Granular Resources Forecast Model User's Guide

For Indian and Northern Affairs Canada and the Inuvialuit Land Administration

James C. McDougall P.Eng.

NORTH OF 60 ENGINEERING LTD.
D602, 500 Eau Claire Avenue S.W.
Calgary, Alberta, Canada, T2P 3R8

March, 1996

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1. Introduction

1.1. Background

Granular resources are an important construction material in the North. Historically, granular material has been used in the construction of roadways, airfield runways, embankments to support buildings and other physical structures, and in the construction of drilling pads and temporary offshore exploration structures in the shallow waters of the Beaufort Sea.

Granular resources (gravel) in the Mackenzie Delta region of the Northwest Territories are limited. Much work has been done during the past quarter century to quantify the volumes and quality of the various eskers (long, narrow ridge of coarse gravel deposited by a stream flowing in a decaying glacial ice sheet) located in the region.

Historically, management of granular resources was the responsibility of the Department of Indian and Northern Affairs, Canada. As part of the Inuvialuit Land settlement in 1984, however, much of the granular resources in the Mackenzie Delta region is now owned by the Inuvialuit. Thus, management of the resource is now divided between the Department and the Inuvialuit Land Administration.

One of the key variables in managing the resource is the ability to forecast potential demands on an ongoing basis. Currently, future demands are forecast by hand every five years.

In March 1993, Supply & Services Canada awarded a contract to NORTH OF 60 ENGINEERING LTD. to develop a computer model to forecast granular requirements. The model would be used by both Indian and Northern Affairs Canada and the Inuvialuit Land Administration. The model would provide benefits beyond simplifying the forecasting process — more frequent and accurate forecasting of granular demands, a better understanding of potential impact that the

demand may have on the resource and supporting infrastructure, the ability to forecast potential business opportunities and, ultimately, better management of the resource.

In March 1996, Supply & Services Canada awarded a follow-up contract to NORTH OF 60 ENGINEERING LTD. to update the model and to enhance its capabilities to estimate granular usage associated with potential mining development within the Northwest Territories.

This user's guide documents Version 2 of the Granular Resource Forecast Model developed by NORTH OF 60 ENGINEERING LTD., its underlying basis, and procedures and tips on how to use the tool in an effective and accurate manner.

1.2. Forecast Model Overview

The primary objective of the initial project was to develop a tool that will allow DIAND and the Inuvialuit Land Administration to forecast granular resource requirements in the Western Arctic Region.

Some of the specific goals of the project were that the model:

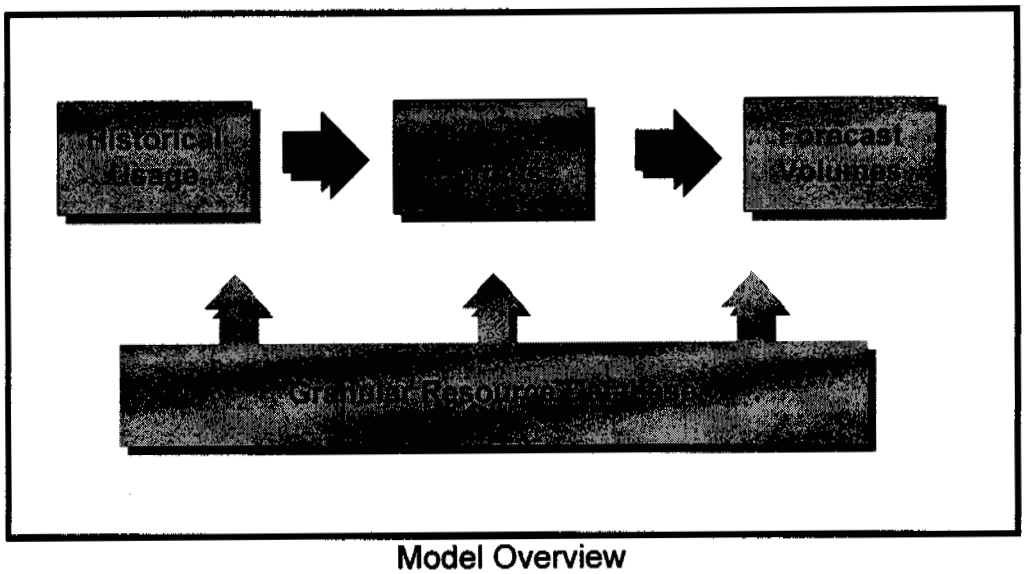
- provide a simple user interface,
- operate under existing platforms (such as Microsoft Excel),
- provide a capability for sensitivity analysis,
- generate the necessary reports, and
- provide flexibility to modify correlations based on historical data.

Generally speaking, these goals were achieved.

Based on discussions with potential users within DIAND and the ILA, it appeared both organizations would benefit from a model that not only forecast future requirements, but tracked current and historical usage.

The broad framework for the model is shown in Figure 1. As identified above, the model can focus on the past, present, and future. It draws this information from one central data base that will contain information pertinent to granular resource usage.

The intent in following this approach was to provide a tool that would help the various groups forecast granular resource usage, as was the intent of the project, plus help in the management of current granular usage.



Model Overview
Figure 1

The primary objective of the current project was to upgrade the model to operate within the recent releases of Microsoft Excel, and to enhance the granular estimating capabilities of the model to include potential mining developments within the NWT. These specific goals have been met.

1.3. Forecast Model Documentation

The Granular Resource Forecast Model© User's Guide describes the program and its underlying basis. It provides basic instructions, procedures and tips on how to use the tool in an effective and accurate manner.

The user's guide is intended for people of all experience levels. The information is organized into six sections. This introduction gives an overview of the contents and conventions. Section 2 defines the system requirements and provides instructions to install and use the Granular Resource Forecast Model©. It also gives an overview of the menu structure. Section 3 defines the Data Management portion of the program, Section 4 the individual parameters contained in the estimating section of the program, and Section 5 the analysis half of the program. Section 6 presents suggested procedures for managing the database and performing forecasts.

It is important to understand the terms and notation conventions in this user's guide before using the Granular Resource Forecast Model©.

1.4. Conventions

General

- The word "choose" is used to select a menu button.
- Bold type in the text and procedures indicates words or characters that are typed or buttons that are selected.
- Bulleted (•) lists, such as this one, provide information, not procedural steps.
- A numbered list (1,2,...) indicates a procedure with two or more sequential steps.

Mouse

- You can use either a single-button or multiple-button mouse with the Granular Resource Forecast Model©.
- If you have a multi-button mouse, the Granular Resource Forecast Model© assumes that you have configured the left mouse button as the primary mouse button.
- "Point" means to position the mouse pointer until the tip of the pointer rests on what you want to point to on the screen. For example, "Point to the button **Add or Update Data**."
- "Click" means to press and immediately release the mouse button without moving the mouse. For example, "Click on the button named **Add or Update Data**."
- "Double-click" means to click the mouse button twice in rapid succession. For example, "Double-click on the Microsoft Excel icon to start Microsoft Excel."

Keyboard

- Key names match the names shown on most keyboards and appear in small capital letters. For example, the Shift key appears as SHIFT.
- The RETURN key and the ENTER key perform the same function. "Press ENTER" means that you can press ENTER or RETURN.

- The keypad refers to the square group of numeric keys to the right of the standard keyboard keys. You may use these keys to enter numbers by turning on NUM LOCK. Press NUM LOCK to turn NUM LOCK mode on and off.

1.5. Technical Support

NORTH OF 60 ENGINEERING LTD. offers a variety of support options to help get the most from the Granular Resource Forecast Model©. These services include:

- Custom modifications to the model
- Customized training
- Technical support

If you encounter a problem or have a question about the application, first look in the printed documentation. If you cannot find the answer, phone or fax NORTH OF 60 ENGINEERING LTD. from 8 a.m. to 5 p.m. (Mountain Time) Monday through Friday.

NORTH OF 60 ENGINEERING LTD. support services are subject to North of 60's prices, terms, and conditions in place at the time the service is required.

When you call, you should be at your computer with the Granular Resource Forecast Model© running. Be prepared to give the following information which is contained in Appendix B of your User's Guide:

The version of Microsoft Excel you are using.

The type of hardware and operating environment you are using.

The exact wording of any messages that appeared on your screen.

A description of what happened and what you were doing when the problem occurred.

NORTH OF 60 ENGINEERING LTD. can be reached by phone, fax or by mail. The mailing address and phone numbers are:

D602, 500 Eau Claire Ave. S.W.
Calgary, Alberta
Canada T2P 3R8

Phone: (403) 263 - 2121
Fax: (403) 263 - 2122
Email: North60_Engineering@msn.com

2. Getting Started

2.1. System Requirements

The Granular Resource Forecast Model© has been developed under Microsoft Excel which requires the Microsoft Windows 3.1, or Windows 95 operating systems. To use the model you need the following minimum hardware:

- An IBM compatible computer with an Intel 386, 486, or Pentium processor.
- A VGA screen and graphics card compatible with Microsoft Windows version 3.1. or Windows 95
- At least 4 megabytes (MB) of random-access memory (RAM).
- A hard disk with at least two megabytes of free space for program files and data files.
- A Microsoft Mouse or compatible pointing device.
- A Microsoft Windows-compatible printer is optional, but recommended.

The following software is required to run the model:

- MS-DOS version 3.1 or later.
- Microsoft Windows 3.1 or Windows for Workgroups or Windows 95.
- Microsoft Excel 5.0 or Excel 7.0.

2.2. Installing the Forecast Model

The following instructions describe how to install the Granular Resource Forecast Model© on your computer. Although the model is not copy protected, Indian and Northern Affairs Canada, and the Inuvialuit Land Administration may make copies only for business use. For complete details, please read the licence agreement in Appendix A.

To install the Granular Resource Forecast Model©:

1. Start Microsoft Windows or Windows 95. If Windows has not been configured to load automatically at start-up, type **WIN** at the DOS prompt.
2. Start File Manager by double clicking on the file manager icon which is usually located in the MAIN group in Windows 3.1, or Windows Explorer in Windows 95 which is under the Program Group on the Start Menu.
3. Create a new directory, or folder in Windows 95 terminology for the program files by selecting Create Directory, or New in Windows 95, under the File Menu. It is recommended that you create this directory as a sub-directory to your "Data" directory. To do this, simply highlight the "Data" directory by clicking on the name.
4. Then select Create Directory which is under the File Menu. Type in the name **GRANULAR** and press ENTER.
5. Copy the files from the disk in drive A: to this new directory. To do this within File Manager, select and click on the drive A: icon in the upper left-hand part of the screen. This will show the files contained on the disk in drive A:. Highlight all of the files on drive A: by clicking on the first file in the list, then hold down the SHIFT key and click on the last file. All of the files should be highlighted. In Windows 3.1, select Copy under the File menu and type in the path of the directory that you just created. It should be **C:\GRANULAR** or **C:\DATA\GRANULAR** if you followed the recommendation above. After entering the path, press the ENTER key. The files will be copied to the new directory. Under Windows 95, simply drag the selected files to the new folder. This action will copy the files from drive A: to the hard drive of your computer.
6. Exit File Manager by selecting Exit under the File Menu in Windows 3.1, or Close under the File Menu of Windows Explorer.

2.3. File Structure of Model

The Granular Resource Forecast Model© has been developed as an application within Microsoft Excel so it requires Excel to operate. The installation procedure outlined in the previous section copied five files onto your hard drive. Their names and function within the application are summarized in Table 1.

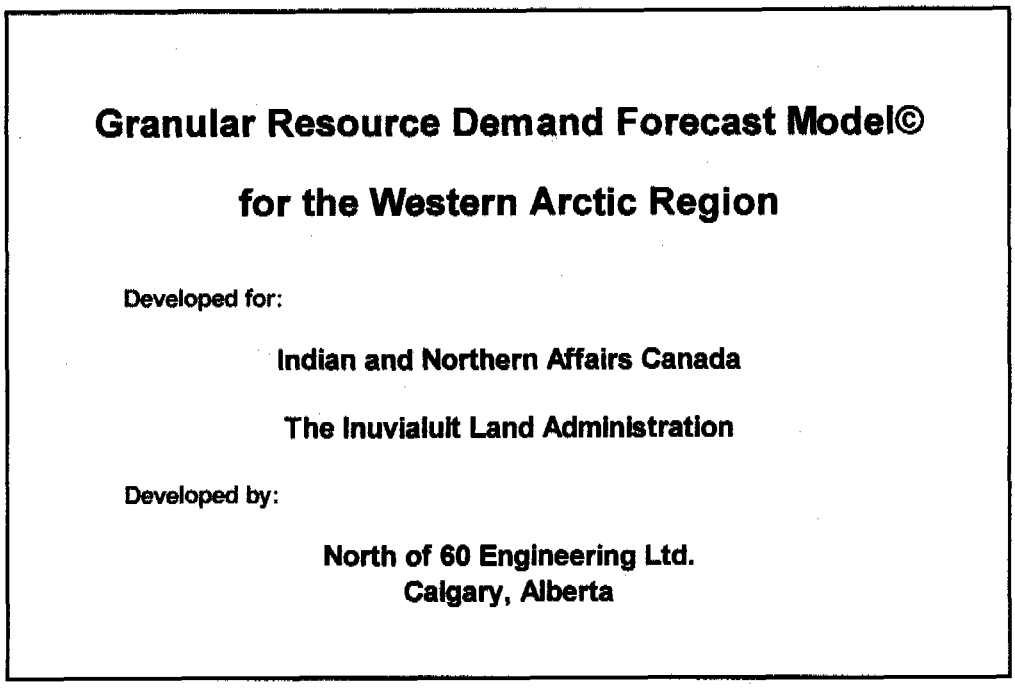
File Name	Description
GRANOPEN.XLS	Key Macros for the Application - Startup file
GRANCALC.XLS	Workbook to Calculate Volumes
GRANANAL.XLS	Workbook used to Analyze Data
GRANDATA.XLS	Database
GRANBACK.XLS	Backup to GRANDATA.XLS

Granular Resource Forecast Model© Files
Table 1

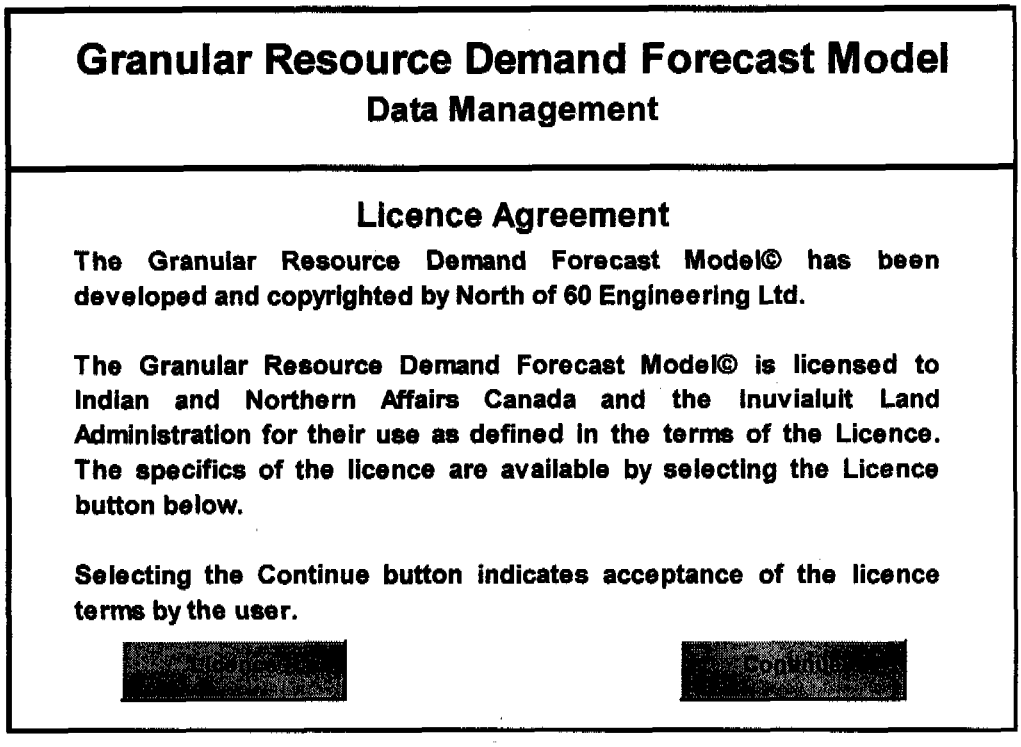
2.4. Starting the Program

To run the Granular Resource Forecast Model© application:

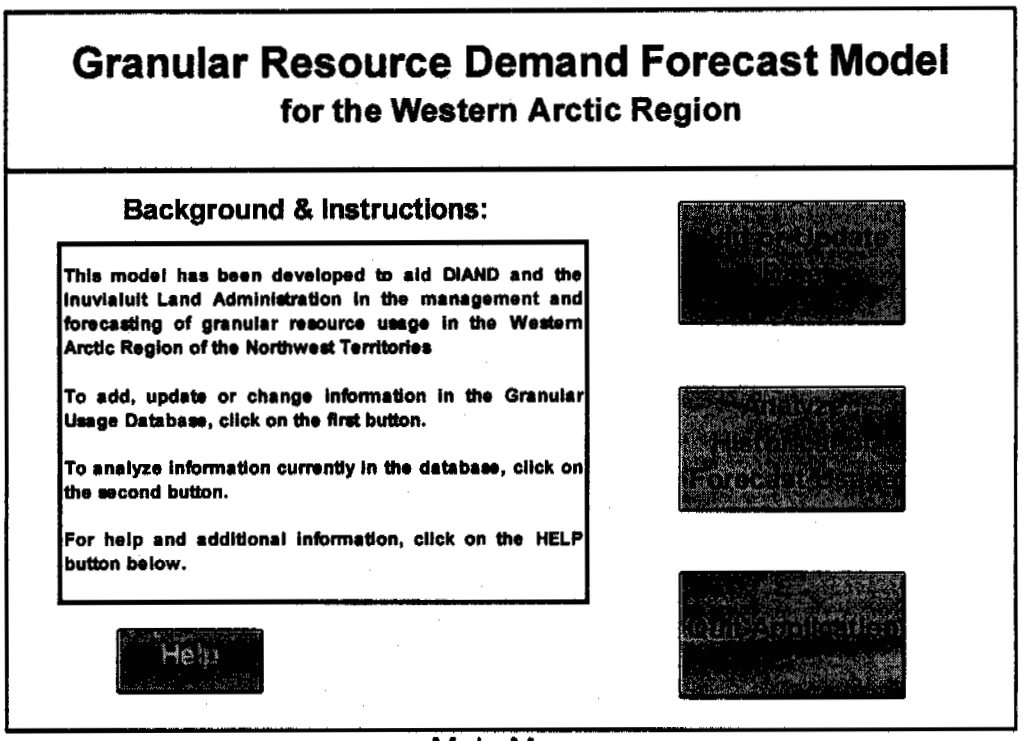
1. Close any unnecessary applications that may be operating on your computer to maximize memory and system resources. This is done by selecting Exit from the File menu of the applications .
2. Start Microsoft Excel Version 5.0 or later.
3. Set the default directory to the one that contains the application files. This is the directory that you created in the previous section.
4. Start the application by opening the GRANOPEN.XLS file. To open a file, select Open under the File menu. Click on the GRANOPEN.XLS file, in the dialog box and then press the ENTER.
5. An introductory screen, Figure 2 will appear, and then the Licence screen, Figure 3.
6. Select the **Continue** button if you accept the Licence terms. A summary of the licence can be seen by selecting the **Licence** button. The entire licence is contained in Appendix A of this guide.
7. The Main menu, as shown in Figure 4 will soon appear.



Introductory Screen
Figure 2



Licence Agreement
Figure 3



Main Menu
Figure 4

2.5. Program Structure

The Granular Resource Forecast Model© is a database of historical, current and future granular requirements. The application has been divided into two major components. As the Main Menu implies, the first half of the application is devoted to adding and maintaining information within the database. The details of the database will be discussed in the next section of the User's Guide.

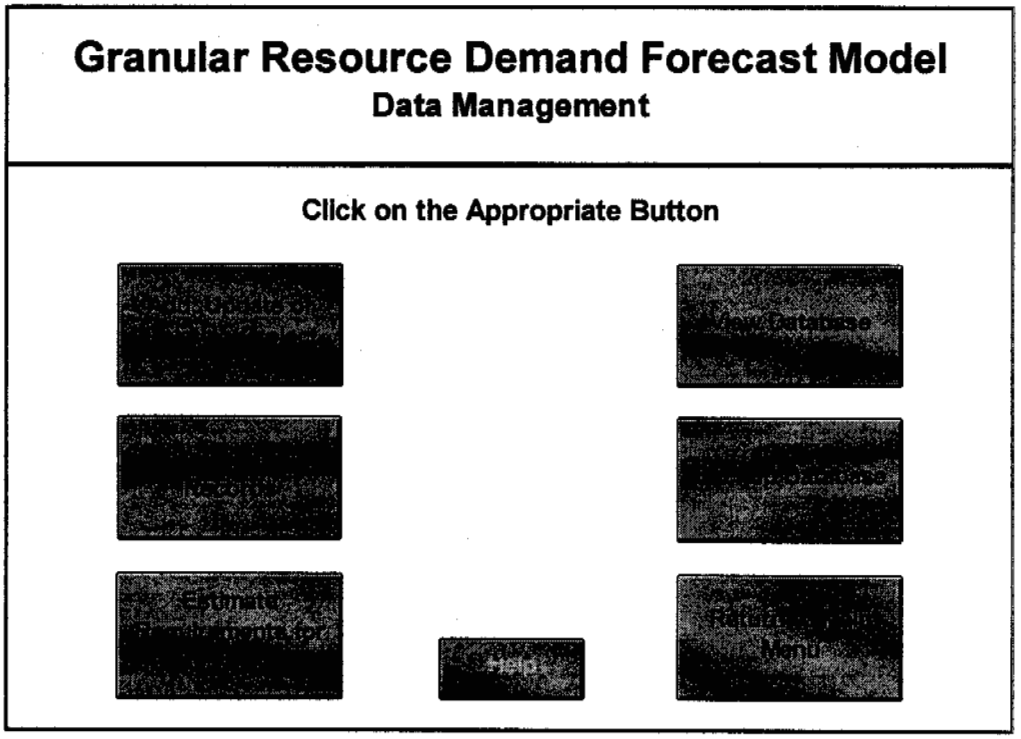
The second half of the application is devoted to analyzing the information within the database, both from historical and future perspectives. You can, for example, compare actual granular usage to historical forecasts, or usage by area, source or quality. The analysis section also allows, with limitations, users to define their own criteria to study the data. The specifics on data analysis and the various reports that are available are presented in Section 5 of the User's Guide.

3. Granular Usage Database

3.1. Introduction

This section of the User's Guide focuses on the Granular Usage Database, its makeup and procedures to maintain it.

As a user, you access the database by clicking on the **Add or Update Data** button (the top button) on the Main Menu (Figure 4). The program will then present the Data Management Menu shown below.



Data Management Menu
Figure 5

3.2. Database Fields

For those unfamiliar with database terminology, a *database*, or *table* as it is often referred to, is a container for data about a particular subject, in this case, granular resource usage. There are two basic elements in a database. Each category of information is called a *field*. Thus, a telephone book has three fields: name, address, phone number. Each set of information is called a *record*. For example, this entry in a phone book constitutes a record:

Doe, John 13 Elm Street 555-4321

There are two basic arrangements for tracking data. The telephone book is a *tabular database*. The information is arranged in a table of columns and rows as outlined in Figure 6. The granular usage database is laid out in this fashion. Another way to look at the information within the database is through *forms*. The right portion of Figure 6 shows each record on a separate form, much like a card file or Rolodex. The Granular Resource Forecast Model© uses both tables and forms to record and view granular usage.

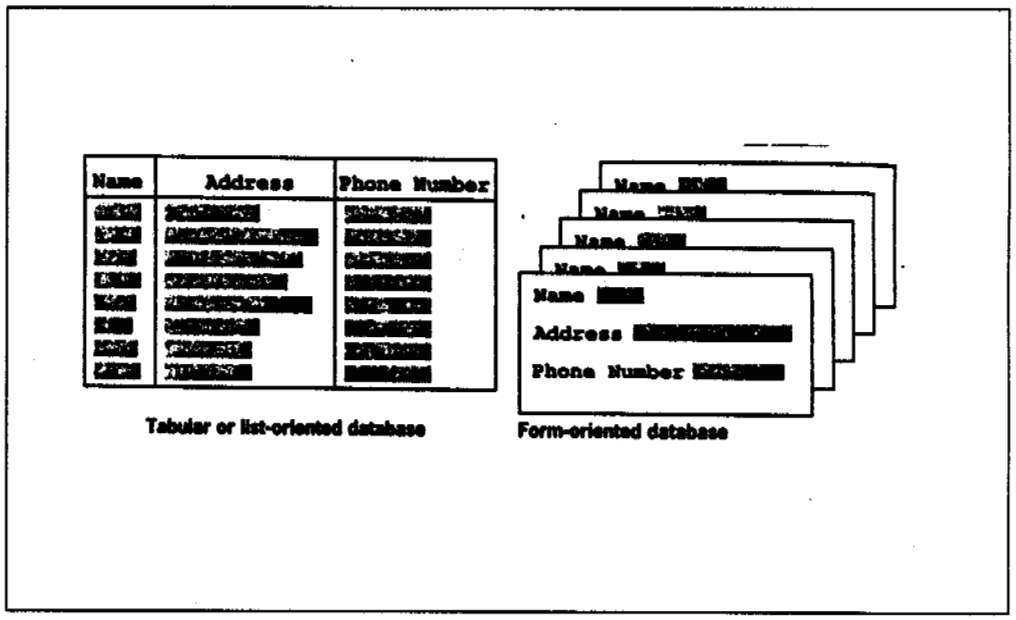


Diagram of two Database Layouts
Figure 6

The granular usage database contains 22 fields of information for each record. These fields are summarized in Table 2 and discussed in detail below. They are presented in the order in which they are presented in the table view of the database.

FIELD	NAME	DESCRIPTION
Record Number	REC#	Record Number
Date of Permit / Estimate	DATE	Date of Permit or Estimate
Quarry Permit #	QUARRY	Actual Permit Number
Land use Permit #	LAND	Actual Number or Estimate Number
Permit / Estimate Status	STATUS	Estimate, Active, Closed
Block / District	BLOCK	General Area i.e. ILA Block, or DIAND District
Source	SOURCE	Source Code Identification
Source Location	LOCATION	Source Location
Permit Holder	PERMITTEE	Company responsible for permits
Contractor	CONTRACTOR	Company that is extracting gravel
Low Estimate	EST_LOW	Low estimate of requirements
Mean Estimate	EST_MEAN	Likely estimate of requirements
High Estimate	EST_HIGH	High estimate of requirements
Estimate Classification	EST_CLASS	Estimated material classifications
Requested Requirements	REQUESTED	Requested requirements
Requested Class	REQ_CLASS	Requested class of material
Actual Requirements	ACTUAL	Actual amount extracted
Actual Class	ACT_CLASS	Actual classification
Year of Usage	EST_YEAR	Year of extraction and placement
Sponsor	SPONSOR	Company Sponsoring the Project
Category	CATEGORY	End user classification e.g. Private, Government, Military, Municipal
Project Description	PROJ_DESCRIP	Description of the project
Location	PROJ_LOC	Actual Location

Granular Resource Data Base
Table 2

Record Number: This is the number of the record. It is automatically generated by the program. Record numbers can change from time to time, if for example an old record is deleted. It is therefore not recommended that they be used to identify land use or quarry permit numbers.

Date of Record: This represents the date the record was first entered or last updated. It is entered by the user.

Quarry Permit #: Is the quarry permit number.

Land use Permit #: Is the land use permit number.

Status: This is the status of the specific project. The user should enter one of the following depending on the stage of development.

- Estimate
- Active
- Inactive
- Closed

Block: The land block from which the granular material is being extracted.

Source #: The gravel source number within the block.

Source Location: The location of the gravel source. Generally speaking, this would be the UTM co-ordinates of the source; however, latitude and longitudes or other descriptors are also allowed.

Permit Holder: The person or company that is requesting the permits. This would generally be the person responsible for the payment of royalties and meeting the conditions of the permit.

Contractor: The person or company actually undertaking the quarry operations. In many cases, this would be the same as the permit holder.

Low Estimate: A low side estimate of the amount of material to be required, expressed in cubic meters.

Mean Estimate: A likely estimate of the amount of material to be required, expressed in cubic meters.

High Estimate: A high side estimate of the amount of material to be required, expressed in cubic meters.

Estimated Class: An estimate of the required class of material (1-5). The specific classes are defined in Appendix C of the User's Guide.

Requested Amount: The amount of material requested at the time of quarry permit application.

Requested Class: The class of material requested at the time of quarry permit application.

Actual Amount: The actual amount of material used. Generally speaking this would be based on trip tickets or an actual survey of the quarry site at the end of the project.

Actual Class: The actual class of the material used.

Year of Use: The year that the material was used. Initially this would be an estimate, but would change to reflect actual year of use.

Sponsor: The name of the individual company or municipality that is sponsoring the project.

Sponsor Category: A descriptive category for the sponsor. NORTH OF 60 ENGINEERING LTD. recommends that a limited number of categories be used. Possible examples are:

- Public
- Private
- Defense

Project Description: A brief description of the project.

Project Location: The location of the project. Generally speaking this would be the UTM coordinates of the source; however latitude and longitudes or other descriptors are also allowed.

3.3. Data Management Menu

The data management menu is shown in Figure 5. This section describes each of the options contained on the menu.

Adding, Updating or Deleting Projects

As the name implies, this option allows you to add, update or delete a project. Clicking on the button takes you to a view similar to Figure 7.

To access the Data Form, click on the **Access Data Form** button in the upper left hand portion of the screen. The data form similar to Figure 8 will appear.

To Add a Record

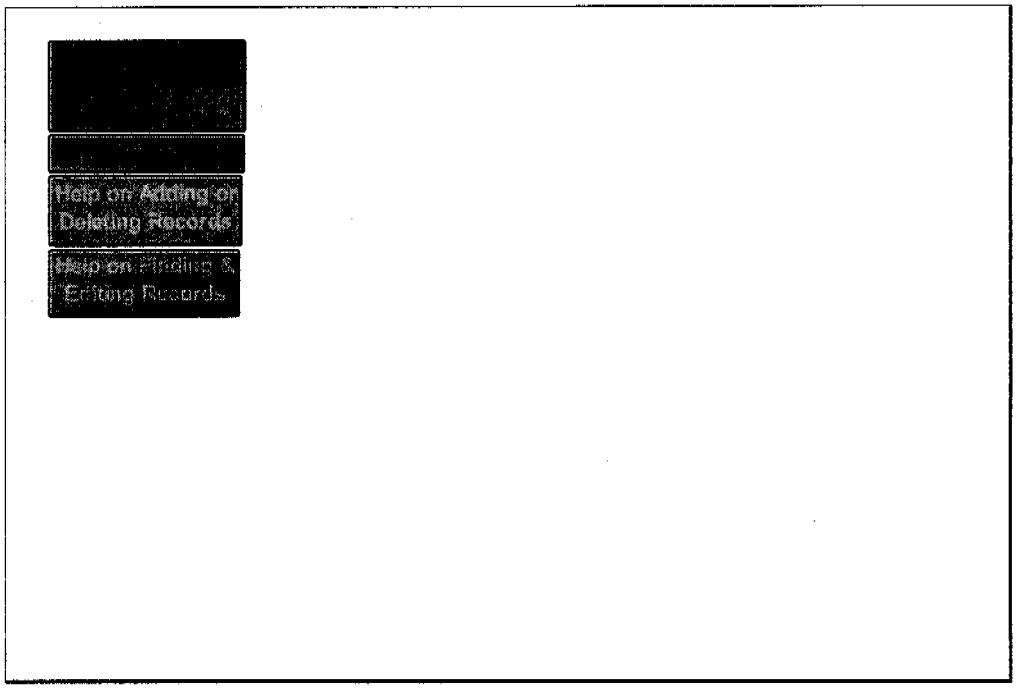
1. Choose the **New** Button.
2. Enter data in the new record's fields. Press TAB to move between fields.
3. Press ENTER.
4. Repeat steps 2 and 3 to add as many records as you want.

To Delete a Record

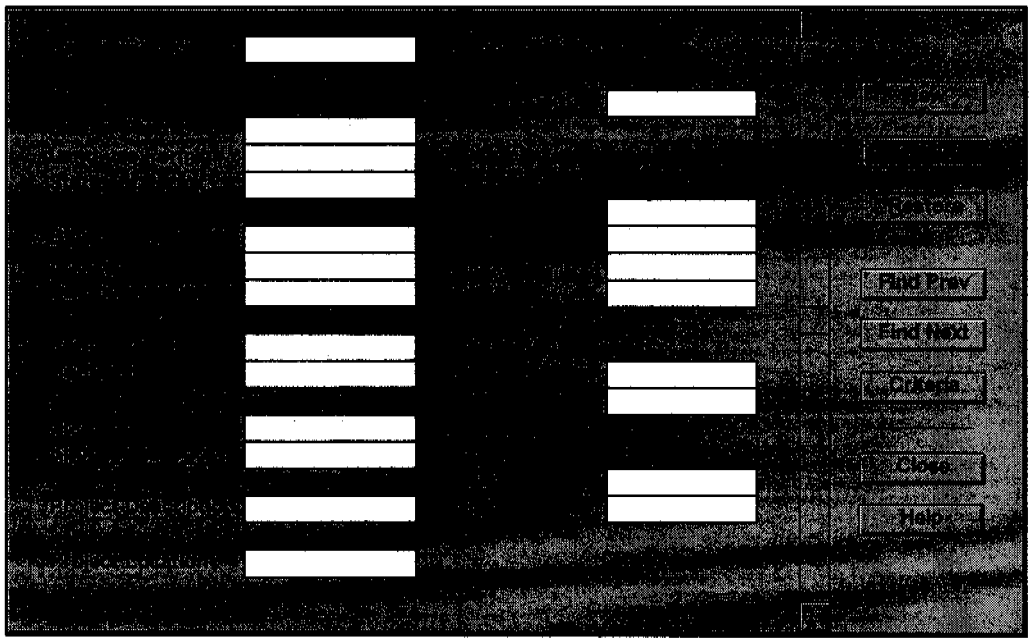
Note: Deleted records cannot be restored. Also note that the first 20 records of the database contain estimates of base demand. They should never be deleted. If one or more is deleted, it will corrupt the database and the user will have to revert to the backup database, thus losing any changes made since the database was last backed up.

To delete a record:

1) Display the record you want to delete.
2) Choose the **Delete** button.



Data Form View
Figure 7



Data Form
Figure 8

To Find a Record

1) Choose the **Criteria** button. Note that the **Criteria** button changes to the **Form** button, which you can choose to return to the data form.
2) In the field name boxes, type the criteria you want to use for the search.
3) Press ENTER. The first matching record will be displayed.
4) Choose the **Find Next** button or **Find Prev** button to display matching records.

To Edit Records

1) To move between records, use the scroll bar, press the UP or DOWN ARROW key, or choose the **Find Prev** or **Find Next** button.
2) Edit each record you want to change. Press TAB to move between fields. To cancel changes of a record, choose the **Restore** button.

To Return to the Data Management Menu

1) Choose the **Close** button when you are finished working in the data form. The Data Form view, Figure 6, will appear.
2) Click on the **Return** Button and the Data Management View, Figure 5 will reappear.

View Database

To view the granular usage database in tabular form, click on the upper right button labeled **View Database**. A view similar to Figure 9 will appear. You may scroll through the database by using the elevator bars at the bottom and right hand sides of the screen. For more information on the use of elevator bars see your Microsoft Windows Manual or the Windows Tutorial.

To return to the Data Management Menu click on the **Return** button located above the database.

Granular Resource Usage Database [redacted]

Record	Date	Quarry	Land	Status	Block	Source	Location
1	10/31/93	EST1993	#N/A	Forecast	#N/A	#N/A	#N/A
2	10/31/93	EST1994	#N/A	Forecast	#N/A	#N/A	#N/A
3	10/31/93	EST1995	#N/A	Forecast	#N/A	#N/A	#N/A
4	10/31/93	EST1996	#N/A	Forecast	#N/A	#N/A	#N/A
5	10/31/93	EST1997	#N/A	Forecast	#N/A	#N/A	#N/A
6	10/31/93	EST1998	#N/A	Forecast	#N/A	#N/A	#N/A
7	10/31/93	EST1999	#N/A	Forecast	#N/A	#N/A	#N/A
8	10/31/93	EST2000	#N/A	Forecast	#N/A	#N/A	#N/A
9	10/31/93	EST2001	#N/A	Forecast	#N/A	#N/A	#N/A
10	10/31/93	EST2002	#N/A	Forecast	#N/A	#N/A	#N/A
11	10/31/93	EST2003	#N/A	Forecast	#N/A	#N/A	#N/A
12	10/31/93	EST2004	#N/A	Forecast	#N/A	#N/A	#N/A
13	10/31/93	EST2005	#N/A	Forecast	#N/A	#N/A	#N/A
14	10/31/93	EST2006	#N/A	Forecast	#N/A	#N/A	#N/A
15	10/31/93	EST2007	#N/A	Forecast	#N/A	#N/A	#N/A
16	10/31/93	EST2008	#N/A	Forecast	#N/A	#N/A	#N/A
17	10/31/93	EST2009	#N/A	Forecast	#N/A	#N/A	#N/A
18	10/31/93	EST2010	#N/A	Forecast	#N/A	#N/A	#N/A
19	10/31/93	EST2011	#N/A	Forecast	#N/A	#N/A	#N/A
20	10/31/93	EST2012	#N/A	Forecast	#N/A	#N/A	#N/A
21	1/1/92	ILA92IQ10		Inactive	Inuvik	Source	
22	1/1/93	ILA93SQ51		Active	Sachs	Mary Sachs Pt.	

Granular Resource Usage Database
Figure 9

View & Print Records

To view and print individual records in the database, select the **View and Print Records** button from the Data Management Window (Figure 5). A record form similar to Figure 10 will appear.

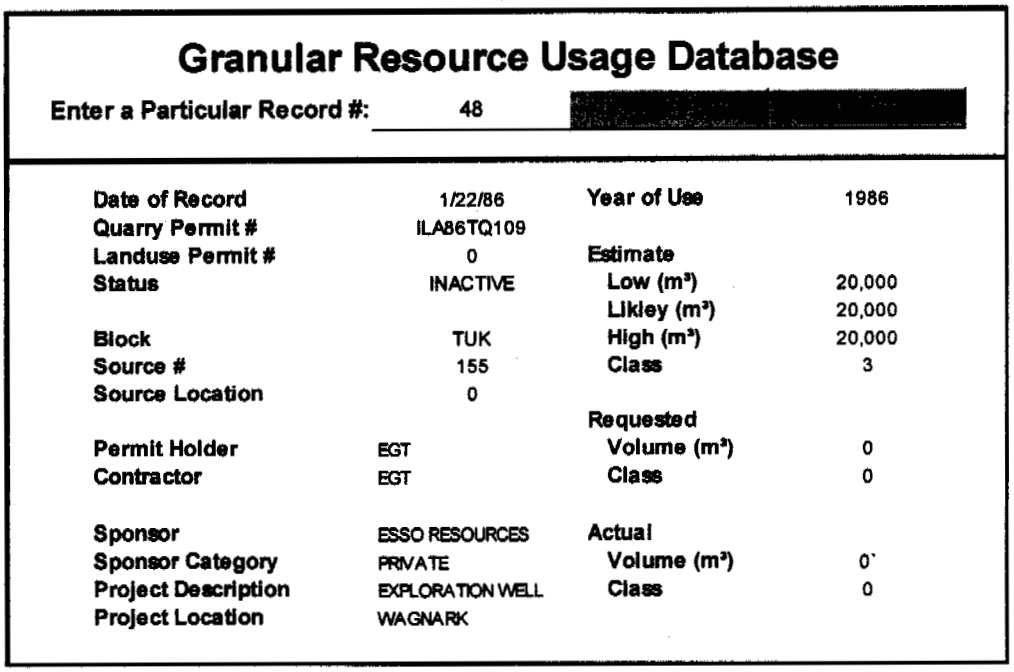
To select a particular record:

1) Click on the light blue colored record box.

2) Enter the record number and click on **OK** or press the ENTER key.

To print a particular record, simply select the record as described above and then click on the **Print Record** button.

To return to the Data Management Menu select the **Return** button.



Granular Resource Usage Database

Enter a Particular Record #: 48

Date of Record	1/22/86	**Year of Use**	1986
Quarry Permit #	ILA86TQ109		
Landuse Permit #	0	**Estimate**	
Status	INACTIVE	**Low (m³)**	20,000
		Likley (m³)	20,000
Block	TUK	**High (m³)**	20,000
Source #	155	**Class**	3
Source Location	0		
		Requested	
Permit Holder	EGT	**Volume (m³)**	0
Contractor	EGT	**Class**	0
Sponsor	ESSO RESOURCES	**Actual**	
Sponsor Category	PRIVATE	**Volume (m³)**	0
Project Description	EXPLORATION WELL	**Class**	0
Project Location	WAGNARK		

Individual Record Form
Figure 10

Backup Database

To backup the database select the **Backup Database** button from the Data Management Menu. This will create a copy of the current database under the file name of GRANBAK.XLS in the directory which contains the program files. It overwrites the last backup that was previously created.

To use the backup database in the event that the current one becomes corrupted:

1) Quit the Granular Resource Forecast Model©.
2) Select Open under the Microsoft Excel File menu.
3) Highlight the GRANBAK.XLS file and click on the **OK** button or press the Enter key. The backup database will appear and also a dialog box asking if Excel should update references to unopened documents. Click on the **NO** button.
4) Select File Save As under the Microsoft Excel File menu. Enter the file name GRANDATA.XLS in the filename box. Press the ENTER key or click on the **OK** button. A dialog box will appear asking if Excel should replace the existing GRANDATA.XLS. Click the **OK** button.

5) Select Close from the File Menu.

Estimate Requirements for a Project

This component of the model allows the user to estimate the granular requirements for an anticipated project. Specific details on the use of the granular estimating tool are covered in the next section.

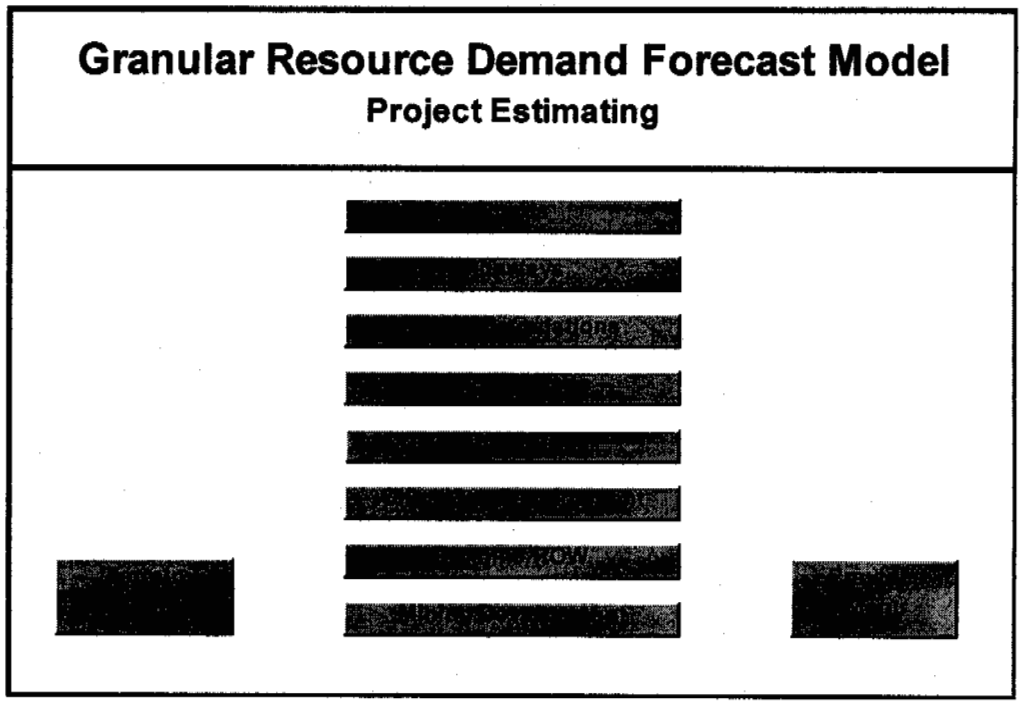
Return to the Main Menu

To return to the Main Menu click on the **Return to Main Menu** in the lower right hand corner of the Data Management Menu.

4. Estimating Granular Requirements

4.1. Introduction

This section of the User's Guide provides information to estimate granular requirements for a number of common projects in the North. This segment of the model is accessed by selecting the **Estimate Requirements for a Project** button from the Data Management Menu (Figure 5). This will bring up the Project Estimating Menu shown below in Figure 11.



Project Estimating Module
Figure 11

Granular resource requirements can be estimated for:

- Roads
- Runways
- Pads / Building Foundations
- Staging Areas
- Exploration Drill Sites
- Oil or Gas Developments
- Pipeline Right-of-ways
- Mine Site Developments

In each case, a number of variables or parameters are used to define the geometry or development scenario under consideration. Figure 12 is a representative view of the Road parameters. The program provides default assumptions for each of the parameters, but it also allows the user to override the assumptions to reflect the specific project under consideration. In this case, for example, the embankment thickness has been decreased from two meters to 1.5 meters, and the length of the road has been increased from one kilometer to 3.5 km. Any changes are entered into the override column and these are then automatically reflected in the Actual column.

The rest of this section discusses the specific parameters within each of the above areas, their basis, and default assumptions.

4.2. Roads

To estimate the granular resource requirements for a road, click on the button labeled **Roads**. The Roadway Embankment Screen, Figure 12 will appear. This screen contains the key parameters necessary to estimate a roadway embankment similar in design to the cross-section shown in Figure 13. They are:

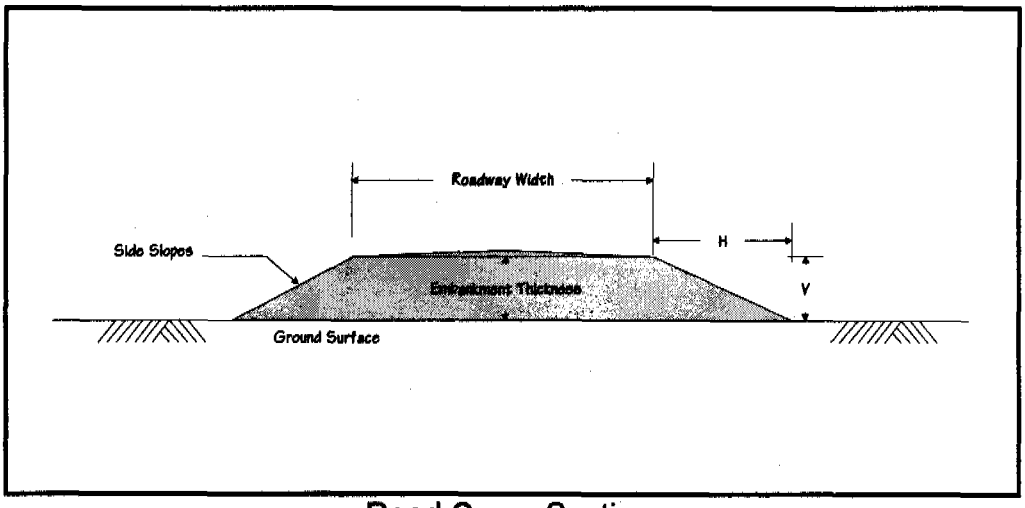
Width of Driving Surface	The default width is 8 metres.
Embankment thickness.	The default thickness is 2 metres. Generally speaking, this depth should be adjusted so as to maintain the permafrost within the embankment.
Slopes	This is the angle of the side slopes. It is the ratio of the horizontal distance divided by the vertical drop in that distance. The default slope is 3 m/m.

Granular Resource Demand Forecast Model

Roadway Embankment

Parameter	Units	Default	Override	Actual
Width of Driving Surface	m	8.0		8.0
Embankment Thickness	m	2.0	1.5	1.5
Slopes	H/V	3.0		3.0
Length	km	1.0	3.5	3.5
Terrain Factor	1 - 5	2		2
Material Class	1 - 5	3		3
Calculated Volume	m^3	41,842		99,082

Roadway Parameters
Figure 12



Road Cross-Section
Figure 13

Length	The length of the road in kilometres. The default is one kilometre.
Terrain Factor	This parameter accounts for different terrain conditions. It is defined in greater detail later in the section. It is a number which ranges from 1 for flat terrain to 5 for hilly terrain. The default value is 3.
Material Class	The type of material that is required. The various classifications are defined in Appendix C. The default material classification for roads is 3.
Calculated Volume	Shows the estimated volume of granular material based on the parameters and the overrides. In this case the actual volume is 99,082 m^3. If there were no overrides then the volume would have been 41,842 m^3.

4.3. Runways

The key parameters for runways are shown in Figure 14 and the corresponding cross-section geometry for the runway is shown in Figure 15.

The parameters specific to runways are:

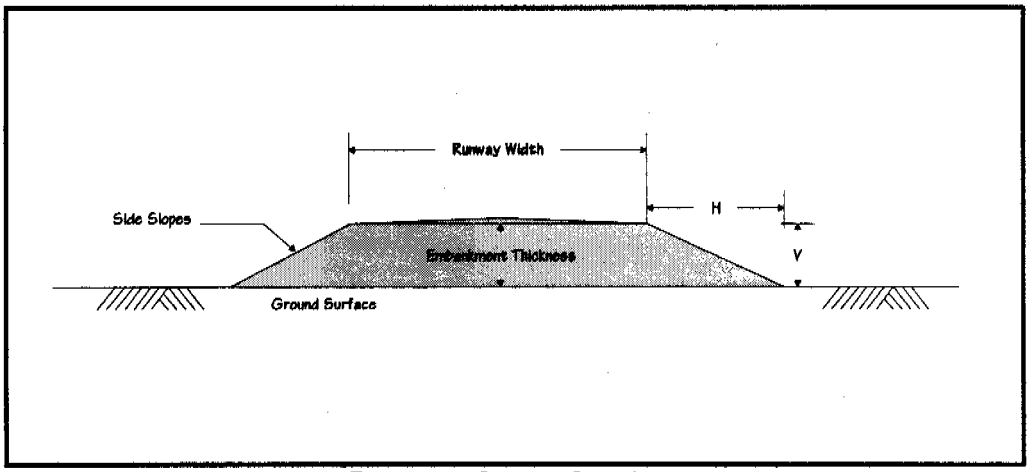
Width of Landing Surface	This is the width of the landing surface. The default value is 50 metres.
Embankment Thickness	The default value is two metres; however this is generally a function of the permafrost conditions in the area.
Slopes	This is the angle of the side slopes. It is the ratio of the horizontal distance divided by the vertical drop in that distance. The default slope is 3 m/m.
Length	The length of the runway in metres. The default value is 1000 metres which would accommodate STOL aircraft similar to the Twin Otter.

Granular Resource Demand Forecast Model

[redacted] **Runway** [redacted]

Parameter	Units	Default	Override	Actual
Width of Landing Surface	m	50.0		50.0
Embankment Thickness	m	2.0		2.0
Slopes	H/V	3.0		3.0
Length	m	1000		1000
Terrain Factor	1 - 5	1		1
Material Class	1 - 5	3		3
Calculated Volume	m^3	166,882		166,882

Runway Parameters
Figure 14



Runway Cross-Section
Figure 15

4.4. Pads / Foundations

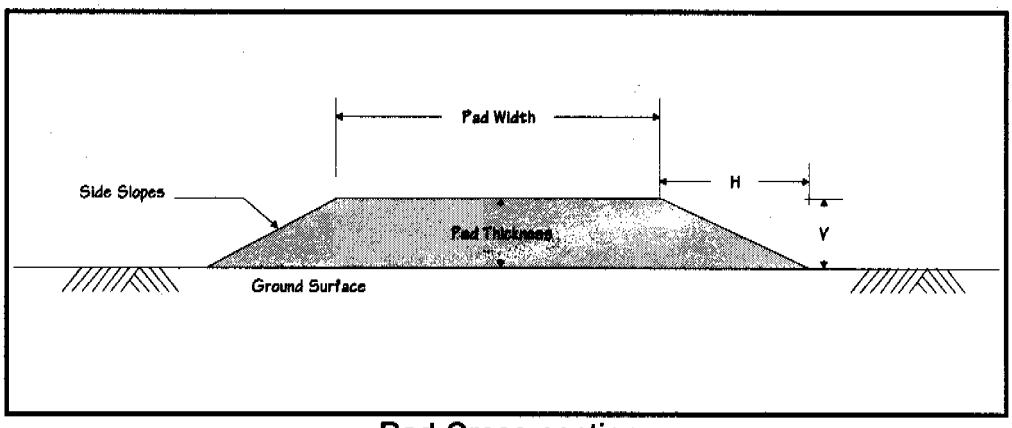
The key parameters for pads or building foundations are shown in Figure 16 and the corresponding cross-section geometry for the pad is shown in Figure 17.

Granular Resource Demand Forecast Model

Pad Foundation

Parameter	Units	Default	Override	Actual
Width of Pad	m	15.0		15.0
Length of Pad	m	15.0		15.0
Thickness of Pad	m	3.0		3.0
Slopes	H/V	1.0		1.0
Terrain Factor	1 - 5	2		2
Material Class	1 - 5	3		3
Calculated Volume	m^3	1,383		1,383

Pad Design Parameters
Figure 16



Pad Cross-section
Figure 17

The parameters specific to runways are:

Width of Pad	This is the surface width of the pad. The default value is 15 metres.
Length of Pad	This is the length of the pad. The default value is 15 metres.
Thickness of Pad	The default value is 3 metres.
Slopes	This is the angle of the side slopes. It is the ratio of the horizontal distance divided by the vertical drop in that distance. The default slope is 1 m/m.

4.5. Staging Areas

The key parameters for staging areas are shown in Figure 18. The cross-section geometry for staging areas is similar to that for pads.

Granular Resource Demand Forecast Model

Staging Area

Parameter	Units	Default	Override	Actual
Width of Pad	m	150.0		150.0
Length of Pad	m	150.0		150.0
Thickness of Pad	m	2.0		2.0
Slopes	H/V	1.0		1.0
Terrain Factor	1 - 5	2		2
Material Class	1 - 5	3		3
Calculated Volume	m^3	67,591		67,591

Staging Area Design Parameters
Figure 18

The key parameters are:

Width of Pad	This is the width of the staging area. The default value is 150 metres.
Length of Pad	The default value is 150 metres.
Pad Thickness	The default value is 2 metres.
Slopes	This is the angle of the side slopes. It is the ratio of the horizontal distance divided by the vertical drop in that distance. The default slope is 1 m/m.

4.6. Drill Sites

The key parameters for exploration drilling site are shown in Figure 19. The plan view of the drill site is shown in Figure 20.

The key parameters and the underlying assumptions are:

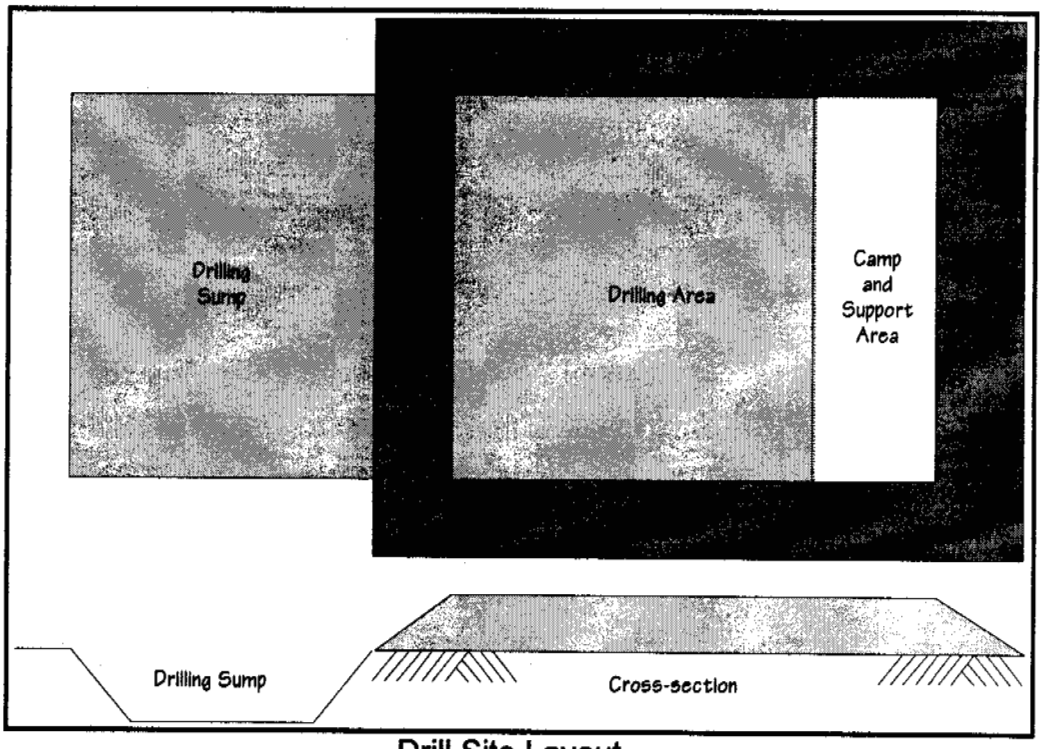
Project Timing	Exploration drilling is by default assumed to take place during the winter from snow work pads. As such, granular material requirements are limited to restoration of the drilling sump. If a summer program is proposed, the user should enter **Summer** as the override.
Drilling Pad	This is the area of the drilling pad. The default value is 0 square metres (m^2) for winter operations and 1,500 m^2 for summer operations.
Camp and Support Area	The default value is zero square metres for winter operations and 900 m^2 for summer sites.
Mud Sump	It is assumed that a mud sump would be excavated into the tundra and that a one metre gravel overlay would be placed at the end of the drilling program to restore the area. The default size of the mud sump is 450 m^2.
Pad Thickness	The default pad thickness is 2 metres.

Granular Resource Demand Forecast Model

Drill Site (Exploration)

Parameter Summer / Winter Program	Units	Default Winter	Override	Actual Winter
Drilling Pad Area	m^2	0.0		0.0
Camp & Support Area	m^2	0.0		0.0
Drilling Sump Area	m^2	450.0		450.0
Pad Thickness	m	2.0		2.0
Terrain Factor	1 - 5	2		2
Material Class	1 - 5	3		3
Calculated Volume	m^3	658		658

Drill Site Parameters
Figure 19



Drill Site Layout
Figure 20

4.7. Oil or Gas Developments

The key parameters for an oil or gas development are shown in Figure 21. A simplified but typical field development plan is shown in Figure 22. It assumes that the development wells would be clustered and drilled from a number of pads within the field boundaries. The actual number of pads is calculated by the program. The number is dependent on the reservoir depth and the field geometry. The size of the pads, also calculated by the program, is a function of the number of wells per pad and the well spacing. The development plan assumes that roads would connect the drilling pads to the production facilities. It also assumes that a camp and staging area would be required next to the production facilities, and that all gathering lines would be supported above ground on vertical support members (piles).

The key parameters for an oil or gas development are:

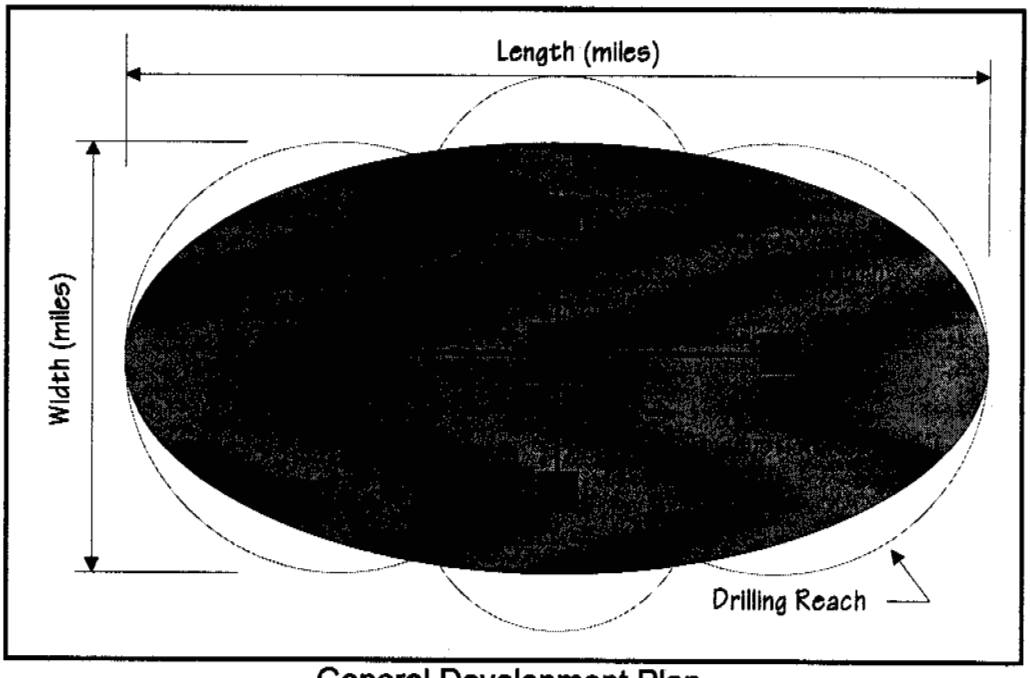
Product Type	Oil or Gas. The default is oil. If a gas development is being considered, the user should enter Gas as the override.
Recoverable Reserves	This is the amount of oil or gas expressed in millions of cubic meters that will be produced over the life of the field.
Reservoir Depth	This is the depth of the reservoir in meters.
Reservoir Area	This is the surface area of the reservoir expressed in square kilometers.
Well Spacing	This is the area, expressed in hectares that each well drains. A default value of 65 hectares is assumed for oil and 300 hectares for each gas well. If the developer provides the total number of wells, the well spacing can be calculated by dividing the aerial extent of the reservoir by the number of wells.
Field Aspect Ratio	This variable defines the general shape of the field. It is the ratio of the length of the field divided by the width. As shown in Figure 22, an oval geometry has been assumed for the field area. The default value is 2. If the field is long and narrow, then the user should increase this value.

Granular Resource Demand Forecast Model

Oil / Gas Development

Parameter	Units	Default	Override	Actual
Oil / Gas		Oil		Oil
Recoverable Reserves	m^3 x 10^6	30		30
Reservoir Depth	m	2750		2750
Reservoir Area	km^2	50		50
Well Spacing	ha	65		65
Field Aspect Ratio	L/W	2		2
# Drilling Pads		6		6
Plant Area	m^2	16875		16875
Runway Length	m	1000		1000
Roadway Length	km	33.2		33.2
Camp & Staging Area	m^2	12500		12500
Drilling Pad Area	m^2	16722		16722
Embankment Thickness	m	2		2
Terrain Factor	1 - 5	2		2
Material Class	1 - 5	3		3
Calculated Volume	m^3	1,364,561		1,364,561

Oil and Gas Development Parameters
Figure 21



General Development Plan
Figure 22

# Drilling Pads	The program calculates the number of well pads required to drain the reservoir properly. The number of pads is a function of many variables, including the size of the reservoir, its shape and depth, the well spacing and a number of drilling assumptions which are beyond the scope of this report. The user should override the calculated number if the developer defines the actual number of drilling pads.
Plant Area	This variable is the surface area of a pad that would support the production facilities. The default area is a function of the plant size.
Runway Length	The development plan assumes a runway is included. The default length is 1,000 metres. If no runway is required the user should override this value to zero.
Roadway Length	The roadway length expressed in kilometres is a function of the number of well pads and the distance from the pads to the production facilities. The user should enter the actual length of roadway if it is known. The default width is 8 metres.
Camp & Staging Area	The default area is 12,500 m^2.
Drilling Pad Area	The drilling pad area is a function of the number of wells per pad. The area is expressed in square metres (m^2).
Embankment Thickness	This is the average embankment thickness expressed in metres. The default is 2 metres.

4.8. Pipeline Right-of-ways

The key parameters for pipeline right-of-ways are shown in Figure 23 and the corresponding cross-section geometry for the pad is shown in Figure 24.

The key parameters and their underlying assumptions are:

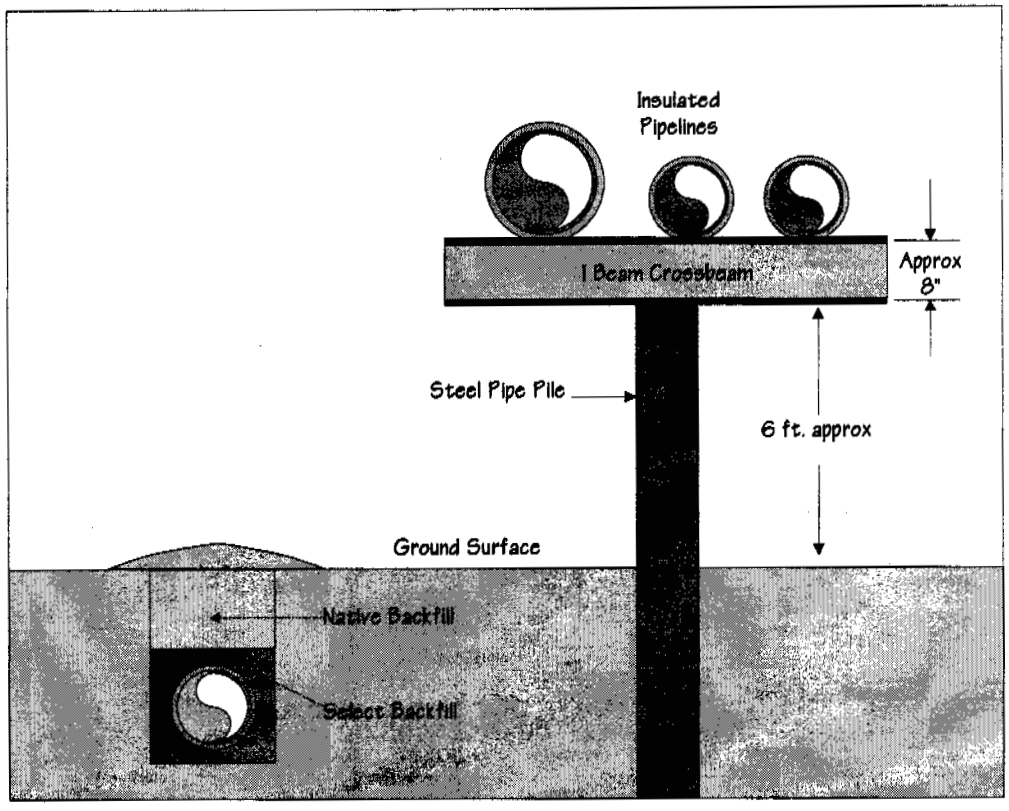
Product	Oil or Gas pipeline. The default is oil.
Line Size	The nominal pipeline diameter expressed in millimeters (mm).
Length	The length of the line expressed in kilometers. The default value is 50 km.
Above Gnd / Buried	Oil pipelines are assumed to be supported above ground, while gas lines are assumed to be buried. The overrides are **Buried** or **Above.**
Support Spacing	The pile support spacing expressed in meters. The default value for elevated lines is 15 m. Buried lines do not require piles.

Granular Resource Demand Forecast Model

Pipeline Right of Way

Parameter	Units	Default	Override	Actual
Oil / Gas		Oil		Oil
Line Size	mm	400		400
Length	km	50		50
Above Gnd / Buried		Above		Above
Support Spacing	m	15		15
Terrain Factor	1 - 5	3		3
Material Class	1 - 5	3		3
Calculated Volume	m^3	3,059		3,059

Pipeline Right-of-Way Parameters
Figure 23

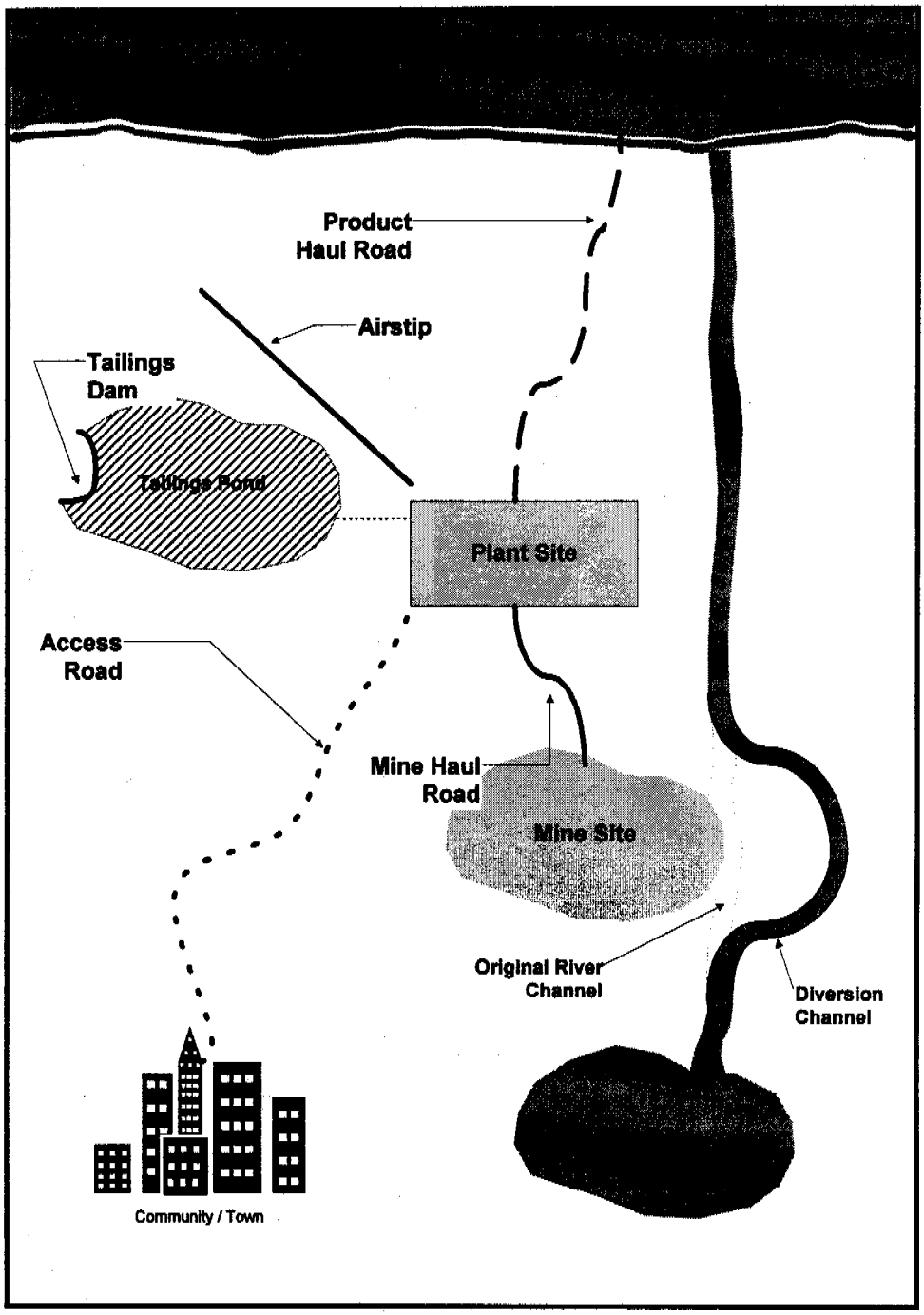


Pipeline Configurations
Figure 24

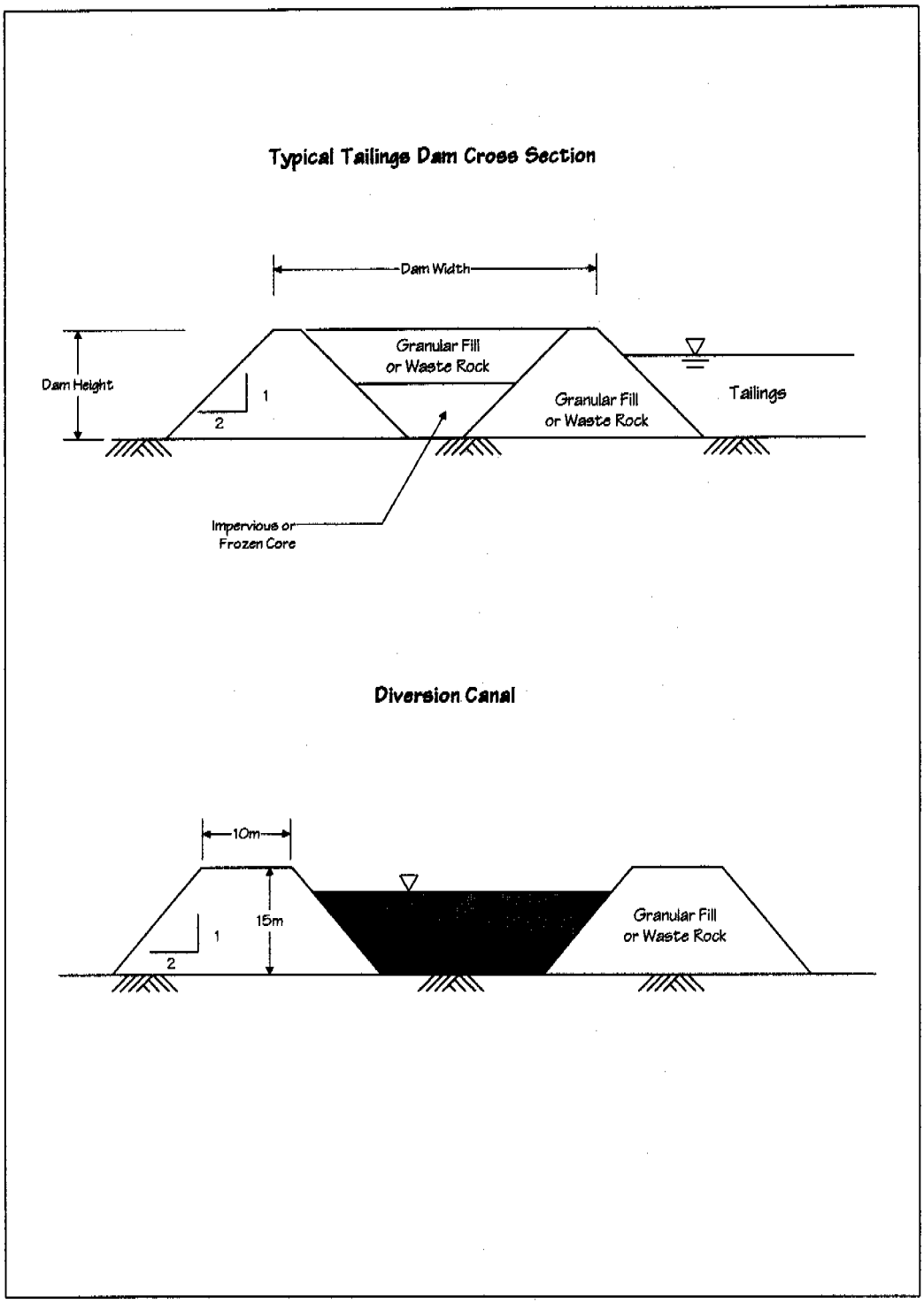
4.9 Mine Sites

A simplified but typical mine development plan is shown in Figure 25. It assumes that ore is mined from either an open surface pit, or an underground shaft / tunnel system The actual configuration will depend on the type of ore body and its depth. Frequently, the developer will have to remove and stockpile rock waste that has no economic value in order to get to the ore body. This waste rock can in some cases replace some of the requirements for natural granular resources. The model includes a provision for using waste rock. The development plan assumes that roads would connect the mine site to the ore processing facilities. It also assumes that a camp and staging area would be required next to the production facilities, The development plan assumes that tailings from the processed ore are contained within a dyked system. It further assumes that water diversion may be required around the pit, waste rock area, or the tailings area.

The corresponding cross-section geometry for the various embankments is shown in Figure 26 and the key parameters for a mine development are shown in Figure 27 and 28.



Mine Development
Figure 25



Embankment Cross Sections
Figure 26

Granular Resource Demand Forecast Model

Mine Development

Parameter		Units	Default	Overrid	Actual
Ore Reserves		M Tonnes	20	50	50
Associated Waste		M Tonnes	50		125
Tailing Waste		M Tonnes	17		42.5
Daily Prouduction		Tonnes/d	3700		9100
Infrastructure				None	
Camp & Staging Area		m²	12500		12500
Plant Area		m²	520000		890000
Tailings Dams	Length	m	1000		1000
	Crest Width	m	20		20
	Avg. Height	m	50		50
	% Waste Rock	%	75		75
Air Strip	Length	m	1875		1875
	Width	m	100		100
	% Waste Rock	%	0		0
Water Diversion	Length	km	0		0
Canals	% Waste Rock	%	50		50

Mine Site Parameters
Figure 27

Granular Resource Demand Forecast Model

Mine Development (Continued)

Parameter		Units	Default	Overrid	Actual
Access Road	Length	km	0		0
	Width	m	10		10
	% Waste Rock	%	0		0
Mine Haul Roads	Length	km	20		20
	Width	m			0
	% Waste Rock	%	50		50
Product Haul Roads	Length	km	5		5
	Width	m			0
	% Waste Rock	%	0		0
Terrain Factor		1 - 5	3		3
Material Class		1 - 5	3		3
Calculated Volume		m³			0

Mine Site Parameters (Page 2)
Figure 28

The key parameters and their underlying assumptions are:

Ore Reserves	This parameter represents the volume of ore reserves to be processed expressed in millions of tonnes.
Associated Waste	This parameter represents the volume of waste material associated with the ore reserve expressed in millions of tonnes. This parameter is a function of the ore reserve volume; however, the user is cautioned that this volume is very site specific.
Tailing Waste	This parameter represents the volume of ore tailings expressed in millions of tonnes. This parameter is a function of the ore reserve volume; however, the user is cautioned that this volume is very site specific.
Daily Production	This parameter represents the daily rate of ore processing expressed in millions of tonnes. This parameter is a function of the ore volume.
Infrastructure	This parameter defines the level of infrastructure in the area of the mine. There are three options; None, Some, and Significant.
Camp & Staging Area	This parameter is the surface area of a pad that would support a camp and staging area. The size is dependent on the amount of infrastructure present.
Plant Area	This variable is the surface area of a pad that would support the production facilities. The default area is a function of the plant size.
Tailings Dams Length	This variable represents the length of dams required to contain the tailings, expressed in meters.
Tailings Dams Crest Width	This is the width of the top portion of the dam expressed in meters.

Tailings Dam Height	This is the average height of the tailings dam expressed in meters.
Percent Waste Rock	This is the percentage of waste rock to be used in the tailings dam.
Airstrip Length	This is the length of the airstrip expressed in meters. The default is a function of existing infrastructure and the daily production rate.
Airstrip Width	This is the width of the airstrip expressed in meters. The default is a function of the airstrip length.
Percent Waste Rock	This is the percentage of waste rock to be used in the tailings dam.
Water Diversion Canals	Two parameters are required, the length expressed in meters, and the percentage of waste rock.
Access Roads	Three parameters are required to define access roads to the mine site. They are the length, expressed in kilometers, the width expressed in meters, and the percentage of waste rock used.
Mine Haul Roads	Three parameters are required to define haul roads used to transport ore within the mine site. They are the length, expressed in kilometers, the width expressed in meters, and the percentage of waste rock used.
Product Haul Roads	Three parameters are required to define haul roads used to transport ore product to market. They are the length, expressed in kilometers, the width expressed in meters, and the percentage of waste rock used.

4.10 Terrain Factors

Terrain Factors have been used throughout the estimating section to account for variable ground conditions. The user can override the default factors that are built into the program by selecting the **Terrain Factors** Button from the Project Estimating Menu (Figure 11). A

screen similar to Figure 29 showing the default terrain factors will appear.

As can be seen from the figure, the terrain conditions are subdivided into five categories varying from Flat with an allowance of 5 per-cent to Rough terrain with a 50 per-cent allowance. These allowances can be adjusted up or down to account for the different terrain types.

One other factor that is used in calculating granular requirements is the in-place multiplier. This factor is used to account for transportation losses and final compaction within the embankment. The default is 33 per-cent. Again this factor can be adjusted to reflect actual experience in a given area.

Granular Resource Demand Forecast Model

Terrain Factors

Parameter	Units	Default	Override	Actual
Terrain Factors				
Flat	1	5%		5%
Gently Rolling	2	10%		10%
Rolling	3	15%		15%
Hilly	4	25%		25%
Rough	5	50%		50%
In-place Multiplier		33%		33%

Terrain Factors
Figure 29

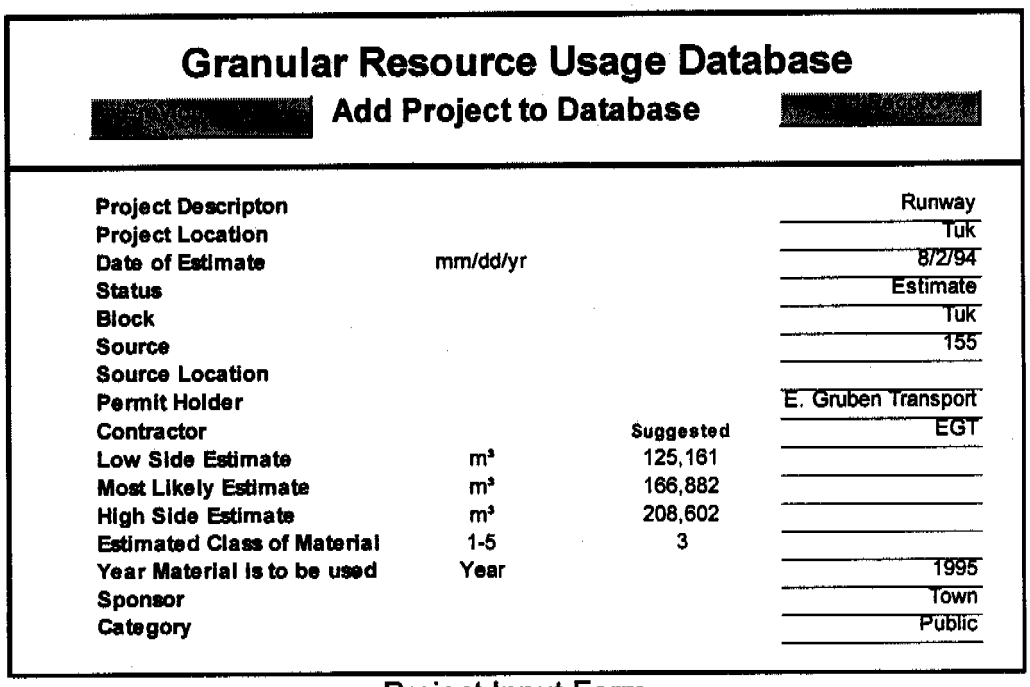
4.11. Adding Estimates to the Database

At the top of each of the estimating screens are two buttons.

The **Menu** button returns the user to Project Estimating Menu (Figure 11) without adding the project to the database.

Clicking on the **Add Record** button accesses the project input form shown in Figure 30 that allows you to add the project to the database.

The input form allows the user to add information pertinent to the project. The project description is automatically selected based on the estimating component being utilized by the user. If one is estimating a runway project, then Runway will appear (as in the example in the Figure). The user would then enter the other pertinent information. The program shows suggested granular resource volumes that have been calculated from the default parameters and overrides for the particular project. The user can accept these values, or change them by entering the changes to the right of the suggestions. With all of the information entered, you add the project to the database by clicking on the **Add Record** Button at the top of the Screen. To return to the estimating portion of the program, select the **Previous Menu** button.



Granular Resource Usage Database

Add Project to Database

Project Descripton			Runway
Project Location			Tuk
Date of Estimate	mm/dd/yr		8/2/94
Status			Estimate
Block			Tuk
Source			155
Source Location			
Permit Holder			E. Gruben Transport
Contractor		Suggested	EGT
Low Side Estimate	m^3	125,161	
Most Likely Estimate	m^3	166,882	
High Side Estimate	m^3	208,602	
Estimated Class of Material	1-5	3	
Year Material is to be used	Year		1995
Sponsor			Town
Category			Public

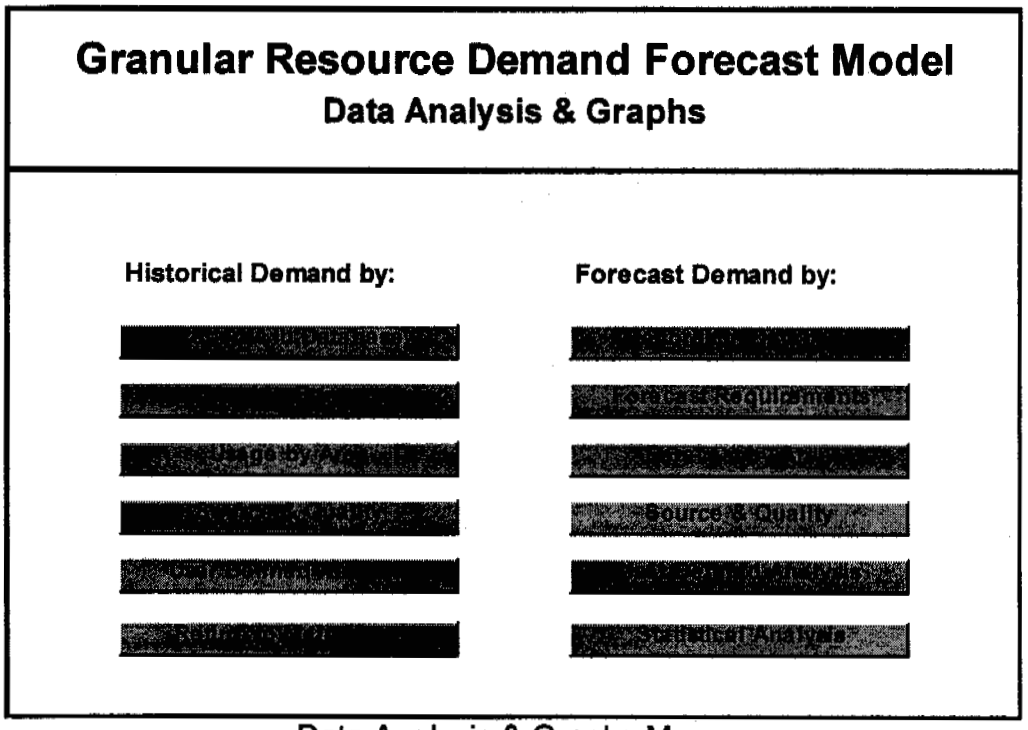
Project Input Form
Figure 30

5. Analyzing Granular Usage

5.1. Introduction

This section of the User's Guide describes the various options available to the user to analyze data within the database. It also covers the available reporting options.

Selecting the **Data Analysis and Graphs** button on the Main Menu (Figure 4) produces the Data Analysis & Graphs menu shown in Figure 31. As evident in the figure, the analysis and reporting is broken into two time frames, historical usage and future demand. Generally speaking, the analysis and reports are the same for both time frames.



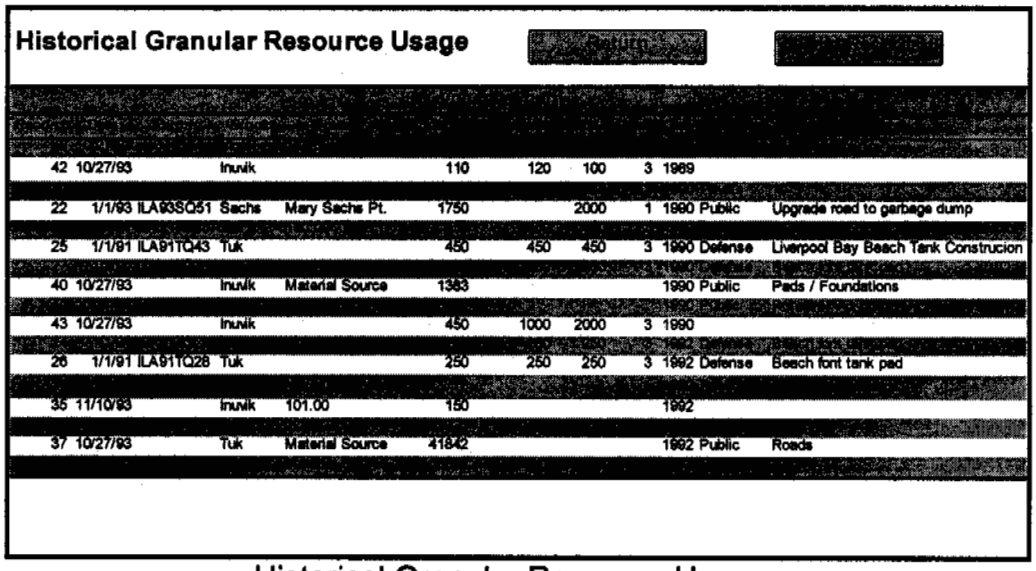
Data Analysis & Graphs Menu
Figure 31

5.2. Historical Demand

Records in the Database

Selecting the **Records in Database** button on the left side of Figure 31 produces a subset of the database showing the historical granular usage. Figure 32 is an example view of historical use.

To print a copy of the database, simply select the **Print Records** button at the top of the screen. It will produce a report similar to that shown as an example in Appendix D - page 62.

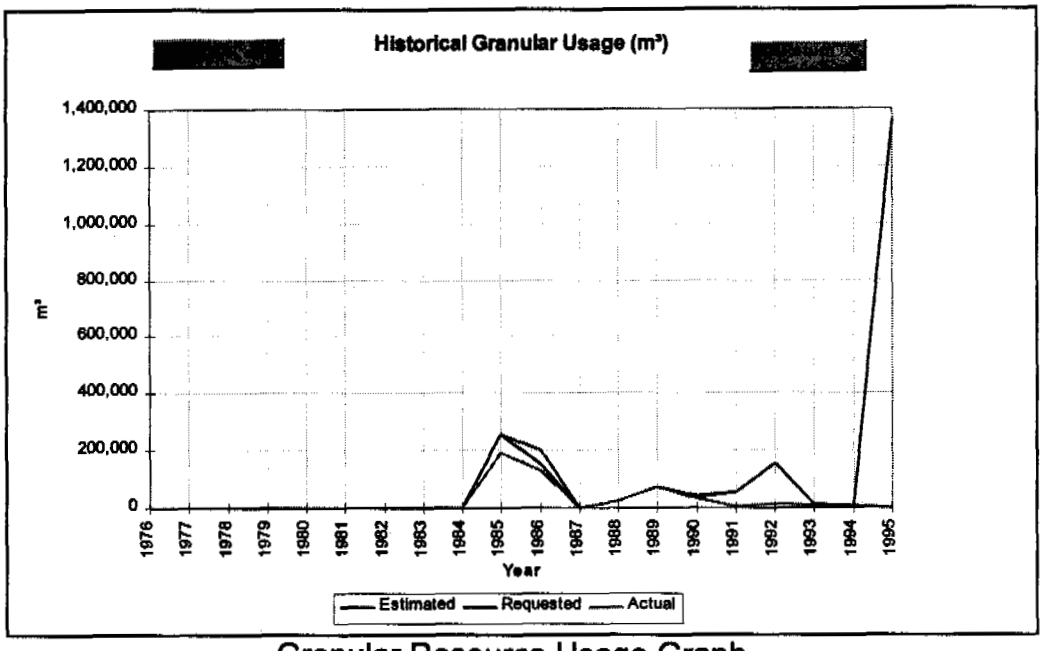


Historical Granular Resource Usage
Figure 32

Actual vs. Forecast

Selecting the **Actual vs. Forecast** button on the left side of Figure 31 produces a graph showing the historical granular usage. The graph shown in Figure 33 plots estimated requirements, requested amounts and actual usage. Over time, this plot will tell whether initial estimates are high or low.

To print a copy of the graph and supporting data, simply select the **Print Usage** button at the bottom right hand side of the screen. It will produce a report similar to that shown as an example in Appendix D - page 62.



Granular Resource Usage Graph
Figure 33

Usage by Area

Selecting the **Usage by Area** button on the left side of Figure 31 produces a cross-tabulation of the database showing the historical granular usage by area. Figure 34 is an example view of resource usage by area.

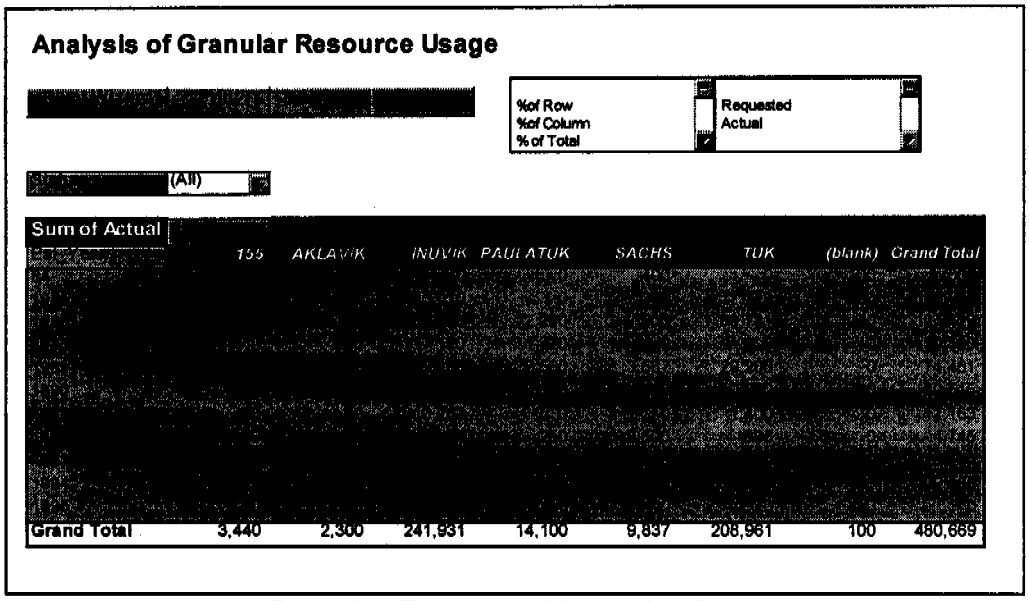
For those unfamiliar with cross-tabulations, or pivot tables as they are referred to in Excel they are a subset of the database representing various categories within the database. In this case, the pivot table is summarizing the usage by year into the various areas. The table shows the years along the side (row) and areas across the top (column). The need and usage of this terminology will become more evident.

To print a copy of the pivot table, select the **Print** button at the top left hand side of the screen. It will produce a report similar to that shown as an example in Appendix D - page 62.

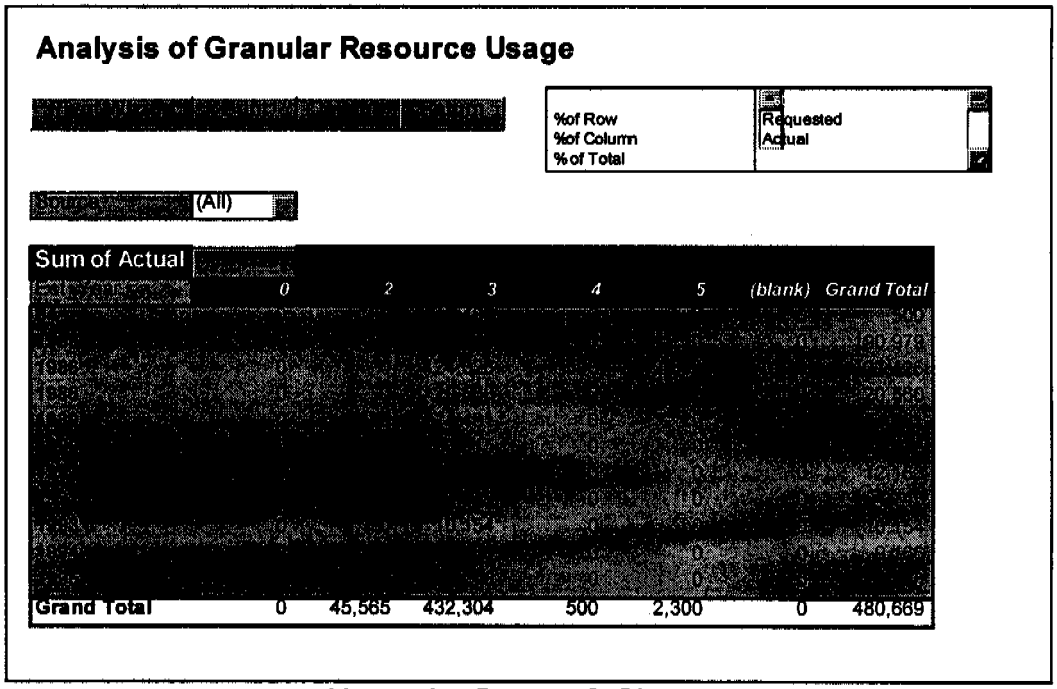
Usage by Source and Quality

Selecting the **Source & Quality** button on the left side of Figure 31 produces a cross-tabulation of the database showing the historical granular usage by source and class of material. Figure 35 is a sample view of resource usage by source and class. In this pivot table, the

sources are listed by page (each page is one source) and the class of material along the top (column).



Granular Resource Usage by Area
Figure 34



Usage by Source & Class
Figure 35

To print a copy of the pivot table, select the **Print** button at the top left hand side of the screen. An example report is shown in Appendix D - page 62.

User Defined Analysis

Selecting the **User Defined Analysis** button from the data analysis and graphs menu (Figure 31) allows the user to define your own pivot table report. The default pivot table, as shown in Figure 36, plots usage by year along the side (column) and project category along the top (row).To modify the Pivot table:

1) Select the Pivot Wizard **Button**.

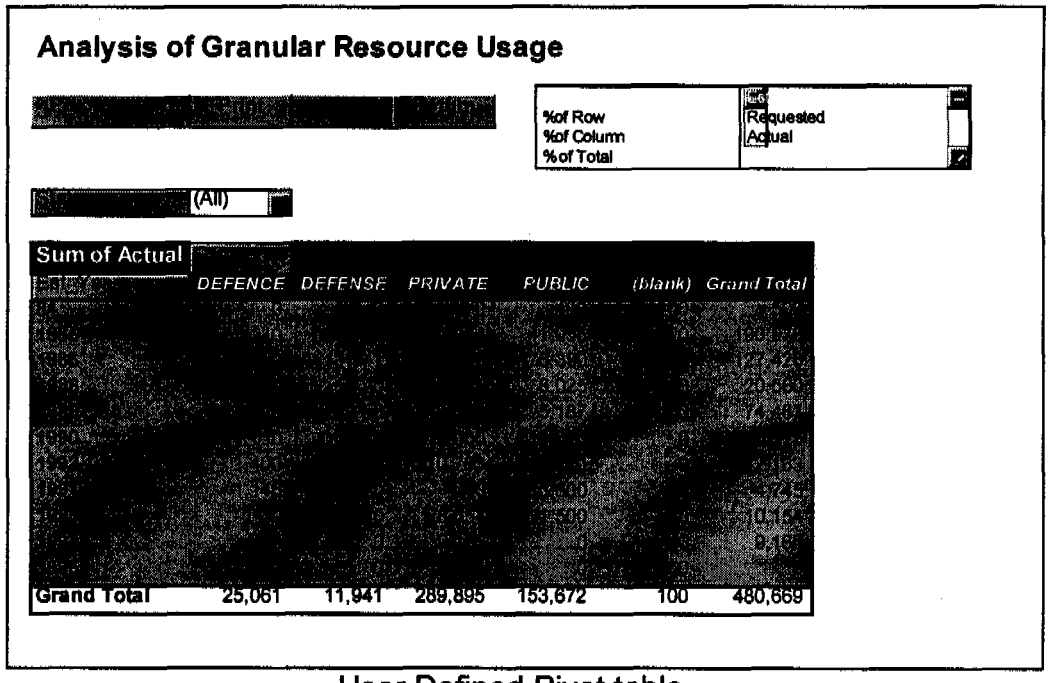
2) A Dialog Box will appear allowing you to modify ROW, COLUMN DATA and PAGE areas of the Pivot Table.

3) To change a category you must first remove the field by selecting the field and dragging it out of the designated area.

4) Then add a new category from the list by selecting it with the mouse (by clicking once) and then dragging it to the appropriate area.

5) Select the **Finish** button to return and calculate the new pivot table. The calculation process may take some time, depending on the speed of your computer.

To print the pivot table click on the **Print** button.



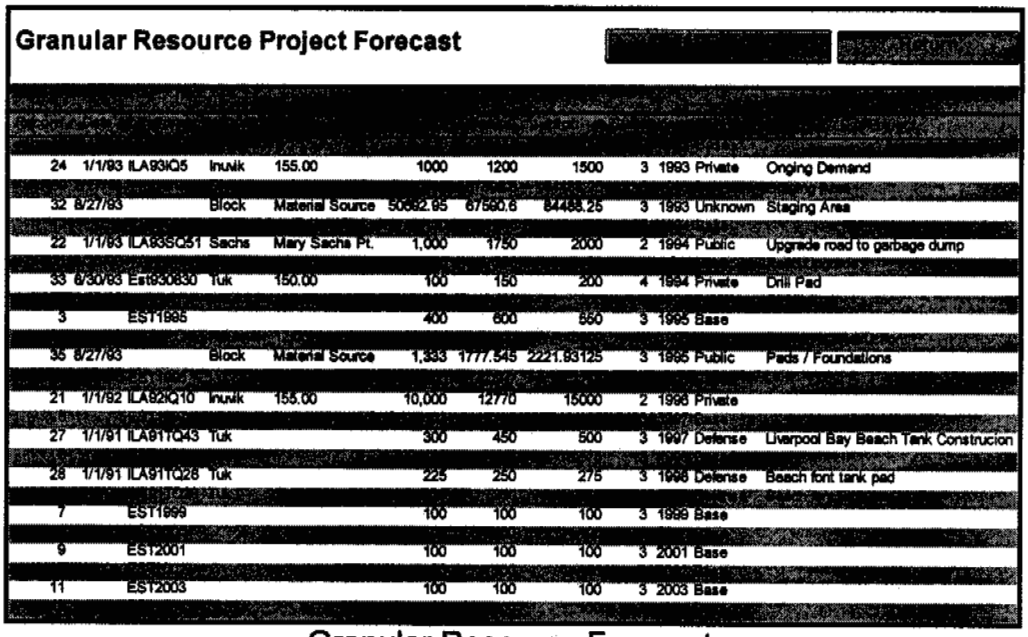
User Defined Pivot table
Figure 36

5.3. Forecast Demand

Records in the Database

Selecting the **Records in Database** button on the right side of Data Analysis & Graphs Menu (Figure 31) produces a subset of the database showing estimated volumes of granular usage for the future. Figure 37 is an example view of future use.

To print a copy of the database, simply select the **Print Records** button at the top of the screen. It will produce a report similar to that shown as an example in Appendix D - page 62.



Granular Resource Project Forecast

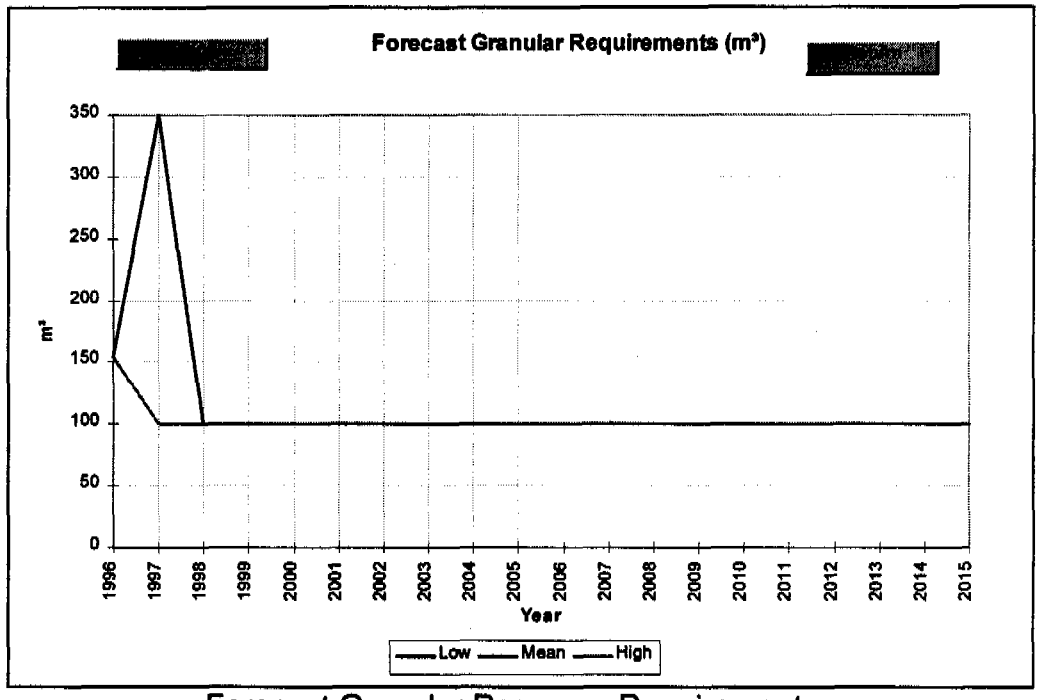
24	1/1/93	ILA93IQ5	Inuvik	155.00	1000	1200	1500	3	1993	Private	Onging Demand
32	8/27/93		Block	Material Source	50662.95	67560.6	84458.25	3	1993	Unknown	Staging Area
22	1/1/93	ILA93SQ51	Sachs	Mary Sachs Pt.	1,000	1750	2000	2	1994	Public	Upgrade road to garbage dump
33	8/30/93	Est930830	Tuk	150.00	100	150	200	4	1994	Private	Drill Pad
3		EST1995			400	600	550	3	1995	Base	
35	8/27/93		Block	Material Source	1,333	1777.545	2221.93125	3	1995	Public	Pads / Foundations
21	1/1/92	ILA92IQ10	Inuvik	155.00	10,000	12770	15000	2	1996	Private	
27	1/1/91	ILA91TQ43	Tuk		300	450	500	3	1997	Defense	Liverpool Bay Beach Tank Construcion
28	1/1/91	ILA91TQ28	Tuk		225	250	275	3	1998	Defense	Beach font tank pad
7		EST1999			100	100	100	3	1999	Base	
9		EST2001			100	100	100	3	2001	Base	
11		EST2003			100	100	100	3	2003	Base	

Granular Resource Forecast
Figure 37

Forecast Requirements

Selecting the **Forecast Requirements** button on the left side of Figure 31 produces a graph that forecasts granular usage. The graph, shown in Figure 38 plots low, mean and high estimates for the current year and the next 20 years.

To print a copy of the graph and supporting data, simply select the **Print Requirements** button at the bottom of the screen. It will produce a report similar to that shown as an example in Appendix D - page 62.



Forecast Granular Resource Requirements
Figure 38

Forecast by Area

Selecting the **Forecast by Area** button produces a pivot table of future requirements by area similar to the historical one shown in Figure 33. Refer to page 44 for additional information.

Forecast by Source and Quality

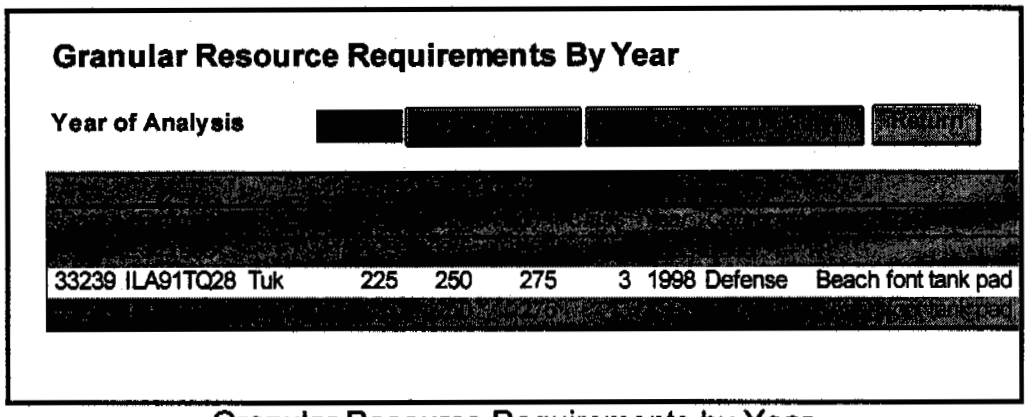
Selecting the **Source & Quality** button produces a pivot table of future requirements by source and quality. The pivot table is similar to the historical view shown in Figure 35.

User Defined Analysis

Selecting the **User Defined Analysis** allows custom pivot tables to analyze future requirements. The procedures for this function are identical to the Historical User Defined Analysis. Refer to page 47 for specific instructions.

Statistical Analysis (Crystal Ball)

Selecting the **Statistical Analysis (Crystal Ball)** button allows the user to perform a statistical analysis of forecast usage for the current year or any other year in the next 20. This portion of the program requires a special add-in program for Microsoft Excel called Crystal Ball developed by Decisioneering Inc., of Denver Colorado. If this program is available a screen similar to Figure 39 will appear.



Granular Resource Requirements by Year
Figure 39

The first step in performing an analysis is to select the appropriate year. This is done by clicking on the **Select Year** button shown in Figure 39. This will allow the user to select from a list of years. All projects for the specified year will appear. The next step is to run Crystal Ball by selecting the **Run Crystal Ball** button. This action will produce a screen like that shown in Figure 40.

To run a Crystal Ball simulation:

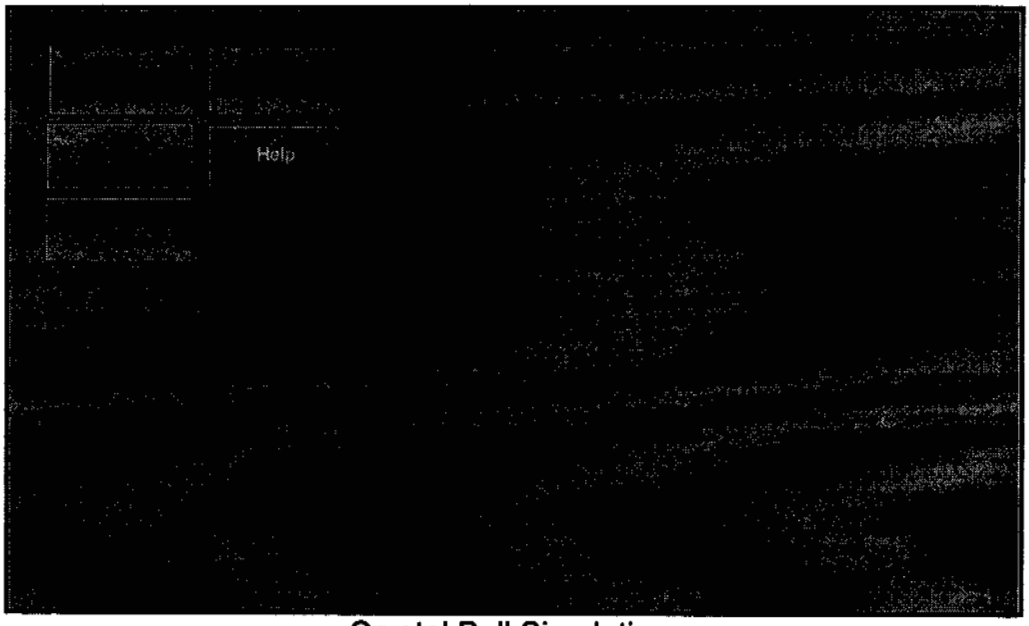
1) Click on the **Set Preferences** Button and enter the appropriate simulation variables. Keep the number of trials to a reasonable value (less than 500) to limit the time required to run the simulation. Crystal Ball simulations take considerable time.

2) Press the **Reset** Button to reset Crystal Ball. This is only necessary if you have already run a simulation.

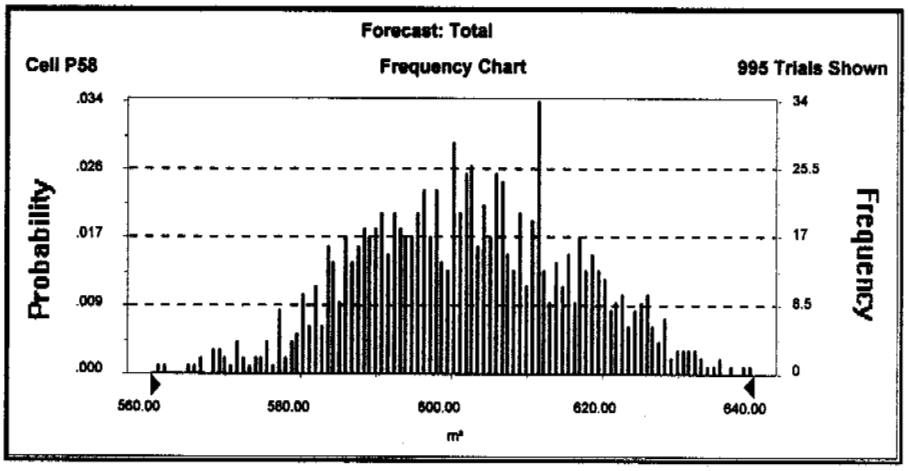
3) Press the **Run Simulation** button to start a simulation. You can stop a simulation during execution by selecting Run Stop from the menu on the simulation results dialog box. A probability distribution chart or frequency chart, as it is also referred to, will be created. Figure 41 is a typical example.

The reader should refer to Chapter 1 of the Crystal Ball manual for instructions on the interpretation of the analysis.

To return to the Data Analysis and Graphs Menu (Figure 31) select the **Return** button shown in Figure 41 and again the **Return** Button shown in Figure 39.



Crystal Ball Simulation
Figure 40



Crystal Ball Frequency Chart
Figure 41

6. Using the Granular Forecast Model

6.1. Historical Records

NORTH OF 60 ENGINEERING LTD. recommends that the users of the model enter historical data if the information for past projects is available. Entering this information into the database will help to:

- identify the variability of demand over time,
- identify base levels of demand,
- identify trends in estimating, if estimated, requested and actual volumes are known,
- identify volume requirements for typical projects,
- identify historical usage by area,
- identify volumes and the class of materials that have been removed from existing sources thus providing the capability to estimate remaining volumes in the various pits, and
- better manage the remaining resources for future development.

6.2. Day to Day Use

The Granular Resource Forecast Model has been designed to be a working tool to help Indian and Northern Affairs Canada, and the Inuvialuit Land Administration manage granular resources. To be effective, it should be used on a day to day basis. The following are some ideas on how the model might be applied to the every day management of granular resources.

Historical Records

The first step is to enter historical records for past projects as discussed above.

Ongoing Projects

Enter any ongoing projects to bring the database up to date.

Near Term Projects

Enter any potential near term projects whenever they are proposed. The important variables to capture are:

- project location,
- the nature of the project,
- project category,
- estimated volumes of material,
- a possible source, and
- year of use.

Remember, a proposed project can always be deleted if it is canceled. If new or additional information regarding a potential project becomes available, then the specific project can be updated within the database.

Long Term Projects

Enter potential long-term projects i.e. those that are five to ten years in the future. Again the key variables to identify are:

- project location,
- the nature of the project,
- project category,
- estimated volumes of material, and
- year of use.

Active Projects

When a project becomes active, edit the project to enter the quarry and land use permit numbers and update any other fields, if necessary. Once a project becomes active though, do not modify the estimated volumes. Comparing estimated to requested and actual

volumes will provide a valuable historical perspective that could help in future forecasts.

Completed Project

When a project is completed, change the status to Completed and enter actual amount of material used.

6.3 Short Term Planning

It is recommend that a short term plan be prepared at least once a year. This plan would focus on the next five years and specifically the upcoming year. Potential elements of the plan would include:

- upcoming projects in the next year and demand requirements by area, gravel source and quality. If there are many projects, it might be worth while to perform a Crystal Ball analysis to assess the variability in potential demand,
- identification of potential projects for the next five years and their requirements by area,
- a financial forecast of revenue from permits and royalties, and
- a revised management plan for the upcoming year that would identify important issues.

6.4 Long Term Planning

The long term plan should also be updated on a yearly basis. This plan would focus on the longer term i.e. the next 20 years, in 5 year increments. Since the short term plan discussed above covers the first five years, the long term plan would focus on the following 15 years. The level of detail would be considerably less than the short term view. The purpose of the plan is to look at potential economic trends and the impact that they might have on the area and in particular granular resources.

The plan would identify potential projects that could take place. These include but are not limited to, oil and gas developments, mining activity and major public works. The key parameters to capture are:

- the nature of the project,

- project location,
- project category,
- estimated volumes of material, and
- year of use.

From a reporting standpoint it is suggested that requirements be grouped into five year periods. The important points to focus on are:

- the potential magnitude of the requirements,
- the impact on overall resources by area, and
- the impact on short term plans -- for example, if these projects were to take place in the time frame specified, would you alter your current practices regarding your short term management plan?

Index

Appendix A - Program Licence

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Appendix B - Hardware / Software Configuration

Hardware

Computer CPU	
Hard Drive Capacity	
Memory	
Monitor	
Printer	
Mouse	

Software

Operating System	
Windows Version	
Excel Version	
Crystal Ball Version	

Appendix C - Granular Material Types

CLASS	MATERIAL DESCRIPTION
1	Excellent quality material consisting of clean, well-graded, structurally-sound sand and gravel suitable for use as high-quality (e.g. runway or roof) surfacing materials, or as asphalt or concrete aggregate, with a minimum of processing.
2	Good quality material generally consisting of well-graded sands and gravels with limited quantities of silt. This material will provide good quality base and surface coarse aggregates or structure-supporting fill. Production of concrete aggregates may be possible with extensive processing, except where deleterious materials are present.
3	Fair quality material consisting generally of poorly-graded sands and gravels with or without substantial silt content. This material will provide fair quality general fill for roads, flexible foundation pads, or staging areas.
4	Poor quality material consisting of silty, poorly-graded, fine grained sand, with minor gravel. May also contain weak particles and deleterious materials and are considered suitable only for marginal, general (non structural) fills.
5	Bedrock of fair to good quality, felsenmeer or talus. Potentially excellent sources of construction material, ranging from general fill to concrete aggregate or building stone if quarried and processed. Also includes erosion control materials such as rip-rap or armour stone.

Appendix D - Selected Reports

Historical Records

Actual vs. Forecast Usage

Usage by Area

Usage by Source & Quality

Forecast Demand

Forecast Requirements

Historical Granular Resource Usage

Record	Date	Quarry	Land	Status	Block	Source	Location	Remarks				
21	1/23/00	ILA84SQ003		INACTIVE	SACHS	MARY SACHS		ENVIRONMENT CANADA				
22	1/24/00	ILA84SQ003							100			2
23	4/1/85	ILA85IQ009		INACTIVE	INUVIK	YA YA	YA YA LAKES	EGT/ENVIRONMENT CANADA				
24	4/1/85	ILA85IQ009		INACTIVE	INUVIK	YA YA	YA YA LAKES	EGT	EGT	300	300	300	3
25	4/1/85	ILA85IQ009		INACTIVE	INUVIK	YA YA	YA YA LAKES	EGT				
26	4/1/85	ILA85IQ009		INACTIVE	INUVIK	YA YA	YA YA LAKES	EGT	EGT	32,450	32,450	32,450	3
27	4/1/85	ILA85IQ009		INACTIVE	INUVIK	YA YA	YA YA LAKES	EGT				
28	11/1/85	ILA85IQ010		INACTIVE	INUVIK	CARIBOU HILLS	CARIBOU HILLS	TRANSPORT CANADA	NORTHERN CONSTRUCTION	500	500	500	3
29	10/1/85	ILA85IQ011		INACTIVE	INUVIK	YA YA	YA YA LAKES	CHEVRON CANADA RESOURCES				
30	1/20/85	ILA85TQ015		INACTIVE	TUK		160	EGT	EGT	22,950	22,950	22,950	3
31	1/28/85	ILA85TQ015		INACTIVE	TUK		160	EGT				
32	1/28/85	ILA85TQ015		INACTIVE	INUVIK	YA YA	YA YA LAKES	EGT	EGT	34,400	34,400	34,400	3
33	1/28/85	ILA85TQ015		INACTIVE	INUVIK	YA YA	YA YA LAKES	EGT				
34	1/28/85	ILA85TQ015		INACTIVE	INUVIK	YA YA	YA YA LAKES	EGT	EGT	19,115	19,115	19,115	3
35	10/1/85	ILA85AQ016		INACTIVE	INUVIK	ROCK QUARRY	MAIN DEPOT	STORRS & SONS				
36	4/29/85	ILA85TQ17		INACTIVE	TUK		160	STORRS & SONS	STORRS & SONS	993	993	993	3
37	4/1/85	ILA85TQ25		INACTIVE	TUK		160	EGT				
38	5/21/85	ILA85TQ26		INACTIVE	TUK	CANYANEK INLET	TUK	EGT	EGT	3,822	3,822	3,822	3
39	6/27/85	ILA85SQ33		INACTIVE	SACHS	MARY SACHS	SACHS	AES-NWAVR				
40	11/29/85	ILA85IQ84		INACTIVE	INUVIK	YA YA	YA YA LAKES	EGT	EGT	1,800	1,800	1,800	3
41	1/8/85	ILA85TQ98		INACTIVE	TUK	YA YA	YA YA LAKES	ESSO RESOURCES				
42	1/8/85	ILA85TQ98		INACTIVE	TUK		163	ESSO RESOURCES	EGT	2,850	2,850	2,850	3
43	7/1/86	ILA86AQ102		INACTIVE	INUVIK	ROCK QUARRY	INUVIK	STORRS & SONS				
44	1/22/86	ILA86IQ107		INACTIVE	INUVIK	YA YA	YA YA LAKES	NORTH STAR SERVICES & CONSTRUCTION	NORTH STAR	12,140	12,140	12,140	3
45	1/22/86	ILA86IQ107		INACTIVE	INUVIK	YA YA	YA YA LAKES	NORTH STAR SERVICES & CONSTRUCTION				
46	1/22/86	ILA86IQ107		INACTIVE	INUVIK	YA YA	YA YA LAKES	NORTH STAR SERVICES & CONSTRUCTION	NORTH STAR	460	460	460	3
47	12/2/86	ILA86TQ108		INACTIVE	TUK		155	EGT				
48	1/22/86	ILA86TQ109		INACTIVE	TUK		155	EGT	EGT	20,000	20,000	20,000	3
49	2/5/86	ILA86TQ117		INACTIVE	TUK	WOOD BAY	TUK	EGT/MACA				
50	3/17/86	ILA86TQ113		INACTIVE	TUK	SITE C	6924N - 1325SW	EGT	EGT	855	855	855	3
51	2/24/86	ILA86TQ117		CANCELLED	INUVIK	YA YA	YA YA LAKES	STORRS & SONS				
52	6/10/86	ILA86PQ136		INACTIVE	PAULATUK	PAULATUK QUARRY	6920N - 12403W	SETTLEMENT COUNCIL	SETTLEMENT COUNCIL	2,290	2,290	2,290	3
53	12/2/86	ILA86TQ158		INACTIVE	TUK		168	EGT				
54	4/29/87	ILA86TQ158		INACTIVE	TUK		168	EGT	EGT	1,500	1,500	1,500	3
55	9/7/87	ILA87SQ134		INACTIVE	SACHS	MARY SACHS		MACA				
56	2/18/88	ILA88IQ196		INACTIVE	INUVIK	YA YA	YA YA LAKES	NORTH STAR SERVICES & CONSTRUCTION	NORTH STAR	7,850	7,850	7,850	3
57	2/22/88	ILA88PQ189		INACTIVE	INUVIK		155	EGT				
58	2/22/88	ILA88IQ189		INACTIVE		155	INUVIK	EGT	EGT	3,440	3,440	3,440	3
59	2/22/88	ILA88IQ200		INACTIVE	INUVIK	YA YA	YA YA LAKES	EGT				
60	2/22/88	ILA88IQ200		INACTIVE	INUVIK	YA YA	YA YA LAKES	EGT	EGT	1,040	1,040	1,040	3
61	10/27/88	ILA88SQ212		INACTIVE	SACHS	MARY SACHS	SACHS	MACA				
62	5/23/89	ILA89PQ256		INACTIVE	PAULATUK	KEATS POINT	KEATS POINT	BOT CONSTRUCTION	BOT CONSTRUCTION	960	960	960	3
63	5/23/89	ILA89TQ258		INACTIVE	TUK	HORTON RIVER	HORTON RIVER	BOT CONSTRUCTION				
64	5/23/89	ILA89TQ260		INACTIVE	TUK	LIVERPOOL BAY	LIVERPOOL BAY	BOT CONSTRUCTION	BOT CONSTRUCTION	1,670	1,670	1,670	3
65	9/29/89	ILA89PQ286		INACTIVE	PAULATUK		23	MACA				
66	11/22/89	ILA89IQ288		INACTIVE	INUVIK		155	INUVIK	EGT	EGT	39,108	39,108	39,108	3
67	11/22/89	ILA89TQ290		INACTIVE	TUK	LIVERPOOL BAY	LIVERPOOL BAY	EGT				
68	11/30/89	ILA89TQ292		INACTIVE	TUK	WOOD BAY	WOOD BAY	EGT	EGT	1,440	1,440	1,440	3
69	11/30/89	ILA89TQ294		INACTIVE	TUK		168	EGT				
70	7/11/90	ILA90PQ25		INACTIVE	PAULATUK		23	SOUTHWIND CAPITAL CONSTRUCTION	SOUTH WIND	2,000	2,000	2,000	3
71	3/27/90	ILA90PQ26		ACTIVE	PAULATUK		23	MACA				
72	7/6/90	ILA93PX33		ACTIVE	PAULATUK		23	PAULATUK	MACA	MACA	2,000	2,000	2,000	3
73	7/24/90	ILA90PQ27		ACTIVE	PAULATUK		12	PAULATUK	DEPT. OF TRANSPORTATION	DEPT. OF TRANSPORTATION			
74	12/21/90	ILA90IQ41		INACTIVE	INUVIK		155	EGT	EGT	15,300	15,300	15,300	3
75	12/21/90	ILA90IQ41		INACTIVE	TUK		155	EGT				

Status	(All)

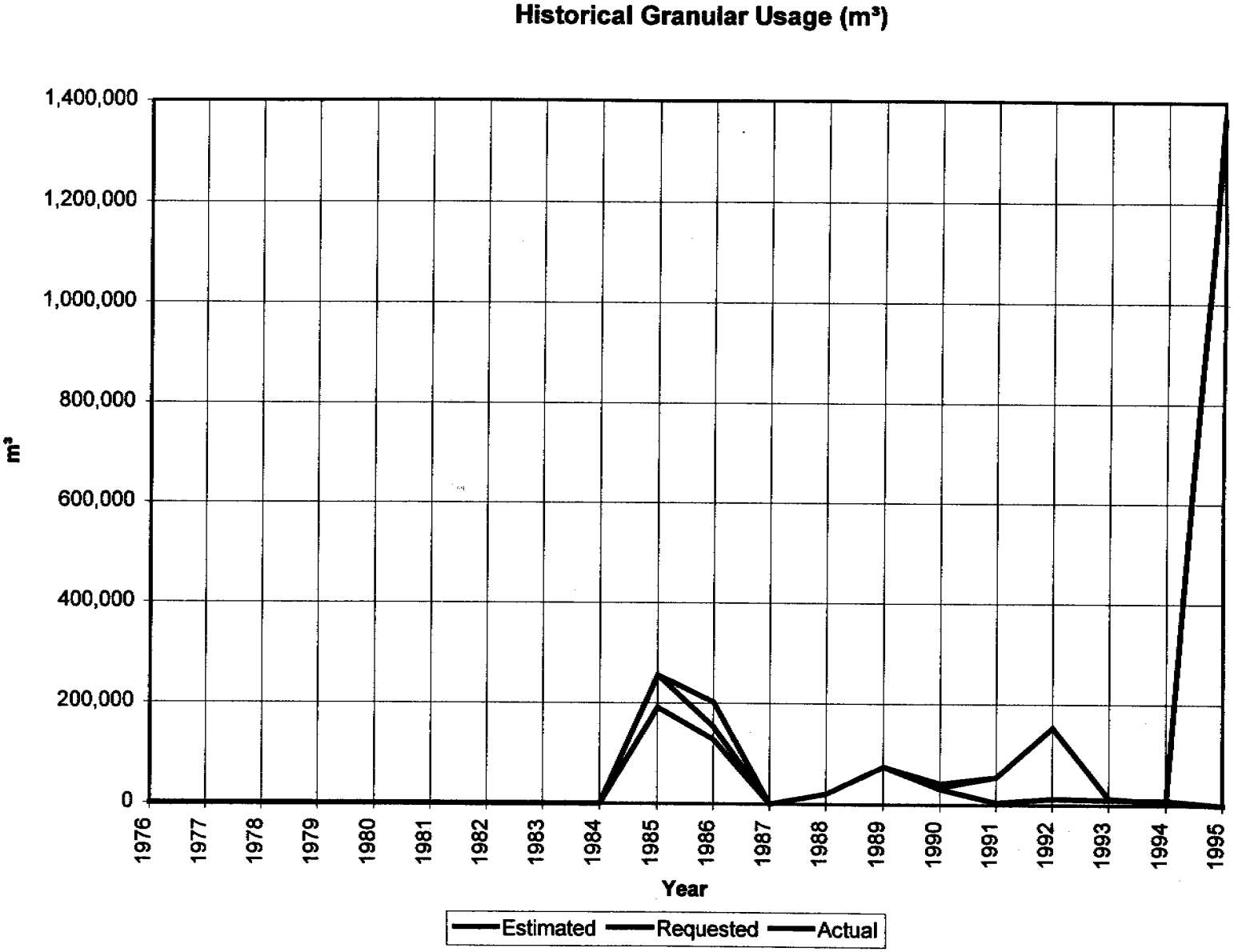
Sum of Actual	Block							
Est_Year	SACHS	(blank)	INUVIK	TUK	AKLAVIK	PAULATUK	155	Grand Total
84	400	100	0	0	0	0	0	500
1985	250	0	113,010	77,719	0	0	0	[illegible]
1986	500	0	32,595	89,741	[illegible]	[illegible]	0	[illegible]
1988	0	0	17,120	0	0	0	[illegible]	[illegible]
1989	3,587	0	39,108	29,206	0	2,[illegible]	0	[illegible]
1990	0	0	11,515	10,000	0	[illegible]	0	[illegible]
1992	0	0	10,763	1,400	0	0	0	[illegible]
1991	3,600	0	0	895	0	[illegible]	0	[illegible]
1993	1,500	0	8,654	0	0	0	0	[illegible]
1994	0	0	9,166	0	0	0	0	[illegible]
1995	0	0	0	0	0	0	0	0
Grand Total	9,837	100	241,931	208,961	2,300	14,100	3,440	480,669

Analysis of Granular Resource Usage

Source	(All)

Sum of Actual	Act_Class						
Est_Year	0	2	3	4	5	(blank)	Grand Total
84	0	100	400	0			500
1985	0	45,465	45,514	0			90,979
1986	0	0	24,626	600	2,300		27,526
1988	0	0	20,560	0			20,560
1989	0	0	74,461	0			74,461
1990	0	0	30,576	0			30,576
1992	0	0	12,663	0			12,663
1991	0	0	3,745	0			3,745
1993	0	0	10,154	0			10,154
1994	0	0	9,166	0			9,166
1995	0	0	0	0			0
Grand Total	0	45,565	432,304	500	2,300	0	480,669

Granular Resource Usage Database



Granular Resource Usage Database

Granular Resource Project Forecast

Record	Date	Quarry	Land	Status	Block	Source	Location	Penalties	Contractor	Est_Low	Est_Mean	Est_High	Est_Class	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1	7/25/96	EST1996	#N/A	Forecast	#N/A	#N/A	#N/A	#N/A	#N/A	154	154	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2	7/25/96	EST1997	#N/A	Forecast	#N/A	#N/A	#N/A	#N/A	#N/A	100	100	100	3	#N/A	#N/A	#N/A	#N/A	1997	#N/A	Base	#N/A	#N/A
3	7/25/96	EST1998	#N/A	Forecast	#N/A	#N/A	#N/A	#N/A	#N/A	100	100	100	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
4	7/25/96	EST1999	#N/A	Forecast	#N/A	#N/A	#N/A	#N/A	#N/A	100	100	100	3	#N/A	#N/A	#N/A	#N/A	1999	#N/A	Base	#N/A	#N/A
5	7/25/96	EST2000	#N/A	Forecast	#N/A	#N/A	#N/A	#N/A	#N/A	100	100	100	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
6	7/25/96	EST2001	#N/A	Forecast	#N/A	#N/A	#N/A	#N/A	#N/A	100	100	100	3	#N/A	#N/A	#N/A	#N/A	2001	#N/A	Base	#N/A	#N/A
7	7/25/96	EST2002	#N/A	Forecast	#N/A	#N/A	#N/A	#N/A	#N/A	100	100	100	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
8	7/25/96	EST2003	#N/A	Forecast	#N/A	#N/A	#N/A	#N/A	#N/A	100	100	100	3	#N/A	#N/A	#N/A	#N/A	2003	#N/A	Base	#N/A	#N/A
9	7/25/96	EST2004	#N/A	Forecast	#N/A	#N/A	#N/A	#N/A	#N/A	100	100	100	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
10	7/25/96	EST2005	#N/A	Forecast	#N/A	#N/A	#N/A	#N/A	#N/A	100	100	100	3	#N/A	#N/A	#N/A	#N/A	2005	#N/A	Base	#N/A	#N/A
11	7/25/96	EST2006	#N/A	Forecast	#N/A	#N/A	#N/A	#N/A	#N/A	100	100	100	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
12	7/25/96	EST2007	#N/A	Forecast	#N/A	#N/A	#N/A	#N/A	#N/A	100	100	100	3	#N/A	#N/A	#N/A	#N/A	2007	#N/A	Base	#N/A	#N/A
13	7/25/96	EST2008	#N/A	Forecast	#N/A	#N/A	#N/A	#N/A	#N/A	100	100	100	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
14	7/25/96	EST2009	#N/A	Forecast	#N/A	#N/A	#N/A	#N/A	#N/A	100	100	100	3	#N/A	#N/A	#N/A	#N/A	2009	#N/A	Base	#N/A	#N/A
15	7/25/96	EST2010	#N/A	Forecast	#N/A	#N/A	#N/A	#N/A	#N/A	100	100	100	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
16	7/25/96	EST2011	#N/A	Forecast	#N/A	#N/A	#N/A	#N/A	#N/A	100	100	100	3	#N/A	#N/A	#N/A	#N/A	2011	#N/A	Base	#N/A	#N/A
17	7/25/96	EST2012	#N/A	Forecast	#N/A	#N/A	#N/A	#N/A	#N/A	100	100	100	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
18	7/25/96	EST2013	#N/A	Forecast	#N/A	#N/A	#N/A	#N/A	#N/A	100	100	100	3	#N/A	#N/A	#N/A	#N/A	2013	#N/A	Base	#N/A	#N/A
19	7/25/96	EST2014	#N/A	Forecast	#N/A	#N/A	#N/A	#N/A	#N/A	100	100	100	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
20	7/25/96	EST2015	#N/A	Forecast	#N/A	#N/A	#N/A	#N/A	#N/A	100	100	100	3	#N/A	#N/A	#N/A	#N/A	2015	#N/A	Base	#N/A	#N/A
68	7/15/96	[illegible]	[illegible]	[illegible]	Inuvik	158	[illegible]	[illegible]	Gruben's	250	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

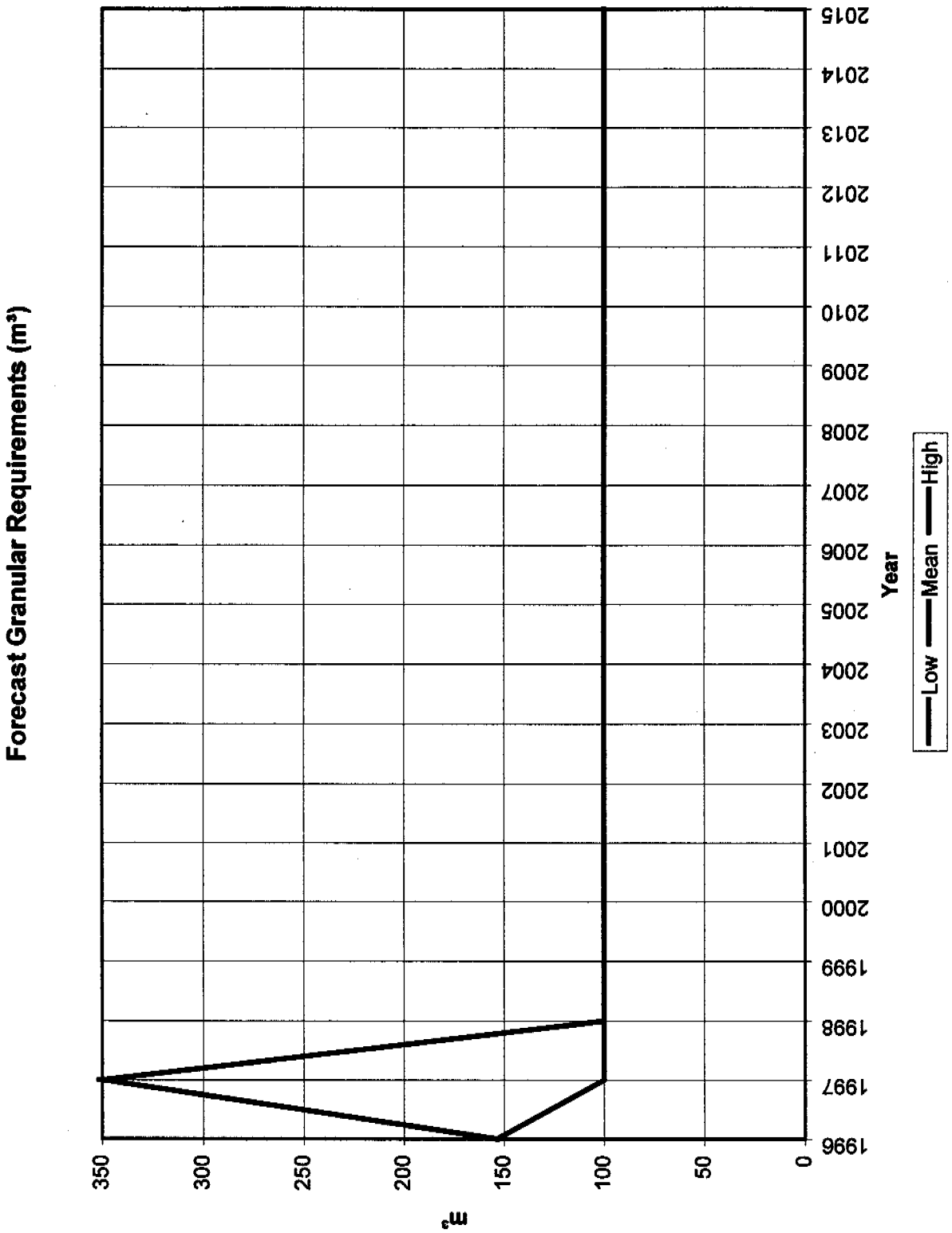

Forecast Granular Requirements (m³)
m³
350
300
250
200
150
100
50
0
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
Year
Low
Mean
High

TABLE OF CHAINS AND FEET

chs.	feet	chs.	feet	chs.	feet	chs.	feet
1	66	26	1716	51	3366	76	5016
2	132	27	1782	52	3432	77	5082
3	198	28	1848	53	3498	78	5148
4	264	29	1914	54	3564	79	5214
5	330	30	1980	55	3630	80	5280
6	396	31	2046	56	3696	81	5346
7	462	32	2112	57	3762	82	5412
8	528	33	2178	58	3828	83	5478
9	594	34	2244	59	3894	84	5544
10	660	35	2310	60	3960	85	5610
11	726	36	2376	61	4026	86	5676
12	792	37	2442	62	4092	87	5742
13	858	38	2508	63	4158	88	5808
14	924	39	2574	64	4224	89	5874
15	990	40	2640	65	4290	90	5940
16	1056	41	2706	66	4356	91	6006
17	1122	42	2772	67	4422	92	6072
18	1188	43	2838	68	4488	93	6138
19	1254	44	2804	69	4554	94	6204
20	1320	45	2970	70	4620	95	6270
21	1386	46	3036	71	4686	96	6336
22	1452	47	3102	72	4752	97	6102
23	1518	48	3168	73	4818	98	6168
24	1584	49	3234	74	4884	99	6534
25	1650	50	3300	75	4950	100	6600

ACREAGE

Acres	Square Feet	1 Acre Equals	
		Length	Width
1	43,560	16.5	2640.
2	87,120	33.	1320.
3	130,680	50.	871.2
4	174,240	66.	660.
5	217,800	75.	580.8
6	261,360	100.	435.6
7	304,920	132.	330.
8	348,480	150.	290.4
9	392,040	208.71	208.71
10	435,600		

FACTORS AND P

Factors are numbers which produce a required number, su are factors of 12; 3 and 15, and

A *prime number* is one that more factors; or, it is a num itself and unity; thus, 1, 2, 3, 5 bers. 2 is the only even numb

A *composite number* is one tors.

A *prime factor* is a prime nu To aid in determining the number, observe the followin

TABLE OF PRIME NUM

1	41	101	167	239	313	397
2	43	103	173	241	317	401
3	47	107	179	251	331	40
5	53	109	181	257	337	41
7	59	113	191	263	347	42
11	61	127	193	269	349	43
13	67	131	197	271	353	43
17	71	137	199	277	359	43
19	73	139	211	281	367	44
23	79	149	223	283	373	44
29	83	151	227	293	379	45
31	89	157	229	307	383	46
37	97	163	233	311	389	46

ARITHMETICAL AND G CHAR

The following signs and cl denote and abbreviate the se

The sign = means *equal to*, or
− means *minus* or *l*
+ means *plus*, or ad
× means *multiplied*
÷ means *divided by*,

The sign ^{2} { *Index* or *power*, meaning that the number to which ^{3} { they are added is to be squared (^{2}) or cubed (^{3}).

: *is to*
: : *so is*
: *to*
} Signs of proportion.

$\sqrt{}$ means that the square root of the number before which it is placed is required.

$\sqrt[3]{}$ means that the cube root of the number before which it is placed is required.

—— The *bar* indicates that all the numbers under it are to be taken together.

( ) The *parentheses* indicate that all the numbers between them are to be taken as one quantity.

. means decimal parts; thus, 2.5 means $2\frac{5}{10}$, and 0.46 means $\frac{46}{100}$

° means *degrees*.

∴ means *hence*.

′ denotes *feet*, or *minutes* (part of a degree).

″ denotes *inches*, or *seconds* (angular measure).

MENSURATION

Area of a triangle	=	base × ½ altitude.
Area of a parallelogram	=	base × altitude.
Area of a trapezoid	=	altitude × ½ the sum of parallel sides.
Area of a trapezium	=	Divide into two triangles and find area of the triangles.
Circumference of circle	=	diameter × 3.1416.
Diameter of circle	=	circumference × .3183.
Area of circle	=	diameter squared × .7854.
Area of sector of circle	=	length of arc × ½ the radius.
Area of segment of circle	=	area of sector of equal radius − area of triangle when the segment is less, and + area of triangle when the segment is greater, than the semicircle.
Area of circular ring	=	sum of the diameters of the two circles × difference of the diameters of the two circles × .7854.
Side of square that shall equal area of circle	=	diameter × .8862, or circumference × .2821.
Diam. of circle that shall contain area of a given square	=	side of square × 1.1284.

Area of ellipse
Area of parabola
Area of regular polygon
Surface of cylinder or prism
Contents of cylinder or prism
Surface of sphere
Contents of sphere
Convex surface of segment of sphere
Contents of segment of sphere
Surface of pyramid or cone
Contents of pyramid or cone
Surface of frustum of cone or pyramid
Contents of frustum of cone or pyramid

Contents of a wedge

GEOM

An angle is formed b
A right angle is one
angle of 90 degree
A polygon is a plane
A quadrilateral is a p
ing four angles.
A parallelogram is a
parallel.
A rectangle is a para
A square is a rectang
A triangle is a surfac
A right-angled triang
posite the right angl
An isosceles triangle
An equilateral triangl
A circle is a plane su
point of which is
thereof from an inte

Page 670

meaning that the number to which
d is to be squared (²) or cubed (³).

proportion.

quare root of the number before which
uired.
cube root of the number before which
uired.
s that all the numbers under it are to
r.
indicate that all the numbers between
aken as one quantity.

parts; thus, 2.5 means $2\frac{5}{10}$, and 0.40

minutes (part of a degree).
r *seconds* (angular measure).

URATION

⅓ altitude.

altitude.
× ½ the sum of parallel sides.
into two triangles and find area of the
s.

r × 3.1416.
erence × .3183.
r squared × .7854.

of arc × ½ the radius.
sector of equal radius—area of tri-
hen the segment is less, and + area of
when the segment is greater, than the
cle.
the diameters of the two circles ×
oe of the diameters of the two circles
4.

er × .8862, or circumference × .2821.

square × 1.1284.

Area of ellipse	=	product of the two diameters × .7854.
Area of parabola	=	base × ⅔ altitude.
Area of regular polygon	=	sum of its sides × perpendicular from its center to one of its sides ÷ 2.
Surface of cylinder or prism	=	area of both ends + length × circumference.
Contents of cylinder or prism	=	area of end × length.
Surface of sphere	=	diameter × circumference.
Contents of sphere	=	diameter × .5236.
Convex surface of segment of sphere	=	height of segment × circumference of the sphere of which it is a part.
Contents of segment of sphere	=	(height squared + three times the square of radius of base) × (height × .5236).
Surface of pyramid or cone	=	circumference of base × ½ of the slant height + area of the base.
Contents of pyramid or cone	=	area of base × ⅓ altitude.
Surface of frustum of cone or pyramid	=	sum of circumference at both ends × ½ slant height + area of both ends.
Contents of frustum of cone or pyramid	=	Multiply areas of two ends together and extract square root. Add to this root the two areas × ⅓ altitude.
Contents of a wedge	=	area of base × ½ altitude.

GEOMETRICAL MENSURATIONS

An angle is formed by two lines which meet.

A right angle is one formed by two lines which meet at an angle of 90 degrees.

A polygon is a plane surface bounded by straight lines.

A quadrilateral is a polygon bounded by four sides and having four angles.

A parallelogram is a quadrilateral whose opposite sides are parallel.

A rectangle is a parallelogram having right angles.

A square is a rectangle whose four sides are equal.

A triangle is a surface having three sides and three angles.

A right-angled triangle has one right angle. The side opposite the right angle is the hypotenuse.

An isosceles triangle has two of its sides equal.

An equilateral triangle has all sides and all angles equal.

A circle is a plane surface bounded by a curved line each point of which is equidistant with every other point thereof from an interior point known as the center.

Hundredths of an Acre Reduced to Square Feet

100ths of Acre	Square Feet	100ths of Acre	Square Feet	100ths of Acre	Square Feet
.1 =	435.60	35 =	15,246.00	69 =	30,056.40
2 =	871.20	36 =	15,681.60	70 =	30,492.00
3 =	1,306.80	37 =	16,117.20	71 =	30,927.60
4 =	1,742.40	38 =	16,552.80	72 =	31,363.20
5 =	2,178.00	39 =	16,988.40	73 =	31,798.80
6 =	2,613.60	40 =	17,424.00	74 =	32,234.40
7 =	3,049.20	41 =	17,859.60	75 =	32,670.00
8 =	3,484.80	42 =	18,295.20	76 =	33,105.60
9 =	3,920.40	43 =	18,730.80	77 =	33,541.20
10 =	4,356.00	44 =	19,166.40	78 =	33,976.80
11 =	4,791.60	45 =	19,602.00	79 =	34,412.40
12 =	5,227.20	46 =	20,037.60	80 =	34,848.00
13 =	5,662.80	47 =	20,473.20	81 =	35,283.60
14 =	6,098.40	48 =	20,908.80	82 =	35,719.20
15 =	6,534.00	49 =	21,344.40	83 =	36,154.80
16 =	6,969.60	50 =	21,780.00	84 =	36,590.40
17 =	7,405.20	51 =	22,215.60	85 =	37,026.00
18 =	7,840.80	52 =	22,651.20	86 =	37,461.60
19 =	8,276.40	53 =	23,086.80	87 =	37,897.20
20 =	8,712.00	54 =	23,522.40	88 =	38,332.80
21 =	9,147.60	55 =	23,958.00	89 =	38,768.40
22 =	9,583.20	56 =	24,393.60	90 =	39,204.00
23 =	10,018.80	57 =	24,829.20	91 =	39,639.60
24 =	10,454.40	58 =	25,264.80	92 =	40,075.20
25 =	10,890.00	59 =	25,700.40	93 =	40,510.80
26 =	11,325.60	60 =	26,136.00	94 =	40,946.40
27 =	11,761.20	61 =	26,571.60	95 =	41,382.00
28 =	12,196.80	62 =	27,007.20	96 =	41,817.60
29 =	12,632.40	63 =	27,442.80	97 =	42,253.20
30 =	13,068.00	64 =	27,878.40	98 =	42,688.80
31 =	13,503.60	65 =	28,314.00	99 =	43,124.40
32 =	13,939.20	66 =	28,749.60	100 =	43,560.00
33 =	14,374.80	67 =	29,185.20		
34 =	14,810.40	68 =	29,620.80		

FRACTIONS OF AN ACRE REDUCED TO SQUARE FEET

Fraction of Acre	Square Feet	Fraction of Acre	Square Feet	Fraction of Acre	Square Feet
$\frac{1}{64}$ =	680.625	$\frac{23}{64}$ =	14,973.75	$\frac{45}{64}$ =	29,047.50
$\frac{1}{32}$ =	1,361.25	$\frac{1}{2}$ =	16,335.00	$\frac{23}{32}$ =	31,308.75
$\frac{3}{64}$ =	2,722.50	$\frac{25}{64}$ =	17,696.25	$\frac{3}{4}$ =	32,670.00
$\frac{1}{16}$ =	4,038.75	$\frac{13}{32}$ =	19,057.50	$\frac{49}{64}$ =	34,031.25
$\frac{5}{64}$ =	5,445.00	$\frac{27}{64}$ =	20,418.75	$\frac{25}{32}$ =	35,392.50
$\frac{3}{32}$ =	6,806.25	$\frac{7}{16}$ =	21,780.00	$\frac{51}{64}$ =	36,753.75
$\frac{7}{64}$ =	8,167.50	$\frac{29}{64}$ =	23,141.25	$\frac{13}{16}$ =	38,115.00
$\frac{1}{8}$ =	9,528.75	$\frac{15}{32}$ =	24,502.50	$\frac{53}{64}$ =	39,476.25
$\frac{9}{64}$ =	10,890.00	$\frac{31}{64}$ =	25,863.75	$\frac{27}{32}$ =	40,837.50
$\frac{5}{32}$ =	12,251.25	$\frac{1}{2}$ =	27,225.00	$\frac{55}{64}$ =	42,198.75
$\frac{11}{64}$ =	13,612.50	$\frac{33}{64}$ =	38,586.25	1 =	43,560.00

CONVERSI

METHOD FOR RE

Rule.—Multiply th
multiply by 23 and po

Example.—How many

Proof:—43,560)130,680(3
180,680

The reason why dividin
.000023 is that dividing b
its reciprocal:

1 ÷ 43,560 = .0

L

This table shows the nun
using the following dimensi
been made for the lots in f
every 800 feet for the smalle
2,000 feet for the largest.

Size of Lots	Numb of Lo per A
40 × 100	8.23
40 × 120	7.07
40 × 150	5.80
45 × 125	6.11
45 × 150	5.25
50 × 150	4.74
50 × 175	4.14
60 × 175	3.48

VARIATI

Appraisers may, occasiona
ment, known as the *vara*, use
descriptions, and which varie

Reduced to Square Feet

Square Feet	*100ths of Acre*	*Square Feet*
15,246.00	69 =	30,056.40
15,681.60	70 =	30,492.00
16,117.20	71 =	30,927.60
16,552.80	72 =	31,363.20
16,988.40	73 =	31,798.80
17,424.00	74 =	32,234.40
17,859.60	75 =	32,670.00
18,295.20	76 =	33,105.60
18,730.80	77 =	33,541.20
19,166.40	78 =	33,976.80
19,602.00	79 =	34,412.40
20,037.60	80 =	34,848.00
20,473.20	81 =	35,283.60
20,908.80	82 =	35,719.20
21,344.40	83 =	36,154.80
21,780.00	84 =	36,590.40
22,215.60	85 =	37,026.00
22,651.20	86 =	37,461.60
23,086.80	87 =	37,897.20
23,522.40	88 =	38,332.80
23,958.00	89 =	38,768.40
24,393.60	90 =	39,204.00
24,829.20	91 =	39,639.60
25,264.80	92 =	40,075.20
25,700.40	93 =	40,510.80
26,136.00	94 =	40,946.40
26,571.60	95 =	41,382.00
27,007.20	96 =	41,817.60
27,442.80	97 =	42,253.20
27,878.40	98 =	42,688.80
28,314.00	99 =	43,124.40
28,749.60	100 =	43,560.00
29,185.20		
29,620.80		

REDUCED TO SQUARE FEET

Square Feet	*Fraction of Acre*	*Square Feet*
= 14,973.75	11/16 =	29,947.50
= 16,335.00	13/16 =	31,308.75
= 17,696.25	3/4 =	32,670.00
= 19,057.50	17/32 =	34,031.25
= 20,418.75	9/16 =	35,392.50
= 21,780.00	19/32 =	36,753.75
= 23,141.25	5/8 =	38,115.00
= 24,502.50	21/32 =	39,476.25
= 25,863.75	11/16 =	40,837.50
= 27,225.00	23/32 =	42,198.75
= 38,586.25	1 =	43,560.00

METHOD FOR REDUCING SQUARE FEET TO ACRES

Rule.—Multiply the number of square feet by .000023, or multiply by 23 and point off six places.

Example.—How many acres in 130,680 square feet?

130,680
.000023
392040
261360
3.005640

Proof:—43,560)130,680(3
130,680

The reason why dividing by 43,560 is the same as multiplying by .000023 is that dividing by a number is the same as multiplying by its reciprocal:

1 ÷ 43,560 = .000023 (the reciprocal of 43,560).

LOTS PER ACRE

This table shows the number of lots that can be obtained per acre, using the following dimensions as average-sized lots. Allowance has been made for the lots in front on a 50-foot street, with cross streets every 800 feet for the smaller lots and increasing proportionately up to 2,000 feet for the largest.

Size of Lots	*Number of Lots per Acre*	*Size of Lots*	*Number of Lots per Acre*
40 × 100	8.23	60 × 200	3.10
40 × 120	7.07	70 × 175	3.00
40 × 150	5.80	70 × 200	2.67
45 × 125	6.11	80 × 200	2.35
45 × 150	5.25	80 × 240	1.99
50 × 150	4.74	100 × 250	1.54
50 × 175	4.14	100 × 300	1.31
60 × 175	3.48		

VARIATIONS IN THE VARA

Appraisers may, occasionally, be interested in the Spanish measurement, known as the *vara*, used in many California and Texas land title descriptions, and which varies in use in different States and countries.

The township lines running north and south are called Range Lines, and are numbered east and west from a principal meridian. The townships are numbered north and south from an established Base Line or standard parallel.

The diagram at the right represents a section of land and its subdivisions, described as follows:

A is the north half of the section, and contains 320 acres.

B is the southwest quarter of the section, and contains 160 acres.

C is the west half of the southeast quarter, and contains 80 acres.

D is the northeast quarter of the southeast quarter, and contains 40 acres.

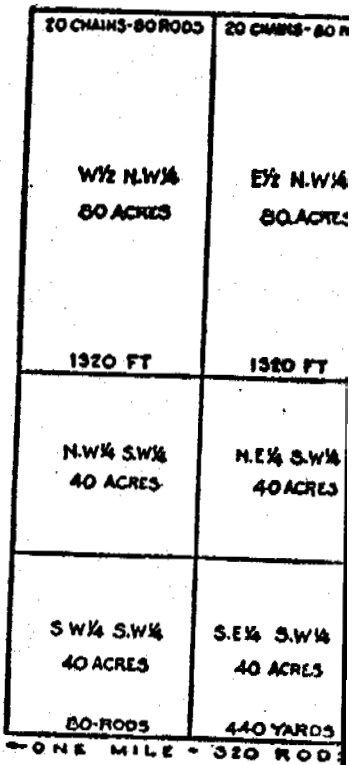


Figure 62. Area and Distance (1 square mile)

LAND MEASURE

The following table will assist appraisers and others in making an accurate estimate of the amount of land in different fields:

10 rods by 16 rods	1 acre	40 yds. by 121 yds.	1 acre
8 rods by 20 rods	1 acre	220 feet by 198 feet	1 acre
5 rods by 32 rods	1 acre	110 feet by 396 feet	1 acre
4 rods by 40 rods	1 acre	60 feet by 726 feet	1 acre
5 yds. by 968 yds.	1 acre	120 feet by 363 feet	1 acre
10 yds. by 484 yds.	1 acre	300 feet by 145.2 feet	1 acre
20 yds. by 242 yds.	1 acre	400 feet by 108.9 feet	1 acre

CONTENTS OF FIELDS AND LOTS

220 feet by 198	feet of land equals 1 acre.
440 feet by 99	feet of land equals 1 acre.
110 feet by 396	feet of land equals 1 acre.
60 feet by 726	feet of land equals 1 acre.
120 feet by 363	feet of land equals 1 acre.
240 feet by 181½	feet of land equals 1 acre.
200 feet by 108$\frac{9}{10}$	feet of land equals ½ acre.
100 feet by 145$\frac{2}{10}$	feet of land equals ¼ acre.

There are 12 city lots, 25 × 100 feet, in an acre with the street cut through; 17$\frac{423}{1000}$ city lots, 25 × 100 feet, in an acre without the street cut through.

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X

rth and south are called
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are numbered north and
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ents a section of land and
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n, and contains 320 acres.
the section, and contains

east quarter, and contains

the southeast quarter, and

SURE

t appraisers and others in
the amount of land in dif-

0 yds. by 121 yds.....1 acre
0 feet by 198 feet.....1 acre
0 feet by 396 feet.....1 acre
0 feet by 726 feet.....1 acre
0 feet by 363 feet.....1 acre
0 feet by 145.2 feet .....1 acre
0 feet by 108.9 feet .....1 acre

S AND LOTS

land equals 1 acre.
land equals 1 acre.
land equals 1 acre.
land equals 1 acre.
land equals 1 acre.
land equals 1 acre.
land equals ½ acre.
land equals ¼ acre.

100 feet, in an acre with the
ts, 25 × 100 feet, in an acre

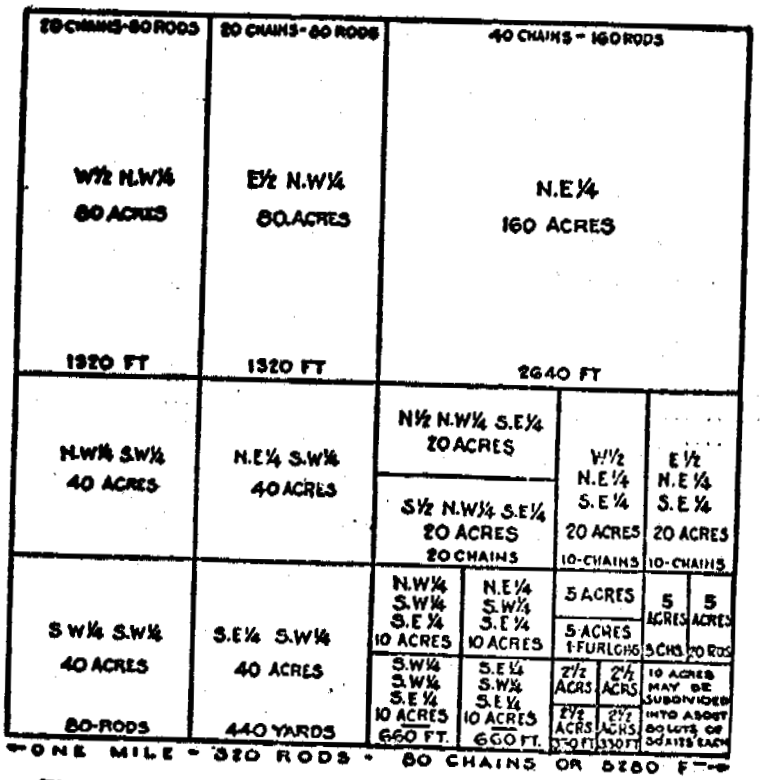

Figure 62. Area and Distances of a Full Section of Land. (1 square mile or 640 Acres).

SURVEYORS' MEASUREMENTS*

7.92 inches = 1 link
25 links = 1 rod
4 rods = 1 chain

10 sq. chains or 160 sq. rods = 1 A.
640 acres = 1 sq. mile
36 sq. mi. (6 mi. sq.) = 1 township

Inches	*Feet*	*Yards*	*Rods*[1]	*Furlongs*	*Miles*
12	1	.....	.....	.....	.....
36	3	1	.....	.....	.....
198	16½	5½	1	.....	.....
7,920	660	220	40	1	.....
63,360	5,280	1,760	320	8	1

Inches (Sq.)	*Feet (Sq.)*	*Yards (Sq.)*	*Rods*[2] *(Sq.)*	*Roods*	*Acres*	*Miles (Sq.)*
144	1	.....	.....	.....	.....	.....
1,296	9	1	.....	.....	.....	.....
.....	272¼	30¼	1	.....	.....	.....
.....	10,890	1,210	40	1	.....	.....
.....	43,560	4,840	160	4	1	.....
.....	.....	.....	.....	2,560	640	1

* Courtesy of True D. Morse, the Doane Agricultural Service.
[1] Rod or perch or pole.
[2] Perch or square rods.

1 Link is 7.92 inches.
1 Foot is 12 inches.
1 Yard is 3 ft. or 36 in.
1 Mile is 8 furlongs, 320 rods, 80 chains, or 5,280 feet.
1 Square Rod is 272¼ square feet or 30¼ square yards.
1 Acre contains 43,560 square feet.
1 Acre contains 160 square rods.
1 Acre is about 8 rods by 20 rods long, or any two numbers (of rods) whose product is 160.
1 Acre may be divided into about 8 lots 30x125 feet.

1 Rod is 16½ feet, 5½ yards, or 25 links.
1 Chain is 66 feet or 4 rods or 100 links.
1 Furlong is 660 feet or 40 rods.

1 Vara = 33⅓ inches.
.26 Varas = 1 foot.
1.08 Varas = 1 yard.

5.94 Varas = 1 pole.
23.76 Varas = 1 chain.
1900.8 Varas = 1 mile.

5½ Yards = 1 pole.
16½ Feet = 1 pole.
66 Feet = 1 surveyor's chain.
7.92 Inches = 1 link.
100 Links = 1 chain.

4 Poles = 1 chain.
25 Links = 1 pole.
320 Poles = 1 mile.
1760 Yards = 1 mile.
5280 Feet = 1 mile.

160 Sq. Rods = 1 acre.
4840 Sq. Yards = 1 acre.

43560 Sq. Feet = 1 acre.

640 Acres = 1 section.
4428.4 Acres = 1 league.

A practical method to redu
each 100 varas, or 50 per c
example: 363 varas plus 3 e
poles.

To find the number of acr
multiply by 177 and point off

To reduce varas to yards, d
multiply by 1.08; varas to fee
tiply by .36.

MEASUREMENTS IN GENERAL USE

7.92 inches make 1 link.
25 links make 1 rod.
16.50 feet make 1 rod.
4 rods make 1 chain.
10 chains make 1 furlong.
8 furlongs make 1 mile.
320 rods make 1 mile.
5,280 feet make 1 mile.
10 square chains make 1 acre.
160 square rods make 1 acre.
640 acres make 1 square mile.
43,560 square feet make 1 acre.
60 geographical miles make 1 degree.
1,728 cubic inches make 1 cubic foot.
27 cubic feet make 1 cubic yard.
Gunter's chain, 22 yards of 100 links.
A section is 640 acres.
A township is 36 sections, each 1 square mile.
A span is 9 inches.
A hand—horse measurement—is 4 inches.
A knot—nautical—is 6,086 feet.
A fathom—nautical—is 6 feet.
A stone is 14 pounds.
A square acre is $208\frac{7}{10}$ feet on each side.

MISCELLANEOUS UNITS OF MEASURE

Sheets, Reams		Palm, Span, Cubit	
12 units or articles	1 dozen	3 inches	1 palm
24 sheets paper	1 quire	9 inches	1 Bible span
20 quires	1 ream	18 inches	1 cubit
2 reams	1 bundle	28.8 inches	1 Bible cubit
5 bundles	1 bale	2½ feet	1 military pace
Printer's token	250 sheets	6 feet	1 fathom

Degrees	
60 seconds	1 minute
60 minutes	1 degree
30 degrees	1 sign
90 degrees	1 quadrant
360 degrees	1 circle
60 miles	1 degree

SURFACE MEASURES

Surface or Square Measure.—144 square inches equal 1 square foot; 9 square feet equal 1 square yard; 30¼ square yards equal 1 measure 20 feet on each side and about a square rod; 40 square rods equal 1 square rood; 4 square roods equal 1 acre; 640 acres equal 1 square mile; 4,840 square yards equal 1 acre.

Pa. 7

MISCELLAN

COMPARISON OF U

Hectoliters × 3.531 = c
Hectoliters × 2.84 = b
Hectoliters × .131 = c
Hectoliters + 26.42 =
Grams × 15.432 = grai
Grams + 981 = dynes.
Grams (water) + 29.57
Grams + 28.35 = ounc
Grams per cubic cent.
Joule × .7373 = foot-p
Kilograms × 2.2046 =
Kilograms × 35.3 = ou
Kilograms + 907.18581
Kilograms per sq. cent.
Kilogram-meters × 7.2
Kilo per Meter × .672
Kilo per Cubic Meter ×
Kilo per Cheval × 2.23
Kilowatts × 1.34 = hor
Watts + 746 = horse p
Watts + .7373 = foot-p
Calories × 3.968 = Brit
Chevaux-vapeur × .986
(Degrees centigrade × 1
Francs × .193 = dollars
Gravity Paris = 980.94

METRIC, O

		Meters	
Millimeter*	=	.001	=
Centimeter†	=	.01	=
Decimeter	=	.1	=
Meter	=	1.	=
Decameter	=	10.	
Hectometer	=	100.	
Kilometer	=	1000.	
Myriameter	=	10000.	

* Nearly the 1/25 part of

METRIC, OR

		Sq. Meters	U.
Sq. Centim.	=	.0001	=
Sq. Decim.	=	.01	=
Centare	=	1.	=
Are	=	10.	= 13
Hectare	=	100.	
Sq. Kilometer	=	.38607	S
Sq. Myriameter	=	38.607	

GHTS AND MEASURES

× .00019	= miles.
× .0006	= miles.
× .007	= square feet.
× .111	= square yds.
× .0002067	= acres.
× .4840	= square yds.
× .00058	= cubic feet.
× .03704	= cubic yards.
× .00546	= square feet.
× .0004546	= cubic feet.
× .02909	= cubic yards.
× .22	= yards.
× .66	= feet.
× 1.5	= links.
× 8	= acres p. mile.
	= 1 square ft.
	= 1 cubic foot.
× 7.48	= U. S. gallons.
× .004329	= U. S. gallons.
× 5.874	= U. S. gallons.
× .0034	= U. S. gallons.
× .13367	= cubic feet.
× 231	= cubic inches.
× .8036	= U. S. bushel.
× .000465	= U. S. bushel.
× .0461	= cubic yards.
× 1.2446	= cubic feet.
× 2150.42	= cubic inches.
× 6	= U. S. gallons.
× .009	= cwt. (112).
× .00045	= tons (2240).
× 62.5	= lbs. avoir.
× .03617	= lbs. avoir.
× 49.1	= lbs. avoir.
× .02842	= lbs. avoir.
	= 1 cwt.
	= 1 ton.

ANEOUS

Cord of wood = 128 cubic feet
1 hand = 4 inches
1 span = 9 inches

WEIGHTS AND MEASURES

Troy Weight

24 grains = 1 pwt.
20 pwt. = 1 ounce.
12 ounces = 1 pound.
(Used for weighing gold, silver, and jewels.)

Apothecaries' Weight

20 grains = 1 scruple.
3 scruples = 1 dram.
8 drams = 1 ounce.
12 ounces = 1 pound.

Avoirdupois Weight

27 11/32 grains = 1 dram.
16 drams = 1 ounce.
16 ounces = 1 pound.
25 pounds = 1 quarter.
4 quarters = 1 cwt.
2,000 lbs. = 1 short ton.
2,240 lbs. = 1 long ton.

Dry Measure

2 pints = 1 quart.
8 quarts = 1 peck.
4 pecks = 1 bushel.
36 bushels = 1 chaldron.

Liquid Measure

4 gills = 1 pint.
2 pints = 1 quart.
4 quarts = 1 gallon.
31½ gallons = 1 barrel.
2 barrels = 1 hogshead.

Long Measure

12 inches = 1 foot.
3 feet = 1 yard.
5½ yards = 1 rod.
40 rods = 1 furlong.
8 furlongs = 1 stat. mile.
3 miles = 1 league.

Mariners' Measure

6 feet = 1 fathom.
120 fathoms = 1 cable length.
7½ cable lengths = 1 mile.
5,280 feet = 1 stat. mile.
6,085 feet = 1 naut. mile.

METRIC EQUIVALENTS

Linear Measure

1 centimeter = 0.3937 in.
1 in. = 2.54 centimeters.
1 decimeter = 3.937 in. = 0.328 feet.
1 ft. = 3.048 decimeters.
1 meter = 39.37 in. = 1.0936 yds.
1 yard = 0.9144 meter.
1 decameter = 1.9884 rods.
1 rod = 0.5029 decameter.
1 kilometer = 0.62137 mile.
1 mile = 16.093 kilometers.

Square Measure

1 sq. centimeter = 0.1550 sq. in.
1 sq. inch = 6.452 square centimeters.
1 sq. decimeter = 0.1076 sq. ft.
1 sq. ft. = 9.2903 square decimeters.
1 sq. meter = 1.196 sq. yd.
1 sq. yd. = 0.8361 sq. meter.
1 are = 3.954 sq. rods.
1 sq. rod = 0.2529 are.
1 hectar = 2.47 acres.
1 acre = 0.4047 hectar.
1 sq. kilometer = 0.386 sq. m.
1 sq. mile = 2.59 square kilometers.

Measure of Volume

1 cu. centimeter = 0.061 cu. in.
1 cu. inch = 16.39 cu. centimeters.
1 cu. decimeter = 0.0353 cu. ft.
1 cu. foot = 28.317 cu. deci meters.
1 cu. m'r. = 1.308 cu. yd.
1 cu. yd. = 0.7646 cu. meter
1 stere = 0.2759 cord.
1 cord = 3.624 steres.
1 liter = { 0.908 qt. dry. / 1.0567 qt. liq.
1 qt. dry = 1.101 liters.
1 qt. liq. = 0.9463 liter.
1 decaliter = { 2.6417 gal. / .135 pecks.
1 gal. = 0.3785 decaliter.
1 peck = 0.881 decaliter.
1 hectoliter = 2.8375 bu.
1 bu. = 0.3524 hectoliter

1076 sq ft in mile

Surveyors' Measure

7.92 inches = 1 link.
25 links = 1 rod.
4 rods = 1 chain.
10 square chains or 160 square rods = 1 acre.
640 acres = 1 sq. mile.
36 sq. miles (6 miles square) = 1 township.

Cubic Measure

1,728 cubic in. = 1 cu. ft.
27 cubic ft. = 1 cubic yd.
128 cu. ft. = 1 cord (wood).
40 cu. ft. = 1 ton (ship'g).
2,150.42 cu. in. = 1 standard bushel.
231 cu. in. = 1 standard gallon.
1 cu. ft. = about ⅘ bushel.

Weights

1 gram = 0.03527 ounce.
1 ounce = 28.35 grams.
1 kilogram = 2.2046 lbs.
1 lb. = 0.4536 kilogram.
1 metric ton = 1.1023 Eng. tons.
1 English ton = 0.9072 metric ton

Approximate Metric Equivalents

1 decimeter = 4 inches.
1 liter = { 1.06 qt. liquid. / 0.9 qt. dry.
1 meter = 1.1 yards.
1 kilometer = ⅝ mile.
1 hectoliter = 2⅘ bu.
1 hectar = 2½ acres.
1 kilogram = 2½ lbs.
1 stere or cu. meter = ¼ cord.
1 metric ton = 2,200 lbs.

UNITS OF MEASUREMENT OF LENGTH

A *meter* (m.) is a unit of length equivalent to the distance between the defining lines on the international prototype meter at the International Bureau of Weights and Measures when this standard is at the temperature of melting ice (0° C.).

A *yard* (yd.) is a unit of length equivalent to $\frac{3600}{3937}$ of a meter.

1 kilometer (km.) = 1,000 meters.
1 hectometer (hm.) = 100 meters.
1 decameter (dcm.) = 10 meters.
1 decimeter (dm.) = 0.1 meter.
1 centimeter (cm.) = 0.01 meter.
1 millimeter (mm.) = 0.001 meter = 0.1 centimeter.
1 micron (μ) = 0.000,001 meter = 0.001 millimeter.
1 millimicron (mμ) = 0.000,000,001 meter = 0.001 micron.
1 foot (ft.) = ⅓ yard = $\frac{1200}{3937}$ meter.
1 inch (in.) = $\frac{1}{36}$ yard = $\frac{1}{12}$ foot = $\frac{1200}{39370}$ meter.
1 link (li.) = 0.22 yard = 7.92 inches.
1 rod (rd.) = 5½ yards = 16½ feet.
1 chain (ch.) = 22 yards = 100 links = 66 feet = 4 rods.
1 furlong (fur.) = 220 yards = 40 rods = 10 chains.
1 statute mile (mi.) = 1,760 yards = 5,280 feet = 320 rods.
1 hand = 4 inches.
1 point = $\frac{1}{72}$ inch.
1 mil = 0.001 inch.
1 fathom = 6 feet.
1 span = 9 inches = ¼ fathom.
1 nautical mile, 1 sea mile, 1 geographical mile } United States = 6,080.20 feet = 1.151,553 statute miles = 1,853.249 meters.

Courtesy United States Bureau of Standards

UNITS OF LENGTH

Units	Inches	Links	Feet	Yards	Rods	Chains	Miles
1 inch =	1	0.126 263	0.083 333 3	0.027 777 8	0.005 050 51	0.001 262 63	0.000 015 782 8
1 link =	7.92	1	0.66	0.22	0.04	0.01	0.000 125
1 foot =	12	1.515 152	1	0.333 333	0.060 606 1	0.015 151 5	0.000 189 393 9
1 yard =	36	4.545 45	3	1	0.181 818	0.045 454 6	0.000 568 182
1 rod =	198	25	16.5	5.5	1	0.25	0.003 125
1 chain =	792	100	66	22	4	1	0.0125
1 mile =	63 360	8000	5280	1760	320	80	1
1 centimeter =	0.3937	0.049 709 60	0.032 808 33	0.010 936 111	0.001 988 384	0.000 497 096 0	0.000 006 213 866
1 meter =	39.37	4.970 960	3.280 833	1.093 611 1	0.198 838 4	0.049 709 60	0.000 621 369 9

UNITS OF AREA

Units	Square Inches	Square Feet	Square Yards	Square Rods			