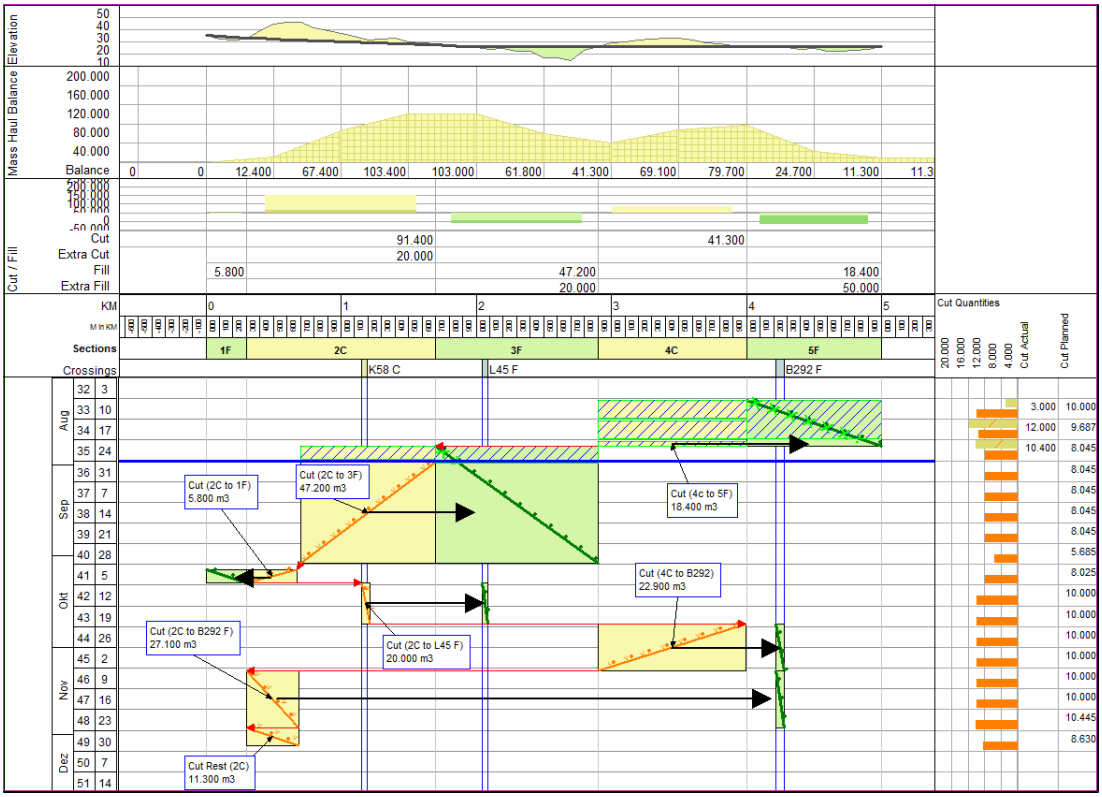
Using TILOS

for

Mass Haul Planning



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1 Overview

The objective of the mass haul approach is to develop an understanding of the mass balance (cut and fill quantities) of material along a project ROW (right-of-way).

The results of the engineering providing elevation of land and quantities a mass haul plan can be developed for effective project execution.

This paper describes a method to monitor, plan and control soil movements on a sample road construction site using TILOS. The methodology is presented with detailed diagrams to illustrate, how the mass haul planning can be much simpler. The application of actual progress data against baseline and rescheduling results is also presented.

2 Mass Haul Analysis

2.1 Quantities

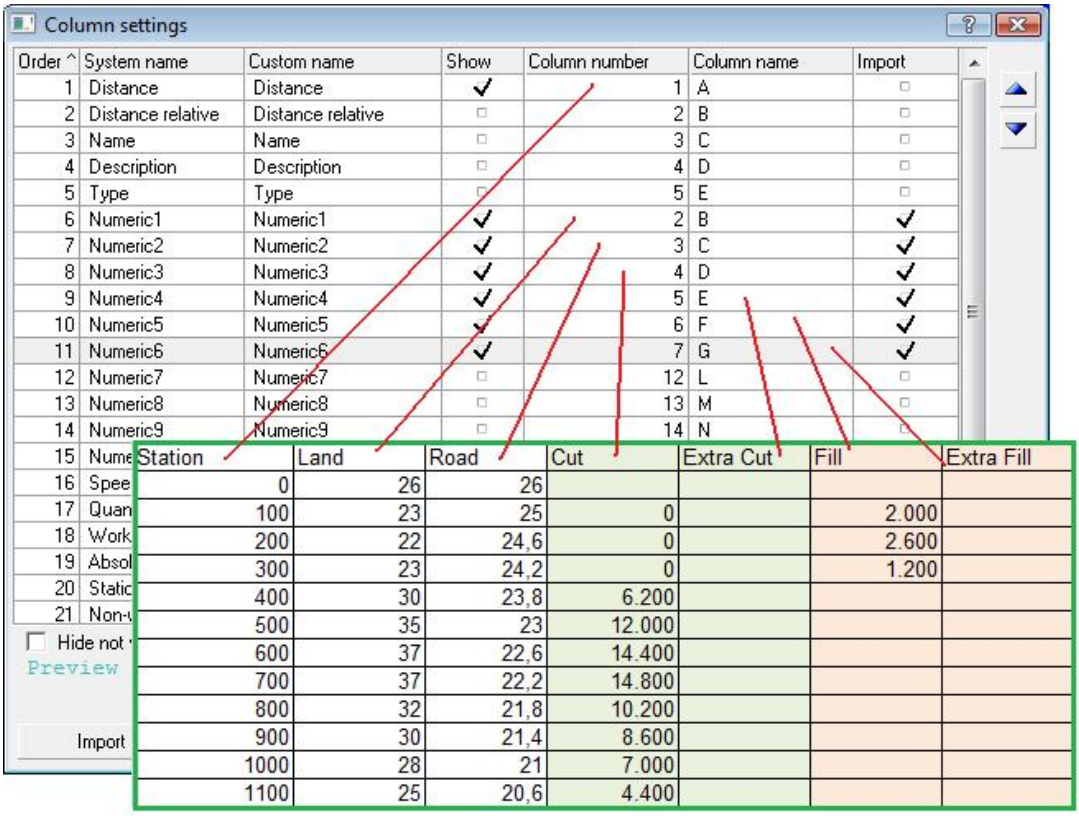
It is assumed that the quantity data is available in an Excel table with the following fields:

Station point	The distance coordinate of each point along the road allowance.
Land	Elevation of Land at given point
Road	Elevation of the road at given point
Cut	Cut quantities on the main line of the road from previous station point to this station point.
Cut Extra	Cut in side areas (Crossing)
Fill	Fill quantities on the main line of the road from previous points to this point.
Fill Extra	Fill in side areas (Crossing)

As a first step of planning, this table is imported into TILOS. The TILOS import algorithm is very flexible and provides the user with up to 10 user-defined fields for different mass haul quantities.

The import can be done by copying the data to the clipboard from any application, assuming that each line contains the data for one station and the fields are separated by tab character.

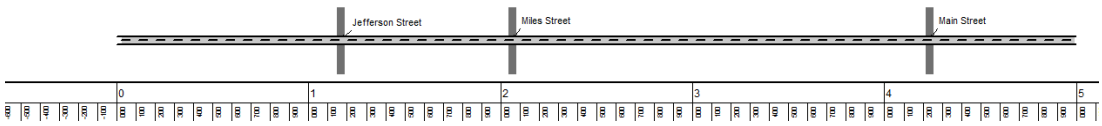
A mapping table allows the user to control the import but also the display inside TILOS with user defined names taken from the column Header of the import.



2.2 *Annotating the distance axis*

For a better understanding of a time distance diagram, a site plan is always added on top or on the bottom of the plan. This can be created inside TILOS using symbols from the symbol library or a by importing a graphic file.

Our project is a road project from station 0 to station 5000 (total length of 5 km) and has 3 crossings. The drawing is constructed by using the internal drawing features of TILOS with predefined symbols. This allows a better scaling and clipping then using just a picture.

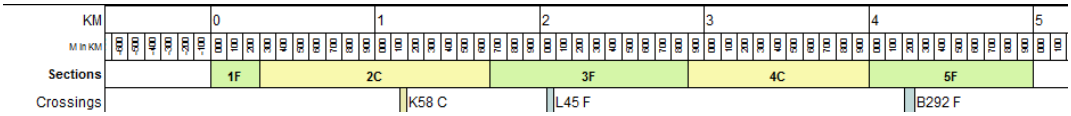


2.3 Cut and fill sections

In the distance scale there are 2 additional scales to show the cut and fill sections with the appropriate annotation showing the section numbers.

The upper displays the sections on the main line. This table will be used later to define the graphs and to generate section based quantities. This can be imported as well, but also edited in TILOS directly.

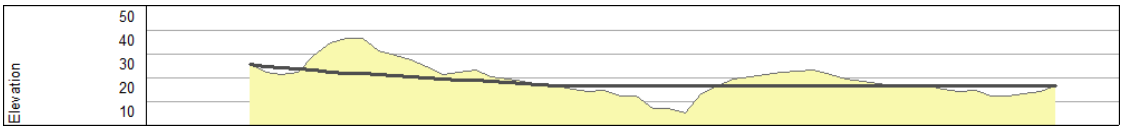
Distance	Name	Type
0		
300	1F	Fill
1.700	2C	Cut
2.900	3F	Fill
4.000	4C	Cut
5.000	5F	Fill



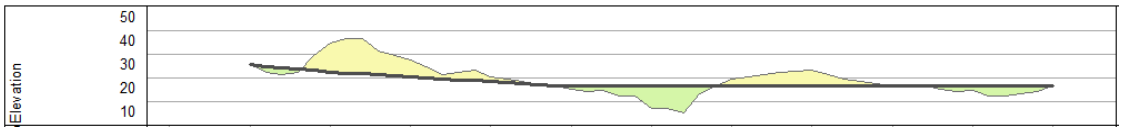
The lower scale displays the special locations for cut and fill.

2.4 Land and Road Profile Diagram

Using the imported data, an elevation diagram can be generated, showing the land height and the road height.

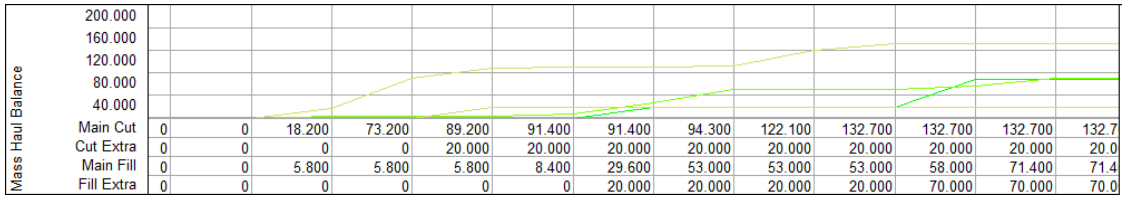


Using the option “fill between the lines”, cut and fill areas can be highlighted.



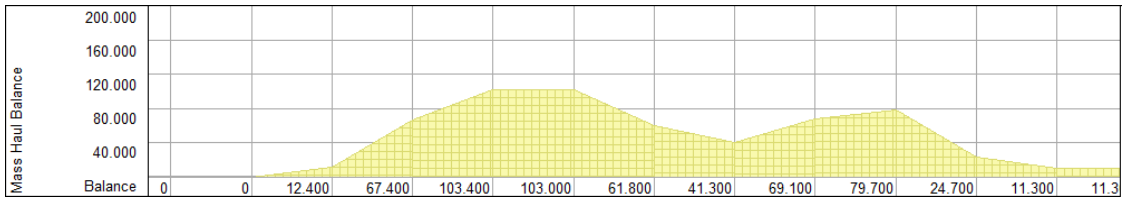
2.5 *Mass Haul Balance Curve*

This graph displays the quantities for all 4 imported values (Cut main, Cut Extra, Fill main, Fill Extra) summed from left to right. In the last value column the totals can be seen.



Grouping this data we can get a balance curve for the mass haul which is the difference between cut and fill.

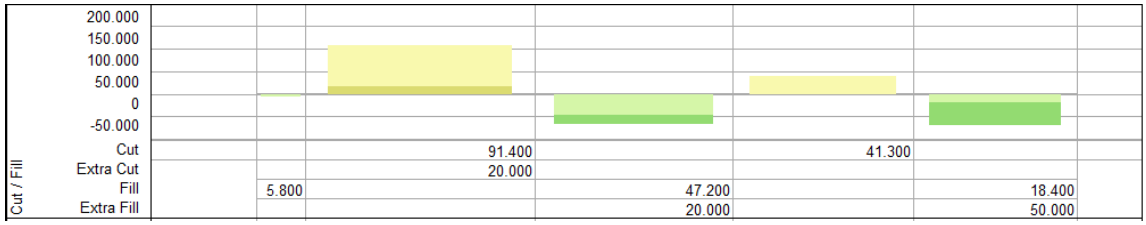
The following diagram displays the mass balance curve for this project.



This mass balance diagram, based on 500 m segments, displays the balance between cut and fill. In total, there is 11 300 m3 more cut than fill. Greater resolution can be realised by defining smaller segments for analysis in TILOS.

2.6 *Cut and fill diagram*

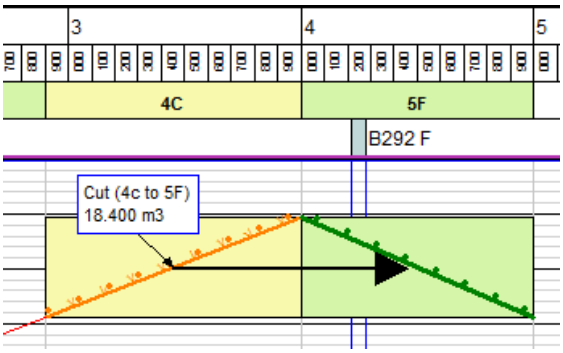
This diagram displays the cut and the fill values as a histogram. From the import these values are defined for every 100 m section. Here they get sliced by the free defined cut and fill section table. Cut is shown as a stacked histogram: the yellow part is showing the values along the ROW, the gold is showing the quantities in side areas. Fill is displayed under the zero-line. This allows an easy identification of cut and fill.



3 Planning Mass Haul transportation

3.1 Planning Cut and Fill

The mass haul is always planned by creating 2 tasks: a cut and a fill task.



The cut task is represented by a rectangle around the main task line. The annotation displays the quantity that is planned. The annotation is user defined, so further values can be added like work rates and resource values.

Preformatted tasks with colors and annotation can be stored in the library, so creating a new task is simply drawing this on screen and entering the quantity. If the whole quantity is planned for removal in a section, then whole profile value can be applied directly. This means: Changing the tasks coordinates also changes the quantity for the task - as the calculation takes all quantities from the profile between the start and end point.

The fill task is created in the same way, but then defined as a hammock task. This has two advantages: The cut quantity is delivered to the fill task and also the time is synchronized.

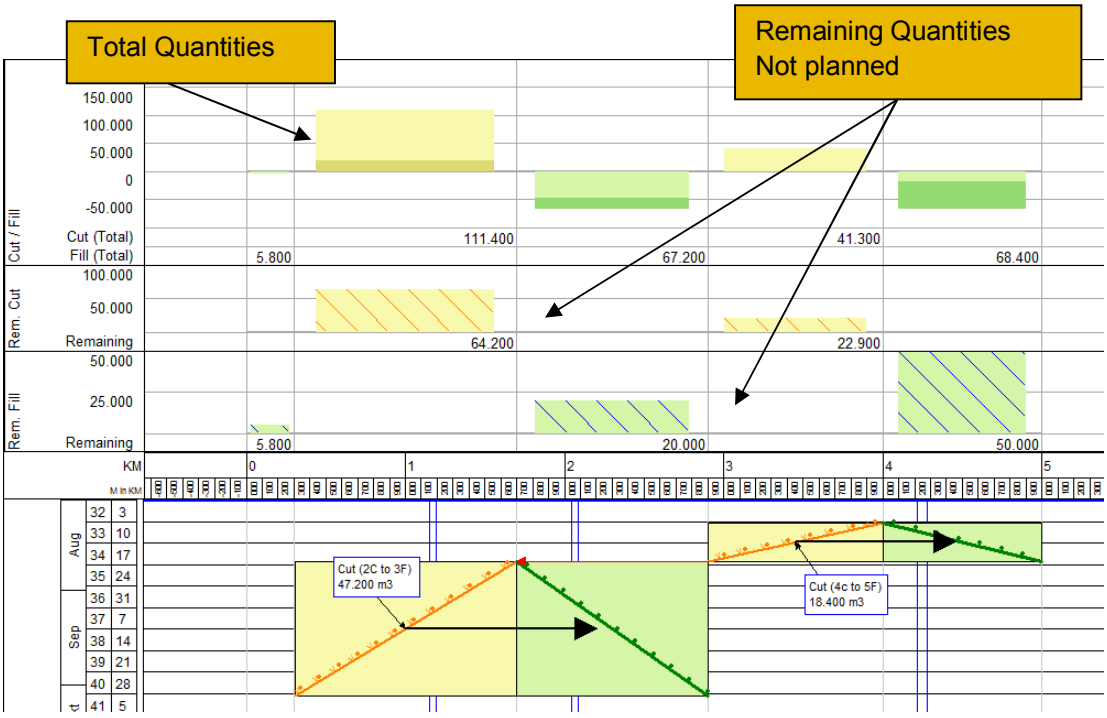
To assist the planner, two further diagrams can be generated:

The **cut planned diagram** is showing the quantity for the cut areas, which is already planned. While all previously described diagrams are generated from the profiles, this diagram is generated from tasks. The task quantity value is analyzed and a filter has been set, to show only evaluate only cut tasks. (This diagram is not shown in the following picture).

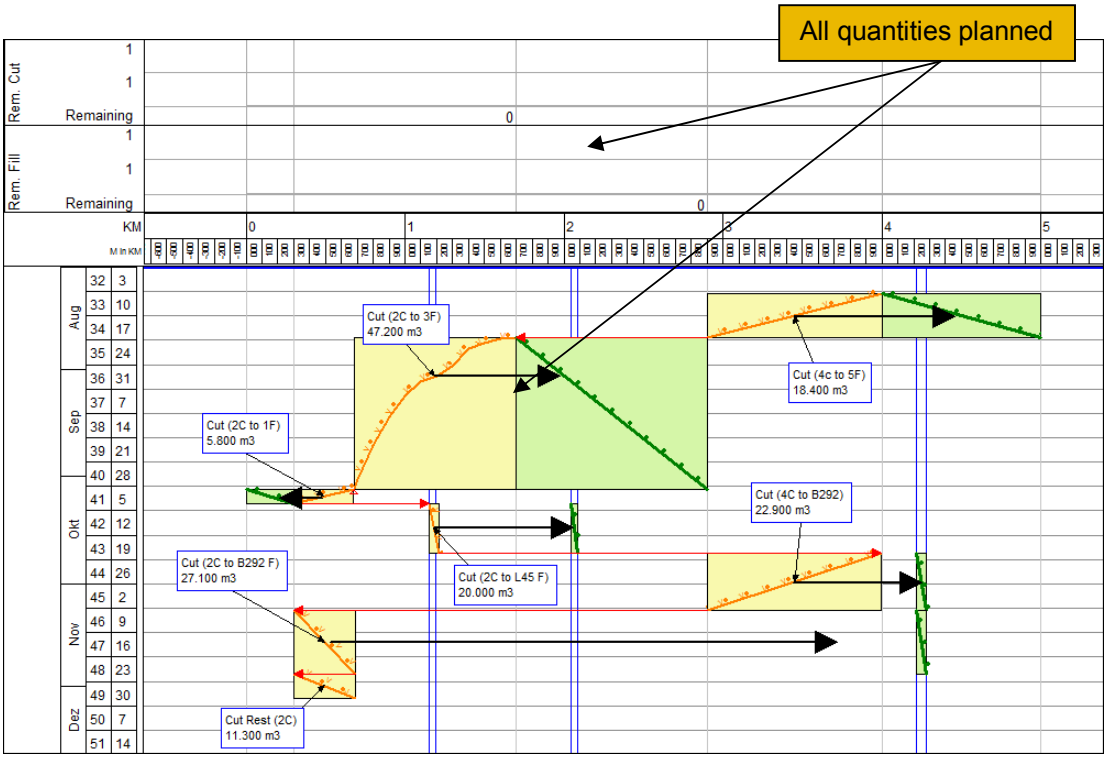
The remaining cut diagram is displaying the amount of cut, which has not been planned yet in each section. This is defined as difference between the total quantity from the profiles and the cut planned diagram.

The following picture displays the remaining quantity in cut and fill, which still needs to be planned after planning the first activity.

From the 114 400 m3 in zone 2 (300 to 1700), 47 200 have already been planned, so the graph displays remaining 64 200.



As more tasks are planned, the remaining quantity in each section is reduced until 0. After the last tasks have been planned, the quantity in the remaining diagram should be 0.

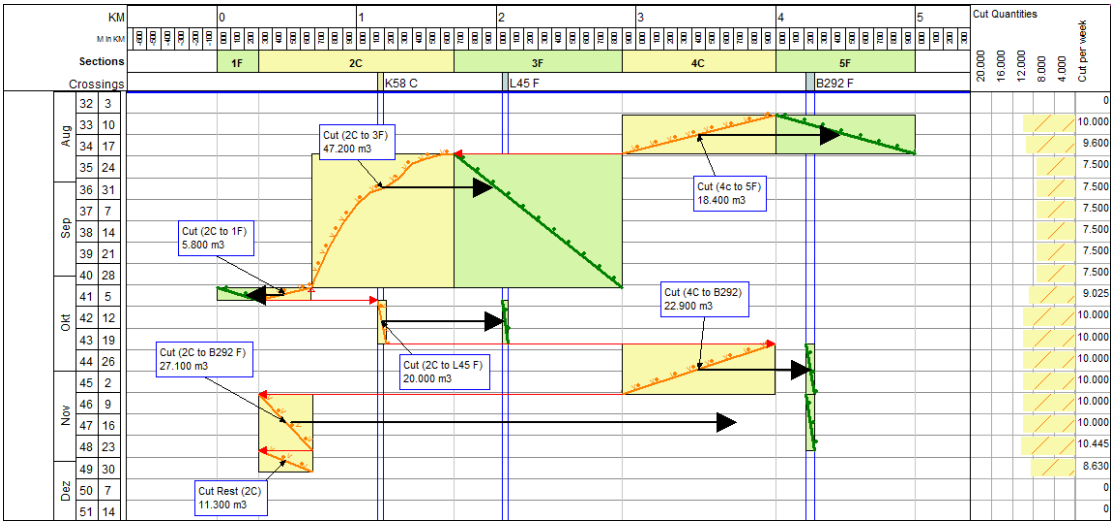


3.2 *Planning Work Rate and Performance*

One of the excellences of TILOS is the task calculation. For each task the quantity sets the amount of work. The work rate describes the performance: how many units can be done in a time unit. The duration of a task is calculated by Quantity / Work rate.

The quantity can be entered by the user directly, but also calculated based on site parameters or other tasks. In our case, we can link the quantity to profile and TILOS calculates the quantity automatically: It considers the start and end location of the tasks and takes the quantity from the profile between this 2 values. If the task is moved or the length is changed, then the quantity is updated and the duration as well.

The work rate can be entered by the user, but also be taken from the resources assigned to this task as driving resources. If in a cut task, the driving resource is the excavator, then TILOS can calculate the number of truck needed to transport the material to the fill area. Based on the work rate of the exactor, the number of trucks is updated.



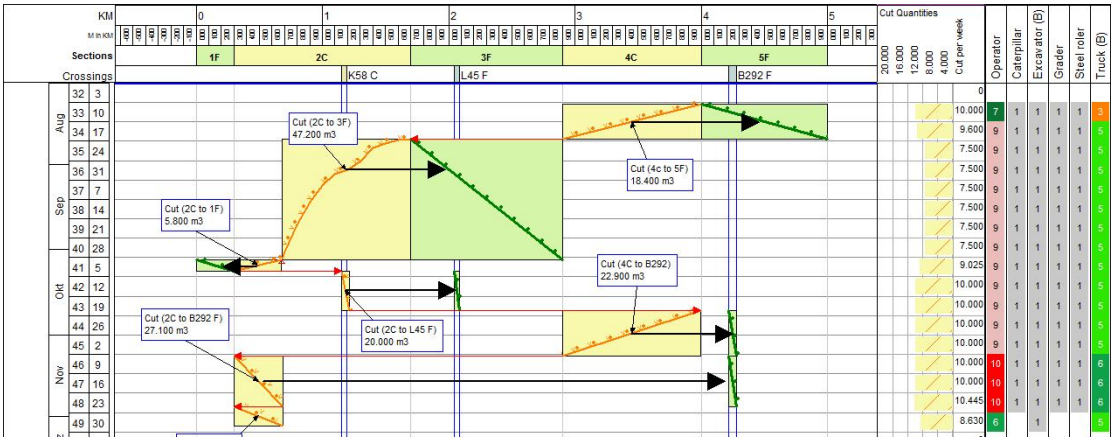
The histogram on the right side displays the cut quantities on a weekly base, but also as an S-Curve.

3.3 *Resource planning*

In TILOS, each task can have one or more resources (with cost) assigned. There are different types of resources: Permanent resources to model labor and machines, consumable resources to model material or complex resources, which can be a collection of consumable and permanent resources (e.g. an excavator can have already an operator, fuel consumption or special buckets assigned).

Based on the allocation of resources to each task the resource, special diagrams and lists can be generated.

The most important diagram for permanent resources is the Resource Usage Bar Chart. It enables the user to show the number of needed resources. Each resource represents one bar line and the colors indicate the number of units needed.



4 Progress and Performance

4.1 Saving planning data (Creating a Baseline)

TILOS provides the flexibility to create as many baselines as required for the project. To create a baseline in TILOS simply select the baseline tab in the subproject definition area and add a new baseline. TILOS provides an option to add all tasks or a subset of the tasks to a baseline. When you create a baseline the start date, end date and quantities of each task is stored (histogram data is converted to a time profile and stored as the planned quantity per week). Once you have defined a baseline you can then measure progress against the plan, essential for project control and EVM (Earned Value Management).

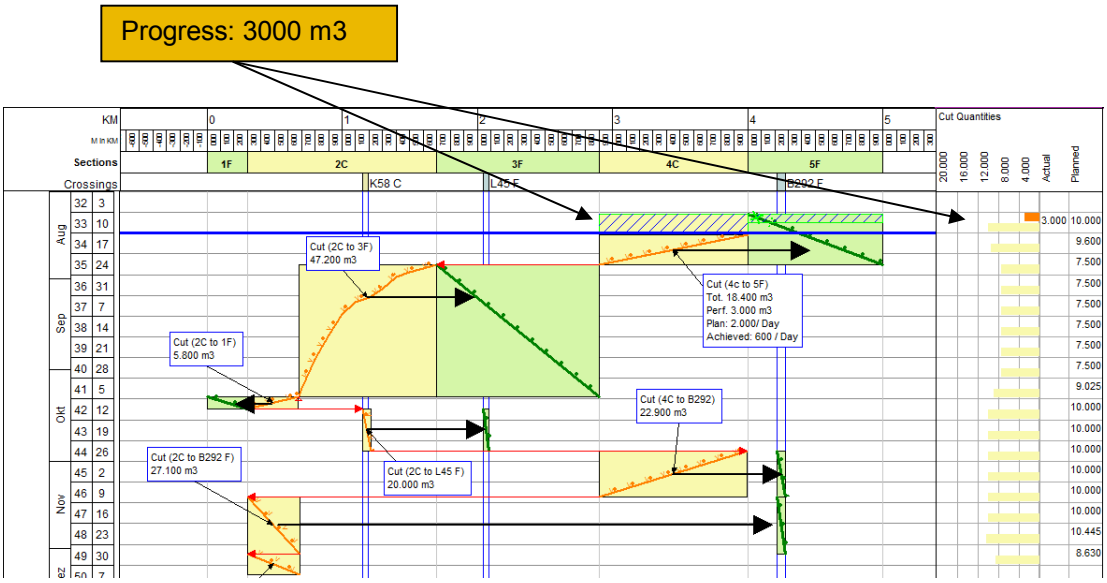
Each diagram prepared as time or distance based diagram can be stored inside TILOS as well. Just export this data to the clipboard, create a new time profile and import the data from clipboard.

4.2 Example 1: Report progress (15.08.2010)

The following chapter describes the work performed until the 15.08.2010.

The blue horizontal line in the following diagram is the data date or the report date (the date of the most recent progress). The weekly actual quantities for the cut activities are entered for each task as reported from the site.

In the following sample a progress of 3 000 m3 has been achieved in the first week. The task is selected and the progress is entered. As the fill task in section 5F is a hammock, this is also progressed by the same amount automatically.



In the following diagram the quantity histogram has been enhanced to show the planned versus actual quantities per week.

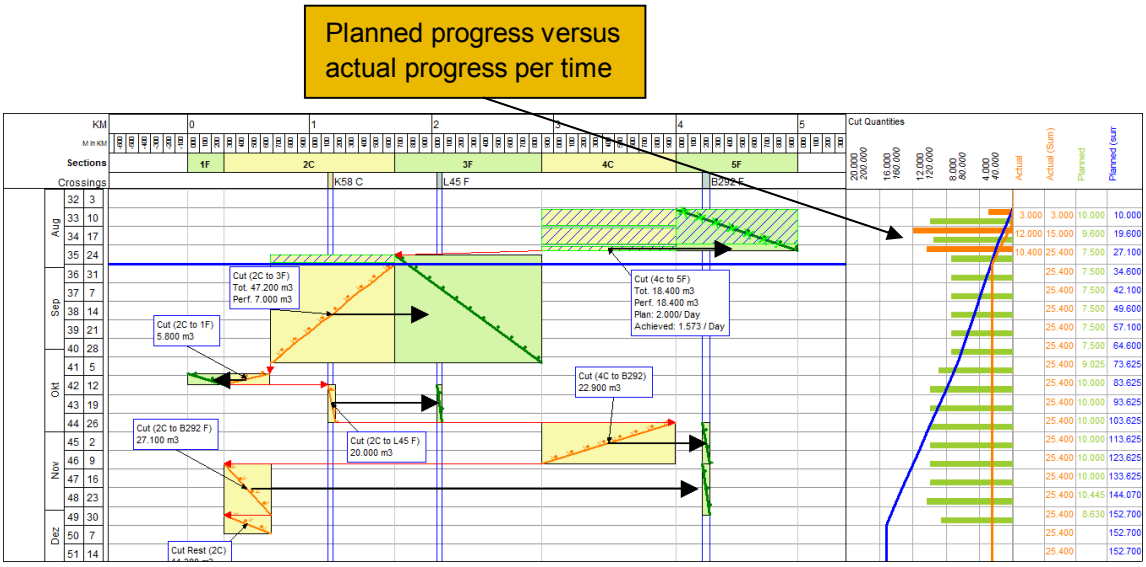
The situation: The actual productivity (work rate) has been well below the planned. The planned quantity was 10 000 m^3 while only 3 000 m^3have been achieved. The planned work rate was 2000 m^3/day while the actual was 600 m^3 /day.

In the following week, 12 000 m^3 of material is moved.

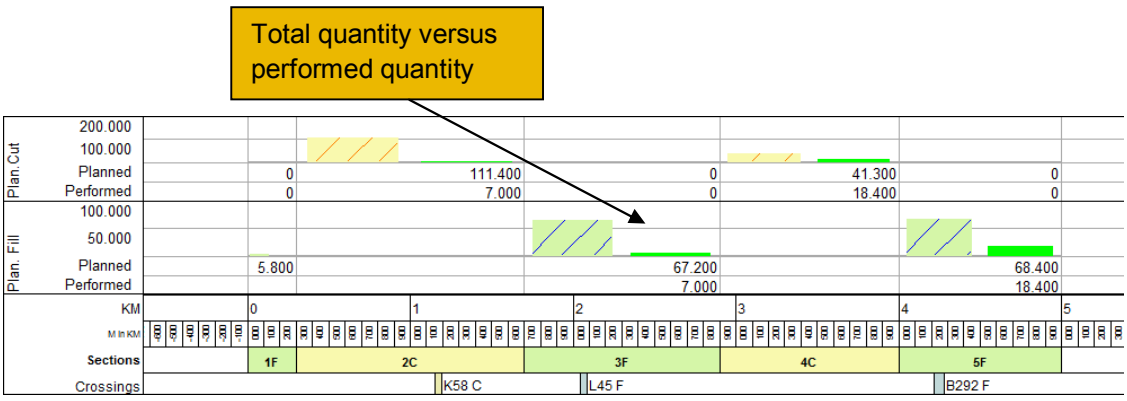
4.3 *Example 2: Progress Report date (29.08.2010)*

In week 3 there was work on 2 tasks and in total 10 400 m^3 were achieved.

The remaining 3 400 m^3 in section 4c and 7 000 in section 2C were moved.



In Total there has been 27 100 planned and 25 400 achieved. This is displayed by the S-curves.



The distance diagrams has been enhanced and display the quantity planned against the quantity performed for each location section, for cut and fill.

5 Summary

Using the quantities from the Excel import provides more precision when planning Mass Haul and enables a straight forward planning without any side calculations.

TILOS displays how much material (either in yd^3 or m^3) has to be moved and where the cut and fill areas are located. During planning the quantity histograms automatically reflect the changes when adding new tasks.

Mass haul planning is easier in TILOS with cut and fill set up as twin tasks. Only the cut needs to be planned as the correct fill quantities are calculated automatically.

During the execution of the project, the achieved quantities are surveyed – this is leading to a direct comparison of planned and performed figures. This comparison is essential for good project control and EVM.