EMERGENCY SERVICES FOUNDATION

Emergency Services Foundation Scholarship

Gavin Parker - CFA

2016

"Investigate best practices for emergency response to brown coal (lignite) mining and combustible dust fires and incidents in open cut coal mines, power generation and clean coal energy facilities"

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Executive Summary

The Emergency Services Foundation (ESF) scholarship has given me the opportunity to visit a number of locations to investigate best practices for emergency response to brown coal (lignite) mining and combustible dust fires and incidents in open cut coal mines, power generation and clean coal energy facilities.

I was able to visit five coal mines, six power stations and a coal gasification plant located in, Montana, Wyoming, North Dakota in the United States and Saskatoon, Canada. I also visited state mine reclamation authorities in North Dakota and Pennsylvania including a number of historic mine sites and the town of Centralia, PA that has had an underground coal mine burning since 1962. I attended a quarterly meeting hosted by the North Dakota Lignite Association, a representative body for the coal industry and meet with three state government commissioners, government mining regulatory officials, managers and representatives from the major mining and power generation facilities within the state of North Dakota. I also visited the US Forest Service office in Bismarck, ND and a number of Fire Departments that respond directly to or support emergency response to the oil, mining and power industry as well as the 81st Civil Support Team. A team that is able to deploy rapidly to assist a local incident commander in determining the nature and extent of and chemical, biological, radiological or nuclear attack or incident; providing expert technical advice on WMD/NBC, response operations; and help identify and support the arrival of follow-on state and federal military response assets.

I also had meetings with representatives of water misting and dust suppression equipment companies located near Chicago, Illinois (Dust Control Technology) and Buffalo New York (Buffalo Turbine).

The opportunity also presented itself to visit a protest site at the Standing Rock Indian Reservation for the Dakota Access Pipeline or Bakken pipeline (oil pipeline) and in Colstrip MT, meet with one of the co-founders of a community based coal industry support group (Colstrip United), this provided a view of community groups that either in some way, support or oppose the oil or coal industry.

The main learning's and outcomes were the procedures practices and equipment in place to prevent, suppress and manage fires and other emergencies in the coal and power industry, as well as the role of the fire services in the management and support to those emergencies. I also learnt about the training and the training standards, the air monitoring equipment and procedures in place and the rehabilitation or reclamation of existing and historic mine sites.

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It has been a great opportunity to learn new skills and knowledge, benchmark what is being done in Victoria against practices and standards in the USA and Canada.

Background & Introduction

Emergency response to coal & energy production incidents in Victoria

Australia has the fourth largest share of coal reserves in the world with 110 years of black coal and 510 years of brown coal. Coal currently accounts for 70% of all power generation; a large part of this is base load energy needs.


Hazelwood mine fire Feb 21014,
Photo credit: - K Pakenham

Fire and emergencies in coal mines, handling and power generation facilities as proven with the February 2014 fires at the Yallourn and Morwell open cut mines can have a devastating effect on the health and wellbeing of residents close to the mines.

These fires have a level of complexity that is unique. The conditions can be demanding on people and equipment. For firefighters the potential for harm to health and the physical demands of the environment cannot be overlooked. As an organisation we need to ensure the methods are effective, efficient and safe as possible. The effectiveness can be enhanced with improvements in

technology, equipment and extinguishing agents. Efficiency can be gained in the strategies and tactics, training, incident and resource management, co-ordination and interoperability. Improvement in effectiveness and efficiency of operations can also improve safety. As with all activities safety has to be our priority, this can include improvements in health checks and monitoring, risk assessment, training personal protective equipment and clothing.

As an organisation we need to plan and prepare for change in the mining and power generation industry; this included “clean coal” and new technology such as carbon capture and storage (CCS), coal to oil and coal to gas and other processes such as refined coal (coal drying) and coal-water slurry fuel. Additionally as mines are rehabilitated and closed, these sites may fall back to into government hand or private ownership. These sites may still provide a risk to fire involving coal as a legacy of the previous use.

Within Australia the Latrobe Valley is the only location that large scale mining of brown coal occurs. Other brown coal mines in Victoria do exist in Bacchus Marsh and Anglesea; however they are relatively small scale operation. The Anglesea mine has recently been closed and the coal mined in Bacchus Marsh is used primarily as a product for organic fertiliser, soil conditioner and top soil in a similar way to the small lignite mines found in New Zealand’s Otago and Southland Regions.

Choice of study location

Internationally a large number of countries such as China, Germany, USA, Poland, Turkey, India, and the Czech Republic have large scale brown coal surface mining.

“The mining and power generation sites selected were located in Montana, Wyoming, North Dakota in the United States and Saskatoon, Canada”

Lignite coal mining in the area in the vicinity of North Dakota was chosen over other locations for a number of reasons, this included access to facilities and subject matter experts, the technology, equipment and procedures currently being used and the type of infrastructure in place. Additionally sub-bituminous coal mines in Montana and Wyoming were also visited to gain an understanding of emergency response in sub-bituminous coal mining operations.

Another important factor is the common language and the access to written and electronic information prior to the proposed study. This has and will continue to enable me to have a greater understanding of the political, economic and social factors that influence the industry in the United States, an understanding of Federal and State bodies, commercial mine and facility operators as well as documented emergency response procedure, planes and arrangements.

This enabled me to achieve a level of understanding of the industry in the United States and Canada that allowed me to optimise the time spent at each location.

Objectives and outcomes and the value to CFA, the community and other agencies

Main Objectives

The four (4) main objectives of the study tour were to investigate the following:

1. Best practices for the prevention, detection and suppression of Brown Coal (lignite) open cut coal mine fires.
2. Combustible dust fires and explosion prevention and suppression in coal handling and power generation facilities.
3. Health and air quality monitoring for large scale fires in coal facilities.
4. Best practices for the prevention, detection and suppression of potential fires in emerging “Clean Coal” technology facilities.

Sites Visited

Main Locations

The mining and power generation sites selected were located in Montana, Wyoming, North Dakota in the United States and Saskatoon, Canada, Equipment manufacturers were located in Illinois and New York state, Mine restoration agencies in North Dakota and Pennsylvania and numerous Fire Departments that supported mining and power generation facilities.

Sites included in visits

The sites included a number of localities and locations, including:

Estevan, Saskatoon, Canada

- Estevan Mine (Westmorland Coal Company)
- Shand Power Station (SaskPower) - 276 megawatt

Central and Northern, North Dakota

- Bulah Mine (Westmorland Coal Company)
- Freedom Mine (North American Coal Company)
- Falkerk Mine (North American Coal Company)
- Coyote Power Station (Otter Tail Power) - 429 megawatts
- Haskett Power Station (MDU Resources Group) - 75 megawatt
- Antelope Valley Power station (Basin Electric Power Cooperative) - 900 megawatts
- Great Planes Synfuels Plant (Basin Electric Power Cooperative)
- Custer Mine (Historic mine site)
- Sims (Historic mine site)
- Noonan and Larson (Old mine sites)

Bismarck, North Dakota, USA

- US Forest Service, Dakota Prairie Grasslands
- Lignite Energy Council
- North Dakota Public Service Commission (PSC) - Abandoned Mine Lands (AML) Division, (Assistant Director Bill Dodd)
- North Dakota National Guard, 81st Civil Support Team (CST)
- Dakota Access Pipeline protest site at Standing Rock (South of Bismarck)

Montana, USA

- Rosebud Mine (Westmorland Coal Company)
- Colstrip Power Station (Talen Energy) - 2094 megawatt
- Colstrip United (Community Group)

Wyoming, USA

- Black Thunder Coal Mine (ArchCoal) - Wright, WY

New York, USA

- Buffalo Turbine, Springville, New York

Illinois, USA

- Dust Control Technology, Peoria, Illinois

Pennsylvania, USA

- Centralia township, Pennsylvania
- Pennsylvania Bureau of Abandoned Mine Reclamation - Harrisburg, PA

Fire Departments/Services

- Estevan Fire Rescue, Estevan, SK
- Toronto Fire Service, Toronto OT
- Bismarck Fire Department, Bismarck ND
- Mandan Fire Department, Mandan, ND
- Minot Fire Department, Minot, ND
- Minot Rural Fire Department, Minot, ND
- Maxbass Rural Fire Protection District, Maxbass Fire Department, ND
- Alexander Fire Department, Alexander ND
- Williston Fire Department, Williston ND
- Des Lacs Fire Department, Des Lacs ND
- Epping Fire Department, Epping ND
- Colstrip Fire Department, Colstrip, MT
- Campbell County Fire Department, Wright, WY

Overview of Coal Surface Mining Operations in the USA and Canada

Mine types and regulatory framework

There are no underground mines operating in North Dakota today while underground mining occurs in Montana, Wyoming and other US states, all of the Lignite and Sub-bituminous mines visited were all surface mines.

Mining operations with pit and spoil piles visible

The Surface Mining Control and Reclamation Act of 1977 (SMCRA) is the primary federal law that regulates the environmental effects of coal mining in the United States.

SMCRA created two programs: one for regulating active coal mines and a second for reclaiming abandoned mine lands. SMCRA also created the Office of Surface Mining, an agency within the Department of the Interior, to promulgate regulations, to fund state regulatory and reclamation efforts, and to ensure consistency among state regulatory programs.

In general terms the process for surface mining includes extensive pre-mine planning and data collection is required and detailed mining permit applications must include:

- Business entity and legal information
- Baseline environmental resource information.
- Detailed mining and water management plans.
- Reclamation and monitoring plans.
- Performance bond.

Pre-mining

Pre-mine Baseline Information includes land use and vegetation information, including:

- Detailed soil survey.
- Surface and ground water resources
- Geologic and topographic information.
- Cultural resources.
- Wildlife surveys.
- Information on manmade features.

Mine Operations Plans

Mining and operations plans will include:

- Soil removal and storage plans.
- Haul roads and other transportation plans.
- Detailed pit layout and extended mining plans.
- Plans for the use of explosives.
- Plans for disposing mine wastes.
- Air pollution control plans.
- Surface water management plans.
- Plans for re-locating any public roads

Mining Operations

Mining process:

- Topsoil and subsoil removal with machinery such as scrapers, excavators and dump trucks, This topsoil and subsoils can either be stockpiled or placed directly back onto other reclamation worksites.
- Depending of the depth of the coal seam a dragline can be used to then remove overburden from on top of the coal and then placed in the adjoining pit from which coal has already been removed. This process starts the reclamation process by filling the previously mined pits
- When the coal seams are deep, pre-benching may have to be done, using in some cases smaller tracked draglines or bucket loaders are used. That overburden may have to be loaded into large dump trucks and the spread over overburden previously removed.
- The coal seam and in some cases multiple coal seams are then mined and coal removed from the site using bucket loaders, excavators and coal haulers, in the case when multiple coal seam occurs, additional overburden is removed between the coal seams.
- The coal is hauled to the tipple, usually by a wheeled coal hauler with either a tipping or center dump body, where it is crushed for use in the power station.

Overview of Coal Mine Reclamation in the USA and Canada

Mine Reclamation in the USA and Canada

North Dakota's first commercial lignite mine was opened in 1873 in Morton County. By the early 1920s, North Dakota had approximately 250 lignite mines. About half of the early mines in North Dakota were underground mines. Still today some of these old underground mines cause problems where sinkholes have been created by the collapse of mine tunnels The Abandoned Mine Lands (AML) Division, a division of the ND Public Service Commission has worked to stabilize these areas by digging out old mine

workings or pumping grout into the cavities. Mining companies pay eight cents per ton of coal, or approximately US$2.5 million a year to fund AML projects across the state. Similar programs are in place in other mining states.

North Dakota's first reclamation law was enacted in 1969. Changes to state laws in 1973 required saving up to 0.6m of topsoil. Further changes in 1975 required saving up to 1.5m of topsoil and subsoil and restoring the pre-mine level of productivity. The Federal Surface Mining Control and Reclamation Act (SMCRA) was enacted in 1977 and it created the federal Office of Surface Mining (OSM) within the Department of the Interior. North Dakota's current laws were passed in 1979.

Reclamation planning and monitoring

Reclamation and monitoring plans:

- Post-mining land use, including landowner preferences.
- Grading and post-mining topographic plans.
- Topsoil and subsoil replacement plans.
- Seeding and management plans
- Plans for removing long-term facilities & structures.
- Vegetation monitoring and yield measurements.
- Surface and ground water monitoring.
- Wildlife monitoring.
- Reclamation cost estimate for setting bond amount.
- The mining company generally needs to purchase a performance bond to guarantee that the land will be properly restored when mining has been completed.

Reclamation of mine works, just prior to bond release

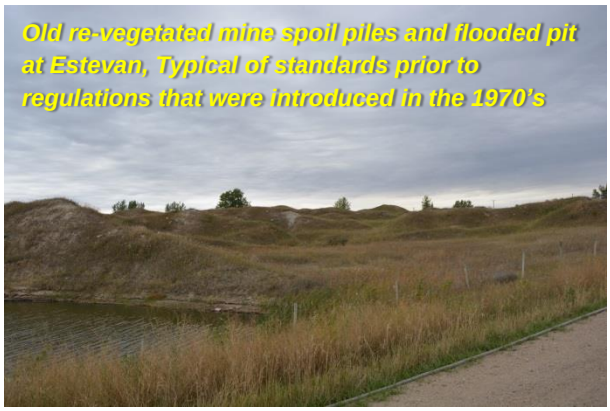
Reclamation mine spoil piles and pits at Estevan, Typical of modern environmental standards

Bonds

Performance Bonds:

- Surety, collateral or self-bonds must be provided before an application is approved.
- Bond amount must cover the worst-case mining and reclamation condition
- Periodic updates are required.
- Final bond release cannot be granted until at least 10 years after reclaimed areas are seeded.
- In the event of forfeiture, the bond money will be used to have a contractor reclaim the disturbed lands.

Mining Reclamation Standards



Reclamation standards:

- Minimize adverse impacts off the permit area.
- Return mined land to the pre-mine or higher land uses.
- Re-contour mined land to ensure that post-mining slopes do not exceed those present before mining and blend in with surrounding land or the approximate original contour.
- Redistribute all the topsoil and a sufficient amount of subsoil that has been saved
- Restore the productivity of reclaimed agricultural lands.
- Replace any water supplies adversely affected by mining.

Success standards:

- Pre-mine soil surveys are used to establish the target yield level that must be achieved to prove reclamation success.
- Actual yield measurements must be taken near the end of the minimum 10-year revegetation liability period.
- Plant ground cover and diversity standards must also be achieved for reclaimed native grasslands.
- Certain stocking rates must be met for tree and shrub plantings.
- Demonstrate that there were no adverse impacts to the hydrologic.

Observations and findings

The discussions that I had with representatives from the North Dakota Public Service Commission that are responsible for mining permits and reclamation had detailed the intent of the regulations and the standards that were required and achieved. Visits to active mine sites confirmed this, significant work, effort and expenditure is undertaken to archive the required results. Significant work and care is also taken in regards to protecting and preserving sites of cultural or historical significance, as well as environmental value. Reclamation planning and works can also add value to the environment with improved wetlands and other native vegetation habitat as well as improvements for farming grazing and cropping.

There is a significant difference between the standards and outcomes of surface mine reclamation done prior to and following ND State regulatory changes in the late 60's and

federal regulations around 1977. This was evident in several sites that I visited, including the old and new sections of the mine site at Estervan. This also included other historic mining sites near Noonan and Larson in North Dakota in the states North and the Custer mine site located in central ND near Garrison.

Overview and outcomes from the main sites that were visited

State Regulatory Organizations, Historic fire sites and Industry Peek bodies

North Dakota Public Service Commission (PSC) - Abandoned Mine Lands (AML) Division.

Located in the state capital building in Bismarck ND, the Public Service Commission administers the Abandoned Mine Lands (AML) Program on behalf of the State of North Dakota. The State AML Program was approved by the U.S. Department of the Interior in 1981 under authority of the Surface Mining Control and Reclamation Act of 1977. Program funding comes from a federal reclamation fee on coal that has been mined in the United States since the late 1970's. These fees are placed into the AML fund and the money that North Dakota receives from this fund is used to eliminate existing and potential public hazards resulting from abandoned surface and underground coal mines. The federal reclamation fee will be collected through September 30, 2021 before the program may end in 2022.

The mission of the Abandoned Mine Lands Division is to eliminate potential or existing hazards associated with abandoned coal mines in North Dakota for which there is no continuing liability under state or federal law such as dangerous highwalls and lands affected by underground mine subsidence. The nature of this mission is not regulatory but rather service-oriented.

Related goals are:

- Reclaim abandoned mine land sites found on the North Dakota AML Inventory.
- Reclaim hazardous abandoned mine land sites not on the AML Inventory but discovered through exploratory drilling or public information.
- Reclaim emergency sites as the highest work priority. Develop emergency reaction plans that will reduce the time taken to eliminate the imminent hazard.

Staff members located in the same office are also responsible for current mining applications, reclamation monitoring and bond release.

While current mining operations and reclamation are the responsibility of and undertaken by the mining companies. Work done on behalf of the AML program is contracted out with occasional assistance by local fire departments or land management organisations. In some cases land management organisations have the AML staff manage work on their behalf. It was interesting to see firsthand and talk to ALM staff about the working relationships that they have with mining companies as well as other organisations such as the USFS and senior state government officials from the North Dakota Public Service Commission.

I had the opportunity to speak with a number of staff from the office about the planning and management of works undertaken, as well as the methods and practices in place. This provided an insight into operations with fire management and suppression of sites under AML management. This included methods and equipment used in sinkhole and dangerous mine (highwall) surfaces as well as fire suppression, the type of works done on hazards and the standards achieved. This also included some interesting methods and innovation in reclamation and hazard management.

Pennsylvania Bureau of Abandoned Mine Reclamation

Located in Harrisburg, PA, the Bureau of Abandoned Mine Reclamation administers and oversees the Abandoned Mine Reclamation Program in Pennsylvania. In much the same way as the North Dakota ALM Division the bureau is responsible for resolving problems with the states abandoned mines. These issues in Pennsylvania can be things such as mine fires, mine subsidence, dangerous highwalls, open shafts and portals, mining-impacted water supplies and other hazards which have resulted from past coal mining (pre-1977) practices in accordance with requirements established by the federal Office of Surface Mining under authority of the Surface Mining Control and Reclamation Act.

I met with several staff and had the opportunity to discuss the work undertaken by the bureau, including the historic mine fire at the town of Centralia and work currently being done near Hazelton PA. We discussed some of the methods used in suppression of underground fires, monitoring emissions and fire activity.

Centralia mine fire, Pennsylvania

The Centralia mine fire is a coal seam fire that has been burning underneath the borough of Centralia, Pennsylvania, since at least May 27, 1962. The fire is suspected to be from deliberate burning of rubbish in a former strip mine that ignited a coal seam.

The fire burns in underground coal mines at depths of up to 100 meters over a 12 km stretch covering 1,500 ha. As of 2016, the fire continues to burn. It has burned for more than 53 years and at its current rate, it could burn for over 250 more years.

The blaze has resulted in most of the town being abandoned. The population dwindled from 2,761 in 1890, about 1,000 in 1980 to only about 7 today, all but a few of the buildings have been leveled.

The visit to Centralia followed the meeting with staff from Bureau of Abandoned Mine Reclamation, and discussions about suppression work and monitoring of that and other sites throughout Pennsylvania.

Lignite Energy Council, ND

The primary objective of the Lignite Energy Council is to maintain a viable lignite coal industry and enhance development of the region's lignite coal resources for use in generating electricity, synthetic natural gas and valuable byproducts.

Members of the Lignite Energy Council include mining companies, major users that use lignite to generate electricity, synthetic natural gas and other valuable byproducts, and businesses that provide goods and services to the lignite industry.

I was given the opportunity to sit in on a meeting held at the office of the council with three North Dakota Commissioners, other government officials, Lignite council members as well as senior management and representatives of the mining and coal industry. Topics discussed included arrangements for mining bonds and bond payments. It was an interesting insight in the work of the representative body and the issues that they are facing. During a latter separate visit I was able to attend a meeting with one on the council staff to discuss the outcomes of my study during visits to the mines and power generation facilities.

Mines and Power plants in North Dakota, Montana, Wyoming and Saskatchewan

Bulah Mine (Westmorland Coal Company)

Dakota Westmoreland Corporation – Beulah Mine is a 3,650 ha surface mine complex located 120 km northwest of Bismarck, North Dakota. It currently produces lignite from one active pit.

Until recently coal from this operation supplies the fuel requirements for the adjacent 427 megawatt Coyote Generating Station. Coyote is a low-cost, base-load generation facility that utilizes emission control technologies and now purchases all of its lignite from the nearby Coyote Creek Mine. Dakota Westmoreland also owns and controls a 7 km rail spur that

connects the mine and plant to the Burlington Northern Santa Fe Railroad's Stanton line, which it uses to supply the two-unit 75 megawatt Heskett Station, located 120 km away. The Beulah Mine produces approximately 2.9 million tons of lignite annually.


Coal rail car loading facility at the Beulah mine

Of particular interest at Bulah mine site was the rail loading facility and a detailed look at the plant equipment used in the mine as well as some local innovation and modifications done the large capacity water tankers. Another interesting aspect was an informative explanation of the sites reclamation process and visit to a number of locations throughout the mine area of reclamation works at various stages through to completion and bond release.

Freedom Mine (North American Coal Company)

Basin Electric Power Cooperative. Coteau's lignite is sold to Dakota Coal Company, a subsidiary of Basin Electric, which then provides lignite to Basin Electric's Antelope Valley Station, a 900-megawatt electric generating plant; as well as by rail to Leland Olds Station, a 650 megawatt electric-generating plant located near Stanton, ND, 35 km away; and the Great Plains Synfuels Plant, the nation's only commercial-scale coal-gasification plant.

At this site I had the opportunity to see firsthand all aspects of mining operations from planning through to delivery of the coal to the tipple, as with all sites I was also shown reclamation works as various stages though to bond release. Also located on a hill adjacent to the site there is great viewpoint to see an overview of the entire mining operation from start to finish.

Falkerk Mine (North American Coal Company)

Falkirk lignite is sold to Great River Energy (GRE) Coal Creek Station, a 1,100 megawatt electric generating plant, and GRE's Spiritwood Station, steam host for two 99 megawatt industrial customers.

I had the opportunity to meet with the mine safety officer and discussed general mining operations at the site the use of conveyors and the overhead conveyor at the freeway crossing, as well the rail coal loading facility. I also visited some of the previous reclamation areas and viewed the current mining operations area.

Coyote Power Station (Otter Tail Power) - 429 megawatts

Located near Beulah, North Dakota. The power plant employs approximately 80 and went on line in 1981. In December 2014 the turbine area suffered significant damage as a result of a fire. I was given a tour of the power plant, and discussed in site prevention and preparedness for emergency incidents, support arrangements and training. I was given a tour of the power station, of particular interest was the methods used for combustible dust containment and collection and was informed about the sites emergency response arrangements and also briefed on the circumstances surrounding the turbine floor fire in 2014 and the emergency response to that incident as well as another smaller fire incident.

Haskett Power Station (MDU Resources Group) - 75 megawatts

The R.M. Heskett Station is a coal-fired power station near Mandan, North Dakota that commenced operating in 1954. I visited the site and spoke briefly to the manager about the frequency of emergency incidents and local response arrangements.

Antelope Valley Power Station (Basin Electric Power Cooperative) - 900 megawatts

Located seven miles northwest of Beulah, ND, the Antelope Valley Station is the newest coal-based power plant in North Dakota. Its two units are each rated at 450 MW each. I was able to tour the Antelope Valley station following the visit to the mine.

The power station visit gave a great insight into power generation operations as well as the procedures and outcomes for maintenance and cleaning to reduce the risk from combustible dust fires.

Great Planes Synfuels Plant (Basin Electric Power Cooperative)

The Great Plains Synfuels Plant (GPSP) in Beulah, North Dakota has been in operation producing synthetic natural gas (SNG) from lignite coal for 25 years and remains the only coal-to-SNG facility in the United States. In addition to the production of SNG, the plant also produces high purity carbon dioxide (CO_2), which is distributed through a pipeline to end users in Canada for enhanced oil recovery (EOR) operations. The plant also produces and sells anhydrous ammonia, as well as the following by-products: ammonium sulfate, krypton, xenon, dephenolized cresylic acid, liquid nitrogen, phenol, and naphtha, most of the last of which is burned as

fuel in plant boilers. I was give and extensive tour of the plant that also included a large "model room" that demonstrated the components of the site and how they work in scale. I was also shown the fleet of emergency response vehicles on site and was briefed on emergency procedures and emergency response arrangements for the gas plant, mine and power plant.

Rosebud Mine (Westmorland Coal Company) and Colstrip Power Station (Talen Energy) - 2,094 megawatts

Western Energy Company – Rosebud Mine is a 10,100 ha surface mine complex located in the northern Powder River Basin near Colstrip, Montana, and the Northern Cheyenne Indian Reservation. Rosebud is a large operation with three active pits and supplies almost all of its current production to the Colstrip Power Station that is adjacent to the mine that was specifically designed to burn Rosebud coal. Some coal is also supplied to nearby 41 MW Rosebud power plant. The visit to the mine site included a tour of the mining operations, mine reclamation, the loading tipple and conveyor system. Of particular interest was the protection and preservation of historic buildings within the mining operations area, as well the protection of sites of cultural and natural values. Also of interest was the dust mitigation infrastructure incorporated into coal handling equipment.

I also had the opportunity to visit the mines workshop area and was given a tour of that facility to examine the repair and maintenance of heavy plant equipment used in the mine.

The Colstrip power plant operates four coal-fired generating units capable of producing up to 2,094 megawatts (MW) of electricity. Units 1 and 2 began commercial operation in 1975 and 1976, and units 3 and 4 started in 1984 and 1986.

I was given a briefing of the power plant operations by the sites safety officer as well as a tour of the facility, including the station and control room, outdoor coal storage area and the coal bunker (coal barn).

As with the other plants emergency procedures and the prevention of incidents and response arrangements being discussed. In relation the closure of the Hazelwood power station in Victoria in 2017, of interest was the discussion about the

programmed closure of Colstrip's units 1 & 2 by 2022 and the impact of the local community and baseline energy production for the state of Montana.

Black Thunder Mine, Wright Wy

Located in Campbell County, Wyoming, the mine is located in what's known as the Powder River Basin (PRB). The coal is classified as "sub-bituminous" coal and PRB contains one of the largest deposits of coal in the world. Black Thunder is the largest coal mine in the United States. The mine was opened in 1977 and run by ARCO Coal until it was acquired in 1998 by Arch Coal. For most of its existence, Black Thunder has been the largest mine in the country (by production), but it was surpassed by the nearby North Antelope Rochelle Mine. The mine was opened in 1977, and run by ARCO Coal until it was acquired in 1998 by Arch Coal. On an average day, Black Thunder loads more than 25 miles of rail cars. Every day, more than 20 trains that pull between 120 to 150 coal hoppers that carries in total more than 14,000 tons of coal is filled at Black Thunder. Operators using a computer controlled loading system at each of the mine's three load outs, can load each train as quickly as 1 hour and 15 minutes. I had a very interesting tour of the mine that involved a detailed look at overburden removal and coal dragline operations. I also had the opportunity to view several small coal fires burning at the site and the railcar loading operations. Also discussed was the work and training of the sites mine rescue team.

Estevan Mine (Westmorland Coal Company) and Shand Power Station (SaskPower) - 279 megawatts

The Estevan Mine covers an area of 20,331 ha and is located in South Eastern Saskatchewan between the City of Estevan and the town of Bienfait. The Estevan Mine operates four active pits and supplies lignite coal to the Boundary Dam Generating Station (4 Units), the Shand Generating Station (1 Unit), the Activated Carbon Plant, the Char Plant, as well as some domestic sales. The generating stations are owned and operated by Saskatchewan Power Corporation.

The Estevan Mine has been supplying coal to the area since 1905 with PMRL acquiring the Bienfait Mines in 1966 and starting the Boundary Dam Mine in 1973.

I was given a very detailed tour and overview of the mining and reclamation operations

at the site, of particular interest was the older reclamation works to former mining areas prior to the changes to the government requirements and the vast difference in the standards. I also had the opportunity to view a dragline that was having major refurbishment as well as equipment being operated and a tour inside another drag line that was out of service at the time.

The Shand Power Station was commissioned in 1992 and has one coal fired 279 megawatts (MW) unit. The site is sized for a potential second unit in the future.

The Shand Greenhouse was built in 1991 near the power station and is part of an initiative to offset the environmental impact of burning coal. The greenhouse facility grows and distributes seedlings free of charge to schools, communities and individuals for conservation and wildlife habitat projects.

I spoke briefly to staff about emergency procedures and emergency response arrangement at the site as well as the Shand Greenhouse programme.

Historic Mine sites

In the period up to 1919 underground mine was the main form of coal mining operations in North Dakota. The next 20 years saw the transition to surface mining with large efficient machines such as steam shovels being introduced. Before state regulations were put in place in 1969, large spoil piles were left behind; covering what was in most cased previously productive farming land. These spoil piles had topsoil's mixed in with overburden, they were steep, unable to support vegetation and erosion of the piles caused water with sediments and air pollution with dusts. Further revisions of the state's regulation were made during the 70's and in 1977 federal laws were passed.

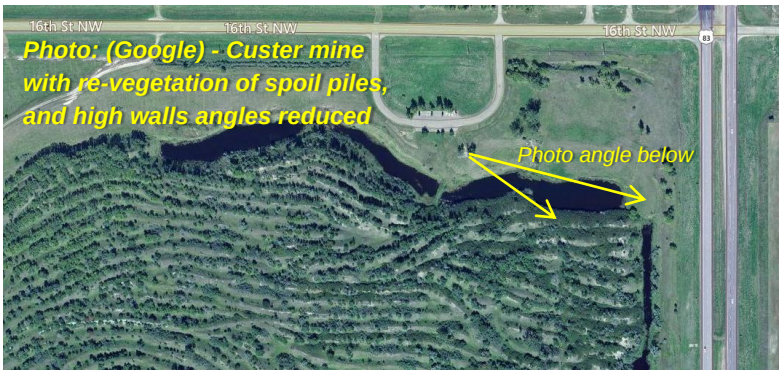
The legacy of the period before these state and federal regulations can be seen in the places that I visited at the Custer mine and at Noonan and Larson. Similar legacy mining works were also seen at the older part of the Estevan mining area.

Although the importance of lignite mining in North Dakota is unquestionable, the effects of past mining prior to environmental regulation has resulted in significant hazards to the public and the environment of the state. Past underground mining has resulted in dangerous collapse features, or sinkholes, and surface mining has left dangerous steep pits, waste piles and structures. Title IV of the Surface Mining Control and Reclamation Act of 1977(SMCRA) established an Abandoned Mine Land (AML) fund to be used to reclaim abandoned coal mines. Money for this fund is from a ten cents per ton federal

tax levied by the Office of Surface Mining Reclamation and Enforcement (OSMRE) on active lignite coal mining in North Dakota.

Custer Mine

The Custer mine is an example of mine rehabilitation undertaken 27 years ago, when a community group from Garrison, ND created the Custer Mine Interpretive Center in celebration of the state's 100th birthday. The Custer Mine Overlook marks the former site of the Truax-Taer Mine, an old strip mining area owned by Consolidation Coal. The mine was in operation between 1947 and 1964. In 1950, the mine's most productive year it produced some 370,530 tons of coal. The site includes a number of kiosks that provide history about the mine as well as the history of the surrounding Fort Totten Trail, which started as a wagon trail that connected Fort Stevenson and Fort Totten. The 200 km long trail dates back to 1867 and was in constant use up until 1872, when railroads became more prevalent. At one point, a portion of the trail near the Dryden Range became known as "The Land of Strange Disappearances" when several mail carriers along the route were attacked and killed. The Custer Mine became the Custer Wildlife Management Area in 1989 when the mine's owners deeded the land to the North Dakota Game & Fish Department. Today, the mine overlook, also known as the Custer Mine Wildlife Management Area, is home to a diversity of wildlife, trout fishing pond, an interpretive site, and multiple outdoor opportunities.



Noonan and Larson Mining areas

These areas saw significant growth in the period from the 1920's and the introduction of surface mining in this area and saw some of the early innovation on large scale mining.

Just east of Larson in 2017 the Columbus Phase 16 AML Project will eliminate about 1.4 km of dangerous highwalls at abandoned surface mine sites located on approximately 17.5 ha south of the city of Columbus, ND, in Burke County. These sites are characterized by steep highwalls that are about 4.5 to 6 m high. The proposed reclamation work involves backfilling the highwalls with earthen material from adjacent

spoil piles. About 172,000 m² of spoil material will be moved in the reclamation process. Work is expected to be conducted between June and September 2017. The estimated project cost is $450,000. This is one of numerous phases of works that have been done by AML over many years including two miles of dangerous pit high wall in 1994-95 at the Noonan site.

Fire Departments

Estevan Fire Rescue, Estevan, SK

Fire Rescue Services employs a full time Chief and Deputy Chief with administrative support. There are approximately 27 paid-on-call firefighters at any time, most of whom hold professional, industry standard certifications in fire suppression, hazardous materials management, and rescue.

I had the opportunity to discuss with the Estevan Fire Chief the training and response arrangements for incidents and fires within the coal and power generation industry.

Toronto Fire Services, Toronto OT

The Toronto Fire Services provides fire protection and first responder and emergency medical responder assistance to the city of Toronto, Ontario, Canada. The Toronto Fire Services is currently the largest municipal fire department in Canada and is a full-time paid fire service with over 3000 staff to a diverse population of about 2.7 million people. I visited two fire stations and discussed a number of topics including the selection and use of the current Air & Light Units that have a similar function to our Breathing Apparatus Support Vehicles, a summary of these findings are included in a supplementary report.

Bismarck Fire Department, Bismarck ND

Bismarck is the second largest city in the state with a population of about 130,000 and North Dakota's capital. The Bismarck Fire Department protects the life and property of the people who live in, work in, and visit the City of Bismarck with five stations located across the city. I visited two of the city's fire stations and discussed with on-duty staff response arrangements for combustible dust fires and incidents and other specialist response such as air monitoring.

Mandan Fire Department, Mandan, ND

The City of Mandan has a population of approximately 21,000 and was founded in 1881 as the centre for western expansion of the railway. In 1883, a railroad bridge spanning the Missouri River linked the east and west. The Mandan Fire Department has two fire stations and provides fire protection for the City of Mandan including the Haskett Power Station across the Missouri river from Bismarck.

Minot Fire Department, Minot, ND

Minot is the fourth largest city in the state with a population of approximately 70,000 and a trading center for a large portion of northern North Dakota, southwestern Manitoba, and southeastern Saskatchewan. Founded in 1886 during the construction of the Great Northern Railway, Minot is also known as "Magic City", commemorating its remarkable growth in size over a short time. Minot Fire Department has three fire stations and I visited and spoke to staff at its headquarters station, primarily about specialist response and combustible dust fire and explosion training and response. An interesting topic was the effect on the department during the North Dakota oil boom with staff leaving to pursue opportunities in the oils industry. This has led to a very young workforce with a reduction of long term experience in that and other Departments in North Dakota.

Minot Rural Fire Department, Minot, ND

Minot Rural Fire Department has one station on the outskirts on the City of Minot and provides fire protection of a large area surrounding the city. I visited the station and spoke to one of the members about the response arrangements and the type of equipment used by the Department.

Maxbass Rural Fire Protection District, Maxbass, ND

Located in Bottineau County, North Dakota, with a population of about 84, Maxbass was founded in 1905 and is typical of some of the small communities that are slowly reducing in size and services. I spoke to the Department Chief about the problems and difficulties of maintaining a fire service in a small community and people willing to take on leadership roles.

Alexander Fire Department, Alexander ND

Located in McKenzie County, North Dakota, with a population of about 223, the oil boom has brought new challenges and a range of new equipment. I was able to view new equipment purchased to meet the specific needs for response to incidents involving the oil industry.

Williston Fire Department, Williston ND

Williston the sixth largest city in North Dakota. The North Dakota oil boom is largely responsible for the sharp increase in population from about 15,000 in 2010 to about 30,000 today. The Williston Fire Department is a combination department that provides Fire and Advanced Life Support (ALS) emergency medical services to the city of Williston, ND. The department also provides ALS to approximately 2590 square km surrounding the City in both Williams and McKenzie Counties. The Department is staffed by up to 53 career personnel and 27 volunteers. I visited the headquarters station and spoke to the on duty staff about response arrangements and procedures for dealing with

fires/incidents with the oil industry. Williston will soon have three stations with two under construction and one temporary station in use as an interim measure. It was another example of a Department that had been competing with high paying jobs in the oil industry and at the same time having to rapidly expand to meet the cities growing needs.

Des Lacs Fire Department, Des Lacs ND

Located in Ward County North Dakota about 22 km east of Minot, Des Lacs has a population of about 204. During a short visit I had the opportunity to discuss the local training and response arrangements and examine the types of appliances the department operates.

Epping Fire Department, Epping ND

Located in Williams County, North Dakota, with a population of about 100, Epping is a small community in the middle of the Bakkon oil formation north east of Willston. It is also located on a major rail line with a rail oil storage and handling facility near the town. I had the opportunity to talk to some of the local fire department members on the impact of the oil boom and its effect on the department, in regards to training and equipment.

Colstrip Fire Department, Colstrip, MT

Located in Rosebud County, Montana, Colstrip have a population of about 2,300. Colstrip's primary industries are coal mining and electricity production. The department has two fire stations and a separate Fire Hall.

The Department provides emergency response to the local coal mine and two power stations. I was given a tour of both of the departments fire stations and well as the training Fire Hall.

Campbell County Fire Department, Wright, WY

The Campbell County Fire Department has ten fire stations throughout Campbell Country with staffed stations at Gillett and Wright, Wyoming, Wright located near the black Thunder Coal Mine has a population of about 1,807. The station at Wright also provides emergency response out to the Black Thunder mine.

Land Management and Emergency Support Agencies

US Forest Service, Dakota Prairie Grasslands

Covering 509,500 ha, the Dakota Prairie Grasslands (DPG) are not solid blocks of National Forest System lands; rather, they are intermingled with other federal, state, and privately owned lands. This mixed ownership pattern contributes to the uniqueness of the DPG. Each of the National Grasslands has savannahs of the Grand and Cedar

River National Grasslands to the rugged badlands of the Little Missouri National Grasslands and the rolling plains of the Sheyenne National Grasslands.

Several early explorers reported coal fires in the northern Great Plains region. Over the years, grass fires have ignited lignite beds many times. In two places in western North Dakota, in Theodore Roosevelt National Park and near Amidon, lignite seams were recently burning for many years. A seam of lignite at Buck Hill in the park burned from 1951-1977

A number of lignite seams have been ignited during widespread fires in the badlands national park. Some of the lignite fires were ignited by juniper tree roots burning down from the surface into the coal other from grass fire igniting exposed coal seams on the surface.

A side effect of the burning of lignite beds is the way the combustion gases affect nearby vegetation. Air pollution resulting from the burning lignite causes trees like the juniper, which is normally bush-shaped, to grow in a columnar shape. Once long burning fires go out the vegetation resumes its normal growth pattern.

Exposed surface coal can be ignited by prairie fire or lightning strikes. There is also the possibility that the fires can also be started by a chemical reaction in the coal. Where pyrite and iron sulfide (also called marcasite) combine with moisture, the reaction produces heat and the coal vein may burn.

When the coal vein is near the surface, especially if there are enough cracks to allow air near the burning lignite, the fire will burn hotter. Smoke rises from the opening. Most burning coal veins, however, suffer from a lack of oxygen and burn very slowly. The coal vein might burn at a rate of only 3-4 meters per year.

We discussed a range of topics including the issue of fire in the environment and its management on private and public lands and the a difference on public land between land management and forest organizations and a how in some cases naturally burning coal seams are seen as a natural event and managed differently.

One area of discussion was the possible effect of carbon monoxide on firefighters and contractors working in the vicinity of long duration fires involving coal. Although that don't have a health or air monitoring program in place they were very interested in CFA experience in this area.

North Dakota National Guard, 81st Civil Support Team (CST)

I had the opportunity to visit the 81st CST and discuss their role in supporting fire departments throughout North Dakota in Hazmat incidents and in particular the

response to incidents in the oil and coal industry. I was briefed of the operational role the team and the response and capability and was shown the range and type of equipment utilised by the team.

On standby around the clock and capable of responding within 90 minutes, CSTs are highly-specialized units that are trained and equipped to assist civilian first responders when reacting to chemical, biological, radiological, nuclear and explosive agents.

Federally resourced and state controlled, CSTs support civil authorities at a domestic Chemical, Biological, Radiological and Nuclear high-yield Explosives (CBRNE) incident sites by identifying CBRNE agents/substances, assessing current or projected consequences, advising on response measures and assisting with appropriate requests for additional follow-on state and federal military forces. This includes:

- Support civil authorities in domestic incidents
- 24/7, rapid deploy capability
- Onsite analytical platform
- Detect & identify chemical, biological & radiological agents/substances
- Determine & assess current & potential hazards to personnel, animals & critical infrastructure
- Advise civil authorities on initial casualty management & minimization measures
- Provide technical & situational awareness
- Link to & augment civil responder communications systems

One item or equipment of particular interest was the TSI DustTrak™ DRX Aerosol Monitor 8533. The unit is able to measure both mass and size fraction. The DustTrak DRX desktop monitor is a battery operated, data-logging, light-scattering laser photometers that gives real-time aerosol mass readings. It uses a sheath air system that isolates the aerosol in the optics chamber to keep the optics clean for improved reliability and low maintenance. It is suitable for clean office settings as well as harsh industrial

workplaces, construction and environmental sites and other outdoor applications. The DustTrak DRX monitor measures aerosol contaminants such as dust, smoke, fumes and mists. It is a desktop unit that can be used for:

- Industrial/occupational hygiene surveys
- Indoor air quality investigations
- Outdoor environmental monitoring
- Baseline trending and screening
- Engineering control evaluations
- Remote monitoring
- Process monitoring
- Emissions monitoring
- Aerosol research studies

The DustTrak™ DRX Aerosol Monitor 8533 provides and features:

- Simultaneously measure size-segregated mass fraction concentrations corresponding to PM1, PM2.5, Respirable, PM10 and Total PM size fractions
- STEL alarm setpoint
- Automatic zeroing (with optional zero module) minimizes the effect of zero drift
- Perform in-line gravimetric analysis for custom reference calibrations
- Manual and programmable data logging functions
- Aerosol concentration range 0.001 to 150 mg/m ^{3}
- Environmental protected and tamper-proof with Environmental Enclosure
- Internet “Cloud Data Management System” for efficient remote monitoring
- Heated Inlet Sample Conditioner to reduce humidity effects

The growing awareness of both PM10 and PM2.5 is largely associated with the potential damaging effects they can have on the human body. The World Health Organisation (WHO) believes particles are affecting more people worldwide than any other pollutant. Primary health effects include damage to the respiratory and cardiovascular systems. Due to the small size of PM10 and PM2.5 particles, they can penetrate the deepest parts of the lungs as well as access the gas exchange regions of the lung via diffusion.

This or a similar item of equipment would enable CFA to have a capability to measure particulate emissions in a range of fires and incidents and provide timely advice to emergency responders and the public.

Equipment Suppliers and Manufacturers

Buffalo Turbine, Springville, New York and Dust Control Technology, Peoria, Illinois

Both companies manufacture Dust Control and Odor Control equipment. Buffalo Turbine also manufactures debris/leaf blowers as well as insect and crop sprayer/dusters.

Dust can be produced in a very wide range of sizes. Larger, heavier particles tend to settle out of the air and onto a surface and smaller, lighter particles have a tendency to hang in the air. While there are typically three different methods of controlling dust: (collection, containment, and suppression), in a mine environment collection and containment would not be possible, wet dust suppression of dust on surfaces (static wetting) can be done by either a mist or jet spray. A misting spray is also capable of reducing dynamic dust spread, by wind or in some cases such as fly ash in smoke convection columns by enveloping the airborne dust particle and the bringing it to settle on a surface.

With firefighting operations in a mine, while typically large volumes of water can be used within the mine environment, eventually this can lead to problems with de-watering of the mine, cracking in the mine due to hydraulic pressure or slippage and failure of mine surfaces causing collapse, at some point there may be a need to avoiding over-saturation.

Mist spray equipment has not only a typical use for dust suppression, but may have fire suppression capability in open cut, surface coal mining operations for a number of applications:

- Containment of fire spread either horizontally along a mine surface or vertically on a mine batter or high wall.
- Extinguishment and containment of the spread of windborne burning coal dust material.

- Containment and extinguishment of coal material burning on the mine surface or deep seated fires.
- Infrastructure protection.
- Reducing airborne particulates and smoke emission by aiming mist spray into the smoke and convection flow.
- Reducing water use and the problems associated with mine de-watering and hydraulic cracking of the mine.

Of product available from Buffalo Turbine, of interest was the “Monsoon Dust Controller – Diesel”, which has a direct coupled 3-cylinder liquid-cooled Kohler diesel engine. For mine and potential fire service application the unit allows for portable dust / odor control with the benefit of a fuel type that is common in these industries. The machine is equipped with 270 degree oscillation as well as several fail-safe features that protect the machine. The Dust Controller – Diesel, does not use nozzle tips therefor blockages are not an issue with their rotary atomizing nozzle. Its lightweight and portable design makes this machine a conveniently packaged item.

As with Buffalo turbine, Dust Control Technology market direct drive, dust suppression equipment powered by an electronic motor. The advantages of this system are that the unit itself has less moving parts and less maintenance. The Buffalo Turbine equipment has a throw or about 40 meters.

Dust Control Technology market four units with a throw of; 30, 45, 60 or 100 meters. These can be typically trailer or skid mounted on a frame and can also be configured with its own genset (generator) package.

Other applications for this type of equipment may be in use for large waste and recycling facility fires. The equipment may have potential for extinguishment, reducing particulate emission in the convection column and reducing the spread of convection gasses.

Community Groups

Colstrip United

Lori Shaw and Ashley Dennehy are founders of the Colstrip United movement in Colstrip, Montana. Colstrip United is a “grassroots” local movement in the small town of Colstrip Montana and was founded in January 2016 with the mission to inform and inspire the citizens of Colstrip to bring them together toward the goal of protecting their way of life and to inform the outside world about Colstrip, coal mining, and their power

plant. Colstrip United has grown to over 9,000 facebook likes and had reached over 4 million people in six months.

Given the developments in Victoria around the same time with the announcement of the closure of the Latrobe Valley Hazelwood power station and mine, this was an interesting aspect of my visit to discuss the issues with people from the local industry and community as well as one of the co-founders of the organization.

They maintain a web site and Facebook page, provide and sell merchandise and have organized public events.

I met with Ashley and discussed the organization and its activities and have since made and maintained contact with Lori to share information of updates of the industry in both Montana and within Australia, particularly with developments in Victoria and South Australia in the time since the visit.

Dakota Access Pipeline Protest Site

The Dakota Access Pipeline is a 1,886 km conduit slated to carry crude oil from North Dakota to southern Illinois when it's completed. Since its approval in late July, the project has sparked protests at the Standing Rock Sioux Reservation in North Dakota, about 60 km south of Bismarck. The protest has been a significant issue within the energy sector in North Dakota, with involvement from State law enforcement and the National Guard. The protest had been in force since April 2016 with local and national involvement from Native Americans from other US states.

The pipeline has united a number of different interest groups with a variety of objections, but Native Americans have been at the center of the opposition. The pipeline would travel underneath the Missouri River, the primary drinking water source for the Standing Rock Sioux, a tribe of around 10,000 with a reservation in the central part of North and South Dakota. Builders of the pipeline insist that they have taken extraordinary measures to safeguard against disaster, but opponents point out that even the safest pipelines can leak. The Standing Rock Sioux also argue that the pipeline traverses a sacred burial ground. While the land being used for the pipeline is

not technically on its reservation, tribal leaders argue that the federal government did not adequately engage the Standing Rock Sioux during the permitting process, a requirement under federal law.

During my visit to the site the protest was peaceful with a large presence of Native American's from all over the United States that had joined the local Standing Rock Sioux tribe. There was also a relatively large presence of North Dakota State Police, and National Guard maintaining traffic control points near the protest site. Latter in the year the protest group increased in size with other groups such as some war veterans joining the protest, The protest became less peaceful and people remaining at the site endured a very harsh winter with the Police and military eventually clearing the site and the state government conducting a large cleanup of the former protest camp sites.

Outcomes

Study outcomes and objectives

The outcomes contained within this document are an overview. Detailed information and recommendations have been provided or being prepared in a number of supplementary reports. Alternatively, some findings will be the basis for further information that has been gathered to be compiled for release or further study and investigation as required.

The four (4) main objectives of the study tour, these are to investigate the following:

1. **Best practices for the prevention, detection and suppression of Brown Coal (lignite) open cut coal mine fires.**

   It was known and identified prior to the study that the nature of the coal seams for lignite coal mines visited is vastly different to that found in Victoria due to the composition of the coal, the depth and thickness of the coal seams.

   Victoria has large areas of uncovered and exposed coal with its open cut mines. Whereas the strip mining is possible in North America due to the deep layers of overburden covering the coal seams; as is done in other countries such as Germany. As mining is done, it is possible to rehabilitate the previously mined area as further mining occurs, leaving relatively small amounts of coal exposed. However this provided a comparison of the different mining and rehabilitation methods and more importantly the differences in prevention, detection and suppression of fires.

Outcomes –

Prevention

Vegetation management - The style of mining witnessed greatly reduced the threat of grassland and other fire entering or leaving the mine; as large areas of soil and sub-soil and removed well forward of the working coal face . As clean overburden is removed to expose the coal seam it is continually dumped over the previously mined area behind the working coal face. As a result, any remaining exposed coal at the bottom of the seam is quickly covered. In this regard the main lesson to be learnt would be the removal and stockpiling of soil ahead of the working face of mines here would not only provide a buffer for vegetation fire risk, but also provide an available source of stockpiled soil/sub/soil for long term mine rehabilitation. Where possible to increase efficiency, as topsoils and subsoils are removed and transported directly to the site for final use to save stockpiling and double handling. This entire process not only removed surface vegetation to prevent the spread of fire, but also forms a vital part of the of the mine restoration process. The issue of the placing or stockpiling of sub-soils and overburden in Victoria is in some cases a means to balance pressures in the mine and mine stability. However it may be worth considering where possible the use of removed top soil, sub-soil and even overburden as part of an ongoing rehabilitation or reclamation plan to cover any remaining exposed coal rather than at the end of the mines working life.

Dust mitigation - Dust prevention was a key area of fire prevention as well as a concern for the environmental and workplace OHS impact. Dust mitigation was mostly achieved with the use of specialist heavy water tankers, as well as in some cases chemicals for dust suppression on conveyors and handling facilities within the mine. In one example on a conveyor was fitted with a mechanical system for flipping the conveyor belt 180º for its return on the underside of the conveyor system this was used to reduce dust so the coal exposed side of the belt always remains in the up position. Additionally sites were kept free of dust and other loose material where possible.

Conveyors in most cases were also covered to reduce the impact of wind to prevent the spread of coal dust.

Detection

Detection systems used in the mines visited relied basically on visual detection, it was suggested that in their experience that was sufficient due to the low instances of fire.

Additional detection systems were fitted to some mobile plant equipment that was used in conjunction with fixed suppression systems. These were a combination of factory fitted systems but in most cases specialist add-on systems.

Suppression

On site suppression when required was usually done with portable extinguishers, site water tankers and other onsite plant equipment, with response from local Fire Departments as required. Most sites had rescue teams with specialist equipment but only one site visited had dedicated fire appliances. Some sites had fixed suppression systems built into coal conveyors, coal handling systems and mobile plant equipment. Within the mines there was an absence of reticulated water supplies as is the case in Victoria, this was due to the type of mining operations.

Although in some cases water additives were used within fixed coal handling, transport and power generation facilities, this was not the case within the surface mines.

In discussion with agencies responsible for fires in underground mines and legacy abandoned mines other methods of sealing fires are used. This can include typically achieved by digging out material with plant equipment and water to cool the fire then capping with clay, fly ash or other approved overburden. In some cases grouts and foams are also used.

It was reported that a fly ash slurry had been used with some success due its ability to flow deep into cracks and fissures, thus sealing potentially more effectively than clay. Other research had also indicated that this

type of mixture excluded oxygen from the fire in the same way as clay, but also allowed some moisture to penetrate and continue cooling any remaining fire. Research and testing in other countries was discussed on the use of sub-surface capped steel pipes that were inserted when mine areas were capped with clay. A steel pipe that can be opened at the top allows air and fire monitoring as well as the further application of water or foam to deep seated fires as required and then the pipe is re-capped again to exclude oxygen.

While High expansion (High Ex) foam, Class “A” and Compressed Air Foam System (CAFS) have been used particularly in underground mines, a method used in Pennsylvania was class “A” foam with compressed nitrogen (nitrogen enhanced foam system), while in other countries it was reported that liquid nitrogen has been used in a similar way. In both examples capping was also done to exclude oxygen.

2. Combustible dust fires and explosion prevention and suppression in coal handling and power generation facilities.

It was found the instances of fire within the power generation and coal handling facilities was low. Two examples of significant fires were a result of major failure of a high pressure hydraulic systems resulting in a major fire and the other was from a dust leak from a dust extraction system and build-up of coal dust in a concealed void that caught fire. Due to the clean state of the power generation facilities, small fires only involved the material normally expected to be involved and not an additional build-up of coal dust.

Outcomes –

Prevention

It was found that a very high standard of “housekeeping” existed in all the sites visited with very little evidence of dust found.

Internal conveyors were in most cases covered and dust extraction systems were also fitted with dust being transferred into a big filtration system with a “shaker’ to empty the bags and then transfer the dust to be used within the power plant. These systems were widespread, even in older power stations. Other systems used chemical crusting agents for reduce dust such as GE Betz Dustreat DC619. Companies such as GE make a range of products that can be used to either reduce dusting, oxidisation or the calorific value of the product.

NFPA 120 (Standard for Fire Prevention and Control in Coal Mines) covers minimum requirements for reducing loss of life and property from fire and explosion in the following:

- Underground bituminous coal mines.
- Coal preparation plants designed to prepare coal for shipment.
- Surface building and facilities associated with coal mining and preparation.
- Surface coal and lignite mines.

Other standards include NFPA 654 as well as National Institute for Occupational Safety and Health (NIOSH) and Occupational Safety and Health Administration (OSHA) standards.

While the very newest of power stations in Victoria are designed and built to a similar standard. Consideration should be given to ensure that any new or refurbished coal handling and power generation facilities meet or exceed the NFPA 120 standard for dust mitigation.

Suppression

It was reported the instances of fire involving coal and coal dust within the power stations visited was very low. This is mostly due to the high level of "housekeeping" and dust mitigation.

At several of the sites products such as F-500 Encapsulator Agent (EA) were used. Staff from these sites reported significantly better results in the effectiveness and efficiency of firefighting using such products, safety was also improved with the reduced risk of flare-ups (flash fires) and dust explosions. Products such as this should be considered for evaluation in Victoria.

Training for firefighting operations is done to National industry standards, apart from general site familiarisation when one site safety officer was asked if additional training was provided or nearby fire departments that were likely to respond to the site. If the national standards are met they are sufficient.

As is the case in regional Victoria, a number of the members of the volunteer Fire Departments located near the power industry in North Dakota, Wyoming and Montana are also mine and power industry employees; this also brought industry knowledge and skills.

Training, awareness and compliance

From discussions with fire service members from a number of fire departments, training and awareness may be on the or about the same level as here. However in industry it would appear that training and particularly awareness and compliance is much higher throughout industries and not just the coal industry with organisation like NIOSH, OSHA and CCOHS in Canada providing a comprehensive regulatory, education and compliance framework.

3. Health and air quality monitoring for large scale fires in coal facilities.

It was found that systems that have been put in place by CFA for health monitoring of crews working in or near the vicinity of coal fires for the effects of Carbon Monoxide (CO) were well ahead of any practices in place for that organisations and agencies as well as in the sites visited. Additionally the systems used for community health monitoring for short term exposure of CO ether met or exceeded those in place at the locations visited.

Atmospheric particulate matter – also known as particulate matter (PM) or particulates, these can be mixture of solid particles and liquid droplets.

As in most developed countries general monitoring is done continually. EPA Victoria monitors the air for two categories of particle size: $PM_{2.5}$ and PM_{10}. These particles are very small and are measured in micrometres (µm). In the case of the Hazelwood coal mine fire, site specific community monitoring was also done.

Outcomes –

Atmospheric Monitoring

In North Dakota the National Guard's 81st Civil Support Team (CST) has that capability to respond to a range of incidents to measure atmospheric particulate matter, this provide site specific air monitoring in the vicinity of an incident

where first responders are operating. This provides a capability that may be difficult for a environmental agency to be able to undertake. This sort of equipment can also provide atmospheric particulate matter monitoring for a range of fires and incidents other than just coal fires.

4. Best practices for the prevention, detection and suppression of potential fires in emerging "Clean Coal" technology facilities.

Basin Electric Power Cooperative, through its subsidiary, Dakota Gasification Company, owns and operates the Great Plains Synfuels Plant. The Synfuels Plant is the only commercial-scale coal gasification plant in the United States that manufactures natural gas. Apart from Synthetic Natural Gas, other products produced include the following categories and products:

Chemicals and Fuels

- Dephenolized Cresylic Acid
- Naphtha
- Phenol
- Tar Oil

Pipeline and Liquefied Gases

- Carbon Dioxide
- Krypton and Xenon Gases
- Liquid Nitrogen

Fertilizers

- Ammonium Sulfate (DakSul 45)
- Anhydrous Ammonia
- Urea

"Dakota Gasification Company's Great Plains Synfuels Plant is an international leader in technologies that capture, compress, and transport carbon dioxide (CO_2) emissions from a coal gasification process. The Synfuels Plant captures more CO_2 from coal conversion than any facility in the world, and is a participant in the world's largest carbon sequestration project. Dakota Gas sends CO_2 through a 205-mile pipeline to Saskatchewan, Canada, where oil companies

use it for enhanced oil recovery operations that result in permanent CO_2 geologic sequestration. The geologic sequestration of CO_2 in the oil reservoir is monitored by the International Energy Agency (IEA) Weyburn CO_2 Monitoring and Storage Project."

[https://www.dakotagas.com/About_Us/CO2_Capture_Storage/]

The work done at plants such as the Gasification Plant and adjoining power plant may provide an insight into the future use of lignite coal in Victoria, with "clean coal" power generation, coal gasification and CO_2 capture.

Outcomes –

Information is available on the Synfuels Plant's web site on general safety as well as emergency guides and brochure on living and working near SNG & CO_2 pipelines at: https://www.dakotagas.com/About_Us/pipelines/pipeline-safety/

I was able to review the company's safety programs that are in place and the emergency training that is also conducted with employees, local emergency responders and transportation employees. Extensive risk management and emergency planning is in place, not only for the plant but for people living and working near the plant, pipelines and transportation networks.

Engagement by the company as has been done with emergency services, transport industry, affected landowners and other stakeholders has been critical in achieving safety standards and response arrangements. This example may provide a suitable benchmark for a similar industry in Victoria.

Recommendations:

Water mist spray equipment

1. That further investigation and evaluation of this type of equipment is done, particularly in the applications of preventing fire spread, suppression and the reduction of airborne particulates.
2. Identify the limitation of the equipment in regards to:
   a. Air movement and evaporation of the fine water spray.
   b. Limitations with water supply filtration in a mine environment for this type of equipment.
   c. The effectiveness of Class A & B foam delivery
3. Identify the equipment typology in regards to:
   a. Optimum throw ranges for potential applications.
   b. Configuration for mounting the equipment for a range of fires and incidents.
   c. The most suitable drive method for the equipment (electric/diesel/hydraulic)
   d. Applications and operational use.
4. Consideration for the selection of equipment needs evaluate industry and purpose built equipment. For example: The benefits of industry equipment over some purpose built alternatives may include procurement and running costs. The availability of industry equipment already in service or available via industry hire companies.

PM 2.5 & PM 10 particulate monitoring

1. Investigate the use and application of hand held and desktop particulate air monitoring equipment and the benefits that it could provide in analysing atmospheres by CFA in conjunction with EPA in the close vicinity of incidents to provide information and advice on the risk of exposure to airborne particulates and the level of respiratory protection needed for responders and the community.
2. Ensure compatibility and interoperability with EPA Victoria and other state agencies with particulate air monitoring equipment if possible.
3. Review the equipment list provided by 81st CST and the performance and capabilities against equipment held by CFA to review what is currently available to CFA.

Breathing Apparatus Support Vehicle replacement options

1. Consider vehicle concepts could supplement vehicles that have a filling capability and may provide benefits in efficiency and effectiveness in operational use and in reduced procurement and operating cost as well as ease of use in operational and non-operational tasking.
2. Consideration should be given to the concept of a BA support vehicle with cylinder stowage only and without a cylinder filling capacity and/or additional operational capability.

Suppression of (lignite) coal dust and coal fires

1. Investigate the use of water additives for coal dust fires to improve effectiveness and reduce the risk of dust explosions.
2. Investigate alternative grouting and “capping” materials/methods and their application to improve effectiveness and efficiency.

About the Author

Senior Station Officer (SSO) Gavin Parker

I joined CFA as a volunteer member of at the age of 16 in 1976 and commenced a full time career with CFA in January 1995.

I have been working in the Latrobe Valley since 2000 and since that time have attended numerous fires and incidents in the power industry including several significant mine fires and currently working as a Senior Station Officer at the Traralgon Fire Station on D Platoon.

Apart from my normal duties I have had a long term interest in aircraft operations, thermal imaging and the coal industry.

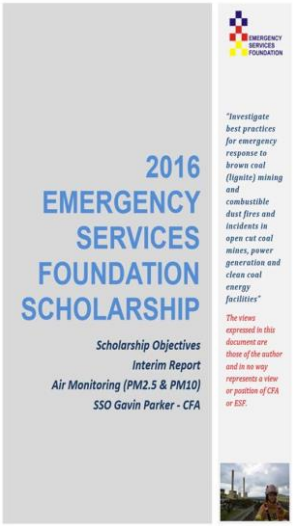
In 1999 was presented a “Prince of Wales Award” which enabled study in fire-fighting aircraft operations, thermal imaging cameras and vehicle mounted data terminals in California, Idaho, Washington State and Oregon in the United States during July to September 2000.

The Emergency Services Foundation Scholarship in 2016 provided an opportunity to gain new skills and knowledge in a range of fires and incidents within the coal fired power generation industry. It has enhanced the ability to safely and effectively deal with the response and management of these types of incidents as well as being able to develop a network of contacts that can continue to be called on and to pass on to others for projects that they are working on in that field. Another aspect of the study has also given experience of dealing with a range of government, industry and community interest groups and bodies, this has been another interesting aspect of the time spent seeing how these group interact and the work done behind the scenes.

Additional Documents

Several other documents have been produced or are being prepared by the author as a result of the study. These provide further detail for information or recommendations and are available on request. They include:

- Coal Fire Suppression Materials and Equipment - 2016 ESF report by Gavin Parker
- Air Monitoring - 2016 ESF report by Gavin Parker
- Colstrip United - 2016 ESF report by Gavin Parker
- Breathing Apparatus Vehicle Selection - 2016 ESF report by Gavin Parker
- Sims, a coal mining ghost town - 2016 ESF report by Gavin Parker
- Resources Boom and Fire Department Staffing - 2016 ESF report by Gavin Parker
- Preventing Combustible Dust Fires and Explosions - 2016 ESF report by Gavin Parker
- Water mist spray equipment for PM reduction in smoke/dust and use during fire suppression - 2016 ESF report by Gavin Parker



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All photos by author, unless otherwise stated.

Disclaimer: *The views and opinions presented in this document are those of the author and in no way represent those of the CFA or ESF. The information presented is believed to be correct at the time of publication and based on discussions and information presented and available during the study period.*

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