TECHNICAL NOTE

Repairing the Damage:
Cleaning up the land, water, and air damaged by the coal industry pre-'77

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Summary

Abandoned mine land (AML) reclamation consists of design, construction, and administration costs. Cost estimates in the official AML inventory, eAMLIS, only reflect construction costs—and many construction cost estimates are old and not updated for inflation or new reclamation techniques.

In order to develop more reasonable construction cost estimates, I use recent cost per unit estimates for each problem type developed by IMCC/NAAMLP and multiply them by the number of unreclaimed units (miles, feet, acres) found in eAMLIS. But, given the current data we have from eAMLIS and the professional opinion of the AML program managers, this approach for calculating construction cost estimates is only applicable for about half of AML problem types (Group A; or, "Priority 1 and 2" AMLs).

For the other problem types (Group B; or, "Priority 3" AMLs), I rely on construction cost estimates in eAMLIS and update them for inflation. We can't be certain when precisely a cost estimate in eAMLIS was last updated, so I use the oldest and newest possible dates for each AML feature to establish high and low scenarios and then average them to estimate a medium scenario.

I then add design costs and administration costs to these updated construction costs. Based on official data from OSMRE, over the history of the AML program, for every dollar spent on construction, an additional $0.24 was spent on design costs and $0.10 was spent on administration costs. After using these historic percentages as a basis to estimate design and administration costs, I estimate total reclamation costs by summing the design, construction, and administration costs. I estimate that $7.9 billion (2020$) AMLs have been reclaimed and that it will cost $18.3 to $24.4 billion (2020$) to address the remaining unreclaimed AMLs in eAMLIS as of 2020 (see table 1).

As we look ahead to the next 30 years of the AML program, I estimate that between $2.7 and $9.2 billion (2020$) of AMLs will be "discovered" (added to eAMLIS) between now and 2050. These estimates are rooted in the rate AMLs were discovered over the past decade, and low-high scenarios represent various assumptions about the rate of decline of that historic rate of AML discovery. Those—and all—of my assumptions are summarized in table 3.

I estimate AML fee collections through 2050 using three different AML fee levels (no AML fees, current fee levels, and double current levels) and two different coal production projections (EIA AEO2020 baseline case, and EIA AEO2020 $35 CO2 fee case). In the medium scenario, I assume all coal production ends in 2035, except for metallurgical coal production. Based on the assumptions in table 3, I estimate that between $0 and $6.0 billion in AML fees will be collected between 2021

and 2050 – though the high scenario assumes coal production will continue at EIA's reference case through 2050, which I think is highly unlikely. If current AML fees continue to be collected through 2035 (and on met coal through 2050), then an estimated $0.7 billion in fees will be collected (medium scenario).

Table 1. AML cost and revenue summary, low, medium, and high scenarios (billions, 2020$)

				LOW	MEDIUM	HIGH
COSTS	Reclaimed	As of 2020	Construction Costs	$5,877,172,940	$5,877,172,940	$5,877,172,940
			Design Costs	$1,410,521,506	$1,410,521,506	$1,410,521,506
			Administration Costs	$587,717,294	$587,717,294	$587,717,294
			2020 Reclaimed SUBTOTAL	$7,875,411,740	$7,875,411,740	$7,875,411,740
	Unreclaimed	As of 2020	Construction Costs	$13,632,289,445	$15,595,044,351	$18,435,689,220
			Design Costs	$3,271,749,467	$3,742,810,644	$4,213,871,822
			Administration Costs	$1,363,228,944	$1,559,504,435	$1,755,779,926
			2020 Unreclaimed SUBTOTAL	$18,267,267,856	$20,897,359,430	$24,405,340,967
		2021-2050	Construction Costs	$2,012,299,861	$4,024,599,722	$6,975,972,852
			Design Costs	$482,951,967	$965,903,933	$1,594,508,080
			Administration Costs	$201,229,986	$402,459,972	$664,378,367
			2021-2050 Unreclaimed SUBTOTAL	$2,696,481,814	$5,392,963,628	$9,234,859,299
			UNRECLAIMED COST THRU 2050 TOTAL	$20,963,749,670	$26,290,323,058	$33,640,200,266
	Total AMLs Discovered (reclaimed & unreclaimed), as of 2050			$28,839,161,410	$34,165,734,798	$41,515,612,006
REVENUE		2021-2050	AML Fee Collections	$0	$660,665,883	$5,988,310,919
		As of 2020	AML Fund Balance	$2,228,778,930	$2,228,778,930	$2,228,778,930
		REVENUE GAP (without AML Fund)		$14,975,438,751	$25,629,657,175	$33,640,200,266
		REVENUE GAP (with AML Fund)		$12,746,659,821	$23,400,878,245	$31,411,421,336

Based on these estimates, by 2050 there will be between $21.0 and $33.6 billion (2020$) in unreclaimed AMLs. This represents an estimated $25.6 billion revenue gap for the AML program (medium scenario) by 2050. It is slightly lower if OSMRE were to spend down the $2.23 AML fund to close the revenue gap, but even then it is not unreasonable to expect a revenue shortfall of upwards of $20 billion (2020$). Most critical is what this shortfall represents: thousands of AML features left unreclaimed to threaten human safety, ecological health, and economic prosperity in impacted areas.

If we were to reclaim half of all unreclaimed costs (medium scenario, as of 2050) between now and 2050, then I estimate that AML reclamation would create/support 6,909 direct jobs annually for the next decade: 3,144 construction jobs with assumed average hourly gross pay of $30.00, 3,286 jobs at state/tribal agencies, and 478 jobs at OSMRE. See table 2 for these estimates, which also provides direct jobs estimates for 2031-2040 and 2041-2050 assuming that 33% and 17% of unreclaimed costs (medium scenario, as of 2050) are reclaimed in those two decades, respectively.

Table 1 is a summary of AML costs, revenue, and projected revenue gap. Table 2 is summary of jobs supported/created by reclamation under two different reclamation timelines. Table 3 is a summary of the assumptions upon which these estimates in tables 1 and 2 rely.

Table 2. Direct jobs estimates, 2021-2050, under low, medium, and high scenarios

Assumes 50% of unreclaimed costs (as of 2050) are reclaimed in 2021-30, 33% in 2031-2040, and 17% in 2041-2050

				LOW	MEDIUM	HIGH
JOBS	Construction	Unreclaimed *Construction* Costs, as of 2050		$15,644,589,306	$19,619,644,073	$25,411,662,071
		Payroll as % of Construction Cost		15%	20%	30%
		Assumed wage-push construction cost increase		-	-	5%
		Average Gross Pay per hour		$25	$30	$50
		Annual labor hours per worker		2080	2080	2080
		Total years		50% of costs in first 10 years, 33% in next 10 years, 17% in final 10 years		
		Labor Hours		93,867,536	130,797,627	152,469,972
		Job Years		45,129	62,883	73,303
		Jobs per year	2021-2030	2,256	3,144	3,665
			2031-2040	1,504	2,096	2,443
			2041-2050	752	1,048	1,222
	Design & Admin (state/tribal agencies)	Unreclaimed Total Costs	2021-2030	10,481,874,835	13,145,161,529	16,820,100,133
		Unreclaimed Annual Costs	2021-2030	1,048,187,483	1,314,516,153	1,682,010,013
			2031-2040	698,791,656	876,344,102	1,121,340,009
			2041-2050	349,395,828	438,172,051	560,670,004
		Jobs per year	2021-2030	2,620	3,286	4,205
			2031-2040	1,747	2,191	2,803
			2041-2050	873	1,095	1,402
	Admin, Research, & Inspection (OSMRE)	Annual AML Discretionary Funding	2021-2030	75,000,000	112,500,000	150,000,000
			2031-2040	50,000,000	75,000,000	100,000,000
			2041-2050	25,000,000	37,500,000	50,000,000
		Jobs per year	2021-2030	319	478	638
			2031-2040	212	319	425
			2041-2050	106	159	212
	Total	Construction jobs as % of total jobs		43%	46%	43%
		State/tribal jobs as % of total jobs		50%	48%	49%
		OSMRE jobs as % of total jobs		6%	7%	7%
		Jobs per year	2021-2030	5,196	6,909	8,508
			2031-2040	3,464	4,606	5,672
			2041-2050	1,732	2,303	2,836

Table 3. Summary of Assumptions

ASSUMPTIONS	LOW Scenario	MEDIUM Scenario	HIGH Scenario
I. COST PER UNIT How much does it cost per unit (acre, mile, feet) to reclaim an AML feature?	Cost per unit estimates are only appropriate (given current eAMLIS data) for some problem types (Group A). I use median cost per unit values estimated by IMCC/NAAMLP (2019), which are based on eAMLIS completed cost and completed unit (2014-2018) data and the professional expertise of the AML program managers.		
II. AGE OF COST ESTIMATES We cannot be certain when a cost estimate for a given AML feature was made. For the purpose of inflation adjustments, on what date should we assume a cost estimate was made?	The most recent date associated with the AML feature: the *Date Revised* in eAMLIS.	The average of the oldest and newest dates associated with the AML feature.	The oldest date associated with the AML feature: the *Date Prepared* in eAMLIS.
III. FUTURE AMLs DISCOVERED How much new AML costs will be discovered (added to eAMLIS) between now and 2050?	During the 2020s, AMLs will be discovered annually at *half* the average rate of the 2010s, then in the 2030s the rate will fall to *half* the previous decade, then in the 2040s the rate will again fall to *half* the previous decade.	During the 2020s, AMLs will be discovered annually at the *same average rate* as the 2010s, then in the 2030s the rate will fall to *half* the previous decade, then in the 2040s the rate will again fall to *half* the previous decade.	During the 2020s, AMLs will be discovered annually at *twice the average rate* as the 2010s, then in the 2030s the rate will fall to *one-third* the previous decade, then in the 2040s the rate will again fall to *one-third* the previous decade.
IV. ADMIN/DESIGN COSTS How much does AML design and administration cost?	Based on official FBMS data from OSMRE, I assume that for every dollar of AML construction there is $0.24 in design costs and $0.10 in administration costs. [1]		
V. AML FEE COLLECTIONS How much AML fees will be collected between now and 2050?	AML fee levels will not be reauthorized and thus will be reduced to zero in 2021.	Current AML fee levels will be assessed through 2050, and coal production will equal the projection in the EIA2020 $35 CO2 fee scenario (the 2020 EIA projection with the lowest coal production). All coal production -- except for metallurgical coal production -- will end in 2035.	AML fee levels will be *doubled* and assessed through 2050, and coal production will equal the projection in the *EIA2020 Reference Case*.
VI. PAYROLLS COSTS What share of AML construction is spent on payroll?	15% of AML construction costs are spent on payroll. This is slightly higher than the lowest value in a sample of 12 recent PA AML projects.	20% of AML construction costs are spent on payroll. This is similar to the mean (22%) and median (18%) from a sample of 12 recent PA AML projects.	30% of AML construction costs are spent on payroll. This is grounded in payroll cost data from a sample of 12 recent PA AML projects, and assumes a scenario in which AML pay rises considerable relative to present rates (more below).
VII. WAGE-PUSH COST INCREASE Will wage increases impact reclamation construction costs?	No assumed change in prices due to wage increases.	No assumed change in prices due to wage increases.	Due to higher assumed wages (see below) and a 10% increase in payroll costs, all construction costs in high scenario are increased by 5% to approximate wage-push price increases.
VIII. HOURLY WAGES What is the average hourly wage of construction workers who do AML construction work?	Hourly gross pay is $25: $20 wage + $5 fringes. This estimate assumes a wage that is slightly lower and fringes that are considerably lower than the medium scenario. This scenario	Hourly gross pay is $30: $20.24 wage + $9.76 fringes. AML wage data is not available. This estimate is based on the weighted average of the mean wages of Laborers & Operators	Hourly gross pay is $50: $30 wage + $20 fringes. This scenario assumes that prevailing wage laws are strengthened significantly and

[1] Abandoned Mine Land (AML) Program landing page of the OSMRE website, accessed December 2020. "OSMRE's DOI Financial Business Management System (FBMS) is the system of record for the AML Program that contains comprehensive information on AML grant allocations and expenditures." < https://www.osmre.gov/programs/aml.shtm>.

	assumes one or all of the following: AML wages/fringes are considerably lower than that of Laborers and Operators in general; the number of AML workers is greater in states with below-median wages; prevailing wage laws are weakened or unionization declines in states with relatively high AML wages. A job-year is 2080 hours of pay.	in each of 25 states with AML (BLS data). The median wage for Laborers ($17.60) and Operators ($22.87) is weighted by each state/tribe's unreclaimed costs as of 2020 (medium scenario)—a rough proxy for how much AML work will be done in each state/tribe. I assume that half of payroll costs are spent on Laborers and half on Operators, which yields a $20.24 hourly wage (the mid point between the avgs. for Laborers and Operators). The medium scenario represents the author's best estimate of AML wages under current market conditions, wage laws, and unionization rates. Level of fringes (32.5%) is comparable with national average for the construction industry, 30.9% (BLS). Based on AML wage range data from 2 states, there is not strong evidence that AML workers make more/less on average than Laborers & Operators in general in a given state. I assume a job-year is 2080 hours of pay.	that unionization rates rise among Laborers and Operators in the heavy civil engineering industry across many AML states. A job-year is 2080 hours of pay.
IX. AML JOBS AT STATE/TRIBAL AGENCIES How many AML jobs at state and tribal agencies are created/supported by AML reclamation?	State/tribal AML staff positions are funded through federal AML grants to states and tribes. Every $1 million in AML grants (AKA every dollar of total reclamation costs) supports 2.5 state/tribal AML jobs. According to official "Annual State Evaluation Reports" that state/tribal AML programs deliver to OSMRE, there were an average of 2.54 FTEs supported by every $1 million in AML grants to states/tribes, across all 28 AML programs in 2019.		
X. AML JOBS AT OSMRE How many AML jobs at OSMRE are created/supported by AML reclamation?	For Case A (reclamation occurs equally over 30 years), this scenario assumes $50 million in annual OSMRE funding, which is a 100% increase from 2019-20 levels ($25M) and 13.5% increase from 2009-10 levels ($44M). To compare OSMRE funding with the level of annual AML work: assuming all unreclaimed AML (low scenario costs) is reclaimed equally over 30 years, then annual reclamation work ($699M) will be 110% more than in 2009-10 ($334M) and 200% more reclamation work than in 2019-20 ($231M). For Case B (under which half of reclamation occurs in the next decade), the $75M in annual OSMRE funding is adjusted accordingly (for Case B, $75 M per year 2021-2030, $50M per year 2031-2040, $25M per year 2041-2050. Federal AML staff at OSMRE are funded through discretionary funding from the US Treasury. I assume that every $1 million in AML discretionary funding supports 4.25 federal jobs at OSMRE.	For Case A (reclamation occurs equally over 30 years), this scenario assumes $75 million in annual OSMRE funding, which is a 200% increase from 2019-20 levels ($25M) and 75% increase from 2009-10 levels ($44M). To compare OSMRE funding with the level of annual AML work: assuming all unreclaimed AML (medium scenario costs) is reclaimed equally over 30 years, then annual reclamation work ($876M) will be 160% more than in 2009-10 ($334M) and 280% more reclamation work than in 2019-20 ($231M). For Case B (under which half of reclamation occurs in the next decade), the $75M in annual OSMRE funding is adjusted accordingly (for Case B, $112.5 M per year 2021-2030, $75M per year 2031-2040, $37.5M per year 2041-2050. Federal AML staff at OSMRE are funded through discretionary funding from the US Treasury. I assume that every $1 million in AML discretionary funding supports 4.25 federal jobs at OSMRE. According to official	This scenario assumes $100 million in annual OSMRE funding, which is a 300% increase from 2019-20 levels ($25M) and 125% increase from 2009-10 levels ($44M). To compare OSMRE funding with the level of annual AML work: assuming all unreclaimed AML (high scenario costs) is reclaimed equally over 30 years, then annual reclamation work ($1,081M) will be 224% more than in 2009-10 ($334M) and 368% more reclamation work than in 2019-20 ($231M). For Case B (under which half of reclamation occurs in the next decade), the $75M in annual OSMRE funding is adjusted accordingly (for Case B, $150 M per year 2021-2030, $100M per year 2031-2040, $50M per year 2041-2050. Federal AML staff at OSMRE are funded through discretionary funding from the US Treasury. I assume that every $1 million in AML discretionary funding supports 4.25 federal jobs at OSMRE. According to official OSMRE budget reports, there were an average of 4.24 FTEs per

	According to official OSMRE budget reports, there were an average of 4.24 FTEs per $1 million in discretionary AML funding across 2009, 2010, 2019, and 2020.	OSMRE budget reports, there were an average of 4.24 FTEs per $1 million in discretionary AML funding across 2009, 2010, 2019, and 2020.	$1 million in discretionary AML funding across 2009, 2010, 2019, and 2020.
XI. CLEANUP SCHEDULE Over what time horizon will AML cleanup happen, and will it be distributed equally across all years?	I calculate low, medium, and high scenario estimates for three different cases: Case A) all unreclaimed costs are reclaimed by 2050, and reclamation is distributed equally across 30 years, Case B) AML reclamation is front-loaded in the first decade, such that 50% of unreclaimed AML is reclaimed in the first 10 years, 33% is reclaimed in the next 10 years, and 17% is reclaimed in the final 10 years, and		

1. How much will it cost to reclaim all AMLs, as of 2020?

The cost of reclaiming an AML feature consists of 1) design costs, 2) construction costs, and 3) administration costs (which includes inspection/monitoring, permitting, planning, managing).

The first step is to establish construction costs, which serve as a base for estimating the other costs. The federal eAMLIS inventory contains construction cost estimates for each AML feature in the federal inventory. State/federal AML officials across the country add AML features – using established procedures –to a common eAMLIS inventory. This is done on a rolling basis, and AML features are updated with new information as they are reclaimed. Some cost estimates in eAMLIS can be as old as 1981, some as new as 2020. Cost estimates in eAMLIS represent the official's best estimate for how much construction will cost to reclaim the site under current AML law (according to the cost estimation procedures in AML-1). Cost estimates in eAMLIS have not been updated for inflation, and mine reclamation techniques have changed over time, which could also affect the actual cost of reclamation. The sum of all unreclaimed construction costs in eAMLIS is $11.0 billion (as of eAMLIS 10.19.20). Yet, there is reason to believe these cost estimates are serious under-estimates: prices have increased (inflation) and older cost estimates represent outdated reclamation techniques.

A second method of estimating reclamation costs is to multiply the extent of unreclaimed AMLs by the average cost of reclamation. The IMCC/NAAMLP (2019) established estimates for average reclamation cost per unit for each of Problem Type.[2] An AML feature can be one of thirty different Problem Types: these range from Dangerous Highwalls to Vertical Openings to Underground Mine Fires. Each Problem Type has a specific standardized unit that AML officials use to measure the extent of the AML. For example, the standardized unit is feet for Dangerous Highwalls, miles for Clogged, acres for Underground Mine Fires, and so on. When officials add AML features to

[2] "Projecting Costs for Future AML Reclamation." Interstate Mining Compact Commission (IMCC). National Association of Abandoned Mine Land Programs (NAAMLP)., September 2019.

eAMLIS, they include standardized unit data – which represents their best estimate of the size/extent of an unreclaimed AML feature.

This is useful because reclamation needs and techniques – and thus costs – vary widely by Problem Type. For each AML feature in eAMLIS that was reclaimed between October 1, 2013 and September 30, 2018, IMCC/NAAMLP divided the construction cost by the units reclaimed. They then took the median of these values for each Problem Type. After reviewing the estimates and based on their professional experience, AML officials from multiple states/tribes determined that the median values for sixteen of the Problem Types were indeed representative of average reclamation costs –but that the median values for fourteen other Problem Types were not representative of their current cost of reclamation. Let's call Group A the Problem Types whose median values are reasonably representative, and Group B the Problem Types whose median values are not. [For those familiar with the AML program, Group A is all Priority 1 and 2 PTs, and Group B is all Priority 3 PTs except for one PT, "Polluted Water: Human Consumption," which is a Priority 1 or 2 PT).

The next step was to sum all of the unfunded standardized units to establish the amount of unreclaimed AML for each problem type, as of 2020. For Group A, I then multiplied the median cost per unit values by the unreclaimed units for each Problem Type. Without reliable average cost per unit values, I was forced to use eAMLIS cost estimates for Group B. First, I used the non-inflation adjusted eAMLIS cost estimates for Group B. Summing the new estimates for Group A PTs and the non-inflation adjusted eAMLIS cost estimates for Group B PTs shows a total unreclaimed construction cost of $12.7 billion. Yet, the cost estimates for the Problem Types in Group B are underestimates because of inflation.

So I then updated the Group B estimates for inflation, using two different approaches. Each AML feature in eAMLIS has two dates attached to it: 1) a Date Prepared, which is auto-created by eAMLIS and never changes, and 2) a Date Revised, which is updated whenever any field in the input for an AML feature is changed. First, I updated the unreclaimed cost estimates for inflation (GDP Deflator, 2020 H1=100) using the Date Revised. We can't be certain when a given cost estimate was created because the Date Revised for an AML feature is updated even if it is not the cost estimate that has been changed (there are 40 different fields for each AML feature in eAMLIS). For example, changes to an AML feature's geographic data (required for some projects due to recent eAMLIS system changes), unit data, or problem type data would all result in a newer Date Revised—each without the cost estimate being updated at this newer date. Thus inflation-adjustment using Date Revised is a conservative estimate for how old the cost estimate: it assumes that the cost estimate was updated at the most recent date associated with the AML feature. This shows a total unreclaimed construction cost of $13.6 billion (low scenario).

Second, I updated the unreclaimed cost estimates for inflation using the Date Prepared. Inflation-adjustment using Date Prepared is a more liberal estimate for how old the cost estimate: it assumes that the cost estimate was updated at the oldest date associated with the AML feature (when it was originally put in the digital eAMLIS system). This shows a total unreclaimed construction cost of $17.6 billion (high scenario).

We know the cost estimates for Group B in eAMLIS are not updated for inflation and can thus reasonably conclude that the total unreclaimed construction cost is higher than $12.7 billion, and that it likely lies somewhere in the range of 13.6 to 17.6 billion (2020$). If you take the simple

average of these two figures, you arrive at $15.6 billion (medium scenario). In terms of a single cost estimate that captures the construction cost of unreclaimed AMLs with the data we currently have available to us, I argue that this is as good a candidate as any.

2. How much AML reclamation has been completed (costs), as of 2020?

When state/tribal AML programs complete an AML reclamation project, they update eAMLIS to reflect the actual construction cost of reclaiming the AML feature. So, unlike with unreclaimed AMLs, we can reasonably assume that reclaimed AML costs in eAMLIS ("completed costs") were last updated on the Date Revised. Without inflation adjustments, the cost of all completed AML reclamation construction in eAMLIS is $4.4 billion. I updated these completed AML costs in eAMLIS for inflation, using the Date Revised as the date associated with the AML's reclamation cost. The total inflation-adjusted construction cost of reclaimed AMLs was 5.1 billion (2020$).

There are also AML features that are currently in the process of being reclaimed by state and tribal AML programs. These are referred to as "funded" AML projects that are not unreclaimed but are also not yet completed. Funded costs in eAMLIS represent recent cost estimates, and so I assume that the date associated with a funded cost estimate is the Date Revised. After updating the funded cost estimates for inflation, there are 0.783 million (2020$) worth of currently in progress construction costs. Note that in table 1, "Reclaimed" construction costs include both completed and in-progress costs.

3. What is the universe of AMLs—unreclaimed and reclaimed—as of 2020?

If, as I have shown, there are an estimated 15.6 billion (2020$) worth of unreclaimed AML construction costs (medium scenario), $0.783 billion (2020$) worth of funded AML construction costs, and 5.1 billion (2020$) worth of AMLs that have already been reclaimed, then the total universe of all AMLs in the federal inventory is 21.5 billion (2020$) worth of construction cost. In other words, the construction cost of all AMLs discovered—reclaimed, in-progress, and unreclaimed—is 21.5 billion (2020$).

4. How many AMLs will be "discovered" between 2021 and 2050?

Over the history of the AML program, the universe of known AML problems has grown, for three main reasons: 1) known AML features degrade over time, requiring expanded or re-reclamation of the AML feature and surrounding site, 2) previously unknown AML features are discovered and added to the AML inventory, 3) mine pools and AMD remediation require ongoing reclamation. For decades, state/tribal have not had the funding resources to actively seek out unknown AML features. Still, unknown AML features are discovered every year from citizen complaints and emergencies who contact AML officials.

New AML problems continue to be added to the AML inventory, though the annual rate at which AML problems have been added has declined over time. In order to estimate the rate at which AML problems are discovered, I assume that an AML feature's Date Prepared is the year it was first added to eAMLIS – i.e. the year it was "discovered." In order to estimate the total AML costs or units "discovered" in a given year, I sum the unreclaimed values and the completed values for all AML

features with a given Date Prepared. In order to update the costs for inflation, I assume that the date associated with the unreclaimed costs is the Date Prepared and, as above, that the date associated with the completed costs is the Date Revised.

For the reasons outlined above, problem types were separated into Group A and Group B. With Group A, I estimated the annual rate of units discovered. For Group B, I estimated the annual rate of costs discovered. After estimating the units or costs discovered in each year, I then calculated an average rate of units (for Group A PTs) and costs (for Group B PTs) discovered for three decades: 1990-1999, 2000-2009, and 2010-2019. After establishing the average annual rate of units and costs discovered for each problem type in these time periods (not shown in table 4), I compared the average annual rates across the decades, and attempted to estimate how the rate of discovered had declined each decade. Table 4 shows comparisons of 1990-1999 v. 2000-2009 and 2000-2009 v. 2010-2019.

Table 4. Change in rate of AML discovery over time[3]

GROUP A: PROBLEM TYPE	**% CHANGE** IN 1990-1999 ANNUAL RATE OF UNITS DISCOVERED AND 2000-2009 ANNUAL RATE	**% CHANGE** IN 2000-2009 ANNUAL RATE OF UNITS DISCOVERED AND 2010-2019 ANNUAL RATE	GROUP B: PROBLEM TYPE	**% CHANGE** IN 1990-1999 ANNUAL RATE OF COSTS DISCOVERED AND 2000-2009 ANNUAL RATE	**% CHANGE** IN 2000-2009 ANNUAL RATE OF COSTS DISCOVERED AND 2010-2019 ANNUAL RATE
CS	-84%	530%	BE	0%	-84%
CSL	-17%	-96%	DP	-40%	-79%
DH	-25%	-52%	EF	56%	-94%
DI	23%	-72%	GO	-65%	-89%
DPE	-47%	-62%	H	-7%	-95%
DS	-18%	-67%	HR	-10%	-93%
GHE	-72%	-41%	MO	12%	-82%
HEF	-2%	-92%	O	-65%	175%
HWB	-36%	-63%	PI	86%	-92%
IRW	-80%	-94%	PWHC	26%	-50%
P	-45%	-72%	SA	-48%	-90%
PWAI	496%	-97%	SL	-43%	-100%
S	-32%	-81%	SP	-42%	-89%
SB	-49%	-89%	WA	57%	-92%
UMF	74%	-85%			
VO	-63%	-64%	**Total**	**-24%**	**-73%**
AVERAGE	1%	-37%	AVERAGE	-7%	-68%
MEDIAN	-34%	-72%	MEDIAN	-10%	-89%
HIGH	496%	530%	HIGH	86%	175%
LOW	-84%	-97%	LOW	-65%	-100%

[3] Author's calculations based on eAMLIS data from 10.19.20. For a breakdown of the acronyms for the listed problem types, see: https://www.osmre.gov/programs/AMLIS/priority1_2.shtm

The decline in the rate of discovery between the 1990s and the 2000s was smaller than the decline between the 2000s and the 2010s. It is hard to summarize the rate of decline into a single estimate because the percent decline varies widely by problem type. Another complicating dynamic is that, despite the general decline in the rate of discovery over time, there is some evidence that the rate of discovery in 2015-2019 actually increased relative to 2010-2014. The rate of discovery for six of the thirty problem types (DH, DI, DPE, UMF, EF, O) increased in the latter half of the 2010s.

Estimating the future rate of AML discovery is not straightforward: a) we simply don't have a good assessment of how many AMLs exist in the field that are not yet in the eAMLIS inventory, b) the rate of degradation of known AMLs could change over time (with increased flooding and other climate change impacts, for example), and c) the rate of discovery is likely impacted by AML policy and funding—if state/tribal AML programs had more funding and policy direction to actively inventory previously unknown AMLs, then the future rate of AML discovery could potentially increase substantially.

Given considerable uncertainty in terms of future AML discovery, I have developed low, medium, and high scenario assumptions. In the low scenario, I assume that the 2021-2030 average annual rate of AML units/costs added to the eAMLIS inventory is half the average rate from 2010-2019, that the 2031-2040 rate is half the 2021-2030 rate, and that the 2041-2050 rate is half the 2031-2040 rate. In this low scenario, the construction cost of AMLs discovered between 2021 and 2050 is 2.0 billion (2020$). In the medium scenario, I assume that the 2020s rate of annual AML discovery is the same as the 2010s rate, that the 2030s rate is half the 2020s rate, and the 2040s rate is half the 2030s rate. In this medium scenario, the construction cost of AMLs discovered between 2021 and 2050 is 4.0 billion (2020$). In the high scenario, I assume that the 2020s rate of annual AML discovery is twice the 2010s rate, that the 2030s rate is one-third the 2020s rate, and the 2040s rate is one-third the 2030s rate. In this high scenario, the construction cost of AMLs discovered between 2021 and 2050 is 6.6 billion (2020$).

For analysis below, I use the medium scenario of AML costs discovered. This reflects that additional AML resources could empower state/tribal agencies to inventory unknown AML features, keeping the 2020s annual rate of discovery the same as the previous decade, and then the following decades falling by 50% each decade—which based on the table above is within historic average/median decade-over-decade reductions.

5. How much are AML design and administration costs relative to construction costs?

In addition to construction costs, reclaiming AML features also requires design and administration costs. The costs for reclamation in eAMLIS only reflect the costs paid to construction contractors, but before that stage in the reclamation process state/tribal officials must survey and design a reclamation plan for the project. State/tribal officials must also administer the program, including inspection/monitoring, obtaining permits, planning, management, and other tasks.

State and tribal AML programs submit annual reports to the Office of Surface Mining Reclamation and Enforcement (OSMRE) on AML expenditures. OSMRE uses the Financial Business Management System (FBMS) as the system of record for the AML Program: it contains comprehensive information on AML grant allocations and expenditures. According to OSMRE's

FBMS data shown in table 5, over the course of the AML program, construction costs (which I assume include AMD costs) have accounted for 74.7% of all AML expenditures. (This analysis excludes Undelivered Orders, which represent less than 5% of total AML expenditures, and will presumably eventually be allocated to one of the other expenditure categories upon delivery).

Table 5. Cost Breakdown of AML Grants[4]

Distribution of "AML Grants to States and Tribes"	**Amount** (billions$)	**%**	**%** (Undelivered Orders excluded)
Construction	4.218	71.1	74.7
Acid Mine Drainage	0.401		
Project design	1	16.8	17.7
Administrative costs	0.43	7.2	7.6
Undelivered orders	0.287	4.8	
Total	5.935	100.0	
Total (minus undelivered orders)	5.648		100.0

Project Design costs have accounted for 17.7% of total costs and Administrative Costs have accounted for 7.6% of total costs. In their 2019 report, IMCC and NAAMLP argue that design plus administrative costs would increase total AML costs by 25-30%, relative to only construction costs.[5] My above analysis of the FBMS data shows that design plus admin increases total costs by 33.4%—a marginally higher but very similar estimate.

Given this breakdown, I assume that for every dollar of AML construction costs, there are an additional $0.24 in design costs, and an additional $0.10 in administration costs. I apply this assumption to the construction cost estimates discussed above, to yield total reclamation cost estimates.

6. How many AML fees will be collected between 2021 and 2050?

I calculate future AML fee collections assuming three different sets of AML fee levels and two different sets of EIA coal production projections. In the low scenario, I assume that the AML fee levels are reduced to zero in 2022.

In the medium scenario, I assume that current AML fee levels are maintained through 2050, but that all coal production ends in 2035 except for premium (metallurgical) coal.[6] I assume the EIA AEO 2020 $35 Carbon Dioxide fee case for coal production projections in the medium scenario.

In the high scenario, I assume that current AML fee levels are doubled in 2022 and assessed through 2050. I assume the EIA AEO 2020 baseline ("Reference Case") for coal production projections in the high scenario. In table 6, I also provide figures for projected collections if current AML fee levels were ten times higher.

[4] Abandoned Mine Land (AML) Program landing page of the OSMRE website, accessed December 2020. "OSMRE's DOI Financial Business Management System (FBMS) is the system of record for the AML Program that contains comprehensive information on AML grant allocations and expenditures." < https://www.osmre.gov/programs/aml.shtm>.

[5] "Projecting Costs for Future AML Reclamation." Interstate Mining Compact Commission (IMCC). National Association of Abandoned Mine Land Programs (NAAMLP)., September 2019. Pp. 4.

[6] I assume all premium coal is underground mined, and that lignite production is part of the total surface mining production.

Table 6. Projected AML Fee Collections, 2021-2050

Under the EIA2020 *$35 CO_2 fee case* scenario, projected coal production is 2,600 tons total from 2022-2050. Under the EIA2020 *Reference Case* scenario, projected coal production is 15,103 tons total from 2022-2050—roughly six times as much coal in the CO_2 fee case. Current AML fee authorization ends in September 2021: all 2021 projected AML collections use current fee levels and EIA2020 Reference Case.

	FEE LEVELS (PER TON)			AML FEE COLLECTIONS ($)				
				2021	2022-2050		2021-2050	
	Surface	Under-ground	Lignite	EIA Case: Reference Case	EIA Case: $35 CO2 fee (only met coal after 2035)	EIA Case: Reference Case	EIA Case: $35 CO2 fee (only met coal after 2035)	EIA Case: Reference Case
Current Fee Levels	0.28	0.12	0.08	113,141,371	547,524,512	1,623,803,463	660,665,883	1,736,944,834
Double Current Fee levels	0.56	0.24	0.16	N/A	1,095,049,024	5,875,169,548	1,208,190,395	5,988,310,919
10x Current Fee Levels	2.8	1.2	0.8	N/A	5,475,245,120	29,375,847,739	5,588,386,491	29,488,989,110

According to the House Report that accompanied the 1976 Surface Mining Control and Reclamation Act (H.R. 13950), legislators considered three factors in setting the AML fee levels: setting a fee level that would 1) not be a burden on the industry, 2) provide revenue "to meet program objectives within a reasonable time frame," and 3) not cause inflation.[7] Congress settled on a differential fee structure, but notably the differential was not rooted in differences in the reclamation costs of different methods of extraction nor was it rooted in a differential in the average price of underground or surface coal (though Congress may have set the lignite rate lower, at least in part due to lower prices). As table 8 shows, the average price of underground coal was *higher* than surface coal, yet underground coal had a *lower* fee level.

Rather, the underground fee was lower because of the "disproportionately high social costs incurred by underground coal mine operators in meeting responsibilities under the Coal Mine Safety and Health Act of 1969)."[8] In other words, the underground level was initially set at a lower rate because Congress felt underground operators were carrying a higher burden—prior to SMCRA—relative to surface operators and decided to adjust the rate accordingly.

As of 2020, 50.5% of construction costs of completed reclamation were spent on AML problems that were a result of underground mining and 49.5% were spent on problems created by surface mining. Though the total costs reclaimed are nearly identical, the median construction cost per standard unit for underground mining is about twice as high as for surface mining. Table 7 provides basic statistics on the completed costs from the federal AML inventory, categorized by whether the damage was a result of underground or surface mining. Note that data in the inventory may contain outliers that are not representative; these figures should be used cautiously here and especially for analysis beyond these basic comparisons.

[7] See pp. 87 of "House Report to Accompany H.R. 13950, Surface Mining Control and Reclamation Act of 1976." Report of the Committee on Interior and Insular Affairs, US House of Representatives. U.S. Government Printing Office, August 31, 1976.

[8] See pp. 87 of "House Report to Accompany H.R. 13950, Surface Mining Control and Reclamation Act of 1976." Report of the Committee on Interior and Insular Affairs, US House of Representatives. U.S. Government Printing Office, August 31, 1976.

Table 7. Comparing Completed Reclamation Costs of Underground and Surface Mined AML Sites
Data is from eAMLIS (10.19.20). All unreclaimed and in-progress AML problems are excluded. Completed projects were excluded if either "Completed Cost" or "Completed Standard Units" was zero.

	Underground	Surface
Count	15,282	8,062
Total Constriction Cost (2020$)	1,656,004,775	1,625,893,614
Total Standard Units	282,595	4,113,261
Average Cost Per Unit	5,860	395
Median Cost Per Unit	8,775	4,206
Low (Cost Per Unit)	0.00033	0.00016
High (Cost Per Unit)	36,758,368	8,067,784

Table 8 calculates the effective fee rates of AML fee levels in 1979 and 2019, as well as projects what the effective fee rate would be if the current AML fee levels were doubled or 10 times higher and assessed in 2019.

Table 8. Calculating the effective rate of AML fees, 1979 & 2019
This table was developed by Ted Boettner, Ohio River Valley Institute, using EIA data and amended by the author.

Method of extraction	Average price per ton	Tonnage (thousands)	Per Ton Fees	Effective Fee Rates
2019 Projection (using AML fee levels that are 10x the levels in 2019)				
Underground	$58.68	267,373	$1.20	2.04%
Surface	$22.47	438,936	$2.80	12.46%
Lignite	$19.86	53,192	$0.80	4.03%
2019 Total	$35.03	759,501	$2.10	5.98%
2019 Projection (using AML fee levels that are 2x the levels in 2019)				
Underground	$58.68	267,373	$0.24	0.41%
Surface	$22.47	438,936	$0.56	2.49%
Lignite	$19.86	53,192	$0.16	0.81%
2019 Total	$35.03	759,501	$0.42	1.20%
2019				
Underground	$58.68	267,373	$0.12	0.20%
Surface	$22.47	438,936	$0.28	1.25%
Lignite	$19.86	53,192	$0.08	0.40%
2019 Total	$35.03	759,501	$0.21	0.60%
1979				
Underground	$27.33	320,891	$0.15	0.55%
Surface*	$22.29	417,698	$0.35	1.57%
Lignite	$6.48	42,545	$0.10	1.54%
1979 Total	$23.50	781,134	$0.25	1.08%

7. What jobs are supported by AML reclamation work?

There are many workers—with a broad range of skills and qualifications—whose labor is necessary for AML reclamation. These range from government employees who inspect, design, administer, and research AML reclamation, to workers of construction firms that execute the reclamation plan.

Employees of state, tribal, and federal agencies, as well as managerial and professional staff (professional engineers, environmental scientists, etc.) employed by construction firms, are typically compensated as salaried staff. Workers who execute the reclamation plan are typically compensated hourly. Construction firms also employ hourly clerical or administrative staff, who are not necessarily assigned specific reclamation projects in the same way that laborers and operating engineers are but whose labor is no less critical.

The salaried staff at state, tribal, and federal agencies and at construction firms earn a range of pay, which I do not include in my estimates. For lack of data, I also do not include estimates of the wages paid to hourly clerical/administrative staff.

Construction jobs comprise a large share of AML jobs, and I focus my estimates on the hourly wage of this class of workers. But a more complete picture of the jobs supported by AML work would also include estimates of the pay of a) salaried worked at agencies, b) salaried workers at AML construction firms, and c) non-construction hourly workers. These are all ripe for future research.

There are also jobs along the AML value chain, which I do not explore in my analysis. If AML reclamation were to increase dramatically as I have estimated, then spending on heavy machinery necessary for reclamation would rise—and jobs needed to manufacture heavy machinery along with it. A similar impact could be expected with other inputs, such as diesel and gasoline, seeds, saplings, fertilizer, and gravel.

8. What share of AML construction costs are spent on payroll?

In order to estimate the number of construction jobs that will be created/supported by AML reclamation, there are a number of variables we need to estimate or assume. A key variable is how much of the money delivered to construction firms through AML contracts makes its way to workers—in other words, how much of the AML contract is spent on payroll.

The PA Department of Labor and Industry collects payroll data from the firms who have been awarded AML contracts posted by the PA Bureau of Abandoned Mine Reclamation (BAMR). Upon request from the author, officials at PA BAMR compiled some payroll data on what they considered a representative sample of twelve AML projects in PA in recent years.[9] This data is summarized in Table 9 below.

[9] 10 of the 12 projects are from 2015-2019, while 2 of the 12 may be older than 2015.

Table 9. Payroll Costs as % of Total Construction Costs
Analysis of a sample of 12 PA AML Projects

Figure	Value	Project type associated with each figure
Mean	22%	Demolition
Median	18%	Subsidence Control
Max	70%	Backfilling Strip Pits
Min	9%	Water Treatment Plant Mechanical & Electrical Upgrades
Ratio Max/Min	7.80	
Std Deviation	16%	
Covariance	0.75	

In my analysis, I assume that 15%, 20%, and 30% of construction costs are spent on payroll in the low, medium, and high scenarios, respectively. The medium scenario (20%) falls neatly between the mean (22%) and median (18%) in the PA sample. The low scenario (15%) falls between the median (18%) and lowest value (9%) in the PA sample. And the high scenario (30%), though significantly higher than the medium scenario, is considerably lower than the highest value in the PA sample (70%), which PA officials explained was not a representative cost.

While PA is only one of many states/tribes with AML, these figures present the best data available and represent a reasonable estimate to assume nationally. Of the 6 Appalachian state AML programs contacted (PA, VA, KY, WV, OH, TN), only two (PA, OH) collect payroll data on AML contracts at present (OH's AML officials did not respond to requests for such data).

Two reasons that payroll costs as a share of construction costs may vary by state/tribe are differences in a) wages paid to AML workers, and b) the types of reclamation projects that are common in the state/tribe. For these reasons and others, we cannot conclude that this sample from PA is perfectly representative of the nation. But, given the considerable diversity of the types of projects in the sample, it is reasonable to assume that 20% captures the average payroll costs—which I use as my medium scenario—and that the range of costs in the sample provide some important info on the lower and upper bounds in the low and high scenarios.

In a recent analysis by Western Organization of Research Councils (WORC) and mining environmental engineers at Kuipers and Associates, the authors assume that payroll costs as a share of reclamation bonds for post-1977 coal mine reclamation projects range from 10%-20%.[10] These figures are similar to the values in the PA sample, though AML projects may be slightly more labor-intensive. For this reason and under a scenario where AML wages increased considerably (I explore this more below), I include a high scenario (30%) that is higher than the assumptions in the WORC report. It is possible, for reasons explored further below, that AML wages are higher in PA than other states at present, which is why I have included a low scenario below 20%.

9. What is the hourly wage of workers who do AML construction work?

I assume that the average hourly rate of gross pay (wages + fringe benefits) for workers doing AML construction work is $25, $30, and $50 under low, medium, and high scenarios, respectively. Lacking

[10] Western Organization of Resource Councils (WORC), "Coal Mine Cleanup Works: A Look at the Potential Employment Needs for Mine Reclamation in the West." October 2020. See page 8. Technical Analysis for the report provided by Kuipers and Associates. URL:< http://www.worc.org/publication/reclamation-jobs-report/>.

wage data on AML workers specifically, I develop assumptions based primarily on BLS data of the wages of common AML occupations—I look at a weighted average of the median wages in each of 25 AML states. I test my assumed wage against data on the *range* of wages among AML workers in OH and PA, where we have a bit more data on AML wages specifically due to wage regulations.[11]

The medium scenario reflects my best approximation, given available data, of an median wage of AML workers under current labor regulations, market conditions, and rates of unionization. While I believe this to be a reasonable assumption, it is not based on AML wage data specifically. The wage could potentially be lower if: AML wages/fringes are considerably lower than that of Laborers and Operators in general; the number of AML workers is greater in states with below-median wages; prevailing wage laws are weakened or unionization declines in states with relatively high AML wages. The low scenario assumes one or all of these scenarios. The high scenario assumes that prevailing wage laws are strengthened significantly and that unionization rates rise among Laborers and Operators in the heavy civil engineering industry across many AML states. Because AML projects are public construction projects, AML wages can be significantly impacted by prevailing wage laws.

AML reclamation is typically completed by workers whose specific occupations fall under two broad categories: a) Construction Laborers ("Laborers," SOC Code472061), and B) Operating Engineers ("Operators," SOC Code472073). Because national/state data on the wages of Laborers and Operators doing AML work specifically is not readily available, calculating an average is not possible. Using BLS data, I gather the median hourly wage of these two occupations (across all industries) for each of the 25 states with AML programs, and find that the weighted average of median hourly wages for Laborers is $17.60 and for Operators is $22.87 (see table 10). This average is weighted by each state's unreclaimed construction costs as of 2020 (medium scenario)—a rough proxy for how much AML work will be done in each state. I assume the average AML wage is within this range.

Table 10. Analysis of Median Hourly Wages of Laborers & Operators (BLS), includes 25 States with AML programs and National Averages[12]

	Construction Laborers		Operating Engineers	
	Median Wage	**State**	**Median Wage**	**State**
Low	14.02	Arkansas	17.70	Arkansas
Weighted Average	**17.60**		**22.87**	
High	27.34	Illinois	38.68	Illinois
National All industries	17.72		23.55	
National Heavy civil engineering Industry only	18.19		25.31	

[11] With publicly available Prevailing Minimum Wage (PMW) postings for the wages that must be paid to workers under AML contracts in PA and OH, we have some information on the *range* of wages paid to AML workers specifically there. OH and PA are the only Appalachian states that require PMW for AML workers, and are the two states where I was able to gain information on the wage scale of AML workers.

[12] "Occupational Employment and Wages, May 2019. 47-2061 Construction Laborers." Bureau of Labor Statistics (BLS). URL: < https://www.bls.gov/oes/current/oes472061.htm#nat>. State statistics were access through the BLS Occupational Employment Statistics Query System: https://data.bls.gov/oes/#/occGeo/One%20occupation%20for%20multiple%20geographical%20areas. See also for heavy civil engineering industry: "May 2019 National Industry-Specific Occupational Employment and Wage Estimates, NAICS 237900 - Other Heavy and Civil Engineering Construction." Bureau of Labor Statistics (BLS). URL: <https://www.bls.gov/oes/current/naics4_237900.htm>.

Is this range a reasonable estimate? I check in two ways. First, it is not far from the median wages of Laborers and Operators nationally ($17.72 and $23.55, respectively; see table 10).[13] Second, in two states (OH, PA) where we have data on the *range* of wages among AML workers, I find that the range of wages of AML Laborers and Operators are similar—though more compressed—to the wages of those two occupations in general in OH and PA (see table 11). Though the comparison is limited to two states, it suggests no reason to believe that the *average* wages for AML Laborers or Operators are significantly different than those occupations in general in a given state.

Table 11. Comparison of wage ranges in AML v. All industries, OH and PA[14]
High wage is the highest Operating Engineer wage
Low wage is the lowest Construction Laborer wage

	OH		PA	
	AML	**All Industries**	**AML**	**All Industries**
High wage	27.46	38.57	46.43	38.94
Low wage	17.39	12.98	21.05	12.56

But the range of average wages among AML Laborers and Operators in OH and PA are considerably higher than the range I assume for AML workers nationally[15]—one might wonder if this is evidence of inconsistency. It is not inconsistent, because Laborers and Operators earn considerably higher wages in OH and PA than in other AML states.[16] Using BLS data, I find that the average wages of Laborers and Operators in OH and PA are in the top quartile among all 25 AML states.[17]

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[13] According to BLS data, the national mean hourly wage rate for Laborers is $20.06 and $26.06 for Operating Engineers, across all industries. See "Occupational Employment and Wages, May 2019. 47-2061 Construction Laborers." Bureau of Labor Statistics (BLS). URL: < https://www.bls.gov/oes/current/oes472061.htm#nat>. If we look specifically at the "Heavy and Civil Engineering Construction" industry—which many AML projects fall under—then these mean wage rates are a slightly higher $21.05 and $28.89, respectively. See "May 2019 National Industry-Specific Occupational Employment and Wage Estimates, NAICS 237900 - Other Heavy and Civil Engineering Construction." Bureau of Labor Statistics (BLS). URL: https://www.bls.gov/oes/current/naics4_237900.htm.

[14] The current Ohio AML wage rate scale provides minimum wage rates for 8 laborer occupations, 16 operator occupations, and 4 mechanic occupations. Ohio's regulations require construction firms awarded AML contracts to pay workers, at minimum, the average wage rate paid by all AML firms over the past three years. Ohio regulators gather pay data and, every three years, establish a set of minimum hourly wage rates. These are calculated for each occupation by averaging the hourly wage rates paid to workers under all AML contracts over the past three years. From 2017-2019 among all AML contracts in Ohio, the average wage rate of the lowest paid Laborer occupation ("Watchman") was $17.39, and the average wage of the highest paid Operator occupation ("Crane Operator") was $27.46. For the Ohio AML wage rate scale (as of Jan. 2021) see: "Bid Documents, Division O – Bidding and Contract Requirements, Section 00200 – Wage and Hour Requirements." Division of Mineral Resources Management, Department of Natural Resources, State of Ohio. 2020.

BLS data shows that in Ohio in 2019 across all industries, the 10th percentile hourly wage for Laborers was $12.98, and the 90th percentile wage for Operators was $38.57. For BLS wage data on both OH and PA see: "Occupational Employment and Wages, May 2019. 47-2061 Construction Laborers." Bureau of Labor Statistics (BLS). URL: < https://www.bls.gov/oes/current/oes472061.htm#nat>. State statistics were access through the BLS Occupational Employment Statistics Query System: https://data.bls.gov/oes/#/occGeo/One%20occupation%20for%20multiple%20geographical%20areas.

Pennsylvania also publishes a prevailing wage rate scale that applies to AML contracts, but it is less specific than the wage rate scale in Ohio and thus less useful for our purposes. For each construction contract in PA, the Department of Labor and Industry published the minimum wage rates for all occupations in the "Highway / Heavy" construction industries. The difficulty is that these wage rate scales include many occupations that do not work on AML projects, such as "Elevator Constructor" and "Painter." So while these wage rate scales do provide a range of wages for AML workers, they are much less precise than the wage rate scale in Ohio: many of the low or, especially, high end wage rates may be for occupations who don't actually work on AML projects. I averaged the lowest wage rate and highest wage rate listed in the wage scales for each of the 8 AML projects in the sample from PA noted above (only projects from 2019-20 were assessed). I found that these averages yielded a range of wages of $21.05 to $46.43 for AML Laborers and Operators in Pennsylvania.

According to BLS data, the low-high range (10th percentile of Laborer wages; 90th percentile of Operators wages) for Laborers and Operators across all industries in Pennsylvania was $12.56 to $38.94.

The wage scale is *compressed* (higher low end, lower high end) for Laborers and Operators who work on AML. If we compare the Ohio AML wage rate scale with the range of Laborers and Operators in the state, it suggests that AML Laborers have a low end that is 31% higher when compared to the 10th percentile of Laborers in all industries; and that Operators have a high end that is 31% lower when compared to the 90th percentile of Operators in all industries. In PA, AML Laborers have a higher low end (by 62%) and the high end for Operators is uncertain but likely around the same (but perhaps higher) as Operators in general in PA.

[15] Across all industries in Ohio, the average hourly rate for Laborers is $22.21, and the average rate for Operators it is $26.99. In PA these figures are $20.94 and $26.77. I assume the average AML wage is within $17.72 and $24.06.

[16] Why are national wages lower than in PA or OH? We can't be certain with the limited data we have, but in general I think it is appropriate to assume that wage rates and, especially, fringe benefits tend to be higher in states with higher union density, and tend to be lower in rural areas relative to metropolitan areas. On the other hand, AML projects are public construction projects and are subject to wage laws and regulations that private sector heavy construction projects aren't—which is an upward force on the wages/fringes of AML Laborers and Operators relative to those workers in general.

[17] According to BLS data, the average wage of Laborers in Ohio (all industries) is ranked the fourth highest (top 16%) among all 25 states with AML programs; similarly, the average among Operators in Ohio is the fifth highest (top 20%). In Pennsylvania the picture is similar: the average wage of Laborers (all industries) is ranked the fifth highest (top 20%) among all 25 states with AML programs; the average among Operators is the sixth highest (top 24%). I thus assume that the national average wage of AML workers is considerably lower than in Ohio or Pennsylvania. How much lower? Of the 25 AML states, the lowest average wage is $14.41 (Arkansas) for Laborers and $18.22 (Arkansas) for Operators. The median average wage is $17.72 (Utah) for Laborers and $24.06 (Iowa) for Operators. See "Occupational Employment and Wages, May 2019. 47-2061 Construction Laborers." Bureau

So, if we assume that the median wage for AML workers lies between $17.60 and $22.87 (weighted average of the median wages of Laborers and Operators, respectively, among all 25 AML states), then for the medium scenario I assume a $20.24 wage, which lies in the middle of this range, and a level of fringe benefits (32.5% of gross pay) that is comparable with the construction industry's 30.9% average, according to BLS.[18] Lacking data, this estimate assumes that half of payroll costs are spent on Laborers and half on Operators.

The $30 gross pay rate in the medium scenario is also consistent with the $30 rate assumed in the 2020 WORC/Kuipers Associates report that assessed post-1977 reclamation job potential.[19] For the low scenario, I assume a slightly lower wage ($20.00) and significantly lower level of fringe benefits (20% total pay) that is about half the level among union construction workers.

For the high scenario, I assume a significantly higher wage ($30.00) and a significantly higher level of fringe benefits (40% of total pay), which is consistent with the averages among union Laborers and Operators nationally (38% and 39%, according to Construction Labor Research Council).[20] The $50 rate of gross pay assumed in the high scenario is within the range of average gross pay for union Laborers ($43.52) and union Operators ($59.79) nationally, according to Construction Labor Research Council, and is consistent with the low-high range among Laborers and Operators on public Heavy/Highway construction contracts in PA ($39.67 to $77.05), where unionization is relatively high and prevailing wage laws relatively strong.[21]

Without data on the pay of Laborers and Operators doing AML reclamation specifically it is difficult to establish an estimate of the average hourly rate of pay among these workers. Any method involves some degree of assumption. By assessing adjacent data on construction worker pay and fringes, I think the assumptions made here provide a reasonably good big-picture estimate of the rate of total pay to AML construction workers on average across the country. If/once data reporting on the pay and hours of workers on AML contracts is required of state/tribal agencies, then future research will be able to develop a more complete assessment.

Across all estimates, I assume that a "job year" is equal to 2080 hours of pay per year.

10. Will potential wage increases raise reclamation costs?

In the high scenario, I assume a $50 hourly rate of gross pay and payroll costs as 30% of construction costs – 10 pp higher than the medium scenario. For the high scenario, I thus assume that construction costs rise by 5% due to assumed wage-push price increases and that remaining increases in payroll are absorbed by productivity increases and profit reductions.

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of Labor Statistics (BLS). URL: < https://www.bls.gov/oes/current/oes472061.htm#nat>. State statistics were access through the BLS Occupational Employment Statistics Query System: https://data.bls.gov/oes/#/occGeo/One%20occupation%20for%20multiple%20geographical%20areas.

[18] See "Employer Costs for Employee Compensation News Release." USDL-20-2266. December 17, 2020. Bureau of Labor Statistics (BLS). URL: < https://www.bls.gov/news.release/ecec.htm >

[19] Western Organization of Resource Councils (WORC), "Coal Mine Cleanup Works: A Look at the Potential Employment Needs for Mine Reclamation in the West." October 2020. See page 8. Technical Analysis for the report provided by Kuipers and Associates. URL:< http://www.worc.org/publication/reclamation-jobs-report/>.

[20] "Union Labor Costs in Construction." 2019. Construction Labor Research Council. See page 5. URL:< https://www.finishingcontractors.org/members-resources/labor-management/research-and-reports-clrc ; www.clrcconsulting.org >.
CLRC notes that the data "has been prepared from information collected and maintained by CLRC."

[21] "Union Labor Costs in Construction." 2019. Construction Labor Research Council. See page 5. URL:< https://www.finishingcontractors.org/members-resources/labor-management/research-and-reports-clrc ; www.clrcconsulting.org >.
CLRC notes that the data "has been prepared from information collected and maintained by CLRC."

The PA low-high range was calculated by averaged the lowest wage and the highest wage in each of the 8 PMW wage rate scales from the PA sample noted above.

11. How many AML jobs would be supported/created at state, tribal, and federal agencies?

In addition to construction, AML reclamation requires design, inspection, administration, and research of improved reclamation techniques. Federal and state/tribal staff currently complete these tasks. Federal staff at OSMRE administer, inspect, and research, while staff at state/tribal agencies perform many tasks that include fielding reclamation requests, inspecting reclamation projects, working with landowners on realty issues, administering and managing the state/tribal AML program, and, perhaps most critically, designing reclamation plans.

State/tribal AML staff positions are funded through federal AML grants to states and tribes, sourced from AML fees (non-certified AML programs) and the US Treasury (certified AML programs) at present. I assume that every $1 million in AML grants (AKA every dollar of total reclamation costs) supports 2.5 state/tribal AML jobs. According to official "Annual State Evaluation Reports" that state/tribal AML programs deliver to OSMRE, there were an average of 2.54 FTEs supported by every $1 million in AML grants to states/tribes, across all 28 AML programs in 2019.[22]

If we assume half of the $26.3 billion in unreclaimed AML (medium scenario, unreclaimed total costs as of 2050), and if we spread the reclamation of these sites out equally over the 10 years, then $1.3 billion in annual reclamation (total costs) will occur annually. The design and administration funding included in this annual figure will create/support an estimated 3,286 AML FTEs at state and tribal reclamation agencies, for 10 years.

Federal AML staff at OSMRE are funded through discretionary funding from the AML Fund, appropriated by Congress annually.[23] I assume that every $1 million in AML discretionary funding supports 4.25 federal AML jobs at OSMRE. According to official "Budget Justification and Performance Information" reports from OSMRE, there were an average of 4.24 FTEs per $1 million in discretionary AML funding across 2009, 2010, 2019, and 2020.[24]

I assume $75, $112.5, and $150 million in annual AML discretionary funding to OSMRE in my low, medium, and high scenarios, respectively (assuming a cleanup schedule where 13.1 billion is cleaned up between 2021-2030). In 2009 and 2010, at the beginning of the Obama administration, AML discretionary funding averaged $44 million annually.[25] By 2019-2020, at the end of the Trump Administration, this average had been cut to $25 million annually. Staffing at OSMRE was not a priority of the Trump Administration, evidenced by the fact that OSMRE was helmed by an Acting Director for more than half of Trump's term.

If we assume that annual AML reclamation increases to the levels outlined above (medium scenario), then federal AML grants to state/tribes would be around $1.3 billion annually. In 2009 and 2010, that figure averaged $334 million and in 2019-2020 averaged $231 million.[26] If we assume that annual AML reclamation increases drastically relative to historic levels, then we might also assume

[22] Annual State Evaluation Reports, OSMRE, 2019. Accessed here: <https://www.odocs.osmre.gov/). Note: annual report for the Hope Tribe is from 2018, and for Tennessee is from 2017 (they were the most recent, as of Nov. 2020).

[23] Larson, Lance N. "The Abandoned Mine Reclamation Fund: Reauthorization Issues in the 116th Congress." Congressional Research Service (CRS), March 12, 2020.

[24] FY2011 and FY2021 "Budget Justifications and Performance Information" reports, Office of Surface Mining Reclamation and Enforcement (OSMRE), US Department of Interior. FY2009 and FY2019 figures are Actual; FY2010 and 2020 figures are Enacted. FY2011 URL: https://www.osmre.gov/resources/budget/docs/FY2011_Justification.pdf; FY2021 URL: https://www.osmre.gov/resources/budget/docs/FY2021_OSMRE_Budget_Justifications.pdf.

[25] See "Total Mandatory Distributions (after reductions)" in the FY2009, FY2010, FY2019, and FY2020 OSMRE AML Grant reports: https://www.osmre.gov/resources/grants.shtm.

[26] Total AML mandatory distributions were $298,072,314 in 2009, $369,085,986 in 2010, $291,295,810 in 2019, and $170,859,620 in 2020.

that OSMRE staffing will increase to ensure effective administration and inspection of the program—as well as to increase research and training.

The low scenario assumes a marginal increase of historic AML discretionary funding levels, up to $75 million annually. This level is unlikely to provide the staffing and resources needed to manage a national program that is doing 3.9 times the reclamation work done in 2009-10 and 5.7 times the reclamation work done in 2019-20. In the medium scenario I assume that discretionary AML funding ($112.5 million annually) 2.6 times 2019-20 levels and 4.5 times 2009-10 levels. In the high scenario, I assume that AML discretionary funding ($150 million annually) is 3.4 times 2019-20 levels and 5 times 2009-10 levels.

Using the assumed 4.25 FTEs per $1 million in discretionary funding, I estimate that the low, medium, and high levels of AML discretionary funding would create/support 213, 319, and 425 AML jobs at OSMRE for 30 years, if all unreclaimed AML were cleaned up 2021-2050.

12. Over what time horizon will AML cleanup happen, and will it be distributed equally across all years?

I calculate various annual AML costs/funding estimates using three different sets of assumptions. Under Case A, I assume that all projected AML reclamation needs will be reclaimed by 2050 and that reclamation occurs equally across the 30 years between now and then. Under Case B (table 2), I assume that AML reclamation is front-loaded in the first decade, such that 50% of unreclaimed AML is reclaimed in the first 10 years, 33% is reclaimed in the next 10 years, and 17% is reclaimed in the final 10 years.