

COMPUTERIZED MINE RECLAMATION PLANNING AT HIGHLAND VALLEY COPPER

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ABSTRACT

Highland Valley Copper is a large low grade open pit copper mine in the Southern Interior of British Columbia and has one of the largest land disturbance areas amongst mining companies in the province. Mining operations have occurred since the early 1960's in four locations: Bethlehem, Highmont, Lornex and Valley, with the latter two still being active. In total, there is 6000 hectares of disturbed ground on the property. Reclaim Scheduler is a computerized mine reclamation planning program developed by Highland Valley Copper to manage this disturbance.

Reclamation Scheduler, designed in Visual Basic, assists in creating annual, five year, mine life and decommissioning reclamation plans. Input data consists of the mine plan reclamation file, a cost file, a work location file and equipment availabilities. This program is run one year at a time, manipulating data from the work location file by reclaiming certain tracts of land. Output from the program includes a summary report of all the reclamation activities and costs and an updated work location file. The summary report presents costs and numbers relating to ground preparation, seeding, maintenance fertilizing, and equipment requirements. The updated work location file reflects all land inventory changes made over the year. In turn, it will be used as an input file for the subsequent year's reclamation plan.

INTRODUCTION

With over 6000 hectares of disturbed ground at Highland Valley Copper, it is a tedious, labour intensive job to plan reclamation activities by hand for the current and future years. One of the first attempts to computerize reclamation planning was made in 1990, by means of numerous Lotus spreadsheets. In 1993, the program Reclamation Scheduler was designed in Visual Basic to simplify reclamation planning. Reclamation Scheduler is designed to run in Microsoft Windows.

To run Reclamation Scheduler, several different types of input data are required. Input files consist of: a work location file, a cost file, a mine plan reclamation file, and an operating variables file. All of these files are entered into the program from the setup screen. From the main program screen, reclamation planning is done by entering amounts of ground to be prepared and revegetated for each work zone location. Reclamation Scheduler keeps track of areas while simultaneously calculating equipment requirements and costs. The program is run on a year by year basis, with output files being created at the end of each year. Output files produced by Reclamation Scheduler include a report of: costs, equipment used, areas worked,

and areas revegetated as well as a new work location data file of ground remaining to be prepared and revegetated.

INPUT REQUIREMENTS

In order to operate Reclamation Scheduler, four types of data input are required. These are: the work location file, the cost file, the mine plan reclamation file and the operating variables file.

Work Location File

This is the most important input data file required to run Reclamation Scheduler. This file divides up the property based on area and type of disturbance. It contains the amount of equipment hours and capping material required to prepare a hectare of ground for each type of disturbance in each locality. The first part of the work location file contains the 20 different types of disturbance categories used at Highland Valley Copper (Figure 1). Disturbance types are classified by the type of reclamation necessary to bring the ground back to a productive state. The first six types on the list relate to flat disturbances, excluding tailings. Categories 7 through 14 are disturbance types with slopes greater than 10%. Category 15, no equipment seed only, refers to tailings ponds where no mine equipment is used to reclaim the site. Type 16, no access seed only, includes locations like pit walls where equipment access and placing capping material is practically impossible. Categories 17 through 19 are sites where preparation and seeding are not required. Finally, category 20 is a total of disturbed areas that have been reclaimed.

Figure 1 - Disturbance Type List

- | | |
|----|-------------------|
| 1 | Scarify Only |
| 2 | Level+Cap O/B |
| 3 | Level+Cap Rock |
| 4 | Cap O/B |
| 5 | Cap Rock |
| 6 | Level |
| 7 | Reslope Only |
| 8 | Reslope+Cap O/B |
| 9 | Reslope+Cap Rock |
| 10 | Round Only |
| 11 | Round+Cap O/B |
| 12 | Round+Cap Rock |
| 13 | Cap O/B |
| 14 | Cap Rock |
| 15 | NoEqu SEEDOnly |
| 16 | NoAxes SEED Only |
| 17 | Disturbed NO-Seed |
| 18 | Un-Disturbed Land |
| 19 | Flooded Area |
| 20 | Reclaimed Area |

The bulk of the file contains site specific data, based on the 20 disturbance types listed above. Highland Valley Copper's property is divided into five work zones: Highmont, Lornex, Valley, Bethlehem, and Highland. All refer to the major mining centers on the property, with the exception of Highland, which is the area in and around the Highland Tailings Pond. These zones are further divided into locations. A location is a specific site like plantsites, pits, dumps, tailings ponds and other inside that particular zone. Other is a group classification to include such disturbances as roads and borrow pits. Figure 2 illustrates a portion of the work location file and how it is set up. Area titles contain both the zone and location names. For each zone location, a list is given of disturbance types and areas requiring ground preparation. Also provided is haul truck, dozer, and loader hours needed to prepare one hectare of ground for each disturbance type. 'CapTn/Ha' is the amount of tonnes (000's) needed to cap one hectare of that disturbance. The column 'Ha Ready' displays the number of prepared hectares that are ready for revegetation. The final five columns are hectares of ground revegetated over the previous five years. These columns are necessary for calculating amounts of maintenance fertilizer required.

Figure 2 - Sample of Data in Work Location File

Lornex	NE Dump	Ha Avail	TrkHr/Ha	CatHr/Ha	LdrHr/Ha	CapTn/Ha	Ha Ready	Ha Y1	Ha Y2	Ha Y3	Ha Y4	Ha Y5
3	Level+Cap Rock	12	0.0	22.0	0.0	25.9	0.0	0	0	0	0	0
5	Cap Rock	51	0.0	8.0	0.0	25.9	33.0	32	0	27	0	0
6	Level	3	0.0	17.0	0.0	0.0	3.0	12	0	0	0	0
7	Reslope Only	11	0.0	25.0	0.0	0.0	2.0	4	0	0	0	0
9	Reslope+Cap Rock	79	0.0	40.0	0.0	25.9	29.0	27	17	23	0	0
12	Round+Cap Rock	5	0.0	20.0	0.0	25.9	0.0	2	0	0	0	0
18	Un-Disturbed Land	1	0.0	0.0	0.0	0.0	0.0	0	0	0	0	0
20	Reclaimed Area	144	0.0	0.0	0.0	0.0	0.0	0	0	0	0	0

Bethlehem	Other	Ha Avail	TrkHr/Ha	CatHr/Ha	LdrHr/Ha	CapTn/Ha	Ha Ready	Ha Y1	Ha Y2	Ha Y3	Ha Y4	Ha Y5
1	Scarify Only	3	0.0	0.0	0.0	0.0	0.0	4	1	0	0	0
2	Level+Cap O/B	15	20.4	22.0	0.0	10.7	6.0	3	0	0	0	0
6	Level	8	0.0	12.0	0.0	0.0	0.0	0	2	0	0	0
7	Reslope Only	4	0.0	15.0	0.0	0.0	0.0	0	0	0	0	0
17	Disturbed No-Seed	21	0.0	0.0	0.0	0.0	0.0	0	0	0	0	0
18	Un-Disturbed Land	0	0.0	0.0	0.0	0.0	0.0	0	0	0	0	0
20	Reclaimed Area	46	0.0	0.0	0.0	0.0	0.0	0	0	0	0	0

Cost File

All costs calculated by Reclamation Scheduler are attained from the cost file. At the top of the file (Figure 3) are costs associated with operating equipment on a per hour basis. These equipment costs include a built in labour rate.

The majority of this file (figure 3) is for costs relating to seeding, planting and maintenance fertilizing. The first cost center is default costs, which includes revegetation costs for flat

ground, sloped ground and tailings ponds. Flat ground relates to any of the first 6 disturbance types. Next is sloped ground, or disturbance types 7 through 14 and 16. Tailings ponds is the third classification, not illustrated, relating to disturbance type 15 in the work location file. Revegetation costs include: seeding grass, planting shrubs, maintenance seeding, maintenance fertilizer, and any preparation work necessary. Annual costs include revegetating the initial year (column 2), followed by up to five years of costs associated with maintenance fertilizing and re-seeding (columns 3 through 7).

Figure 3 - Sample of Cost Data File For Use With Reclamation Scheduler

TrkCst	180.98					
CatCst	119.19					
LdrCst	163.34					
Default Revegetation Maintenance Schedule & Costs (\$/Ha)						
FLATS:						
Init Seed	762					
Maint Seed		115				
Maint Fert		240	240	240		
Seedlings	1760					
Prep Work						
TOTF_DEF	2522	355	240	240	0	0
SLOPES:						
Init Seed	762					
Maint Seed		115				
Maint Fert		240	240	240		
Seedlings	1760					
Prep Work						
TOTS_DEF	2522	355	240	240	0	0

In addition to the default cost center, this file also contains other cost centers which relate to specific parts of the property. These are listed as optional cost areas and have the same setup as the default cost center (Figure 3). The file can have as many optional cost areas as desired. When an area being revegetated or maintenance fertilized is of a zone location that matches an optional cost area, Reclamation Scheduler will use the costs in that particular cost center in place of the default values.

Mine Plan Reclamation File

Highland Valley Copper's mine planning software produces a file specifically designed for the Reclamation Scheduler program. This particular file (figure 4) contains two important pieces of information: tonnes of reclaim suitable overburden mined and truck hours used. Geologists at the mine have divided overburden into three categories: overburden suitable for reclamation,

overburden requiring blasting, and free dig overburden. Through the mine planning scheduler, the amount of reclamation suitable overburden which will be available for waste rock capping on an annual basis is determined. The mine plan also calculates amount of truck hours required to haul all material from the pits. Since the haul truck fleet size is fixed, Reclamation Scheduler calculates how many truck hours are available for long overburden hauls to reclamation sites. In Figure 4, columns 3 and 7 illustrate reclaim overburden release and truck requirements for the various sub pits mined during that year.

Figure 4 - Sample Portion of Mine Plan Reclamation File

All Tonnes Reported in 000's

Mining For Period 3 Year 1996. Per.Length: 1.0 CTF= .23/2.

Pit	TN Str	OBRec	OBBist	OBFre	W.R.	TrkHrs
L8	18162	694	207	487	17468	53132
410	1	0	0	0	1	9962
5L3	637	0	0	0	637	3874
5B3	13029	611	611	2912	9506	35975
5L4	1591	0	0	4	1587	6641
5D0	2522	0	0	0	2522	27673
5L5	2813	0	0	0	2813	27673
5HA	7132	3094	3094	4038	0	17711
5HB	2599	25	25	2580	-6	6088
	-----	-----	-----	-----	-----	-----
	48486	4423	3936	10021	34529	188729

Operating Variables File

The operating variables file is the same file used by the mine planning scheduler. Important data utilized by Reclamation Scheduler from this file include: start year, work hours per day, truck availability, truck use of availability, shift efficiency, and period interval. Primary purpose of this file is to provide Reclamation Scheduler with enough information to calculate the number of truck hours available for reclamation projects in a given year.

RECLAMATION PLANNING

There are two main screens for Reclamation Scheduler: Setup Screen and Form 6. Setup Screen, also known as Form 1, is where all the input data files are entered and the report output file is given a name. Form 6 is the main planning screen where all reclamation ground preparation and revegetation are entered by the operator.

Setup Screen

When Reclamation Scheduler is run, the first display is the Setup Screen (Figure 5). From this screen, necessary input files are entered, a name for the output file is entered, and a location for describing the particular program run. One part of Reclamation Scheduler not fully developed is the 'Previous Reclam Recording', '# of Periods', and 'This Reclam Recording' file entries seen on the Setup Screen. These three boxes relate to the ability of being able to re-run a previous reclamation recording, making changes in any year without having to enter all the data again for that and any subsequent year. This option is available on the mine planning scheduler, and will be coded in the future for Reclamation Scheduler.

Figure 5 - Reclamation Scheduler Setup Screen

Setup Screen

RECLAMATION SCHEDULER
Highland Valley Copper

INPUT FILES

Prev. Reclam Recording: ☐ RECLAM01 (File 7)

of Periods: 1

Rec Cost File: 1996

Work Loc. Module #1: FB221996

Rec File From Scheduler: TEST0B

Op. Variables File: SIX
Edit

OUTPUT FILES

This Reclam Recording: ☐ RECLAM02 (File 9)

Reclamation Report: ☐ FB241996 (File 6)

Description:
Reclamation Scheduler Demonstration

RUN Exit Print List Edit PrtScr

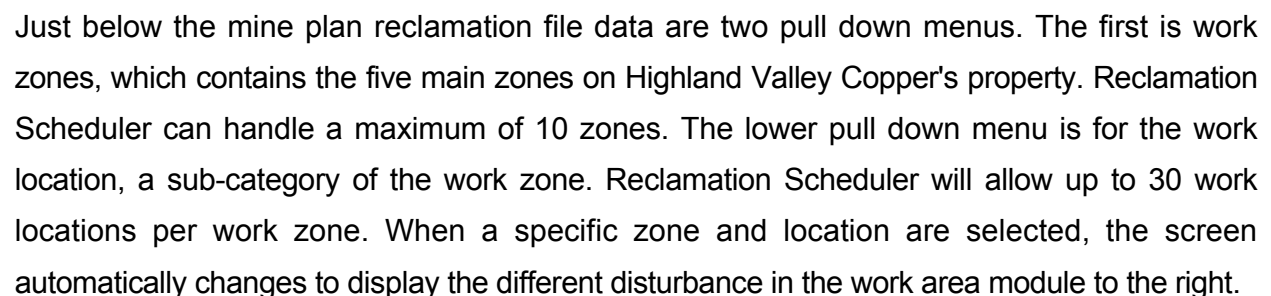
The four inputs necessary to operate the program are described under input requirements. Locations for file entry are the marked boxes called: 'Rec Cost file', 'Work Loc. Module #1', 'Rec File From Scheduler' and 'Op. Variables File'. Beside each of the input files is a small white circle, which by clicking on, will give a pull down menu on the right side of the monitor of all available files found in the corresponding directory. Input for the operating variables file has the ability to be directly edited from this screen by clicking the edit button located below the file box.

Reclamation Scheduler will produce two output files: a reclamation report and an output work location file. The latter is automatically created after each year has been planned, reflecting all changes made over the period. No box is associated with this file as the output file is given the same name as the corresponding input file, except that the year increases by one. A space is provided to give the reclamation report output file a title. A pull down menu will appear on the right side of the screen to display all report file names previously used. Duplication of a reclamation report file name will result in the new file overwriting the old. As a warning mechanism, Reclamation Scheduler will highlight the 'Reclamation Report' box in red if the file name entered matches that of any previous report.

At the bottom of the Setup Screen, there is a command box labeled 'RUN'. If clicked this will initiate the Reclamation Scheduler program with the selected input files, open the output report file, and proceed to the Form 6 display screen.

Form 6

Form 6 (Figure 6) is the screen from which all reclamation planning is completed. In the upper left hand corner is a display of the mine plan reclamation file. In the upper right hand corner are target values for dollars spent, equipment hours, capping material used, and ground vegetated. Target values are budgeted amounts for the given year. Remaining values are a continuous display of the target values less the quantity used. The categories closely watched are: dollars spent, truck hours, dozer hours, loader hours, overburden tonnes available, and hectares seeded. With the exception of truck hours and overburden tonnes, all have had their budgeted values placed into the Reclamation Scheduler's software. Truck hours and overburden tonnes are determined by input from the mine plan reclamation file. If any of the presented targets are not correct, the values can be manually changed from the display screen. 'Used' figures will automatically increase as more reclamation activity is planned for that year. When Form 6 is first entered, a value will already exist in the used '\$ Spent' slot. This money is the cost for maintenance fertilizer, already computed by Reclamation Scheduler for the given year.



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ground is prepared during the planning year. The small box Labeled 'Do' in each of these categories records the total number of hectares revegetated. The "Do" box located in slopes also keeps track of tailings hectares seeded. Costs associated with revegetating one hectare in that zone location are also provided. Maintenance fertilizer cost is also broken down into flats and slopes. The group of boxes labeled 'Yr' through 'Yr5' are the number of hectares seeded in these two categories over the previous five years.

Reclamation planning primarily involves using columns to the right side of the display. Columns involved start at 'Work Area Module' in the center through to 'Scrfy' on the right side (Figure 6). Work area module displays 18 of the 20 disturbance types, leaving out categories 19 and 20, flooded and reclaimed areas respectively. Number of disturbed hectares for each disturbance type in that work zone location are in the column marked 'Avail'. 'Cst' column lists the associated cost of preparing one hectare of that particular disturbance type. These costs are based on the equipment hour rates to prepare a hectare. The 'Do' column on this side refers to preparing hectares, not revegetating. Numbers entered here are based on what is expected to be done during the year. For each disturbance type, the number of hectares chosen to be done cannot exceed the amount in the available column for the same disturbance. When one or more hectares are done, the number of truck hours, dozer hours, loader hours, and tonnes of capping needed for that area are automatically calculated and displayed over the following four columns. In addition, all equipment hours, capping tonnes and related costs are automatically added to their respective columns on the 'Used' row at the top of the display. When a hectare is prepared in the 'Do' column, a hectare is removed from the 'Avail' column while one is added to the 'Rdy' column. Reverse is true when the program operator chooses to remove a prepared hectare after it was planned. Hectares ready for revegetation are illustrated in the 'Rdy' column. The last column, 'Scrfy', is another input column. All hectares to be revegetated in that planning year are entered in this column. Hectares revegetated can not exceed the number of hectares ready. When a given amount of hectares is revegetated for a disturbance type, an equivalent number of hectares is removed from that disturbance's ready column. All hectares revegetated under the first six disturbance types will be added to the flats 'Do' box under 'Revegetation'. Likewise, all hectares seeded from the remaining categories will be added to the slopes 'Do' box under 'Revegetation'.

Costs and number of revegetated hectares are added to '\$Spent' and 'HaSeed' respectively in the 'Used' row at the top of Form 6 after areas are planned to be revegetated. Costs and dozer hours will also increase for hectares revegetated on flat surfaces, as a dozer allowance for scarification is added per hectare.

At the bottom of Form 6 is a clock, which acts as a built in delay to allow all processing of data in a particular work zone and location before another area may be selected. When all zone locations are completed for ground preparation and revegetation, the "Remaining" values for costs, equipment hours and ground seeding should be close to zero. Surplus overburden tonnes reflects amounts of reclaim material sent to stock piles. Once a year is completed, the 'Next Period' command button will create two output files for the completed year and advance Reclamation Scheduler to the proceeding year for planning.

OUTPUT

After the 'Next Period' button is clicked, Reclamation Scheduler advances to the next year. Two output reports are created when a period is completed. These are a new work location file and a summary report. The new work location file contains an updated version of the ground inventory relative to the input work location file. The Summary report provides the costs, areas prepared, areas revegetated during the current year and over the previous five years, equipment hours, and area receiving maintenance fertilizer.

Work Location File

The work location output file is of identical format to the input work location file. This output file from the completed year also serves as an input work location file for the proceeding year. The output form of the work location module differs from the input form by numbers only (Figure 7). Hectares available will be lower for any disturbance that had ground prepared during the year. Hectares ready for revegetation will reflect changes made by adding hectares prepared and subtracting hectares revegetated. All the previous years revegetation will move over one column, i.e. vegetated areas in the column marked 'Ha Y1' will move to 'Ha Y2' column. All revegetation in the completed year are displayed in 'Ha Y1' column, and the values located in the input work location file under 'Ha Y5' will be dropped from the output work location file.

Figure 7 - Sample of Work Location Output File

Lornex	NE Dump	Ha Avail	TrkHr/Ha	CatHr/Ha	LdrHr/Ha	CapTn/Ha	Ha Ready	Ha Y1	Ha Y2	Ha Y3	Ha Y4	Ha Y5
3	Level+Cap Rock	12	0.0	22.0	0.0	25.9	0.0	0	0	0	0	0
5	Cap Rock	29	0.0	8.0	0.0	25.9	22.0	33	32	0	27	0
6	Level	3	0.0	17.0	0.0	0.0	0.0	3	12	0	0	0
7	Reslope Only	9	0.0	25.0	0.0	0.0	2.0	2	4	0	0	0
9	Reslope+Cap Rock	41	0.0	40.0	0.0	25.9	38.0	29	27	17	23	0
12	Round+Cap Rock	5	0.0	20.0	0.0	25.9	0.0	0	2	0	0	0
18	Un-Disturbed Land	1	0.0	0.0	0.0	0.0	0.0	0	0	0	0	0
20	Reclaimed Area	144	0.0	0.0	0.0	0.0	0.0	0	0	0	0	0

Bethlehem	Other	Ha Avail	TrkHr/Ha	CatHr/Ha	LdrHr/Ha	CapTn/Ha	Ha Ready	Ha Y1	Ha Y2	Ha Y3	Ha Y4	Ha Y5
1	Scarify Only	3	0.0	0.0	0.0	0.0	0.0	0	4	1	0	0
2	Level+Cap O/B	11	20.4	22.0	0.0	10.7	4.0	6	3	0	0	0
6	Level	8	0.0	12.0	0.0	0.0	0.0	0	0	2	0	0
7	Reslope Only	4	0.0	15.0	0.0	0.0	0.0	0	0	0	0	0
17	Disturbed NO-Seed	21	0.0	0.0	0.0	0.0	0.0	0	0	0	0	0
20	Reclaimed Area	46	0.0	0.0	0.0	0.0	0.0	0	0	0	0	0

Summary Report

The summary report output file (Figure 8) contains all relevant data for reclamation activities during the planning year. At the top of the report is an overall cost for all reclamation activities including revegetation, maintenance fertilizer, and equipment expenses. A maintenance fertilizer cost is also provided to illustrate it's portion of the overall reclamation expense. Number of hectares of ground revegetated on flats and slopes are given for five years prior to the planned year. All expected equipment requirements to achieve the annual plan are listed below the maintenance program.

Figure 8 - Sample of Summary Report Output File

Total Money Spent This period Was \$1,446,649 This Period 174Ha were newly Seeded.

The Maintenance Program Used \$203,922 Of This Money for the following Hectares:

Years Since Original Seeding....	1Yr	2Yrs	3Yrs	4Yrs	5Yrs
Flat Hectares-	139	93	111	129	51
Sloped Hectares-	91	70	83	37	23

Cat 789 Haul Trucks 1009 Op Hrs
D9&D10 Track Dozers 4361 Op Hrs
LeTourneau Loader 225 Op Hrs

Work Zone: Lornex Location: NE Dump

Job Discription	Ha Preped	TrkHrs	CatHrs	LdrHrs	Cap-Tns	Ha-RdyToSeed	Ha-Seeded	Tot-Cost
Cap Rock	22	0.0	176.0	0.0	569.0	55	33	20966
Level	0	0.0	0.0	0.0	0.0	3	3	0
Reslope Only	2	0.0	50.0	0.0	0.0	4	2	5958
Reslope+Cap Rock	38	0.0	1520.0	0.0	984.0	67	29	181146
Total for Loc...	62	0.0	1746.0	0.0	1553.0	129	67	208070

In addition to the total numbers, the summary report also provides a detailed breakdown for each disturbance type in every work zone location that has had ground preparation or been revegetated. For each disturbance type in all active work zone locations, there is a detailed breakdown that provides: hectares prepared, truck hours, dozer hours, loader hours, capping tonnes, area ready for revegetation, and area revegetated. Each line has an individual cost for all the reclamation activity it received. All of the aforementioned categories are sub-totaled for each work zone location. This summary report provides a hard copy of all reclamation activities completed each and every year that is planned through Reclamation Scheduler. From the summary reports, one year, five year, mine life and decommissioning reclamation plans are developed.

SUMMARY

Reclamation Scheduler is a valuable tool in assisting reclamation planning of durations one year or longer. It is currently used in creating one year, five year, mine life and decommissioning reclamation plans. All 6000 plus hectares of ground disturbance are broken down into zones and locations where the ground is divided up into 20 different classes of ground disturbance. Reclamation Scheduler can be considered a land management program, in its ability to track all the disturbances and modifications made thereof. Reclamation Scheduler systematically organizes all input data into a simple format where it can be manipulated. Working on a year by year basis, the operator controls what areas will be prepared and revegetated. Reclamation Scheduler monitors costs, equipment usage, capping material used, ground prepared and ground revegetated. These are all presented in the summary report on a year by year basis. The other output created by the program is a detailed work location module file, which is used as input for planning in the subsequent year. Reclaim Scheduler is an effective computer program that has simplified reclamation planning at Highland Valley Copper.

ACKNOWLEDGMENTS

I would like to acknowledge the efforts put forth by Mr. Ralph Kintzi (Senior Mine Engineer, HVC) and Mr. Peter Witt (Mine Engineer, HVC) who designed the original Lotus spreadsheet system for which Reclamation Scheduler was based from. As well, I want to acknowledge Mr. Grant Piwek (Mine Engineer, HVC) who wrote and edited all code for the Reclamation Scheduler program.