# Acid Mine Drainage Challenge: Design Brief

Water is the most important resource to sustain life. Communities have relied on their local sources of water since the beginning of time. When these sources become threatened, communities can lose their sense of identity in addition to losing their way of life. Water sources in the American Southwest—already an arid environment with limited rainfall—face additional challenges.

In New Mexico alone, there are 15,000 abandoned mines and only a small percent have been remediated. Water flowing through abandoned mines or tailings from mining can mix with sulfide minerals to produce acid mine drainage, polluting the already limited water in the Southwest.

In August of 2015, over 3 million gallons of acid mine water from the Gold King Mine in Colorado were accidentally released into the Animas river by the Environmental Protection Agency during routine remediation activities. This river feeds into the San Juan River Basin which is one of the sole sources of water for many rural communities and the Navajo Nation [1]. The response to the incident left many who call the watershed their home feeling neglected and distrustful [2]. The Navajo Nation claimed the EPA misled the community about the extent to which the mine water was toxic [2]. They also claimed that the EPA did not accurately assess the cleanup procedures and whether or not they were successful. According to a report by the US Department of the Interior, the Gold King Mine spill was caused in part because of a lack of understanding of the “engineering complexity” of abandoned mines [1]. They warn that if teams don’t include this expertise, we should expect more such disasters in the future.

As chemical engineers, you can help protect one of our most valuable resources: water. Your challenge is to design a comprehensive response plan, including community engagement strategies and choosing a treatment system that could filter water for an entire rural community in the event of pollution from abandoned mines. You will create a prototype and conduct a bench scale test.

# Student Learning Outcomes

Students will be able to:

# conduct literature research and cite using a numbered citation style

# identify needs of stakeholders

# analyze the feasibility, including estimating costs, of possible solutions

# plan a simple experimental design

# optimize a design based on financial, material, and space constraints

# propose and present a comprehensive response plan

# Project Constraints

You must choose a specific rural community in New Mexico that could be faced with water contaminated by acid mine drainage.

# Project Management

You will be required to work in groups, and will decide amongst yourselves who will perform each section of the challenge. You will research the Gold King Mine spill, abandoned mines, acid mine drainage, water filtration systems, and community engagement strategies. Keeping a courteous and respectful attitude with your collaborators and time management will be key in finishing within the time given.

|  |  |
| --- | --- |
| Job title | Job Description |
| Project Manager | Responsible for submitting team deliverables, keeping the team on track and within the budget. Everyone will pitch in with the design and aid in the brainstorming, but at some point, you will need to decide on an idea, and the project manager has final say. This reflects the real world, and sometimes ideas may be selected that are not your own. Compromise for affordable solutions! |
| Lead Research Scientist | Leads the team in conducting research. This person should organize documents and information gathered by the team and can assign specific research tasks to members of the team. This person should be organized and analytic. |
| Lead Data Analyst | This person should ensure data is properly collected during the experiment for later analysis. Responsible for understanding and reviewing the analysis of your design performance. Additionally responsible for the presentation of the data in an appropriate format. |
| Lead Requirements Engineer | Responsible for keeping stakeholder requirements and community needs in focus. This person should be able to consider the impact of the full scale design and consider different points of view, while also considering material constraints. |

# Some Useful References

The following are sample references that you may use to supplement your own research. They are cited using a numbered style, so use them as a reference when citing your own documents.

1. United States Bureau of Reclamation, *Technical Evaluation of the Gold King Mine Incident*, in *Reclamation: Managing water in the west*. 2015, U.S. Department of the Interior: Denver, CO.

2. Duara, N., *How the Gold King Mine continues to Affect Navajo Life*, in *Los Angeles Times*. 2015: Los Angeles.

# Project Deliverables

You will be expected to meet the following criteria to receive full credit for this challenge.

|  |  |
| --- | --- |
| **Deliverable (completed as a group)** | **Points** |
| Deliverable 1: Define the problem and plan a test of your prototype | 25 |
| Deliverable 2: Bench scale experiment | 25 |
| Deliverable 3: Identify community needs | 25 |
| Deliverable 4: Analysis, estimation, & recommendations | 25 |
| Deliverable 5: Final Presentation | 50 |
| Individually-completed self- and peer-evaluation | 10 |
| **TOTAL** | **160** |

Acid Mine Drainage Challenge

Deliverable 1: Define the problem and plan a test of your prototype

*completed as a team*

**Team Number:**

**Date:**

Task 1: Chose team roles and plan the responsibilities for each team member.

|  |  |
| --- | --- |
| **Team member name** | **Tasks** |
| **Project Manager:** |  |
| **Lead Research Scientist:** |  |
| **Lead Data Analyst:** |  |
| **Lead Requirements Engineer:** |  |

**Task 2. Gather information to define the problem**

As chemical engineers, you can help protect one of our most valuable resources: water. Your challenge is to design a comprehensive response plan, including community engagement strategies and choosing a treatment system that could filter water for an entire community in the event of pollution from abandoned mines.

Your task is to define the problem. This worksheet will guide you to do this by conducting research and considering the problem from different perspectives.

In order to understand the problem, you will need to do some research. You should investigate:

* the Gold King mine spill as a case study, including the response by the EPA and the reactions of the Navajo Nation **(at least 2 sources)**
* abandoned mines and acid water drainage **(at least 2 sources)**
* current treatment technologies **(at least 3 sources)**

## Source 1: Gold King Mine Spill

*Make sure you can describe how the spill occurred, how communities were affected, how the EPA responded, and how the affected communities responded.*

Citation (in CEP style):

Notes:

## Source 2: Gold King Mine Spill

*Make sure you can describe how the spill occurred, how communities were affected, how the EPA responded, and how the affected communities responded.*

Citation (in CEP style):

Notes:

## Source 3: Abandoned mines & acid mine drainage

*Make sure you can explain how common abandoned mines are in the Southwest, how they can pollute our water, and the chemicals typically found in acid mine drainage.*

Citation (in CEP style):

Notes:

## Source 4: Abandoned mines & acid mine drainage

*Make sure you can explain how common abandoned mines are in the Southwest, how they can pollute our water, and the chemicals typically found in acid mine drainage.*

Citation (in CEP style):

Notes:

## Source 5. Treatment system #1

Citation (in CEP style):

|  |  |
| --- | --- |
| Name / type of system |  |
| Approximate cost |  |
| Size of community it is scaled for |  |
| Describe how the treatment system functions. |  |
| What are some pros/benefits for this system? |  |
| What are some cons/problems for this system? |  |
| What kinds of contaminants can the system remove from water? |  |

## Source 6. Treatment system #2

Citation (in CEP style):

|  |  |
| --- | --- |
| Name / type of system |  |
| Approximate cost |  |
| Size of community it is scaled for |  |
| Describe how the treatment system functions. |  |
| What are some pros/benefits for this system? |  |
| What are some cons/problems for this system? |  |
| What kinds of contaminants can the system remove from water? |  |

## Source 7. Treatment system #3

Citation (in CEP style):

|  |  |
| --- | --- |
| Name / type of system |  |
| Approximate cost |  |
| Size of community it is scaled for |  |
| Describe how the treatment system functions. |  |
| What are some pros/benefits for this system? |  |
| What are some cons/problems for this system? |  |
| What kinds of contaminants can the system remove from water? |  |

Task 3. Design a bench scale prototype

Based in part on your research, you will design and test a prototype in the CBE lab. A complicated system such as that needed for a treatment system that could filter water for an entire community could take years and millions of dollars to design and build. For this reason, scale testing is done prior to final design decisions. The smallest scale test, bench testing, is done in a laboratory and often reduces the flow rates and volumes by multiple orders of magnitude. Pilot testing will occur based off those learnings and is often at the site of the final design at 25-50% of the final volume.

You will not have access to every possible solution or technology. Instead, we want you to design a bench scale model that can make use of materials that are relatively common.

You will receive a 50 mL reaction column that will hold your selected materials. The cost of each material is detailed in the table below. Your budget for the bench scale model is $5000. You do not have to spend it all, but you may not go over. Keep in mind when designing your column, you want to be able to make a conclusion at the end.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Material** | **Amount** | **Cost** | **Amount desired** | **Subtotal** |
| Limestone | 1 g | $250 |  |  |
| Activated Charcoal | 0.5 g | $2500 |  |  |
| CaCO3 Powder | 0.5 g | $1500 |  |  |
| Soda ash solution (pH 9) | 50 mL | $1000 |  |  |
| **Total** | | | |  |

Task 4. Plan a bench scale test of your prototype

You will conduct a bench scale test of your model in the Chemical Engineering Lab in Centennial Engineering room 1039. Your team will test how well your bench scale model neutralizes simulated acid mine drainage. After the lab you are responsible for analyzing the data, sharing your results with the class, and comparing the different data sets.

To prepare, consider what you know and what you need to know:

1. What do you think you need to measure to evaluate your bench scale model?

2. What is pH? How is it calculated? How can it be measured?

3. What is the target pH post-treatment for your design? What do you predict you will achieve?

|  |  |
| --- | --- |
| The following terms will be important in understanding the lab next week. What do you know about each, in relation to the problem of acid mine drainage? If you don’t know, you should look them up before the lab next week: | |
| Neutralization |  |
| Filtering |  |
| Scalability |  |

Acid Mine Drainage Challenge

Deliverable 2: Bench Scale Experiment

*completed as a team*

**Team Number:**

**Date:**

**Task 1: Plan the responsibilities for each team member.**

|  |  |
| --- | --- |
| **Team member name** | **Tasks** |
| **Project Manager:** |  |
| **Lead Research Scientist:** |  |
| **Lead Data Analyst:** |  |
| **Lead Requirements Engineer:** |  |

Note: *You will complete some sections of this during the lab on paper, but still must submit this information electronically. Please transfer your handwritten information to this sheet.*

Task 1: Experimental set-up

**Material List**

|  |  |  |
| --- | --- | --- |
| Material *(cost per unit)* | Amount (as measured, if used) | Total Cost (if used) |
| Limestone  *($250/1 g)* |  |  |
| Activated Charcoal  *($2500 /0.5 g)* |  |  |
| CaCO3 Powder  *($1500/0.5 g)* |  |  |
| Soda ash solution (pH 9)  *($1000/50 mL)* |  |  |

**Diagram**

*Diagram your design, labeling the materials. Describe how you assembled it. It may be helpful to take a photo.*

Task 2. Experimental Data

Record your data in the table below.

|  |  |  |
| --- | --- | --- |
|  | **pH of acid mine drainage** | **Time elapsed** |
| Initial |  |  |
| After 50mL treated |  |  |
| After 100mL treated |  |  |
| After 150mL treated |  |  |
| After 200mL treated |  |  |
| After 250mL treated\* |  |  |
| After 300mL treated\* |  |  |
| After 350mL treated\* |  |  |
| After 400mL treated\* |  |  |
| After 450mL treated\* |  |  |
| Final |  |  |

\*Only use if design included soda ash solution

Task 3. Record your data in the whole-class repository.

You will work with data from other teams in Deliverable 4. You must submit your data in the following form: <https://forms.gle/jnSvZ7FCYJ5P1Lqq7>

Task 4: Analysis & Conclusions

Create a scatterplot of your data. Your axes must be labeled with time (in seconds) and pH.

What was the rate of throughput (mL/min) for your design?

How much acid was neutralized by your design (mols)?

What in your design accounted for this pH change?

Task 5: Scaling and Redesigning

What would you change to make your design scalable?

|  |  |
| --- | --- |
| If you needed to treat a larger volume of acid? |  |
| If the acid pH was lower? |  |
| If the water needed to be treated at a faster rate? |  |

Assuming you could run a second experiment, including materials not available today, what would you test?

**Acid Mine Drainage Challenge**

**Deliverable 3: Identify community needs**

*Completed as a team*

Team Number:

Date:

**Task 1: Plan the responsibilities for each team member.**

|  |  |
| --- | --- |
| Team member name | Tasks |
| Project Manager: |  |
| Environmental Engineer(s): |  |
| Community coordinator: |  |
| Water systems Engineer(s): |  |

**Task 2: Designing for social systems: Community engagement strategies**

Technical designs often fail when we forget to consider the human element. The community members may be reluctant to accept outside advice. They may hold values and beliefs that have been threatened or marginalized. They may not be convinced that your water filtration system is needed. They might not trust government or industry representatives. Your complete design should include strategies for working with the community.

Search for information on strategies for working with communities. You can choose to focus on rural or Indigenous communities. If you focus on the latter, consider the sovereignty of such communities.

|  |
| --- |
| Strategy 1: |
| Citation (in CEP style): |
| Notes: |

|  |
| --- |
| Strategy 2: |
| Citation (in CEP style): |
| Notes: |

**Task 3. Multiple points of view**

**Community.** Choose a specific rural New Mexico community that could be impacted by acid mine drainage. What are important things to know about this community, such as population, location, cultures, important history? Include citations, but also include your own first hand experiences if you have a team member from the community.

Designers use **empathy** to meet needs. This means they consider problems from points of view held by different stakeholders. Below, discuss and write your ideas for each point of view, considering the specific community you selected.

|  |  |
| --- | --- |
| Community member. Imagine you live in a community whose water was unsafe due to acid mine drainage. Describe how you would feel and what you would need. |  |
| Farmer. Imagine you are the owner of a farm and the water for your livestock appears unsafe due to acid mine drainage. Describe how you would feel and what you would need. |  |
| Government employee. Imagine you work for the state government and it is your job to help in the cleanup efforts. Describe how you would feel and what you would need. |  |

Are any of these stakeholders likely to benefit more than others from your design or have greater need for it? Will they be able to afford it and access it? If not, what are some ways you can make it more affordable or accessible to those who need it most?

Based on these points of view, what are the most important needs?

**Task 4. Optimal solution**

Engineers look for optimal designs that meet needs in a balanced way while considering all requirements and constrains. For instance, a system that can filter everything out perfectly and is scaled to a small community, but that is prohibitively expensive is not an optimal solution. Based on your research, your bench scale experiment, and the specific community you chose, make a recommendation of a treatment system.

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Deliverable 4: Analysis, Estimation, & Recommendations

*Completed as a team*

**Team Number:**

**Date:**

**Task 1: Chose team roles and plan the responsibilities for each team member.**

|  |  |
| --- | --- |
| Team member name | Tasks |
| Project Manager: |  |
| Environmental Engineer(s): |  |
| Community coordinator: |  |
| Water systems Engineer(s): |  |

**Task 2. Analysis of multiple bench tests**

As an engineer, you will often collaborate with other engineers and researchers to solve the same problem. These partners may be at the same institution or located throughout the world. In order to effectively work together, you must use clear documentation and learn how to analyze multiple sets of data. After the bench scale model experiment, all groups uploaded their results to a common google spreadsheet. You will use the data from other teams to find trends, identify outliers, and plan a potential future experiment.

You’ll find the spreadsheet here: <https://docs.google.com/spreadsheets/d/129V1UfGLOWr833EOn6BYnwo_jxDmFk-CRZ8mhp2BA68/edit?usp=sharing>

Note that you should make a copy of this. You do not have permission to edit it directly.

Compare and contrast your results to those of other teams. Include a figure and write 4-5 sentences that convey the important information from this analysis. Trends related to material usage or flow rate would be a good place to start. Justify your choices, such as using only some of the data or using all of the data.

**Task 3. Estimation**

Make an estimation about the amount of time needed to treat the water for the specific community you selected. Choose a flow rate from the class data set or use an average of different sets. Explain which flow rate you are using and why. State how much water you are treating for the specific community and why you’ve chosen that amount. Show the calculation and explain your assumptions in 4-5 sentences.

**Task 4. Recommendations**

Following promising bench scale testing, engineers move into the pilot testing stage. Given the results from your own bench testing, the results about from the class, the research you conducted, and the particular community you selected, what process or materials would you want to pilot test? How would you make this test a more accurate or informative study?

Acid Mine Drainage Challenge

# Deliverable 5: Final Presentation Guidelines

As chemical engineers, you can help protect one of our most valuable resources: water. Your challenge is to design a comprehensive response plan, including community engagement strategies and choosing a treatment system that could filter water for an entire community in the event of pollution from abandoned mines.

All engineers and scientists must learn to convey findings from their research in a technical, but approachable manner. For this presentation, you will give a **short** technical talk that conveys your comprehensive plan and how it has been shaped from your bench scale test.

*Your presentation should meet the following elements*

**Time:** Your presentation can be no longer than 2.5 minutes. To ensure everyone can present, there will not be time for questions, though panelists and audience members will write questions down for you to answer by the end of class.

**Dress:** Dress professionally.

**The Problem:** Concisely explain the problem. Include a few details about the community you selected. Include a brief story that helps the audience understand the perspective of a community member affected by contaminated water.

**Solution feasibility and findings:** Concisely explain your proposed solution. Make the case that your proposed system can meets the needs you identified in terms of (1) filtering or removing the contaminants and (2) being accepted by the community. This should be supported by findings and figure(s) from either your bench scale experiment or your analysis of data from the whole class repository.

**Next steps:** Your presentation should propose what should be done to test or demonstrate your system.

**Slides:** Your PowerPoint or Prezi slides should include the following:

* Use a sans serif, easy-to-read professional font
* Do not use font size smaller that 20pts
* Use color and images professionally
* Include citations as appropriate (these may be a smaller font at the bottom of the slide or as a final slide)

If you choose to do a Prezi, you may want to look at examples in their gallery: https://prezi.com/gallery/ or search for Prezi pitch templates.

**Cost of Materials**

|  |  |  |
| --- | --- | --- |
| Material | Amount | Cost |
| Limestone | 1 g | $250 |
| Activated Charcoal | 0.5 g | $2500 |
| CaCO3 Powder | 0.5 g | $1500 |
| Soda ash solution (pH 9) | 50 mL | $1000 |

Budget for project - $5000

You do not have to spend it all, but you may not go over.

Keep in mind when designing your column, you want to be able to make a conclusion at the end.

**Questions you have for teams during their presentation**

Your name: Your team:

**Questions for:**

Team 1A

Team 1B

Team 2A

Team 2B

Team 3A

Team 3B

Team 4A

Team 4B

Team 5A

Team 5B

Team 6A

Team 6B

Team 7A

Team 7B

Judge Name: Expertise/Field:

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| *TEAM 1A Please evaluate the students on the following:* | *Strongly agree* | *Agree* | *Neutral* | *Disagree* | *Strongly disagree* |
| 1. The students presented confidently or worked to overcome any nervousness |  |  |  |  |  |
| 2. The students concisely explained the problem and needs addressed by their design. |  |  |  |  |  |
| 3. The pitch helps understand the need and how your system will change customers’ lives for the better. |  |  |  |  |  |
| 4. The idea presented is feasible |  |  |  |  |  |
| Please provide any comments here: |  |  |  |  |  |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| *TEAM 1B Please evaluate the students on the following:* | *Strongly agree* | *Agree* | *Neutral* | *Disagree* | *Strongly disagree* |
| 1. The students presented confidently or worked to overcome any nervousness |  |  |  |  |  |
| 2. The students concisely explained the problem and needs addressed by their design. |  |  |  |  |  |
| 3. The pitch helps understand the need and how your system will change customers’ lives for the better. |  |  |  |  |  |
| 4. The idea presented is feasible |  |  |  |  |  |
| Please provide any comments here: |  |  |  |  |  |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| *TEAM 2A Please evaluate the students on the following:* | *Strongly agree* | *Agree* | *Neutral* | *Disagree* | *Strongly disagree* |
| 1. The students presented confidently or worked to overcome any nervousness |  |  |  |  |  |
| 2. The students concisely explained the problem and needs addressed by their design. |  |  |  |  |  |
| 3. The pitch helps understand the need and how your system will change customers’ lives for the better. |  |  |  |  |  |
| 4. The idea presented is feasible |  |  |  |  |  |
| Please provide any comments here: |  |  |  |  |  |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| *TEAM 2B Please evaluate the students on the following:* | *Strongly agree* | *Agree* | *Neutral* | *Disagree* | *Strongly disagree* |
| 1. The students presented confidently or worked to overcome any nervousness |  |  |  |  |  |
| 2. The students concisely explained the problem and needs addressed by their design. |  |  |  |  |  |
| 3. The pitch helps understand the need and how your system will change customers’ lives for the better. |  |  |  |  |  |
| 4. The idea presented is feasible |  |  |  |  |  |
| Please provide any comments here: |  |  |  |  |  |

Judge Name: Expertise/Field:

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| *TEAM 3A Please evaluate the students on the following:* | *Strongly agree* | *Agree* | *Neutral* | *Disagree* | *Strongly disagree* |
| 1. The students presented confidently or worked to overcome any nervousness |  |  |  |  |  |
| 2. The students concisely explained the problem and needs addressed by their design. |  |  |  |  |  |
| 3. The pitch helps understand the need and how your system will change customers’ lives for the better. |  |  |  |  |  |
| 4. The idea presented is feasible |  |  |  |  |  |
| Please provide any comments here: |  |  |  |  |  |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| *TEAM 3B Please evaluate the students on the following:* | *Strongly agree* | *Agree* | *Neutral* | *Disagree* | *Strongly disagree* |
| 1. The students presented confidently or worked to overcome any nervousness |  |  |  |  |  |
| 2. The students concisely explained the problem and needs addressed by their design. |  |  |  |  |  |
| 3. The pitch helps understand the need and how your system will change customers’ lives for the better. |  |  |  |  |  |
| 4. The idea presented is feasible |  |  |  |  |  |
| Please provide any comments h |  |  |  |  |  |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| *TEAM 4A Please evaluate the students on the following:* | *Strongly agree* | *Agree* | *Neutral* | *Disagree* | *Strongly disagree* |
| 1. The students presented confidently or worked to overcome any nervousness |  |  |  |  |  |
| 2. The students concisely explained the problem and needs addressed by their design. |  |  |  |  |  |
| 3. The pitch helps understand the need and how your system will change customers’ lives for the better. |  |  |  |  |  |
| 4. The idea presented is feasible |  |  |  |  |  |
| Please provide any comments h |  |  |  |  |  |