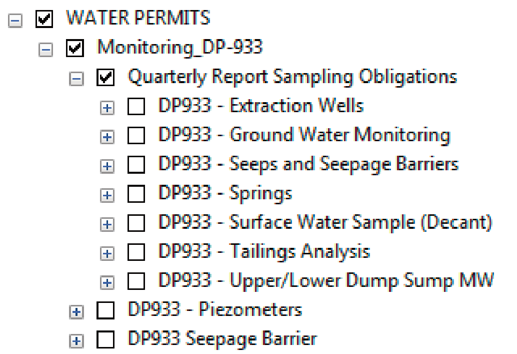

Fig. 3 *Groundwater Discharge Permit*

GIS projects with the same coordinate system, thereby allowing the image to align for digitizing.

During the production phase of creating the datasets, the first datasets created within the geodatabase were the permit monitoring points. To accomplish this, each permit has its own feature class which represents the individual compliance datasets within that class of the geodatabase. Fig. 3 represents the individual monitoring points for one of the NMED groundwater discharge permits.

Additionally, each monitoring feature was populated along with the specifications related to that particular well. For instance, all of the monitoring well fields were given the permit identifier (*i.e.* well number) and subsequently well design information was entered. Therefore each monitoring well table included (Fig. 4):

- Permit Sampling Schedule
- Permit Sampling Constituents
- Well Installation Date
- Well Completion Zone
- Casing Diameter
- Well Depth
- Well Screen Specifics
- Depth to Water

Other compliance datasets were populated with the sampling frequency as well as the required analytical suite for each site.

At the same time the Environmental GIS system was being configured, a MS Access database (DBMS) was created, as a repository for holding all sample results and compliance inspections. The structure of the DBMS tables was tailored in a manner that allowed the tables to easily join within the GIS tables. This allowed a seamless interaction between the field monitoring DBMS and the GIS datasets; therefore the data is dynamic since it feeds from the

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Feature_id	FirstQ	SecondQ	ThirdQ	FourthQ	DateInstalled	CasingDiameter	CompletionZone	WellDepth	TopOfScreen	BottomOfScreen	ScreenLength	DepthToWater	ScreenLngth	SampleAnalysisType
MW-1	Group 1, 2, 3 Table 1	Group 1, 2, 3 Table 1	Group 1, 2, 3 Table 1	Group 1, 2, 3 Table 1	1/1/1979	6	Basal Bedrock (Volc.) Aquifer	117	65	100	35	49	35	All Analytes
MW-10	Group 1, 2, 3 Table 1	Group 1 Table 1	Group 1, 2, 3 Table 1	Group 1 Table 1	7/1/1993	6	Basal Alluvial Aquifer	124	94	124	30	26	30	All Analytes
MW-11	Group 1, 2, 3 Table 1	Group 1, 2, 3 Table 1	Group 1, 2, 3 Table 1	Group 1, 2, 3 Table 1	7/1/1993	8	Basal Bedrock (Volc.) Aquifer	247	207	247	40	195	40	All Analytes
MW-12	Water Level Only	Water Level Only	Water Level Only	Water Level Only	2/15/1995	4	Basal Alluvial Aquifer	230	214	230	16	129	16	Water Level Only
MW-13	Group 1, 2, 3 Table 1	Group 1, 2, 3 Table 1	Group 1, 2, 3 Table 1	Group 1, 2, 3 Table 1	9/5/1997	4	Basal Bedrock (Volc.) Aquifer	227	212	222	10	203	10	All Analytes
MW-14	Group 1, 2, 3 Table 1	Group 1 Table 1	Group 1, 2, 3 Table 1	Group 1 Table 1	8/22/1997	4	Upper Alluvial Aquifer	64	39	59	20	47	12	All Analytes
MW-15	Group 1 Table 1	Group 1 Table 1	Group 1 Table 1	Group 1 Table 1	1/30/2001	2	Upper Alluvial Aquifer	75	64	74	10	32	10	Water Level and Field Parameters
MW-17	Group 1, 2, 3 Table 1	Group 1, 2, 3 Table 1	Group 1, 2, 3 Table 1	Group 1, 2, 3 Table 1	10/19/2002	2	Upper Alluvial Aquifer	155	135	155	20	130	20	All Analytes
MW-2	Group 1, 2, 3 Table 1	Group 1, 2, 3 Table 1	Group 1, 2, 3 Table 1	Group 1, 2, 3 Table 1	1/1/1979	6	Upper Alluvial Aquifer	80	28	78	50	66	12	All Analytes
MW-20	Group 1 Table 1	Group 1 Table 1	Group 1, 2, 3 Table 1	Group 1 Table 1	10/4/2002	2	Basal Alluvial Aquifer	289	269	289	20	101	20	Water Level and Field Parameters
MW-22	Group 1 Table 1	Group 1 Table 1	Group 1, 2, 3 Table 1	Group 1 Table 1	5/12/2003	4	Basal Bedrock (Volc.) Aquifer	430	419	429	10	417	10	Water Level and Field Parameters
MW-23	Group 1, 2, 3 Table 1	Group 1, 2, 3 Table 1	Group 1, 2, 3 Table 1	Group 1, 2, 3 Table 1	4/1/2003	4	Basal Bedrock (Volc.) Aquifer	400	370	400	30	388	12	All Analytes
MW-24	Group 1, 2, 3 Table 1	Group 1 Table 1	Group 1, 2, 3 Table 1	Group 1 Table 1	10/11/2002	2	Basal Alluvial Aquifer	255	235	255	20	74	20	All Analytes
MW-25	Group 1, 2, 3 Table 1	Group 1, 2, 3 Table 1	Group 1, 2, 3 Table 1	Group 1, 2, 3 Table 1	5/22/2003	2	Basal Bedrock (Volc.) Aquifer	180	160	180	20	110	20	All Analytes
MW-26	Group 1, 2, 3 Table 1	Group 1, 2, 3 Table 1	Group 1, 2, 3 Table 1	Group 1, 2, 3 Table 1	5/22/2003	2	Upper Alluvial Aquifer	45	25	45	20	26	19	All Analytes
MW-27	Group 1, 2, 3 Table 1	Group 1, 2, 3 Table 1	Group 1, 2, 3 Table 1	Group 1, 2, 3 Table 1	5/30/2003	2	Basal Bedrock (Volc.) Aquifer	184	163	183	20	45	20	All Analytes
MW-29	Group 1, 2, 3 Table 1	Group 1, 2, 3 Table 1	Group 1, 2, 3 Table 1	Group 1, 2, 3 Table 1	6/1/2003	2	Upper Alluvial Aquifer	40	35	40	5	23	5	All Analytes
MW-30	Group 1, 2, 3 Table 1	Group 1, 2, 3 Table 1	Group 1, 2, 3 Table 1	Group 1, 2, 3 Table 1	12/16/2005	2	Upper Alluvial Aquifer	81	60	80	20	18	20	All Analytes
MW-31	Group 1, 2, 3 Table 1	Group 1, 2, 3 Table 1	Group 1, 2, 3 Table 1	Group 1, 2, 3 Table 1	12/14/2005	2	Upper Alluvial Aquifer	80	60	80	20	38	20	All Analytes
MW-32	Group 1, 2, 3 Table 1	Group 1, 2, 3 Table 1	Group 1, 2, 3 Table 1	Group 1, 2, 3 Table 1	12/11/2005	2	Upper Alluvial Aquifer	141	121	141	20	83	20	All Analytes
MW-33	<Null>	<Null>	<Null>	<Null>	12/9/2005	2	Upper Alluvial Aquifer	161	140	160	20	140	20	All Analytes
MW-34	Group 1, 2, 3 Table 1	Group 1, 2, 3 Table 1	Group 1, 2, 3 Table 1	Group 1, 2, 3 Table 1	12/17/2005	2	Upper Alluvial Aquifer	100	80	100	20	82	18	All Analytes
MW-35	<Null>	<Null>	<Null>	<Null>	4/1/2008	4	Basal Alluvial Aquifer	286	265	285	20	76	20	All Analytes
MW-36	<Null>	<Null>	<Null>	<Null>	3/29/2008	4	Basal Alluvial Aquifer	281	260	280	20	146	20	All Analytes
MW-4	Group 1, 2, 3 Table 1	Group 1 Table 1	Group 1, 2, 3 Table 1	Group 1 Table 1	1/1/1979	6	Upper Alluvial Aquifer	102	60	95	35	42	35	All Analytes
MW-7A	Group 1 Table 1	Group 1 Table 1	Group 1 Table 1	Group 1 Table 1	7/1/1993	2	Upper Alluvial Aquifer	88	78	88	10	68	10	Water Level and Field Parameters
MW-9A	Group 1, 2, 3 Table 1	Group 1, 2, 3 Table 1	Group 1, 2, 3 Table 1	Group 1, 2, 3 Table 1	7/1/1993	2	Upper Alluvial Aquifer	43	33	43	10	28	10	All Analytes
MW-9B	Group 1 Table 1	Group 1 Table 1	Group 1 Table 1	Group 1 Table 1	7/1/1993	2	Basal Alluvial Aquifer	144	115	144	29	NM	-	Water Level and Field Parameters
MW-A	Water Level Only	Water Level Only	Water Level Only	Water Level Only	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>
MW-B	Water Level Only	Water Level Only	Water Level Only	Water Level Only	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>
MW-CH	Group 1, 2, 3 Table 1	Group 1 Table 1	Group 1, 2, 3 Table 1	Group 1 Table 1	6/13/1967	8	Basal Alluvial Aquifer	250	149	250	101	NM	-	All Analytes

Fig. 4 *Monitoring Well Table*

backend DBMS tables. For example, Questa Mine monitors all active surface water seep flows, which are reported on an annual basis to USEPA as part of a NPDES condition. To comply with this requirement, an environmental staff member conducts the seep inspections on a monthly basis on-site. In turn, that staff member then enters that data into the field monitoring DBMS.

The NPDES permit condition requires that Questa Mine report any changes in seepage flow from the previous year. To conduct this analysis a date range query is created in the DBMS, which updates a “results table” that is joined with the Environmental GIS system. This allows staff to analyze the flow results in a spatial environment and subsequently a GIS exhibit is produced for the regulatory stakeholders, which fulfills that regulatory condition. Fig. 5 represents the “Annual Seep Flow” exhibit that is reviewed on a monthly basis and is produced annually as a permit condition. The product is intended to depict the current annual water flow, which is compared to the previous year in order to gauge whether the flow has increased or decreased.

By creating the DBMS system, which holds the environmental data, the user can retrieve data and depict any monitored environmental theme in a geospatial platform within the Environmental GIS program. Additionally, the DBMS has built into the system, data integrity rules and queries that allow staff to evaluate compliance trends such as the pH readings for the NPDES requirements. The NPDES permit has a maximum and minimum compliance threshold that cannot be exceeded. Since the DBMS is available to all of the mine staff, a simple date range query can be entered, in order to evaluate the pH results and any other non-compliance trend. Fig. 6 is an example of the DBMS ph query that is used to evaluate compliance with the NPDES permit.

Value Added Products

Since the inception of implementing the Environmental GIS program at Questa Mine, additional environmental datasets have been created, which has added even more value to the system. Essentially it has been expanded to encompass all environmental regulatory obligations and the following are the datasets that reside within the geodatabase.

- **Air Monitoring** Identifies the location of all monitoring equipment and areas of

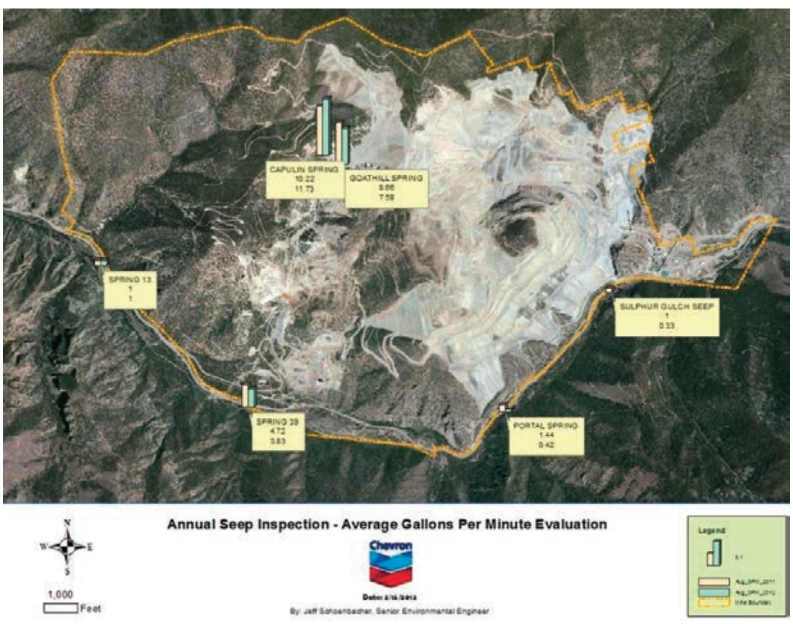

Fig. 5 Annual Seep Flows GIS Exhibit

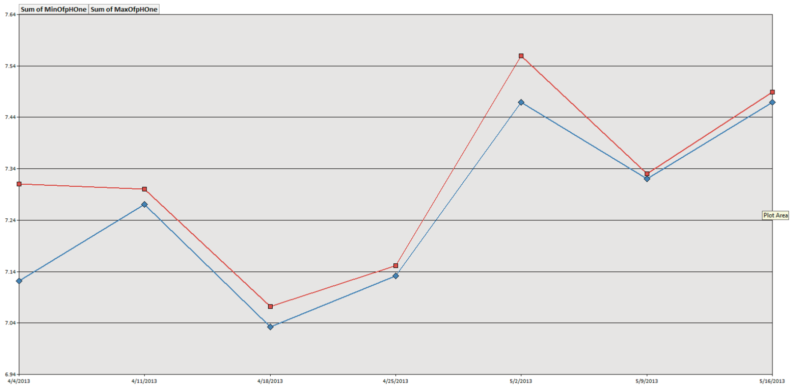

Fig. 6 *Date Range pH DBMS Query*

observation in accordance with the air permit.

- **Emergency Response** Location of incident, corrective actions, engineering controls, and history.
- **Sampling** Inventories all miscellaneous sampling conducted at the mine not related to the water permits.
- **Reclamation** Surface disturbance, treatment plots and history.
- **Safe Drinking Water** Raw water wells, monitoring locations, results.
- **Spill Prevention** SPCC Plan locations, tank locations, tank specifications.
- **Stormwater Inventory** of all engineering controls and as-builts.
- **Surface Drilling** Locations, permitting, footprint specifications.
- **Transects** Location and specifications.

In addition, the Environmental GIS datasets are provided to the entire mine staff, since the datasets have been published into an ArcReader.pmf format. The ArcReader software is part of the ESRI ArcGIS suite and works with maps authored within ArcMap. ArcReader is an easy-to-use desktop mapping application that allows users to view datasets and print their own maps. This allows anyone with an ArcReader license to view high-quality interactive maps authored in ArcMap which have been published with the ArcGIS Publisher extension. The following benefits have been recognized from implementing ArcReader licenses:

- Allows datasets to be deployed to mine staff, which are new to GIS and only have the interest in viewing Questa Mine's environmental datasets (*i.e.* aerials, well locations, and engineering controls).
- The distribution of the datasets has allowed mine staff to communicate more effectively and while also providing flexibility for graphically marking up maps and distribute internally via email.
- The application increases the knowledge of Questa Mine's regulatory obligations and the locations, requirements and specifics of each monitoring location.
- Lastly, the PMF file preserves a live connection to the datasets within the geodatabase, so the users have up to date views of the environmental themes.

Fig. 7 represents that ArcReader appearance that allows mine staff to become more familiar with Questa Mine's footprint and the associated themes.

Conclusions

At a time when mines are experiencing unprecedented regulatory scrutiny and oversight, Questa Mine's Environmental GIS has been found to be an essential tool in managing the numerous regulatory compliance obligations. Both the field monitoring DBMS and the GIS are dynamic systems, which frequently provide new deliverables at the mine site. Furthermore, the systems that are in place have greatly improved the organization of the envi-

Fig. 7 *ArcReader Default Appearance*

ronmental datasets since they are now located in one geodatabase. Before, many of the datasets were on hard copy maps or in AutoCad files. Adding to that benefit, is that all of mine staff has access to a database resource that can be used for disseminating and analyzing environmental themes in a very prescriptive regulatory environment. This has resulted in the staff becoming more aware of environmental monitoring locations, monitoring requirements, as well as providing a spatial product via the ArcReader application.

Nonetheless, this author believes that the success of the system was due to the pre-planning stage of developing both systems. Specifically, the step to develop a comprehensive needs assessment streamlined the process by flushing out priorities, and resources while providing a framework for constructing both systems. However, as with any data management system the challenge will be in maintaining the data integrity and the numerous datasets in an ever expanding mining regulatory environment.

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