Draft Coal Bond Calculation Guidelines

Mining Bureau
Air, Energy, and Mining Division
Montana Department of Environmental Quality

TABLE OF CONTENTS

LIST OF TABLES

ACRONYMS

ARM	Administrative Rules of Montana
BCY	Bank Cubic Yards
CMI	Costmine Intelligence
CPH	Caterpillar Performance Handbook
LCY	Loose Cubic Yards
MCA	Montana Code Annotated
DEQ	Montana Department of Environmental Quality
MPH	Miles Per Hour
MSUMRA	Montana Strip and Underground Mine Reclamation Act
OSMRE	Office of Surface Mining, Reclamation and Enforcement
PMT	Postmine Topography
TSF	Truck/Shovel Fleet

REVISION HISTORY

Version 1.0 – Initial document.

1.0 INTRODUCTION

The purpose of this guideline is to assist Montana Department of Environmental Quality (DEQ) staff with consistently applying the regulations and operators with complying with the regulations. DEQ is responsible for administrating the Montana Strip and Underground Mine Reclamation Act (MSUMRA) (the Act) (82-4-201 et seq., MCA) and implementation of Administrative Rules of Montana (ARM 17.24.301-1309) adopted under MSUMRA. Pursuant to ARM 17.24.1102, the standard applied by the department in determining the amount of performance bond is the estimated cost to the department if it had to perform the reclamation, restoration, and abatement work required of an operator or a prospecting permittee under the Act, the rules adopted thereunder, and the permit.

Applicable bonding rules outlined in this guideline apply to the following:

ARM 17.24.305	**Maps**
ARM 17.24.313	**Reclamation Plan**
ARM 17.24.413	**Conditions of Permit**
ARM 17.24.416	**Permit Renewal**
ARM 17.24.1016	**Bond Requirements for Drilling Operations**
ARM 17.24.1101	**Bonding: Definitions**
ARM 17.24.1102	**Bonding: Determination of Bond Amount**
ARM 17.24.1104	**Bonding: Adjustment of Amount of Bond**
ARM 17.24.1111	**Bonding: Bond Release Application Contents**

2.0 BOND CALCULATION STANDARDIZED COSTS

2.1 EQUIPMENT COSTS

Equipment sizing and classification are based on equipment available and easily mobilized by a third-party contractor to the project site. All equipment utilized in bond calculations should be selected from the table below unless further justification can be provided on availability through a heavy civil contractor.

Standardized equipment costs were determined through utilization of Costmine Intelligence's Equipment Cost Calculator 2024-2025. This report provides a comprehensive list of capital costs and hourly operating costs associated with mine specific reclamation operations. The rates provided by Costmine Intelligence have been modified to utilize the average Montana diesel fuel price and accepted Montana operator rate. The values provided by Costmine are stated to be suitable for preliminary engineering estimates and align with resources necessary for bond determination under ARM 17.24.1102.

Equipment rates published by Costmine are sourced directly from manufactures, dealers, and mining companies. These rates are generalized and do not include manufacture information to provide protection to third party data sources; the equivalent match of specific equipment listed in Table 2-1 are provided to ease in equipment selection based on a historic understanding and utilization of manufacture specific equipment.

All production calculations utilize a standard efficiency factor of 0.83, based on a fifty-minute working hour as recommended and referenced by the Komatsu Specifications & Applications Handbook and Caterpillar Performance Handbook.

Table 2-1. Standardized Equipment Costs ($/hr without operator)

Equipment Type	Equipment Description	Equivalent Match	Hourly Ownership Cost	Hourly Operating Cost	Total Hourly Cost (Ownership and Operating)	Data Source
Dozer	11.5 ft (3.5 m) blade width, 265 hp	CAT D6	$55.92	$73.43	**$129.35**	Costmine Intelligence Equipment Cost Calculator 2024-2025
Dozer	13.0 ft (4.0 m) blade width, 350 hp	CAT D8	$76.67	$87.72	**$164.39**	Costmine Intelligence Equipment Cost Calculator 2024-2025
Dozer	15.0 ft (4.6 m) blade width, 574 hp	CAT D9	$108.79	$128.93	**$237.72**	Costmine Intelligence Equipment Cost Calculator 2024-2025
Dozer	16.2 ft (4.9 m) blade width, 600 hp	CAT D10	$152.56	$156.09	**$308.65**	Costmine Intelligence Equipment Cost Calculator 2024-2025
Rubber Tire Dozer	17.75 ft (5.4 m) blade width, 680 hp	CAT 844	$70.96	$212.33	**$283.29**	Costmine Intelligence Equipment Cost Calculator 2024-2025
Blade	12 ft (3.7 m) blade width, 215 hp	CAT 140 GC	$36.07	$47.75	**$83.82**	Costmine Intelligence Equipment Cost Calculator 2024-2025
Blade	16 ft (4.9m) blade width, 280 hp	CAT 16	$44.71	$60.15	**$104.86**	Costmine Intelligence Equipment Cost Calculator 2024-2025
Scraper	31 cu yd (23.7 cu m), 17.2 in (43.6 cm) cut depth, 500 hp	CAT 637	$88.28	$133.77	**$222.05**	Costmine Intelligence Equipment Cost Calculator 2024-2025
On-Highway Truck	20 ft (6.1 m) dump body, Class 8	10-12 CY	$7.46	$51.73	**$59.19**	Costmine Intelligence Equipment Cost Calculator 2024-2025
Haul Truck	32.9 cu yd (25.2 cu m) capacity, 6 x 6 traction, 475 hp	CAT 745	$22.23	$57.80	**$80.03**	Costmine Intelligence Equipment Cost Calculator 2024-2025
Haul Truck	78.5 cu yd (60.0 cu m), mechanical drive, 1,200 hp	CAT 777	$49.33	$145.83	**$195.16**	Costmine Intelligence Equipment Cost Calculator 2024-2025
Water Truck	55 ton rigid frame chassis, 12,000 gal tank, 550 hp	12,000 gal WT	$31.79	$77.59	**$109.38**	Costmine Intelligence Equipment Cost Calculator 2024-2025
Loader	7.5 cu yd (5.7 cu m) bucket, 10 ft 6 in (3.2 m) dump height	CAT 980	$43.87	$80.30	**$124.17**	Costmine Intelligence Equipment Cost Calculator 2024-2025
Loader	17.0 cu yd (13 cu m) bucket, 14 ft 8 in (4.5 m) dump height	CAT 992	$158.71	$199.00	**$357.71**	Costmine Intelligence Equipment Cost Calculator 2024-2025
Backhoe Loader	0.44 cu yd (0.34 cu m) bucket size, 98 hp	CAT 430	$12.45	$20.70	**$33.15**	Costmine Intelligence Equipment Cost Calculator 2024-2025
Excavator	2.98 cu yd (2.3 cu m) bucket size, 367 hp	CAT 340	$55.11	$70.70	**$125.81**	Costmine Intelligence Equipment Cost Calculator 2024-2025
Pickup Truck	1 ton, automatic, crew cab, heavy duty	F350 Diesel Crew	$2.36	$25.20	**$27.56**	Costmine Intelligence Equipment Cost Calculator 2024-2025

2.2 DIESEL PRICING

Diesel pricing is calculated from Montana contracting and bidding resources provided by the Montana Department of Transportation. These values are reported monthly and averaged throughout the year to calculate a yearly average fuel price.

Rates are based on the average Montana diesel fuel price per year provided by the Montana Department of Transportation (https://www.mdt.mt.gov/business/contracting/fuel-prices.aspx).

Table 2-1. Montana Diesel Fuel Pricing (Yearly Average)

Fuel Type	Year				
	2021	2022	2023	2024	**2025**
Ultra Low Sulfur Diesel	$1.48	$2.50	$3.96	$3.29	**$2.68**

2.3 LABOR PRICING

Supervision costs are assumed to be covered by contractor overhead and profit. No additional specific cost will be applied for supervision during reclamation.

Auxiliary support equipment with utilization less than 1.0 are assumed to be servicing work areas with additional equipment during the operating shift. Example: Water truck and blading during a shift could be assigned to a single operator if conditions allow.

The accepted operator rate is based on Montana Prevailing Wage Rates for Heavy Construction Services (https://erd.dli.mt.gov/_docs/labor-standards/Prevailing-Wage/Heavy-Final-2025.pdf).

Table 2-2. Montana Prevailing Wage ($/hr)

Title	Wage	Benefit	Total
Construction Equipment Op, Group 3	$38.00	$16.35	**$54.35**

2.4 PURCHASE OPTION FOR LARGE EQUIPMENT FLEET

Some operations may have enough backfill material where relocation with larger style equipment may be more efficient. The list in **Table 2-3** represents equipment not typically utilized or owned by third-party contractors but may be considered for purchase if material movements are large enough. As many operations would not be suitable for this size of equipment, additional justification is required for DEQ to approve the use of large equipment in the bond calculation. As utilization and application of equipment will vary by project, DEQ will consider capitalization of equipment outside the list provided with additional justification. Equipment necessary for site specific workflow should be readily available for mobilization and sourced through local vendors. Due to market fluctuation and availability, used equipment will not be acceptable for capitalization. Reclamation must continue during capitalized equipment lead time; this would be completed with contractor owned equipment listed in Table 2-1.

Capital purchase costs per unit utilized in bond calculations are required to be added at the end of the overall bond calculation to account for purchase of this equipment by third-party contractors. Operating costs have been separated from capital costs and are utilized in production calculation appendices.

As large sized equipment is not as easily mobilized to project sites, additional mobilization, demobilization and construction costs have been added. No salvage value is allowed at the end of the reclamation project.

Table 2-3. Large Equipment Costs ($/hr without operator) [1] [2]

Equipment Type	Equipment Description	Equivalent Match	Purchase Price per Unit	Equipment Mob/Demob and Construction	Total Capital Cost per Unit	Hourly Operating Cost	Data Source
Hydraulic Shovel	38.0 cu yd (29.0 cu m) bucket capacity, 43.0 ft (13.1 m) dump height	KOMATSU PC5500	$14,000,000.00	$420,000.00	**$14,420,000.00**	**$1,022.00**	Costmine Intelligence Equipment Cost Calculator 2024-2025
Haul Truck	205 st (186 mt), 145 cu yd (111 cu m), electric drive, 20 ft 3 in (7.2 m) empty loading height	KOMATSU 730E	$2,400,000.00	$72,000.00	**$2,472,000.00**	**$247.96**	Costmine Intelligence Equipment Cost Calculator 2024-2025
Haul Truck	250 st (227 mt), 207 cu yd (158 cu m), electric drive, 20 ft 10 in (6.4 m) empty loading height	KOMATSU 830E	$3,100,000.00	$93,000.00	**$3,193,000.00**	**$315.90**	Costmine Intelligence Equipment Cost Calculator 2024-2025
Dozer	21.0 ft (6.4 m) blade width, 850 hp	CAT D11	$3,498,900.00	$104,967.00	**$3,603,867.00**	**$218.65**	Costmine Intelligence Equipment Cost Calculator 2024-2025

[1] 200/250-Ton Truck/Shovel Fleet & 850-hp Dozer
[2] Equipment mobilization based on estimates provided by Modern Machinery (3.0% of purchase price). The total capital cost is added separated to the bond calculation (additional cost without indirect percentages applied). Operating cost is used for each unit in backfilling / grading calculations

3.0 DIRECT COSTS

Bond calculation methodology in this guideline aligns with ARM 17.24.1102 and utilizes third-party contractor assumptions for completion of all reclamation activities. These guidelines utilize standard construction industry cost-estimating practices for determining earthmoving, facilities demolition, and revegetation costs which account for most of the bond amount. The direct costs items listed in the bond determination are intended to capture the primary components of reclamation.

DEQ bond calculation steps align with OSMRE guidelines for completing the following steps sequentially:

- Determination of the point of maximum reclamation cost liability for the responsibility period;
- Estimation of direct costs including backfill and grading, drill and blast, facilities demolition, haul road removal, pond and trap removal, scarification and finish grading, and revegetation;
- Adjustment of direct costs for inflation;
- Estimation of indirect reclamation costs including mobilization and demobilization, engineering redesign, contractor profit and overhead, project management, and contingencies; then
- Determination of the total bond amount.

3.1 BACKFILL AND ROUGH GRADING

The bond calculation should include all equipment, procedures, volumes, and costs associated with relocation of all materials; this would be represented by the difference between an updated topography and approved postmine topography (PMT) surface.

Backfill and grading calculations must be based on the **worst-case scenario**; for operators completing yearly adjustments to bond amounts, this would be based on the projected surface for the future year of worst-case disturbance for the bond year. If bond adjustments are completed on 5-year renewal periods, the worst-case scenario must represent the estimated topography at the end of the 5-year period. If mine plans are updated or are reported to deviate from the proposed worst-case scenario, updated bond calculations will be necessary. Bond calculations must be based on the difference between the projected worst-case disturbance surface and an approved PMT surface.

Backfill and grading calculations must align with **ARM 17.24.501(6)(b):** *"Backfilling and grading must be completed within two years after coal removal from each pit has been concluded. For the purpose of this provision, "each pit" means any continuous dragline pass within a particular permit area."*

Backfilling and rough grading calculation are typically completed through determination of cut/fill polygons to efficiently balance worst-case topography to the approved PMT surface. Operators must submit all elements of these calculations including polygon boundaries, equipment utilized in material movement, volume moved from cut polygon, destination polygon for fill material, cut/fill centroid determination, average grade for each material movement step, haul distances and grades for Truck/Shovel Fleet (TSF) movement, and applicable drill and blast costs for individual polygons.

Dozer push lengths must be limited to 600 feet. As efficiency greatly decreases with excessive dozer push lengths, these material movements should be reclassified from dozer movement to TSF movement.

Appendices A through **D** detail costs associated with accepted equipment through traditional earthmoving methods.

3.2 Drill and Blast

Drill and blast costs associated with fragmentation of bank material must be applied to applicable areas; this typically includes highwall reduction and compacted zones. Site specific blasting costs ($/BCY) can be applied though, if additional drilling in required, contractor quotes may be necessary for specific drilling applications. As earthmoving contractors' availability of drilling equipment may be limited, drill and blast company standard pricing should be utilized.

3.3 Facilities

All facilities and structures not approved for retention in postmining land use must be demolished and disposed of per approved permit conditions. This includes but is not limited to:

- Mining related buildings (shops, warehouses, offices, etc.)
- Crushers
- Coal storage bunkers and silos
- Conveyor systems
- Fences
- Foundations
- Power lines
- Rail spurs and embankments
- Utilities
- Bridges
- Equipment and supply storage facilities
- Haul roads or hard-surface roads
- Scoria or shale pits
- Ponds and sediment traps
- Sewage lagoons
- Culverts
- Support facilities (fuel tanks, equipment ready-lines, water tanks, explosive storage tanks)

Specific line-item costs for each demolition step are required in calculating facilities removal. Gordian's RS Means Software offers comprehensive cost estimates for heavy civil construction demolition and is commonly used in facilities removal estimations (https://www.gordian.com/products/rsmeans-data-services/).

When referencing cost estimation data sources, total costs should not include contractor overhead and profits; these costs are regarded as an indirect and are added later as a percentage of total direct costs.

Salvage value of building materials or abandoned supplies and equipment are not allowed due to volatility in the salvage market. Unless cost references specifically note disposal within the description, additional transportation, landfill disposal, and other costs associated with disposal of demolition debris in an approved solid waste disposal facility must be addressed.

A plan and associated supporting materials for hydrocarbon soil testing and hazardous material removal must be included in facility removal and cost calculations.

Building demolition specific cost items should include the following (if-applicable):

- Building demolition based on construction of materials (wood, concrete, reinforced concrete, steel, etc.)
- Concrete slab demolition
- Footer demolition
- Column footer demolition
- Retaining wall demolition
- Equipment dismantling
- Conveyor removal
- Gutting costs
- Electrical removal
- Above ground piping and valves
- Well pump removal and abandonment
- Concrete disposal (on or off-site)
- Investigation and testing of hazardous building materials
- Hazardous material removal and disposal

Ripping and grading of haul roads and compacted surfaces with dozers are calculated with associated costs in **Appendix F**.

3.4 SCARIFICATION/FINISH GRADING AND SOIL REDISTRIBUTION

Recontouring, scarification, and drainage finish grading of backfilled areas in preparation for topsoil redistribution must be planned and calculated separately from backfill and grading. Any backfill or regraded area that does not have Phase I bond release approval will need to apply grading costs with dozers; this work relates to field tie-in and drainage establishment where motor grader efficiencies would not apply. Costs associated with scarification and finish grading with motor graders are calculated in **Appendix E** and should be applied in soiling calculations. Any heavily compacted surfaces must be ripped and prepared for soil redistribution; **Appendix F** has associated costs for ripping heavily compacted surfaces with dozers.

As earthmoving contractors typically have 100-ton TSF and motor graders available, all related topsoil redistribution must be calculated utilizing this standard equipment fleet, unless capital costs for large style equipment have been captured in backfill and grading. Topsoil stockpiles must be tracked and reported by horizon or designated use of the soil and utilized entirely for reclamation activities. Topsoil

movement must be reported by topsoil cut location, volume of material relocated, destination of relocated material, haul distances and grades, and equipment utilized.

If the stockpiled topsoil on-site will not be sufficient for the complete permitted cover depth, a mitigation plan must be provided and estimated costs for completion of mitigation efforts added.

3.5 REVEGETATION

Calculations for revegetation should consist of seedbed preparation, soil sampling, soil amendment application, seeding, planting and mulching. The total acres of disturbance will need revegetation costs applied. As weather and site conditions will vary and may impact vegetative growth, necessary funds for additional seeding, weed control, monitoring, etc., will need to be included in bond calculations until all disturbed acres are released in a final (typically Phase IV) bond release. The costs associated with reseeding and replanting are determined by the specific conditions of the site and historical rates of vegetative failure for the operation being assessed, as well as comparable operations on similar sites. This cost estimate should account for any necessary soil sampling, regrading, and earthmoving expenses involved in evaluating and repairing the site as part of the reseeding and replanting process.

3.6 SUBCATEGORY RECLAMATION COSTS

Additional costs for subcategory items necessary for successful reclamation should be considered such as soil and water sampling, monitoring, site dewatering, drill hole plugging, hazardous waste disposal, and post-mining site management. These topics represent some of the generic costs encountered during bond calculations; each site will encounter permit specific costs which should be captured and calculated based on the operator's best judgement.

3.6.1 Sampling

Sampling costs should include both initial and ongoing sampling of soil and water quality. Initial sampling before reclamation operations begin may be necessary to track any impacts to water and soil resources during the life of the project. Ongoing sampling will be necessary to track changes throughout reclamation and determine site balance. The costs associated with collecting samples, laboratory analysis and reporting should be included in the bond calculation.

3.6.2 Monitoring

Continuous monitoring is crucial to ensure regulatory compliance and assess any impacts post-mining or during the reclamation process. This may include installation of monitoring wells, sensors and other equipment to measure groundwater levels, determine surface and ground water quality, and monitor for potential contaminants. Costs for equipment, maintenance, and data analysis should be included in bond calculations.

3.6.3 Dewatering

Pit dewatering for highwall reduction or pit backfill reclamation operations may be necessary if conditions require. Costs for pumping, maintenance, and monitoring should be included for dewatering

operations. Pit inflow assumptions must be included in calculations; historic data must be utilized, if any exists, in site inflow calculations.

3.6.4 Drilled Holes

Removal and full reclamation of monitoring wells and prospecting holes needs to be calculated and considered in bond calculations. A list of all prospect drill holes requiring reclamation should include but is not limited to:

- Hole identification
- Total depth
- Acres disturbed
- Equipment utilized in site reclamation
- Seed mix applied to drill pad

DEQ bond rates for prospecting drill holes can be found at the following link.
https://deq.mt.gov/files/Land/CoalUranium/Forms/ProspectingLongForm.docx

3.6.5 Hazardous Waste Disposal

Any hazardous waste encountered during reclamation of the site, such as disposal of land farmed material, will need to be disposed of complying with ARM 17.24.507 through ARM 17.24.510. Operators should calculate associated costs typically encountered with waste disposal while aligning with ARM 17.24.507(a) stating, 'Placement, storage, and disposal must ensure that leachate and surface runoff do not degrade surface or ground water, that fires are prevented, and that the area remains stable and suitable for reclamation and revegetation compatible with the natural surroundings.' Ripping and grading of haul roads and compacted surfaces with dozers are calculated with associated costs in **Appendix F**.

3.6.6 Post-Mining Site Management

If conditions require, post-mining site management costs must be added to bond calculations. These costs would include management personnel travel to the site along with any additional engineering necessary with monitoring reclamation conditions.

3.7 INFLATION ADJUSTMENT

Once direct costs have been calculated, inflation adjustments must be made prior to applying indirect cost percentages. This procedure aligns with OSMRE bonding guidelines to account for anticipated inflationary increases in reclamation costs during the permit term and after permit expiration. Inflation adjustments must be applied based on the length of time between bond recalculations.

Inflation adjustments for other varying permit term schedules will be calculated by using historical cost indexes from RS Means. For example, to calculate a 5-year permit term adjustment, the most recent RS Means cost index would be divided by the historical cost index from 5-years prior to determine the inflation factor.

Inflation factors will be multiplied by the total direct costs to determine the inflated total direct costs before computing indirect costs.

4.0 INDIRECT COSTS

Indirect costs are applied as a percentage of the inflated total direct costs to account for any additional expenses DEQ may incur upon bond forfeiture. DEQ accepted indirect cost rates are based on historically acknowledged rates and OSMRE recognized rates (Office of Surface Mining Reclamation and Enforcement, 2020). OSMRE considers their rates acceptable after their review of Federal indirect costs (Office of Surface Mining Reclamation and Enforcement, 2020, Table C1-D Indirect Cost Guidelines).

4.1 MOBILIZATION AND DEMOBILIZATION

Costs associated with moving equipment to and from the reclamation site will vary based on the size, type, and number of equipment utilized. If additional steps for reclamation are planned to be completed once the primary equipment fleet has been demobilized (sedimentation pond removal, additional seeding and weed control, etc.) separate mobilization/demobilization will be necessary and costs will need to be calculated accordingly. As mobilization and demobilization rates are determined by time constraints, special need, presence of non-standard features or conditions impacting mobility, and location, determination of actual rates will vary by permit; operators must provide narrative explaining the basis of cost estimation for this indirect cost.

The DEQ acceptable value for mobilization/demobilization is 3.0%; this value is consistent with OSMRE guidelines.

4.2 ENGINEERING REDESIGN

In the event of bond forfeiture, additional planning and redesign may be required as the bond calculation at the time of forfeiture may not reflect actual site conditions. Plans may not be adequately detailed enough to act as contractor plans and specifications; in this event, DEQ would be required to modify the plans for reclamation. OSMRE identifies potential activities necessary for modification as:

- Preparing maps and plans to show the extent of required reclamation;
- Surveying topsoil and overburden stockpiles to determine the amount of material available;
- Analyzing topsoil and overburden stockpiles to determine whether special handling is necessary;
- Evaluating structures to assess the difficulty of demolition and removal;
- Evaluating impoundments and roads to determine any special reclamation needs (such as the presence of toxic materials), the feasibility of leaving those structures in place, and the rehabilitation needed to ensure stability and facilitate the postmining land use;
- Assessing the condition of areas reclaimed by the permittee to determine whether additional work is needed to complete the reclamation plan; and
- Preparing contract documents.

Operators must provide narrative explaining the basis of cost estimates, citing references, for this indirect cost.

The DEQ acceptable value for engineering redesign is 4.0%; this value is consistent with ranges listed in OSMRE's Handbook for Calculation of Reclamation Bond Amounts (Office of Surface Mining Reclamation and Enforcement, 2020, Table C1-D Indirect Cost Guidelines).

4.3 CONTRACTOR PROFIT AND OVERHEAD

Contractor profit and overhead are commonly paired under the label "O&P" in civil cost estimating, though project specific rates for contractor overhead must be considered separately from contractor profit rates; overhead rates are project size dependent while contractor profit range is typically based on overall risk of the project.

The DEQ acceptable value for contractor profit is 10.0%.

The DEQ acceptable value for contractor overhead is 10.0%; these values are consistent with ranges listed in OSMRE's Handbook for Calculation of Reclamation Bond Amounts (Office of Surface Mining Reclamation and Enforcement, 2020, Table C1-D Indirect Cost Guidelines).

4.4 PROJECT MANAGEMENT

This indirect cost applies to costs associated with hiring a project management firm to inspect and supervise work performed by the reclamation contractor.

The DEQ acceptable value for project management is 3.0%; this value is consistent with values listed in OSMRE's Handbook for Calculation of Reclamation Bond Amounts (Office of Surface Mining Reclamation and Enforcement, 2020, Table 1 Project Management Fee).

4.5 CONTINGENCIES

Bond calculations must include a contingency allowance to account for any unanticipated costs; this cost is typical based on unknowns and uncertainty in assumptions utilized in reclamation plans and cost estimates. This cost should not be used to cover any reclamation step or cost where sufficient information is available to determine the associated direct cost. This allowance would also be used to cover any costs incurred between the delay of bond forfeiture and beginning of reclamation work on-site.

DEQ acceptable standard for contingency allowance is 5.0%; these values are consistent with ranges listed in OSMRE's Handbook for Calculation of Reclamation Bond Amounts (Office of Surface Mining Reclamation and Enforcement, 2020, Table C1-D Indirect Cost Guidelines).

5.0 ADDITIONAL BONDING GUIDANCE

The following topics are intended to provide operators with clear standards on submittal guidance of additional bonding documents or utilization of elements within bond calculations.

5.1 ANNUAL BONDING

Pursuant to ARM 17.24.501(4), final grading must conform to the approximate original contour of the land. This requirement is satisfied through the development of an approved PMT. DEQ is responsible for ensuring compliance with this requirement during the bond determination process, as outlined in ARM 17.24.1102. All bonding calculations must be completed based on an approved PMT. All annual bonding applicants must provide calculations based on their approved PMT.

5.2 MAPS

The following maps must be submitted for the bond calculation.

5.2.1 Projected Disturbance Map

This map shall depict the actual or projected worst-case topographic conditions at time of the bond calculation.

5.2.2 PMT Map

This map illustrates the approved postmine topography utilized in cut/fill balances for bond calculations. The approved PMT must follow all MSUMRA reclamation requirements and have prior approval by DEQ before utilization in bond calculations.

5.2.3 Cut/Fill Map

This map provides a comparison between the Disturbance Map and the approved PMT Map. It identifies areas where cut or fill is necessary to adjust the worst-case topography to the approved PMT Map.

5.2.4 Earthwork Map

The Cut/Fill Map serves as the basis for the creation of the Earthwork Map, which identifies volumetric polygons for dozer, truck/shovel, and scraper overburden material movement. Each cut polygon is paired with an associated fill polygon. The map will delineate polygon centroids, grades and haul routes between polygons. It is required that all centroids include elevation values if haulage grades are used for equipment productivity calculations. The routing of truck and scraper haulage must be realistic and include valid haul roads. The purpose is to determine variables utilized in calculations for dozing and TSF movement.

5.2.5 Topsoil Map

This map shall show the planned topsoil replacement activities associated with the bond estimate. This typically includes:

- Topsoil source stockpile
- Final reclamation field polygon
- Haul distance
- Dozer push distance and slope
- Permit specific details (spoil only areas, etc)

5.3 RECLAMATION TIMETABLE

Pursuant to ARM 17.24.313(b), operators must provide 'a detailed timetable for the estimated completion of each major step in the reclamation plan'. The timetable will aid in DEQ's understanding of proposed reclamation steps and major developments; in the event of bond forfeiture, this document would represent project scope for reclamation and be sent to contractors in the bid solicitation process. A general reclamation map showing progression of reclamation operations must be included in the submittal package.

A Gantt chart with each step in reclamation would be suitable for submittal.

5.4 DOCUMENT SUBMITTAL

Applicants must submit all documents pursuant to ARM 17.24.313 including:

- Reclamation plan and narrative
- Reclamation timetable
- Bond calculation documents (Excel and PDF format)
- Maps (AutoCAD and PDF format)
    - Disturbance Map
    - PMT Map
    - Cut/Fill Map (created from difference between Disturbance Map and PMT Map)
    - Earthwork Map (including dozer and TSF polygons)
    - Topsoil Map (including all relevant information utilized in calculations)

Any information or data utilized in calculations must be submitted and available for DEQ validation.

WORKS CITED

Caterpillar. (2011). *Caterpillar Performance Handbook Edition 41.*

Caterpillar. (2011, 7 24). *Caterpillar Performance Handbook Edition 41.*

Caterpillar. (2019). *Caterpillar Performance Handbook Edition 49.*

Costmine Intelligence. (2024). *Costmine Intelligence*. Retrieved from https://www.costmine.com/

Komatsu. (2019). *Specifications & Applications Handbook Edition 32.*

Montana Department of Labor and Industry. (2025, 5). *Montana Prevailing Wage Rates*. Retrieved from https://erd.dli.mt.gov/labor-standards/state-prevailing-wage-rates/

Montana Department of Transportation. (2025, 5). *Monthly Average Fuel Prices*. Retrieved from https://www.mdt.mt.gov/business/contracting/fuel-prices.aspx

Office of Surface Mining Reclamation and Enforcement. (2020). *Handbook for Calculation of Reclamation Bond Amounts.*

APPENDIX A: MATERIAL RELOCATION WITH STANDARD 100-TON TRUCK/SHOVEL FLEET

The cost tables listed within Appendix A only apply to relocation of materials; additional costs will be required for grading once material has been hauled to its destination. Additional costs will also need to be applied if drill/blast is required (See **Section 3.2 Drill and Blast**).

Determine cost per BCY by utilizing the tables below. All tables listed below include a 4.0% rolling resistance in the equivalent grades; add the average road grade and 4.0% rolling resistance to achieve the equivalent grade, then match to the applicable table. No additional calculations should be necessary. The following calculations assume that the total cost per hour for equipment includes the operator.

Table A-1. 100-Ton TSF Operating Cost [3]

Equipment	Quantity Used in Fleet	Cost ($/hr)
CAT 992 Loader	1	$412.06
CAT 777 Haul Trucks	TBD	$249.51
12,000 Gal. Water Truck	0.5	$81.87
CAT 140 Grader for Road Maintenance	0.5	$111.00
CAT D8 Dozer for Loader Support	1	$218.74
Total Fleet Cost (Less Trucks)		**$823.66**

Table A-2. Loader Production Inputs (Caterpillar, 2019)

Operation	Value
Loader Capacity (LCY)	16.00
Fill Factor	0.95
Truck Capacity (LCY)	75.00
Passes to Load Truck (round up)	5.00
Time/Loader Cycle (min)	0.65
Total Loader Cycle Time (min)	3.25
Operation Efficiency	0.83
Total Loader Productivity (LCY/hr)	**1,149**

[3] Does not include hauling costs; these costs are truck dependent and are calculated in Tables A-4 through A-8

Table A-3. 100-Ton TSF Appendix Table Summary (Caterpillar, 2011)[4]

Appendix Table	Loaded Road Grade	Rolling Resistance	Loaded Total Grade	Empty Total Grade
A-4	0.0%	4.0%	4.0%	4.0%
A-5	-5.0%	4.0%	-1.0%	9.0%
A-6	-10.0%	4.0%	-6.0%	14.0%
A-7	5.0%	4.0%	9.0%	-1.0%
A-8	10.0%	4.0%	14.0%	-6.0%

[4] Required trucks for loader balance are rounded up to the nearest half truck

Table A-4. 100-Ton TSF Production with 4.0% Loaded Grade and 4.0% Empty Grade.

One-Way Haul Distance (ft)	Load Time (min)	Maneuver Time (min)	Loaded Travel Time (min)	Dump Time (min)	Empty Travel Time (min)	Total Cycle Time (min)	Trips Per Hour	Truck Payload (LCY)	Total Truck Production (LCY/hr)	Loader Production (LCY/hr)	Trucks Required	Total Cost ($/LCY)
500	3.25	0.70	0.25	1.10	0.15	5.45	11.0	75.0	826	1,149	1.5	$1.04
1,000	3.25	0.70	0.56	1.10	0.30	5.91	10.2	75.0	761	1,149	2.0	$1.15
1,500	3.25	0.70	0.85	1.10	0.45	6.35	9.4	75.0	709	1,149	2.0	$1.15
2,000	3.25	0.70	1.13	1.10	0.60	6.78	8.8	75.0	664	1,149	2.0	$1.15
2,500	3.25	0.70	1.41	1.10	0.75	7.21	8.3	75.0	624	1,149	2.0	$1.15
3,000	3.25	0.70	1.69	1.10	0.90	7.64	7.9	75.0	589	1,149	2.0	$1.15
3,500	3.25	0.70	1.98	1.10	1.05	8.08	7.4	75.0	557	1,149	2.5	$1.26
4,000	3.25	0.70	2.26	1.10	1.20	8.51	7.1	75.0	529	1,149	2.5	$1.26
4,500	3.25	0.70	2.54	1.10	1.35	8.94	6.7	75.0	503	1,149	2.5	$1.26
5,000	3.25	0.70	2.82	1.10	1.50	9.37	6.4	75.0	480	1,149	2.5	$1.26
5,500	3.25	0.70	3.10	1.10	1.65	9.80	6.1	75.0	459	1,149	3.0	$1.37
6,000	3.25	0.70	3.39	1.10	1.80	10.24	5.9	75.0	439	1,149	3.0	$1.37
6,500	3.25	0.70	3.67	1.10	1.95	10.67	5.6	75.0	422	1,149	3.0	$1.37
7,000	3.25	0.70	3.95	1.10	2.10	11.10	5.4	75.0	405	1,149	3.0	$1.37

Table A-5. 100-Ton TSF Production with -1.0% Loaded Grade and 9.0% Empty Grade.

One-Way Haul Distance (ft)	Load Time (min)	Maneuver Time (min)	Loaded Travel Time (min)	Dump Time (min)	Empty Travel Time (min)	Total Cycle Time (min)	Trips Per Hour	Truck Payload (LCY)	Total Truck Production (LCY/hr)	Loader Production (LCY/hr)	Trucks Required	Total Cost ($/LCY)
500	3.25	0.70	0.14	1.10	0.28	5.47	11.0	75.0	823	1,149	1.5	$1.04
1,000	3.25	0.70	0.28	1.10	0.58	5.91	10.2	75.0	761	1,149	2.0	$1.15
1,500	3.25	0.70	0.42	1.10	0.83	6.30	9.5	75.0	714	1,149	2.0	$1.15
2,000	3.25	0.70	0.56	1.10	1.10	6.71	8.9	75.0	671	1,149	2.0	$1.15
2,500	3.25	0.70	0.70	1.10	1.40	7.15	8.4	75.0	629	1,149	2.0	$1.15
3,000	3.25	0.70	0.87	1.10	1.66	7.58	7.9	75.0	594	1,149	2.0	$1.15
3,500	3.25	0.70	0.98	1.10	1.91	7.94	7.6	75.0	567	1,149	2.5	$1.26
4,000	3.25	0.70	1.11	1.10	2.21	8.37	7.2	75.0	538	1,149	2.5	$1.26
4,500	3.25	0.70	1.25	1.10	2.50	8.80	6.8	75.0	511	1,149	2.5	$1.26
5,000	3.25	0.70	1.39	1.10	2.80	9.24	6.5	75.0	487	1,149	2.5	$1.26
5,500	3.25	0.70	1.53	1.10	3.08	9.66	6.2	75.0	466	1,149	2.5	$1.26
6,000	3.25	0.70	1.67	1.10	3.30	10.02	6.0	75.0	449	1,149	3.0	$1.37
6,500	3.25	0.70	1.81	1.10	3.61	10.47	5.7	75.0	430	1,149	3.0	$1.37
7,000	3.25	0.70	1.95	1.10	3.85	10.85	5.5	75.0	415	1,149	3.0	$1.37

Table A-6. 100-Ton TSF Production with -6.0% Loaded Grade and 14.0% Empty Grade.

One-Way Haul Distance (ft)	Load Time (min)	Maneuver Time (min)	Loaded Travel Time (min)	Dump Time (min)	Empty Travel Time (min)	Total Cycle Time (min)	Trips Per Hour	Truck Payload (LCY)	Total Truck Production (LCY/hr)	Loader Production (LCY/hr)	Trucks Required	Total Cost ($/LCY)
500	3.25	0.70	0.14	1.10	0.44	5.63	10.7	75.0	799	1,149	1.5	$1.04
1,000	3.25	0.70	0.28	1.10	0.87	6.20	9.7	75.0	726	1,149	2.0	$1.15
1,500	3.25	0.70	0.42	1.10	1.31	6.78	8.8	75.0	664	1,149	2.0	$1.15
2,000	3.25	0.70	0.56	1.10	1.74	7.35	8.2	75.0	612	1,149	2.0	$1.15
2,500	3.25	0.70	0.70	1.10	2.18	7.93	7.6	75.0	567	1,149	2.5	$1.26
3,000	3.25	0.70	0.87	1.10	2.61	8.53	7.0	75.0	528	1,149	2.5	$1.26
3,500	3.25	0.70	0.98	1.10	3.05	9.08	6.6	75.0	496	1,149	2.5	$1.26
4,000	3.25	0.70	1.11	1.10	3.35	9.51	6.3	75.0	473	1,149	2.5	$1.26
4,500	3.25	0.70	1.25	1.10	3.92	10.22	5.9	75.0	440	1,149	3.0	$1.37
5,000	3.25	0.70	1.39	1.10	4.36	10.80	5.6	75.0	417	1,149	3.0	$1.37
5,500	3.25	0.70	1.53	1.10	4.79	11.37	5.3	75.0	396	1,149	3.0	$1.37
6,000	3.25	0.70	1.67	1.10	5.23	11.95	5.0	75.0	377	1,149	3.5	$1.48
6,500	3.25	0.70	1.81	1.10	5.66	12.52	4.8	75.0	359	1,149	3.5	$1.48
7,000	3.25	0.70	1.95	1.10	6.10	13.10	4.6	75.0	344	1,149	3.5	$1.48

Table A-7. 100-Ton TSF Production with 9.0% Loaded Grade and -1.0% Empty Grade.

One-Way Haul Distance (ft)	Load Time (min)	Maneuver Time (min)	Loaded Travel Time (min)	Dump Time (min)	Empty Travel Time (min)	Total Cycle Time (min)	Trips Per Hour	Truck Payload (LCY)	Total Truck Production (LCY/hr)	Loader Production (LCY/hr)	Trucks Required	Total Cost ($/LCY)
500	3.25	0.70	0.62	1.10	0.14	5.81	10.3	75.0	775	1,149	1.5	$1.04
1,000	3.25	0.70	1.24	1.10	0.29	6.58	9.1	75.0	684	1,149	2.0	$1.15
1,500	3.25	0.70	1.86	1.10	0.43	7.34	8.2	75.0	613	1,149	2.0	$1.15
2,000	3.25	0.70	2.49	1.10	0.57	8.11	7.4	75.0	555	1,149	2.5	$1.26
2,500	3.25	0.70	3.11	1.10	0.71	8.87	6.8	75.0	507	1,149	2.5	$1.26
3,000	3.25	0.70	3.73	1.10	0.86	9.64	6.2	75.0	467	1,149	2.5	$1.26
3,500	3.25	0.70	4.35	1.10	1.00	10.40	5.8	75.0	433	1,149	3.0	$1.37
4,000	3.25	0.70	4.97	1.10	1.14	11.16	5.4	75.0	403	1,149	3.0	$1.37
4,500	3.25	0.70	5.59	1.10	1.29	11.93	5.0	75.0	377	1,149	3.5	$1.48
5,000	3.25	0.70	6.21	1.10	1.43	12.69	4.7	75.0	355	1,149	3.5	$1.48
5,500	3.25	0.70	6.84	1.10	1.57	13.46	4.5	75.0	334	1,149	3.5	$1.48
6,000	3.25	0.70	7.46	1.10	1.71	14.22	4.2	75.0	316	1,149	4.0	$1.59
6,500	3.25	0.70	8.08	1.10	1.86	14.99	4.0	75.0	300	1,149	4.0	$1.59
7,000	3.25	0.70	8.70	1.10	2.00	15.75	3.8	75.0	286	1,149	4.5	$1.69

Table A-8. 100-Ton TSF Production with 14.0% Loaded Grade and -6.0% Empty Grade.

One-Way Haul Distance (ft)	Load Time (min)	Maneuver Time (min)	Loaded Travel Time (min)	Dump Time (min)	Empty Travel Time (min)	Total Cycle Time (min)	Trips Per Hour	Truck Payload (LCY)	Total Truck Production (LCY/hr)	Loader Production (LCY/hr)	Trucks Required	Total Cost ($/LCY)
500	3.25	0.70	0.99	1.10	0.14	6.18	9.7	75.0	728	1,149	2.0	$1.15
1,000	3.25	0.70	1.98	1.10	0.29	7.32	8.2	75.0	615	1,149	2.0	$1.15
1,500	3.25	0.70	2.97	1.10	0.43	8.45	7.1	75.0	533	1,149	2.5	$1.26
2,000	3.25	0.70	3.96	1.10	0.57	9.58	6.3	75.0	470	1,149	2.5	$1.26
2,500	3.25	0.70	4.95	1.10	0.71	10.71	5.6	75.0	420	1,149	3.0	$1.37
3,000	3.25	0.70	5.94	1.10	0.86	11.85	5.1	75.0	380	1,149	3.5	$1.48
3,500	3.25	0.70	6.93	1.10	1.00	12.98	4.6	75.0	347	1,149	3.5	$1.48
4,000	3.25	0.70	7.91	1.10	1.14	14.10	4.3	75.0	319	1,149	4.0	$1.59
4,500	3.25	0.70	8.96	1.10	1.29	15.30	3.9	75.0	294	1,149	4.0	$1.59
5,000	3.25	0.70	9.89	1.10	1.43	16.37	3.7	75.0	275	1,149	4.5	$1.69
5,500	3.25	0.70	10.88	1.10	1.57	17.50	3.4	75.0	257	1,149	4.5	$1.69
6,000	3.25	0.70	11.87	1.10	1.71	18.63	3.2	75.0	242	1,149	5.0	$1.80
6,500	3.25	0.70	12.86	1.10	1.86	19.77	3.0	75.0	228	1,149	5.5	$1.91
7,000	3.25	0.70	13.85	1.10	2.00	20.90	2.9	75.0	215	1,149	5.5	$1.91

APPENDIX B: MATERIAL RELOCATION COSTS WITH LARGE 200/250-TON TRUCK/SHOVEL FLEETS

The cost tables listed within Appendix B only apply to relocation of materials; additional costs will be required for grading once material has been hauled to its destination. Additional costs will also need to be applied if drill/blast is required (See **Section 3.2 Drill and Blast**). Capital purchase costs for equipment will need to be added in addition to calculated operating costs.

Determine cost per BCY by utilizing the tables below. All tables listed below include a 4.0% rolling resistance in the equivalent grades; add the average road grade and 4.0% rolling resistance to achieve the equivalent grade, then match to the applicable table. No additional calculations should be necessary. The following calculations assume that the total cost per hour for equipment includes the operator.

Table B-1: 200-Ton TSF Operating Cost [5]

Equipment	Quantity Used in Fleet	Cost ($/hr)
PC5500 Shovel	1	$1,076.35
730E Haul Trucks	TBD	$302.31
12,000 Gal. Water Truck	0.5	$81.87
CAT 16 Grader for Road Maintenance	0.5	$79.61
CAT D8 Dozer for Shovel Support	1	$218.74
Total Fleet Cost (Less Trucks)		**$1,456.56**

Table B-2: 200-Ton TSF Production Inputs (Komatsu, 2019)

Operation	Value
Shovel Capacity (LCY)	38.00
Fill Factor	0.95
Truck Capacity (LCY)	145.00
Passes to Load Truck (round up)	4.00
Time/Shovel Cycle (min)	0.67
Total Shovel Cycle Time (min)	2.67
Operation Efficiency	0.83
Total Shovel Productivity (LCY/hr)	**2,708**

[5] Does not include hauling costs. Hauling costs are truck dependent and are calculated in Tables B-4 through B-8

Table B-3: 250-Ton TSF Operating Cost [6]

Equipment	Quantity Used in Fleet	Cost ($/hr)
PC5500 Shovel	1	$1,076.35
830E Haul Trucks	TBD	$370.25
12,000 Gal. Water Truck	0.5	$81.87
CAT 16 Grader for Road Maintenance	0.5	$79.61
CAT D8 Dozer for Shovel Support	1	$218.74
Total Fleet Cost (Less Trucks)		**$1,456.56**

Table B-4: 250-Ton TSF Production Inputs (Komatsu, 2019)

Operation	Value
Shovel Capacity (LCY)	38.00
Fill Factor	0.95
Truck Capacity (LCY)	170.00
Passes to Load Truck (round up)	5.00
Time/Shovel Cycle (min)	0.67
Total Shovel Cycle Time (min)	3.33
Operation Efficiency	0.83
Total Shovel Productivity (LCY/hr)	**2,540**

[6] Does not include hauling costs. Hauling costs are truck dependent and are calculated in Tables B-9 through B-13

Table B-3. 200/250-Ton TSF Appendix Table Summary (Komatsu, 2019) [7] [8]

Appendix Table	Loaded Road Grade	Rolling Resistance	Loaded Total Grade	Empty Total Grade
B-4, B-9	0.0%	4.0%	4.0%	4.0%
B-5, B-10	-5.0%	4.0%	-1.0%	9.0%
B-6, B-11	-10.0%	4.0%	-6.0%	14.0%
B-7, B-12	5.0%	4.0%	9.0%	-1.0%
B-8, B-13	10.0%	4.0%	14.0%	-6.0%

[7] Required trucks for shovel balance are rounded up to the nearest truck
[8] Maximum speed in calculations limited to 30 MPH

Table B-4. 200-Ton TSF Production with 4.0% Loaded Grade and 4.0% Empty Grade.

One-Way Haul Distance (ft)	Load Time (min)	Maneuver Time (min)	Loaded Travel Time (min)	Dump Time (min)	Empty Travel Time (min)	Total Cycle Time (min)	Trips Per Hour	Truck Payload (LCY)	Total Truck Production (LCY/hr)	Shovel Production (LCY/hr)	Trucks Required	Total Cost ($/LCY)
500	2.67	0.80	0.27	1.20	0.19	5.13	11.7	145.0	1,696	2,708	2.0	$0.76
1,000	2.67	0.80	0.55	1.20	0.38	5.59	10.7	145.0	1,555	2,708	2.0	$0.76
1,500	2.67	0.80	0.82	1.20	0.57	6.06	9.9	145.0	1,436	2,708	2.0	$0.76
2,000	2.67	0.80	1.10	1.20	0.76	6.52	9.2	145.0	1,334	2,708	3.0	$0.87
2,500	2.67	0.80	1.37	1.20	0.95	6.99	8.6	145.0	1,245	2,708	3.0	$0.87
3,000	2.67	0.80	1.65	1.20	1.14	7.45	8.1	145.0	1,168	2,708	3.0	$0.87
3,500	2.67	0.80	1.92	1.20	1.33	7.91	7.6	145.0	1,099	2,708	3.0	$0.87
4,000	2.67	0.80	2.20	1.20	1.52	8.38	7.2	145.0	1,038	2,708	3.0	$0.87
4,500	2.67	0.80	2.47	1.20	1.70	8.84	6.8	145.0	984	2,708	3.0	$0.87
5,000	2.67	0.80	2.74	1.20	1.89	9.31	6.4	145.0	935	2,708	3.0	$0.87
5,500	2.67	0.80	3.02	1.20	2.08	9.77	6.1	145.0	891	2,708	4.0	$0.98
6,000	2.67	0.80	3.29	1.20	2.27	10.23	5.9	145.0	850	2,708	4.0	$0.98
6,500	2.67	0.80	3.57	1.20	2.46	10.70	5.6	145.0	813	2,708	4.0	$0.98
7,000	2.67	0.80	3.84	1.20	2.65	11.16	5.4	145.0	780	2,708	4.0	$0.98

Table B-5. 200-Ton TSF Production with -1.0% Loaded Grade and 9.0% Empty Grade.

One-Way Haul Distance (ft)	Load Time (min)	Maneuver Time (min)	Loaded Travel Time (min)	Dump Time (min)	Empty Travel Time (min)	Total Cycle Time (min)	Trips Per Hour	Truck Payload (LCY)	Total Truck Production (LCY/hr)	Loader Production (LCY/hr)	Trucks Required	Total Cost ($/LCY)
500	2.67	0.80	0.19	1.20	0.27	5.13	11.7	145.0	1,696	2,708	2.0	$0.76
1,000	2.67	0.80	0.38	1.20	0.55	5.59	10.7	145.0	1,555	2,708	2.0	$0.76
1,500	2.67	0.80	0.57	1.20	0.82	6.06	9.9	145.0	1,436	2,708	2.0	$0.76
2,000	2.67	0.80	0.76	1.20	1.10	6.52	9.2	145.0	1,334	2,708	3.0	$0.87
2,500	2.67	0.80	0.95	1.20	1.37	6.99	8.6	145.0	1,245	2,708	3.0	$0.87
3,000	2.67	0.80	1.14	1.20	1.65	7.45	8.1	145.0	1,168	2,708	3.0	$0.87
3,500	2.67	0.80	1.33	1.20	1.92	7.91	7.6	145.0	1,099	2,708	3.0	$0.87
4,000	2.67	0.80	1.52	1.20	2.20	8.38	7.2	145.0	1,038	2,708	3.0	$0.87
4,500	2.67	0.80	1.70	1.20	2.47	8.84	6.8	145.0	984	2,708	3.0	$0.87
5,000	2.67	0.80	1.89	1.20	2.74	9.31	6.4	145.0	935	2,708	3.0	$0.87
5,500	2.67	0.80	2.08	1.20	3.02	9.77	6.1	145.0	891	2,708	4.0	$0.98
6,000	2.67	0.80	2.27	1.20	3.29	10.23	5.9	145.0	850	2,708	4.0	$0.98
6,500	2.67	0.80	2.46	1.20	3.57	10.70	5.6	145.0	813	2,708	4.0	$0.98
7,000	2.67	0.80	2.65	1.20	3.84	11.16	5.4	145.0	780	2,708	4.0	$0.98

Table B-6. 200-Ton TSF Production with -6.0% Loaded Grade and 14.0% Empty Grade.

One-Way Haul Distance (ft)	Load Time (min)	Maneuver Time (min)	Loaded Travel Time (min)	Dump Time (min)	Empty Travel Time (min)	Total Cycle Time (min)	Trips Per Hour	Truck Payload (LCY)	Total Truck Production (LCY/hr)	Loader Production (LCY/hr)	Trucks Required	Total Cost ($/LCY)
500	2.67	0.80	0.19	1.20	0.44	5.29	11.3	145.0	1,644	2,708	2.0	$0.76
1,000	2.67	0.80	0.38	1.20	0.87	5.92	10.1	145.0	1,470	2,708	2.0	$0.76
1,500	2.67	0.80	0.57	1.20	1.31	6.55	9.2	145.0	1,329	2,708	3.0	$0.87
2,000	2.67	0.80	0.76	1.20	1.75	7.17	8.4	145.0	1,213	2,708	3.0	$0.87
2,500	2.67	0.80	0.95	1.20	2.19	7.80	7.7	145.0	1,116	2,708	3.0	$0.87
3,000	2.67	0.80	1.14	1.20	2.62	8.43	7.1	145.0	1,033	2,708	3.0	$0.87
3,500	2.67	0.80	1.33	1.20	3.06	9.05	6.6	145.0	961	2,708	3.0	$0.87
4,000	2.67	0.80	1.52	1.20	3.50	9.68	6.2	145.0	899	2,708	4.0	$0.98
4,500	2.67	0.80	1.70	1.20	3.93	10.30	5.8	145.0	844	2,708	4.0	$0.98
5,000	2.67	0.80	1.89	1.20	4.37	10.93	5.5	145.0	796	2,708	4.0	$0.98
5,500	2.67	0.80	2.08	1.20	4.81	11.56	5.2	145.0	753	2,708	4.0	$0.98
6,000	2.67	0.80	2.27	1.20	5.24	12.18	4.9	145.0	714	2,708	4.0	$0.98
6,500	2.67	0.80	2.46	1.20	5.68	12.81	4.7	145.0	679	2,708	4.0	$0.98
7,000	2.67	0.80	2.65	1.20	6.12	13.44	4.5	145.0	647	2,708	5.0	$1.10

Table B-7. 200-Ton TSF Production with 9.0% Loaded Grade and -1.0% Empty Grade.

One-Way Haul Distance (ft)	Load Time (min)	Maneuver Time (min)	Loaded Travel Time (min)	Dump Time (min)	Empty Travel Time (min)	Total Cycle Time (min)	Trips Per Hour	Truck Payload (LCY)	Total Truck Production (LCY/hr)	Loader Production (LCY/hr)	Trucks Required	Total Cost ($/LCY)
500	2.67	0.80	0.62	1.20	0.19	5.47	11.0	145.0	1,589	2,708	2.0	$0.76
1,000	2.67	0.80	1.24	1.20	0.38	6.28	9.6	145.0	1,385	2,708	2.0	$0.76
1,500	2.67	0.80	1.85	1.20	0.57	7.09	8.5	145.0	1,227	2,708	3.0	$0.87
2,000	2.67	0.80	2.47	1.20	0.76	7.89	7.6	145.0	1,102	2,708	3.0	$0.87
2,500	2.67	0.80	3.09	1.20	0.95	8.70	6.9	145.0	1,000	2,708	3.0	$0.87
3,000	2.67	0.80	3.71	1.20	1.14	9.51	6.3	145.0	915	2,708	3.0	$0.87
3,500	2.67	0.80	4.32	1.20	1.33	10.32	5.8	145.0	843	2,708	4.0	$0.98
4,000	2.67	0.80	4.94	1.20	1.52	11.12	5.4	145.0	782	2,708	4.0	$0.98
4,500	2.67	0.80	5.56	1.20	1.70	11.93	5.0	145.0	729	2,708	4.0	$0.98
5,000	2.67	0.80	6.18	1.20	1.89	12.74	4.7	145.0	683	2,708	4.0	$0.98
5,500	2.67	0.80	6.79	1.20	2.08	13.54	4.4	145.0	642	2,708	5.0	$1.10
6,000	2.67	0.80	7.41	1.20	2.27	14.35	4.2	145.0	606	2,708	5.0	$1.10
6,500	2.67	0.80	8.03	1.20	2.46	15.16	4.0	145.0	574	2,708	5.0	$1.10
7,000	2.67	0.80	8.65	1.20	2.65	15.96	3.8	145.0	545	2,708	5.0	$1.10

Table B-8. 200-Ton TSF Production with 14.0% Loaded Grade and -6.0% Empty Grade.

One-Way Haul Distance (ft)	Load Time (min)	Maneuver Time (min)	Loaded Travel Time (min)	Dump Time (min)	Empty Travel Time (min)	Total Cycle Time (min)	Trips Per Hour	Truck Payload (LCY)	Total Truck Production (LCY/hr)	Loader Production (LCY/hr)	Trucks Required	Total Cost ($/LCY)
500	2.67	0.80	0.96	1.20	0.19	5.82	10.3	145.0	1,495	2,708	2.0	$0.76
1,000	2.67	0.80	1.93	1.20	0.38	6.97	8.6	145.0	1,248	2,708	3.0	$0.87
1,500	2.67	0.80	2.89	1.20	0.57	8.12	7.4	145.0	1,071	2,708	3.0	$0.87
2,000	2.67	0.80	3.85	1.20	0.76	9.28	6.5	145.0	938	2,708	3.0	$0.87
2,500	2.67	0.80	4.82	1.20	0.95	10.43	5.8	145.0	834	2,708	4.0	$0.98
3,000	2.67	0.80	5.78	1.20	1.14	11.58	5.2	145.0	751	2,708	4.0	$0.98
3,500	2.67	0.80	6.74	1.20	1.33	12.73	4.7	145.0	683	2,708	4.0	$0.98
4,000	2.67	0.80	7.70	1.20	1.52	13.89	4.3	145.0	627	2,708	5.0	$1.10
4,500	2.67	0.80	8.67	1.20	1.70	15.04	4.0	145.0	579	2,708	5.0	$1.10
5,000	2.67	0.80	9.63	1.20	1.89	16.19	3.7	145.0	537	2,708	6.0	$1.21
5,500	2.67	0.80	10.59	1.20	2.08	17.34	3.5	145.0	502	2,708	6.0	$1.21
6,000	2.67	0.80	11.56	1.20	2.27	18.50	3.2	145.0	470	2,708	6.0	$1.21
6,500	2.67	0.80	12.52	1.20	2.46	19.65	3.1	145.0	443	2,708	7.0	$1.32
7,000	2.67	0.80	13.48	1.20	2.65	20.80	2.9	145.0	418	2,708	7.0	$1.32

Table B-9. 250-Ton TSF Production with 4.0% Loaded Grade and 4.0% Empty Grade.

One-Way Haul Distance (ft)	Load Time (min)	Maneuver Time (min)	Loaded Travel Time (min)	Dump Time (min)	Empty Travel Time (min)	Total Cycle Time (min)	Trips Per Hour	Truck Payload (LCY)	Total Truck Production (LCY/hr)	Shovel Production (LCY/hr)	Trucks Required	Total Cost ($/LCY)
500	3.33	0.80	0.27	1.20	0.19	5.80	10.3	170.0	1,759	2,540	2.0	$0.81
1,000	3.33	0.80	0.55	1.20	0.38	6.26	9.6	170.0	1,629	2,540	2.0	$0.81
1,500	3.33	0.80	0.82	1.20	0.57	6.72	8.9	170.0	1,517	2,540	2.0	$0.81
2,000	3.33	0.80	1.10	1.20	0.76	7.19	8.3	170.0	1,419	2,540	2.0	$0.81
2,500	3.33	0.80	1.37	1.20	0.95	7.65	7.8	170.0	1,333	2,540	2.0	$0.81
3,000	3.33	0.80	1.65	1.20	1.14	8.12	7.4	170.0	1,257	2,540	3.0	$0.93
3,500	3.33	0.80	1.92	1.20	1.33	8.58	7.0	170.0	1,189	2,540	3.0	$0.93
4,000	3.33	0.80	2.20	1.20	1.52	9.04	6.6	170.0	1,128	2,540	3.0	$0.93
4,500	3.33	0.80	2.47	1.20	1.70	9.51	6.3	170.0	1,073	2,540	3.0	$0.93
5,000	3.33	0.80	2.74	1.20	1.89	9.97	6.0	170.0	1,023	2,540	3.0	$0.93
5,500	3.33	0.80	3.02	1.20	2.08	10.44	5.7	170.0	977	2,540	3.0	$0.93
6,000	3.33	0.80	3.29	1.20	2.27	10.90	5.5	170.0	936	2,540	3.0	$0.93
6,500	3.33	0.80	3.57	1.20	2.46	11.36	5.3	170.0	898	2,540	3.0	$0.93
7,000	3.33	0.80	3.84	1.20	2.65	11.83	5.1	170.0	862	2,540	3.0	$0.93

Table B-10. 250-Ton TSF Production with -1.0% Loaded Grade and 9.0% Empty Grade.

One-Way Haul Distance (ft)	Load Time (min)	Maneuver Time (min)	Loaded Travel Time (min)	Dump Time (min)	Empty Travel Time (min)	Total Cycle Time (min)	Trips Per Hour	Truck Payload (LCY)	Total Truck Production (LCY/hr)	Loader Production (LCY/hr)	Trucks Required	Total Cost ($/LCY)
500	3.33	0.80	0.19	1.20	0.27	5.80	10.3	170.0	1,759	2,540	2.0	$0.81
1,000	3.33	0.80	0.38	1.20	0.55	6.26	9.6	170.0	1,629	2,540	2.0	$0.81
1,500	3.33	0.80	0.57	1.20	0.82	6.72	8.9	170.0	1,517	2,540	2.0	$0.81
2,000	3.33	0.80	0.76	1.20	1.10	7.19	8.3	170.0	1,419	2,540	2.0	$0.81
2,500	3.33	0.80	0.95	1.20	1.37	7.65	7.8	170.0	1,333	2,540	2.0	$0.81
3,000	3.33	0.80	1.14	1.20	1.65	8.12	7.4	170.0	1,257	2,540	3.0	$0.93
3,500	3.33	0.80	1.33	1.20	1.92	8.58	7.0	170.0	1,189	2,540	3.0	$0.93
4,000	3.33	0.80	1.52	1.20	2.20	9.04	6.6	170.0	1,128	2,540	3.0	$0.93
4,500	3.33	0.80	1.70	1.20	2.47	9.51	6.3	170.0	1,073	2,540	3.0	$0.93
5,000	3.33	0.80	1.89	1.20	2.74	9.97	6.0	170.0	1,023	2,540	3.0	$0.93
5,500	3.33	0.80	2.08	1.20	3.02	10.44	5.7	170.0	977	2,540	3.0	$0.93
6,000	3.33	0.80	2.27	1.20	3.29	10.90	5.5	170.0	936	2,540	3.0	$0.93
6,500	3.33	0.80	2.46	1.20	3.57	11.36	5.3	170.0	898	2,540	3.0	$0.93
7,000	3.33	0.80	2.65	1.20	3.84	11.83	5.1	170.0	862	2,540	3.0	$0.93

Table B-11. 250-Ton TSF Production with -6.0% Loaded Grade and 14.0% Empty Grade.

One-Way Haul Distance (ft)	Load Time (min)	Maneuver Time (min)	Loaded Travel Time (min)	Dump Time (min)	Empty Travel Time (min)	Total Cycle Time (min)	Trips Per Hour	Truck Payload (LCY)	Total Truck Production (LCY/hr)	Loader Production (LCY/hr)	Trucks Required	Total Cost ($/LCY)
500	3.33	0.80	0.19	1.20	0.44	5.96	10.1	170.0	1,711	2,540	2.0	$0.81
1,000	3.33	0.80	0.38	1.20	0.87	6.59	9.1	170.0	1,549	2,540	2.0	$0.81
1,500	3.33	0.80	0.57	1.20	1.31	7.21	8.3	170.0	1,414	2,540	2.0	$0.81
2,000	3.33	0.80	0.76	1.20	1.75	7.84	7.7	170.0	1,301	2,540	2.0	$0.81
2,500	3.33	0.80	0.95	1.20	2.19	8.47	7.1	170.0	1,205	2,540	3.0	$0.93
3,000	3.33	0.80	1.14	1.20	2.62	9.09	6.6	170.0	1,122	2,540	3.0	$0.93
3,500	3.33	0.80	1.33	1.20	3.06	9.72	6.2	170.0	1,050	2,540	3.0	$0.93
4,000	3.33	0.80	1.52	1.20	3.50	10.34	5.8	170.0	986	2,540	3.0	$0.93
4,500	3.33	0.80	1.70	1.20	3.93	10.97	5.5	170.0	930	2,540	3.0	$0.93
5,000	3.33	0.80	1.89	1.20	4.37	11.60	5.2	170.0	879	2,540	3.0	$0.93
5,500	3.33	0.80	2.08	1.20	4.81	12.22	4.9	170.0	834	2,540	4.0	$1.05
6,000	3.33	0.80	2.27	1.20	5.24	12.85	4.7	170.0	794	2,540	4.0	$1.05
6,500	3.33	0.80	2.46	1.20	5.68	13.48	4.5	170.0	757	2,540	4.0	$1.05
7,000	3.33	0.80	2.65	1.20	6.12	14.10	4.3	170.0	723	2,540	4.0	$1.05

Table B-12. 250-Ton TSF Production with 9.0% Loaded Grade and -1.0% Empty Grade.

One-Way Haul Distance (ft)	Load Time (min)	Maneuver Time (min)	Loaded Travel Time (min)	Dump Time (min)	Empty Travel Time (min)	Total Cycle Time (min)	Trips Per Hour	Truck Payload (LCY)	Total Truck Production (LCY/hr)	Loader Production (LCY/hr)	Trucks Required	Total Cost ($/LCY)
500	3.33	0.80	0.62	1.20	0.19	6.14	9.8	170.0	1,661	2,540	2.0	$0.81
1,000	3.33	0.80	1.24	1.20	0.38	6.95	8.6	170.0	1,468	2,540	2.0	$0.81
1,500	3.33	0.80	1.85	1.20	0.57	7.75	7.7	170.0	1,315	2,540	2.0	$0.81
2,000	3.33	0.80	2.47	1.20	0.76	8.56	7.0	170.0	1,191	2,540	3.0	$0.93
2,500	3.33	0.80	3.09	1.20	0.95	9.37	6.4	170.0	1,089	2,540	3.0	$0.93
3,000	3.33	0.80	3.71	1.20	1.14	10.18	5.9	170.0	1,002	2,540	3.0	$0.93
3,500	3.33	0.80	4.32	1.20	1.33	10.98	5.5	170.0	929	2,540	3.0	$0.93
4,000	3.33	0.80	4.94	1.20	1.52	11.79	5.1	170.0	865	2,540	3.0	$0.93
4,500	3.33	0.80	5.56	1.20	1.70	12.60	4.8	170.0	810	2,540	4.0	$1.05
5,000	3.33	0.80	6.18	1.20	1.89	13.40	4.5	170.0	761	2,540	4.0	$1.05
5,500	3.33	0.80	6.79	1.20	2.08	14.21	4.2	170.0	718	2,540	4.0	$1.05
6,000	3.33	0.80	7.41	1.20	2.27	15.02	4.0	170.0	679	2,540	4.0	$1.05
6,500	3.33	0.80	8.03	1.20	2.46	15.82	3.8	170.0	645	2,540	4.0	$1.05
7,000	3.33	0.80	8.65	1.20	2.65	16.63	3.6	170.0	613	2,540	5.0	$1.17

Table B-13. 250-Ton TSF Production with 14.0% Loaded Grade and -6.0% Empty Grade.

One-Way Haul Distance (ft)	Load Time (min)	Maneuver Time (min)	Loaded Travel Time (min)	Dump Time (min)	Empty Travel Time (min)	Total Cycle Time (min)	Trips Per Hour	Truck Payload (LCY)	Total Truck Production (LCY/hr)	Loader Production (LCY/hr)	Trucks Required	Total Cost ($/LCY)
500	3.33	0.80	0.96	1.20	0.19	6.49	9.3	170.0	1,573	2,540	2.0	$0.81
1,000	3.33	0.80	1.93	1.20	0.38	7.64	7.9	170.0	1,335	2,540	2.0	$0.81
1,500	3.33	0.80	2.89	1.20	0.57	8.79	6.8	170.0	1,160	2,540	3.0	$0.93
2,000	3.33	0.80	3.85	1.20	0.76	9.94	6.0	170.0	1,026	2,540	3.0	$0.93
2,500	3.33	0.80	4.82	1.20	0.95	11.10	5.4	170.0	919	2,540	3.0	$0.93
3,000	3.33	0.80	5.78	1.20	1.14	12.25	4.9	170.0	833	2,540	4.0	$1.05
3,500	3.33	0.80	6.74	1.20	1.33	13.40	4.5	170.0	761	2,540	4.0	$1.05
4,000	3.33	0.80	7.70	1.20	1.52	14.55	4.1	170.0	701	2,540	4.0	$1.05
4,500	3.33	0.80	8.67	1.20	1.70	15.71	3.8	170.0	649	2,540	4.0	$1.05
5,000	3.33	0.80	9.63	1.20	1.89	16.86	3.6	170.0	605	2,540	5.0	$1.17
5,500	3.33	0.80	10.59	1.20	2.08	18.01	3.3	170.0	566	2,540	5.0	$1.17
6,000	3.33	0.80	11.56	1.20	2.27	19.16	3.1	170.0	532	2,540	5.0	$1.17
6,500	3.33	0.80	12.52	1.20	2.46	20.31	3.0	170.0	502	2,540	6.0	$1.29
7,000	3.33	0.80	13.48	1.20	2.65	21.47	2.8	170.0	475	2,540	6.0	$1.29

APPENDIX C: MATERIAL RELOCATION COSTS WITH SCRAPER FLEET

As scrapers require a uniform material type and contractors do not typically have this equipment in their fleets, a suitable regrade plan will need to be demonstrated to DEQ for consideration; specific applications will be allowed at the discretion of DEQ.

The cost tables listed within Appendix C only apply to relocation of materials; additional costs will be required for grading once material has been hauled to its destination. Additional costs will also need to be applied if drill/blast is required (See **Section 3.2 Drill and Blast**).

Determine cost per BCY by utilizing the tables below. All tables listed below include a 4.0% rolling resistance in the equivalent grades; add the average road grade and 4.0% rolling resistance to achieve the equivalent grade, then match to the applicable table. No additional calculations should be necessary. The following calculations assume that the total cost per hour for equipment includes the operator.

Table C-1: Scraper Fleet Operating Cost

Equipment	Quantity Used in Fleet	Cost ($/hr)
CAT 637 Scrapers	1	$276.40
12,000 Gal. Water Truck	0.125	$20.47
CAT 140 Grader for Road Maintenance	0.125	$17.27
CAT D9 Dozer for Scraper Support	0.125	$36.51
Total Fleet Cost Per Scraper		**$350.65**

Table C-2: Scraper Fleet Appendix Table Summary (Caterpillar, 2011)

Appendix Table	Loaded Road Grade	Rolling Resistance	Loaded Total Grade	Empty Total Grade
C-3	0.0%	4.0%	4.0%	4.0%
C-4	-5.0%	4.0%	-1.0%	9.0%
C-5	-10.0%	4.0%	-6.0%	14.0%
C-6	5.0%	4.0%	9.0%	-1.0%
C-7	10.0%	4.0%	14.0%	-6.0%

Table C-3. Scraper Production with 4.0% Loaded Grade and 4.0% Empty Grade.

One-Way Haul Distance (ft)	Load Time (min)	Loaded Travel Time (min)	Maneuver & Spread Time (min)	Empty Travel Time (min)	Total Cycle Time (min)	Trips Per Hour	Scraper Payload (BCY)	Efficiency Factor (50 min/hr)	Scraper Production (BCY/hr)	Total Cost ($/BCY)
500	1.00	0.36	0.60	0.36	2.32	25.9	27.0	0.83	580	$0.61
1,000	1.00	0.63	0.60	0.57	2.80	21.4	27.0	0.83	480	$0.73
1,500	1.00	0.90	0.60	0.75	3.25	18.5	27.0	0.83	414	$0.85
2,000	1.00	1.13	0.60	0.92	3.65	16.4	27.0	0.83	368	$0.95
2,500	1.00	1.30	0.60	1.10	4.00	15.0	27.0	0.83	336	$1.04
3,000	1.00	1.60	0.60	1.26	4.46	13.5	27.0	0.83	301	$1.16
3,500	1.00	1.80	0.60	1.45	4.85	12.4	27.0	0.83	277	$1.26
4,000	1.00	2.05	0.60	1.60	5.25	11.4	27.0	0.83	256	$1.37
4,500	1.00	2.26	0.60	1.80	5.66	10.6	27.0	0.83	238	$1.48
5,000	1.00	2.50	0.60	1.95	6.05	9.9	27.0	0.83	222	$1.58
5,500	1.00	2.70	0.60	2.15	6.45	9.3	27.0	0.83	208	$1.68
6,000	1.00	2.90	0.60	2.30	6.80	8.8	27.0	0.83	198	$1.77
6,500	1.00	3.18	0.60	2.45	7.23	8.3	27.0	0.83	186	$1.89
7,000	1.00	3.30	0.60	2.65	7.55	7.9	27.0	0.83	178	$1.97

Table C-4. Scraper Production with -1.0% Loaded Grade and 9.0% Empty Grade.

One-Way Haul Distance (ft)	Load Time (min)	Loaded Travel Time (min)	Maneuver & Spread Time (min)	Empty Travel Time (min)	Total Cycle Time (min)	Trips Per Hour	Scraper Payload (BCY)	Efficiency Factor (50 min/hr)	Scraper Production (BCY/hr)	Total Cost ($/BCY)
500	1.00	0.28	0.60	0.30	2.18	27.5	27.0	0.83	617	$0.57
1,000	1.00	0.50	0.60	0.63	2.73	22.0	27.0	0.83	493	$0.71
1,500	1.00	0.71	0.60	0.96	3.27	18.3	27.0	0.83	411	$0.85
2,000	1.00	0.87	0.60	1.27	3.74	16.0	27.0	0.83	360	$0.98
2,500	1.00	1.03	0.60	1.60	4.23	14.2	27.0	0.83	318	$1.10
3,000	1.00	1.19	0.60	1.82	4.61	13.0	27.0	0.83	292	$1.20
3,500	1.00	1.36	0.60	2.23	5.19	11.6	27.0	0.83	259	$1.35
4,000	1.00	1.52	0.60	2.50	5.62	10.7	27.0	0.83	239	$1.47
4,500	1.00	1.68	0.60	2.78	6.06	9.9	27.0	0.83	222	$1.58
5,000	1.00	1.85	0.60	3.10	6.55	9.2	27.0	0.83	205	$1.71
5,500	1.00	2.01	0.60	3.39	7.00	8.6	27.0	0.83	192	$1.83
6,000	1.00	2.17	0.60	3.72	7.49	8.0	27.0	0.83	180	$1.95
6,500	1.00	2.33	0.60	4.00	7.93	7.6	27.0	0.83	170	$2.07
7,000	1.00	2.50	0.60	4.31	8.41	7.1	27.0	0.83	160	$2.19

Table C-5. Scraper Production with -6.0% Loaded Grade and 14.0% Empty Grade.

One-Way Haul Distance (ft)	Load Time (min)	Loaded Travel Time (min)	Maneuver & Spread Time (min)	Empty Travel Time (min)	Total Cycle Time (min)	Trips Per Hour	Scraper Payload (BCY)	Efficiency Factor (50 min/hr)	Scraper Production (BCY/hr)	Total Cost ($/BCY)
500	1.00	0.28	0.60	0.52	2.40	25.0	27.0	0.83	560	$0.63
1,000	1.00	0.50	0.60	1.00	3.10	19.4	27.0	0.83	434	$0.81
1,500	1.00	0.71	0.60	1.42	3.73	16.1	27.0	0.83	360	$0.97
2,000	1.00	0.87	0.60	1.93	4.40	13.6	27.0	0.83	306	$1.15
2,500	1.00	1.03	0.60	2.28	4.91	12.2	27.0	0.83	274	$1.28
3,000	1.00	1.19	0.60	2.80	5.59	10.7	27.0	0.83	241	$1.46
3,500	1.00	1.36	0.60	3.30	6.26	9.6	27.0	0.83	215	$1.63
4,000	1.00	1.52	0.60	3.73	6.85	8.8	27.0	0.83	196	$1.79
4,500	1.00	1.68	0.60	4.21	7.49	8.0	27.0	0.83	180	$1.95
5,000	1.00	1.85	0.60	4.65	8.10	7.4	27.0	0.83	166	$2.11
5,500	1.00	2.01	0.60	5.18	8.79	6.8	27.0	0.83	153	$2.29
6,000	1.00	2.17	0.60	5.58	9.35	6.4	27.0	0.83	144	$2.44
6,500	1.00	2.33	0.60	6.08	10.01	6.0	27.0	0.83	134	$2.61
7,000	1.00	2.50	0.60	6.50	10.60	5.7	27.0	0.83	127	$2.76

Table C-6. Scraper Production with 9.0% Loaded Grade and -1.0% Empty Grade.

One-Way Haul Distance (ft)	Load Time (min)	Loaded Travel Time (min)	Maneuver & Spread Time (min)	Empty Travel Time (min)	Total Cycle Time (min)	Trips Per Hour	Scraper Payload (BCY)	Efficiency Factor (50 min/hr)	Scraper Production (BCY/hr)	Total Cost ($/BCY)
500	1.00	0.58	0.60	0.27	2.45	24.5	27.0	0.83	549	$0.64
1,000	1.00	1.10	0.60	0.40	3.10	19.4	27.0	0.83	434	$0.81
1,500	1.00	1.59	0.60	0.66	3.85	15.6	27.0	0.83	349	$1.00
2,000	1.00	2.12	0.60	0.83	4.55	13.2	27.0	0.83	296	$1.19
2,500	1.00	2.58	0.60	0.99	5.17	11.6	27.0	0.83	260	$1.35
3,000	1.00	3.05	0.60	1.15	5.80	10.3	27.0	0.83	232	$1.51
3,500	1.00	3.58	0.60	1.31	6.49	9.2	27.0	0.83	207	$1.69
4,000	1.00	4.00	0.60	1.48	7.08	8.5	27.0	0.83	190	$1.85
4,500	1.00	4.53	0.60	1.64	7.77	7.7	27.0	0.83	173	$2.03
5,000	1.00	5.02	0.60	1.80	8.42	7.1	27.0	0.83	160	$2.20
5,500	1.00	5.56	0.60	1.96	9.12	6.6	27.0	0.83	147	$2.38
6,000	1.00	6.07	0.60	2.13	9.80	6.1	27.0	0.83	137	$2.56
6,500	1.00	6.53	0.60	2.29	10.42	5.8	27.0	0.83	129	$2.72
7,000	1.00	7.00	0.60	2.45	11.05	5.4	27.0	0.83	122	$2.88

Table C-7. Scraper Production with 14.0% Loaded Grade and -6.0% Empty Grade.

One-Way Haul Distance (ft)	Load Time (min)	Loaded Travel Time (min)	Maneuver & Spread Time (min)	Empty Travel Time (min)	Total Cycle Time (min)	Trips Per Hour	Scraper Payload (BCY)	Efficiency Factor (50 min/hr)	Scraper Production (BCY/hr)	Total Cost ($/BCY)
500	1.00	0.83	0.60	0.27	2.70	22.2	27.0	0.83	498	$0.70
1,000	1.00	1.58	0.60	0.40	3.58	16.8	27.0	0.83	376	$0.93
1,500	1.00	2.36	0.60	0.66	4.62	13.0	27.0	0.83	291	$1.20
2,000	1.00	3.11	0.60	0.83	5.54	10.8	27.0	0.83	243	$1.44
2,500	1.00	3.86	0.60	0.99	6.45	9.3	27.0	0.83	208	$1.68
3,000	1.00	4.61	0.60	1.15	7.36	8.2	27.0	0.83	183	$1.92
3,500	1.00	5.42	0.60	1.31	8.33	7.2	27.0	0.83	161	$2.17
4,000	1.00	6.19	0.60	1.48	9.27	6.5	27.0	0.83	145	$2.42
4,500	1.00	6.87	0.60	1.64	10.11	5.9	27.0	0.83	133	$2.64
5,000	1.00	7.65	0.60	1.80	11.05	5.4	27.0	0.83	122	$2.88
5,500	1.00	8.32	0.60	1.96	11.88	5.1	27.0	0.83	113	$3.10
6,000	1.00	9.10	0.60	2.13	12.83	4.7	27.0	0.83	105	$3.35
6,500	1.00	9.92	0.60	2.29	13.81	4.3	27.0	0.83	97	$3.60
7,000	1.00	10.65	0.60	2.45	14.70	4.1	27.0	0.83	91	$3.83

APPENDIX D: MATERIAL BACKFILL AND GRADING WITH DOZERS

The cost tables listed within Appendix D apply to backfilling and grading costs associated with dozing. Materials in this appendix are assumed to be unconsolidated; additional costs will also need to be applied if drill/blast is required (See **Section 3.2 Drill and Blast**). Capital purchase cost for D11 equipment will need to be added in addition to calculated operating costs.

Determine cost per LCY by utilizing the tables below. No additional calculations should be necessary.

Table D-1: Dozer Grading Modifying Factors (Caterpillar, 2019)[9]

Operator	Material	Visibility	Efficiency	Slot Dozing	Grade (%)						
					-30	-20	-10	0	10	20	30
0.88	1.00	0.90	0.83	1.20	1.59	1.41	1.21	1.00	0.79	0.55	0.28

[9] Slot dozing modifying factor is only applied to D10/D11 equivalent dozer production

Table D-2: Material Movement with CAT D8 Dozer

Push Distance (ft)	Unadjusted Production Rate (LCY/hr)	Modified Production Rate (LCY/hr)	Costs ($/LCY)	Modified Production Rate (LCY/hr)	Costs ($/LCY)	Modified Production Rate (LCY/hr)	Costs ($/LCY)	Modified Production Rate (LCY/hr)	Costs ($/LCY)	Modified Production Rate (LCY/hr)	Costs ($/LCY)	Modified Production Rate (LCY/hr)	Costs ($/LCY)	Modified Production Rate (LCY/hr)	Costs ($/LCY)
Grade:		**-30%**		**-20%**		**-10%**		**0%**		**10%**		**20%**		**30%**	
50	1,400	1,463	$0.15	1,298	$0.17	1,114	$0.20	920	$0.24	727	$0.30	506	$0.43	258	$0.85
100	850	888	$0.25	788	$0.28	676	$0.32	559	$0.39	441	$0.50	307	$0.71	156	$1.40
150	600	627	$0.35	556	$0.39	477	$0.46	394	$0.55	312	$0.70	217	$1.01	110	$1.98
200	475	496	$0.44	440	$0.50	378	$0.58	312	$0.70	247	$0.89	172	$1.27	87	$2.50
250	400	418	$0.52	371	$0.59	318	$0.69	263	$0.83	208	$1.05	145	$1.51	74	$2.97
300	325	340	$0.64	301	$0.73	259	$0.85	214	$1.02	169	$1.30	118	$1.86	60	$3.66
350	300	314	$0.70	278	$0.79	239	$0.92	197	$1.11	156	$1.40	108	$2.02	55	$3.96
400	250	261	$0.84	232	$0.94	199	$1.10	164	$1.33	130	$1.68	90	$2.42	46	$4.75
450	235	246	$0.89	218	$1.00	187	$1.17	154	$1.42	122	$1.79	85	$2.57	43	$5.06
500	200	209	$1.05	185	$1.18	159	$1.38	131	$1.66	104	$2.11	72	$3.03	37	$5.94
550	190	199	$1.10	176	$1.24	151	$1.45	125	$1.75	99	$2.22	69	$3.18	35	$6.25
600	170	178	$1.23	158	$1.39	135	$1.62	112	$1.96	88	$2.48	61	$3.56	31	$6.99

Table D-3: Material Movement with CAT D9 Dozer

Push Distance (ft)	Unadjusted Production Rate (LCY/hr)	Modified Production Rate (LCY/hr)	Costs ($/LCY)	Modified Production Rate (LCY/hr)	Costs ($/LCY)	Modified Production Rate (LCY/hr)	Costs ($/LCY)	Modified Production Rate (LCY/hr)	Costs ($/LCY)	Modified Production Rate (LCY/hr)	Costs ($/LCY)	Modified Production Rate (LCY/hr)	Costs ($/LCY)	Modified Production Rate (LCY/hr)	Costs ($/LCY)
Grade:		**-30%**		**-20%**		**-10%**		**0%**		**10%**		**20%**		**30%**	
50	2,150	2,247	$0.13	1,993	$0.15	1,710	$0.17	1,413	$0.21	1,117	$0.26	777	$0.38	396	$0.74
100	1,275	1,333	$0.22	1,182	$0.25	1,014	$0.29	838	$0.35	662	$0.44	461	$0.63	235	$1.24
150	900	941	$0.31	834	$0.35	716	$0.41	592	$0.49	467	$0.62	325	$0.90	166	$1.76
200	700	732	$0.40	649	$0.45	557	$0.52	460	$0.63	364	$0.80	253	$1.15	129	$2.27
250	575	601	$0.49	533	$0.55	457	$0.64	378	$0.77	299	$0.98	208	$1.40	106	$2.76
300	490	512	$0.57	454	$0.64	390	$0.75	322	$0.91	254	$1.15	177	$1.65	90	$3.24
350	425	444	$0.66	394	$0.74	338	$0.86	279	$1.05	221	$1.32	154	$1.90	78	$3.73
400	375	392	$0.75	348	$0.84	298	$0.98	247	$1.18	195	$1.50	136	$2.15	69	$4.23
450	340	355	$0.82	315	$0.93	270	$1.08	224	$1.31	177	$1.65	123	$2.38	63	$4.67
500	300	314	$0.93	278	$1.05	239	$1.22	197	$1.48	156	$1.87	108	$2.69	55	$5.29
550	275	287	$1.02	255	$1.15	219	$1.34	181	$1.62	143	$2.05	99	$2.94	51	$5.77
600	250	261	$1.12	232	$1.26	199	$1.47	164	$1.78	130	$2.25	90	$3.23	46	$6.35

Table D-4: Material Movement with CAT D10 Dozer

Push Distance (ft)	Unadjusted Production Rate (LCY/hr)	Modified Production Rate (LCY/hr)	Costs ($/LCY)	Modified Production Rate (LCY/hr)	Costs ($/LCY)	Modified Production Rate (LCY/hr)	Costs ($/LCY)	Modified Production Rate (LCY/hr)	Costs ($/LCY)	Modified Production Rate (LCY/hr)	Costs ($/LCY)	Modified Production Rate (LCY/hr)	Costs ($/LCY)	Modified Production Rate (LCY/hr)	Costs ($/LCY)
Grade:		**-30%**		**-20%**		**-10%**		**0%**		**10%**		**20%**		**30%**	
50	3,000	3,763	$0.10	3,337	$0.11	2,863	$0.13	2,366	$0.15	1,870	$0.19	1,302	$0.28	663	$0.55
100	1,800	2,258	$0.16	2,002	$0.18	1,718	$0.21	1,420	$0.26	1,122	$0.32	781	$0.46	398	$0.91
150	1,250	1,568	$0.23	1,390	$0.26	1,193	$0.30	986	$0.37	779	$0.47	542	$0.67	276	$1.31
200	950	1,192	$0.30	1,057	$0.34	907	$0.40	749	$0.48	592	$0.61	412	$0.88	210	$1.73
250	800	1,003	$0.36	890	$0.41	764	$0.48	631	$0.58	499	$0.73	347	$1.05	177	$2.05
300	675	847	$0.43	751	$0.48	644	$0.56	532	$0.68	421	$0.86	293	$1.24	149	$2.43
350	590	740	$0.49	656	$0.55	563	$0.64	465	$0.78	368	$0.99	256	$1.42	130	$2.79
400	510	640	$0.57	567	$0.64	487	$0.75	402	$0.90	318	$1.14	221	$1.64	113	$3.22
450	450	564	$0.64	501	$0.73	430	$0.85	355	$1.02	280	$1.29	195	$1.86	99	$3.65
500	425	533	$0.68	473	$0.77	406	$0.89	335	$1.08	265	$1.37	184	$1.97	94	$3.87
550	375	470	$0.77	417	$0.87	358	$1.01	296	$1.23	234	$1.55	163	$2.23	83	$4.38
600	350	439	$0.83	389	$0.93	334	$1.09	276	$1.31	218	$1.66	152	$2.39	77	$4.70

Table D-5: Material Movement with CAT D11 Dozer

Push Distance (ft)	Unadjusted Production Rate (LCY/hr)	Modified Production Rate (LCY/hr)	Costs ($/LCY)	Modified Production Rate (LCY/hr)	Costs ($/LCY)	Modified Production Rate (LCY/hr)	Costs ($/LCY)	Modified Production Rate (LCY/hr)	Costs ($/LCY)	Modified Production Rate (LCY/hr)	Costs ($/LCY)	Modified Production Rate (LCY/hr)	Costs ($/LCY)	Modified Production Rate (LCY/hr)	Costs ($/LCY)
Grade:		**-30%**		**-20%**		**-10%**		**0%**		**10%**		**20%**		**30%**	
50	5,500	6,898	$0.04	6,117	$0.04	5,250	$0.05	4,339	$0.06	3,427	$0.08	2,386	$0.11	1,215	$0.22
100	3,175	3,982	$0.07	3,531	$0.08	3,030	$0.09	2,505	$0.11	1,979	$0.14	1,377	$0.20	701	$0.39
150	2,350	2,947	$0.09	2,614	$0.10	2,243	$0.12	1,854	$0.15	1,464	$0.19	1,020	$0.27	519	$0.53
200	1,800	2,258	$0.12	2,002	$0.14	1,718	$0.16	1,420	$0.19	1,122	$0.24	781	$0.35	398	$0.69
250	1,460	1,831	$0.15	1,624	$0.17	1,394	$0.20	1,152	$0.24	910	$0.30	633	$0.43	322	$0.85
300	1,250	1,568	$0.17	1,390	$0.20	1,193	$0.23	986	$0.28	779	$0.35	542	$0.50	276	$0.99
350	1,100	1,380	$0.20	1,223	$0.22	1,050	$0.26	868	$0.31	685	$0.40	477	$0.57	243	$1.12
400	975	1,223	$0.22	1,084	$0.25	931	$0.29	769	$0.35	608	$0.45	423	$0.65	215	$1.27
450	850	1,066	$0.26	945	$0.29	811	$0.34	671	$0.41	530	$0.52	369	$0.74	188	$1.45
500	775	972	$0.28	862	$0.32	740	$0.37	611	$0.45	483	$0.57	336	$0.81	171	$1.59
550	725	909	$0.30	806	$0.34	692	$0.39	572	$0.48	452	$0.60	315	$0.87	160	$1.70
600	650	815	$0.33	723	$0.38	620	$0.44	513	$0.53	405	$0.67	282	$0.97	144	$1.90

APPENDIX E: SCARIFICATION AND FINISH GRADING

The cost tables listed within Appendix E apply to the costs associated with scarification and finish grading of spoil and soil materials. Table E-3 should be utilized for cut/fill areas requiring final dozer grading for tie-ins and drainage establishment; this will be required for any disturbance areas not approved for phase I bond release. The following calculations assume that the total cost per hour for equipment includes the operator.

Table E-1: Scarification with CAT 16 Grader

Operation	Value	Unit	Data Source
CAT 16 Grader Total Cost	$159.21	$/hr	CMI Equipment Cost Calculator 2024-2025
Effective Ripping Length	9.90	ft	CPH 49
Grading Pass Overlap	2.0	ft	CPH 49
Scarification Ripping Speed	2.5	mph	CPH 49
Feet Per Mile	5,280	ft/mile	
Square Feet Per Acre	43,560	sqft	
Operating Efficiency	0.83		CPH 49
Effective Grading Production	**1.99**	**acres/hr**	
CAT 16 Finish Grading Total Cost	**$80.13**	**$/acre**	

Table E-2: Soil Finish Grading with CAT 16 Grader

Operation	Value	Unit	Data Source
CAT 16 Grader Total Cost	$159.21	$/hr	CMI Equipment Cost Calculator 2024-2025
Effective Blade Length (20°)	15.45	ft	CPH 49
Grading Pass Overlap	2.0	ft	CPH 49
Finish Grading Speed	2.5	mph	CPH 49
Feet Per Mile	5,280	ft/mile	
Square Feet Per Acre	43,560	sqft	
Operating Efficiency	0.83		CPH 49
Effective Grading Production	**3.38**	**acres/hr**	
CAT 16 Finish Grading Total Cost	**$47.06**	**$/acre**	

Table E-3: Phase I Grading with CAT D10 Dozer

Operation	Value	Unit	Data Source
CAT D10 Dozer Cost	$363.00	$/hr	CMI Equipment Cost Calculator 2024-2025
Effective Blade Width (Universal)	17.30	ft	CPH 49
Grading Pass Overlap	2.0	ft	CPH 49
Grading Speed	2.5	mph	CPH 49
Feet Per Mile	5,280	ft/mile	
Square Feet Per Acre	43,560	sqft	
Operating Efficiency	0.83		CPH 49
Effective Grading Production	**3.85**	**acres/hr**	
CAT D10 Finish Grading Total Cost	**$94.33**	**$/acre**	

APPENDIX F: DOZER RIPPING

The cost tables listed within Appendix F apply to the costs associated with ripping and soil preparation with dozers; this would apply to all haul roads, railroad beds, facilities, and heavily compacted surfaces. The following calculations assume that the total cost per hour for equipment includes the operator.

Table F-1: Ripping with CAT D10 Dozer Single-Shank

Operation	Value	Unit	Data Source
CAT D10 Dozer Total Cost	$363.00	$/hr	CMI Equipment Cost Calculator 2024-2025
Effective Ripping Width - Single-Shank	4.79	ft	CPH 49, half multi-shank width
Ripping Pass Overlap	0.0	ft	CPH 49
Dozer Ripping Speed	1.0	mph	CPH 49
Feet Per Mile	5,280	ft/mile	
Square Feet Per Acre	43,560	sqft	
Operating Efficiency	0.664		CPH 49, 80% of 0.83 standard eff.
Effective Ripping Production	**0.39**	**acres/hr**	
CAT D10 Ripping Total Cost	**$941.25**	**$/acre**	

Table F-2: Ripping with CAT D10 Dozer Multi-Shank

Operation	Value	Unit	Data Source
CAT D10 Dozer Total Cost	$363.00	$/hr	CMI Equipment Cost Calculator 2024-2025
Effective Ripping Width - Multi-Shank	11.50	ft	CPH 49, 120% of multi-shank width
Ripping Pass Overlap	0.0	ft	CPH 49
Dozer Ripping Speed	1.0	mph	CPH 49
Feet Per Mile	5,280	ft/mile	
Square Feet Per Acre	43,560	sqft	
Operating Efficiency	0.664		CPH 49, 80% of 0.83 standard eff.
Effective Ripping Production	**0.93**	**acres/hr**	
CAT D10 Ripping Total Cost	**$392.19**	**$/acre**	