An Automated Tool for Optimizing Waste Transportation Routing and Scheduling

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ABSTRACT

An automated software tool has been developed and implemented to increase the efficiency and overall life-cycle productivity of site cleanup by scheduling vehicle and container movement between waste generators and disposal sites on the Department of Energy's Oak Ridge Reservation. The software tool identifies the best routes or accepts specifically requested routes and transit times, looks at fleet availability, selects the most cost effective route for each waste stream, and creates a transportation schedule in advance of waste movement. This tool was accepted by the customer and has been implemented.

INTRODUCTION

Bechtel Jacobs Company[11] (BJC) is under contract with the Department of Energy (DOE) for decontamination and demolition (D&D) of the K-25 Gaseous Diffusion Building as well as other process buildings at the East Tennessee Technology Park (ETTP) in Oak Ridge, Tennessee. During the demolition phase, it is estimated that this will require up to 150 loads of waste per day moving to the Environmental Management Waste Management Facility (EMWMF) and to the Oak Ridge Reservation Landfill (ORRLF) in order to meet the September 30, 2008 milestone. Strata-G, LLC (Strata-G) was contracted by BJC to help solve this logistical challenge.

PROJECT HISTORY

Prior to use of this tool, BJC was shipping approximately 60 waste streams per day from various projects across the DOE Oak Ridge Reservation. The waste movement prioritization schedule dictated that it be disposed to the following four areas: left in situ, ORRLF, EMWMF, and offsite disposal. It has been determined that more than ninety percent of the solid waste will be disposed of on the Oak Ridge Reservation at either the EMWMF or the ORRLF – both facilities

[1] Managed by Bechtel Jacobs Company LLC, under contract DE-AC05-98OR2270 with the Department of Energy.

located near the Y-12 National Security Complex. BJC, recognizing that the scope of the Accelerated Cleanup Project involved moving over 2.4 million yd3 of waste and projecting an increase in shipments, took action to work with the disposal sites in scheduling to meet the September 2008 milestone.

PROBLEM DEFINITION

Creating a manual daily schedule over the telephone, or via email, for 150 loads of waste and involving generators, disposal sites, and multiple transportation companies was not only labor intensive but also prevented BJC from maximizing efficiency and controlling costs. With that process in place, the historical waste movement rate has not achieved a level of high-volume movement that would be sufficient to meet Accelerated Cleanup Project objectives. In addition, an inefficient schedule would almost certainly dictate working more than one shift to meet waste movement goals. Without an advance schedule, both the generator and disposal sites could not effectively project workforce needs. The transportation subcontractors could not plan for future fleet needs or for workforce scheduling. Sixty percent of waste movement delays were a direct result of too many vehicles arriving at the EMWMF disposal facility and waiting in the queue. When disposal site hours were extended, no more loads were processed than during a normal operating day. Overall, a manual daily schedule was time consuming and did not produce efficient results. BJC recognized these logistical issues and sought ideas to mitigate these project/EMWMF-related risks.

In contrast to the EMWMF, the ORRLF was not included in the schedule prior to the implementation of this tool. This disposal site operated on a first-come first-serve basis and did not know exactly how many or what type of loads would be arriving each day. The daily staffing of the disposal site was based on previous traffic patterns rather than specific knowledge of incoming waste streams. This uncertainty presented staff and resource dilemmas (too many or too few) based on sporadic arrival times as well as vehicle queues created by several vehicles converging on the entry portal at the same time.

OBJECTIVES AND PROCESS IMPROVEMENT

In order to achieve the milestone objectives and meet projected loads per month into each disposal site, we determined that there should be an optimized waste movement schedule, created one week in advance. The initial process mapped the flow from generator to disposal site. At the generator site, the operating hours, portal entry time, loading time, radcon time, and transportation paperwork processing were documented. Similar documentation, including queue time, was documented for each disposal site on the Oak Ridge Reservation. Specifications for each transportation subcontractor and vehicle type were obtained. This information included driver schedules, truck load capacity, fueling and maintenance times, and current routes and transit times. In addition to that information, several variables had to be researched. These variables included:

- Volume forecasts per project
- Truckload volume calculations

- All routing possibilities
- Load and unload rates by truck type
- Accurate transit times
- Varied software in use

TIMING STUDIES AND OBSERVATIONS

BJC was able to provide significant amounts of information on conveyance times based on vehicle type, transit times at disposal cells, weather related factors, and waste type. We were able to use that information along with performing additional observations and time studies. An initial task was designed to benchmark activities and to identify and define relevant metrics such as cycle times during employee breaks, cycle times impacted by staffing and supervision, and conveyance times on generator sites and specific vehicles that had a history of delays. Cycle time studies analyzed the following processes:

- Travel time to generator site including transit through security portals
- Radcon survey
- Loading
- Paperwork completion
- Exit
- Travel time through portal to disposal site
- Queue time at disposal site
- Paperwork, scale, and incoming survey
- Unload
- Transit to next site

OVERVIEW OF SOLUTION

Dispatch Pro is a commercial-off-the-shelf software package that runs under Microsoft Windows NT/2000/XP[2]. The application creates daily shipping schedules from generator requests for waste pickup and/or delivery of empty containers, transportation fleet data (i.e. vehicle numbers and types, time required to load/unload, etc.), and routing data (i.e. time to travel between points, etc.). Generator data may be entered directly into Dispatch Pro or imported from other database systems. The user may also adjust numerous model parameters (such as average ingress/egress

[2] Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof or its contractors or subcontractors.

time through gates, time to travel routes between sites, time to load/unload vehicles by site and project, and number of available vehicle types) and regenerate schedules, allowing for quick "what-if" analyses of complex parameter interactions.

Basic Operation

These are the typical steps used to generate schedules with Dispatch Pro. Details on each step follow:

- Generator Request Data: User imports and/or inputs generator request data (i.e. pickup date/time(s) and locations, number of loads, waste/container/vehicle types, disposal sites, etc.).
- Location and Vehicle Data: For new locations or vehicles not previously defined in Dispatch Pro, user enters applicable model parameters (i.e. location on map, average ingress/egress times to enter/leave, times to load/unload vehicles, etc.). Dispatch Pro automatically flags missing or incomplete model parameters, making update of new locations and vehicles easy.
- Vehicle Availability: User enters fleet data (i.e. number and types of vehicles available for scheduling, operators, initial starting locations, etc.)
- Topographical Data: User enters data on the roads that connect locations. This only has to be entered once. Using this data, the application automatically calculates the shortest routes between any two points (using Dijkstra's Algorithm). Dispatch Pro has built-in data on roads and locations for the Oak Ridge Reservation.
- Generate Schedule: User generates the schedule. Dispatch Pro also calculates the corresponding driver shift lengths for each vehicle. The application displays generated schedules in tabular and graphical formats, and can also export the data to other systems.

Generator Request Data

Generator request data defines what needs to be transported on a given day. This information may be typed directly into Dispatch Pro (Figure 1) or imported from another system that collects the data from generators. Pull-down menus are provided for most inputs (Table I), making data entry straight-forward.

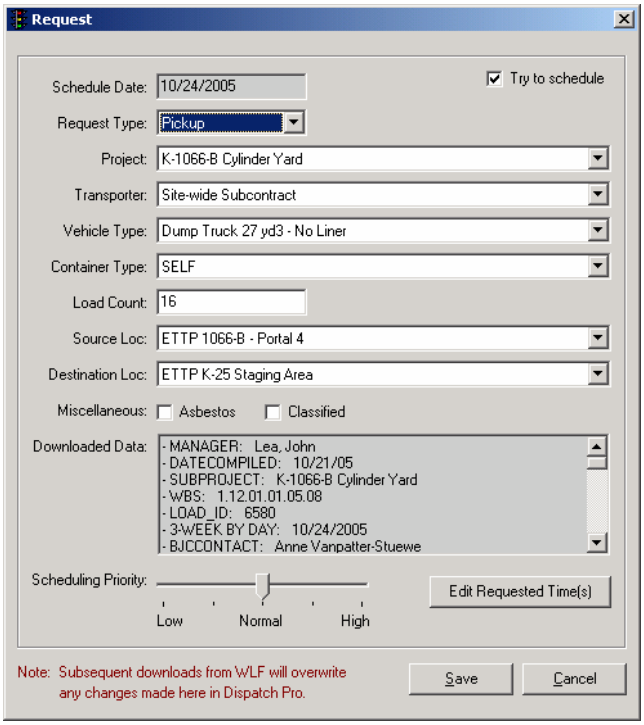


Fig. 1. Dispatch Pro Generator Request Screen

Table I. Dispatch Pro Generator Request Screen Definitions

FIELD	DESCRIPTION
Schedule Date	Date that generator wants waste picked up or empty containers delivered
Request Type	Defines if generator wants waste picked up or empty container(s) delivered
Project	Name of project for which generator is working.
Transporter	Name of transportation company that should service the request. Only vehicles in the specified transporter's fleet will be used for the request.
Vehicle Type	Type of vehicle required (ex. dump truck, flatbed, compactor truck, etc.)
Container Type	Defines how the waste is packaged (ex. 55 gallon drum, intermodal, self-contained, etc.)
Load Count	Defines the number of vehicles required to transport all the loads. This may differ from the total number of containers.
Source Location	Where the waste or empty container should be picked up by the vehicle.
Destination Location	Where the waste or empty container should be dropped off by the vehicle.

Table I. Dispatch Pro Generator Request Screen Definitions (continued)

Asbestos Flag	Designates whether or not the waste load contains asbestos.
Classified Flag	Designates whether or not the waste load contains classified material.
Downloaded Data	A list of the raw data imported from another system.
Scheduling Priority	An indicator of the importance of this request compared to other requests scheduled on the same day. For cases where not all requests can be serviced in a day due to limited resources (i.e. not enough vehicles to service all requests), requests marked high priority will get precedence in the scheduling process over requests of lower priority.
Try to Schedule Flag	If checked (default), then this request will be included in the scheduling process. If unchecked, this request will be ignored during scheduling (i.e. waste will not be picked up nor empty containers delivered).
Edit Requested Time(s)	Optional. Allows generator to specify specific times during day when waste may be picked up or empty containers may be delivered.

Location Data

Location data defines how generator locations and disposal sites should be modeled during schedule generation. Dispatch Pro includes pre-defined logic (Table II) for Oak Ridge Reservation sites, such as EMWMF and the ORRLF that models how waste is handled at the disposal cells.

Table II. Dispatch Pro Generator Location Screen Definitions

FIELD	DESCRIPTION
Location Name	Name of location
Nearest Map Point	Map points are points connected by roads. This parameter tells Dispatch Pro where on the map the location is found.
Process Model	Some locations have specialized waste handling rules (ex. send asbestos loads to a specific ramp). This parameter allows designation of pre-defined site-specific waste handling rules.
Disposal Site	Designates whether or not this location accepts waste for disposal. If checked, this site will appear in the Generator Request screens as a "destination" location.

Table II. Dispatch Pro Generator Location Screen Definitions (continued)

Edit Operating Times	Defines times when location is open for business. Vehicles will only be scheduled to service a location during times defined here.
Average Ingress Time	The average number of minutes a vehicle takes to enter the location. This parameter is used to model, for example, length of time to pass through security.
Average Egress Time	The average number of minutes a vehicle takes to leave the location. This parameter is used to model, for example, length of time to complete exit surveys.

Vehicle Data

Vehicle data defines how particular vehicle types are modeled during scheduling. This information (Table III) generally remains static once defined, but may be updated at any time as desired.

Table III. Dispatch Pro Vehicle Data Screen Definitions

FIELD	DESCRIPTION
Vehicle Name	Name of vehicle type.
Average Load Time	The average number of minutes required to load waste onto the vehicle.
Average Unload Time	The average number of minutes required to unload waste from a vehicle.
Apply Liner Time	The average number of minutes required to apply liner, absorbent materials, etc. to the truck bed before loading of waste.
Use Rad Flag	If checked, then this vehicle will be modeled as contaminated if loaded with radioactive material.

Vehicle Availability Data

Vehicle availability data (Figure 2, Table IV) defines the number and types of vehicles specific transporters have in their fleets.

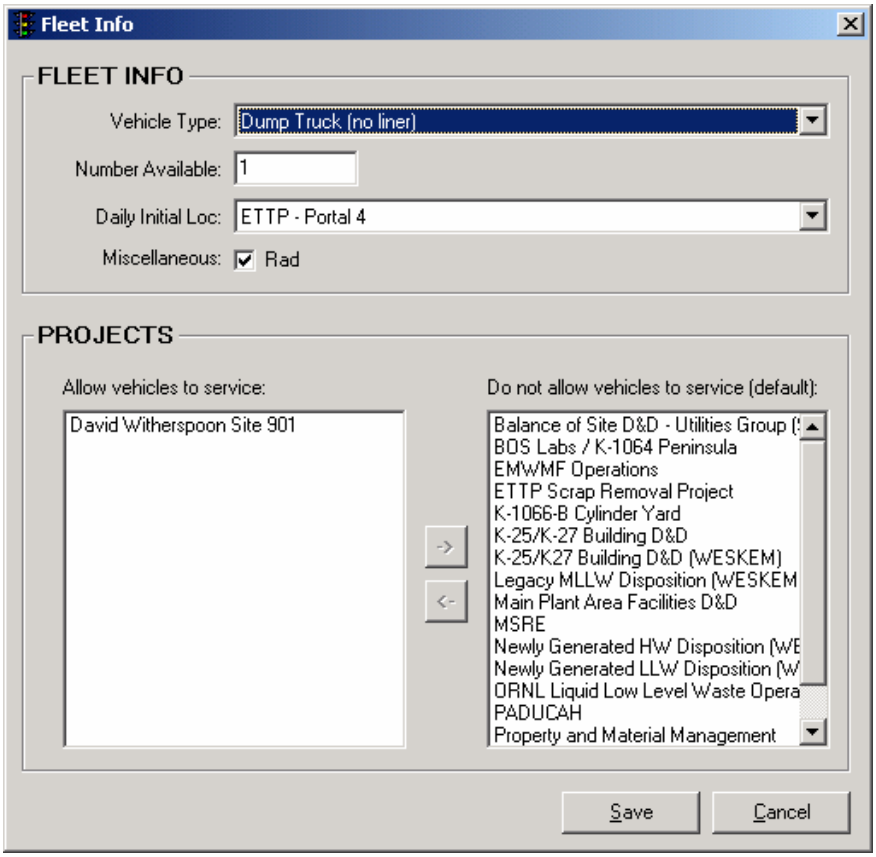


Fig. 2. Dispatch Pro Fleet Information Screen

Table IV. Dispatch Pro Fleet Information Entry Screen Definitions

FIELD	DESCRIPTION
Vehicle Type	Type of vehicle in fleet (ex. dump truck, rolloff truck, etc.)
Number Available	Total number in fleet.
Daily Initial Location	Location where the vehicle(s) begin at start of schedule
Rad Flag	If checked, then vehicle(s) are modeled as rad contaminated
Allow Vehicles to Service	Only projects listed here will be serviced by vehicle(s). This parameter is used to restrict vehicles to specific projects.
Do Not Allow Vehicles to Service	Projects listed here will not be serviced by vehicle(s). This parameter is used to restrict vehicles from servicing specific projects.

Topographical Data

Topographical data defines the roads that connect points. The user enters all locations, roads between those locations, and road traversal times into Dispatch Pro. Using Dijkstra's Algorithm, Dispatch Pro then calculates all the shortest routes between any two locations.

In the following example (Figure 3), map points A, B, C, D, and E are defined with roads between them as shown. The numbers next to the roads indicate the time in minutes required to traverse the road. To compute the travel time from map point A to map point E, Dispatch Pro calculates the shortest route as the roads linking A to B to E (bold lines in Figure 3).

Hence the total traversal time is calculated as 4 minutes from map point A to map point E.

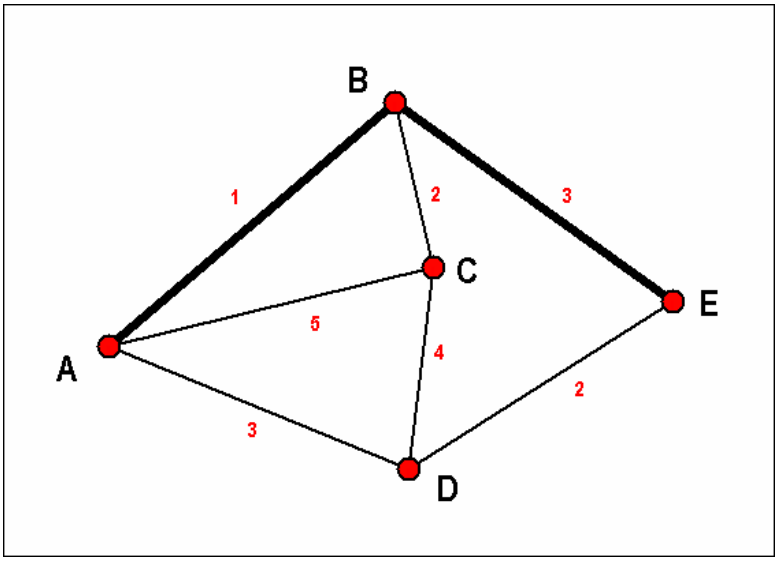


Fig. 3. Illustration of algorithm used to calculate route traversal times

Generate Schedule

After all model parameters (Table V) have been entered, schedules may be generated (Figure 4). This is typically an iterative process, particularly when limited resources (i.e., vehicles) are a dominant factor.

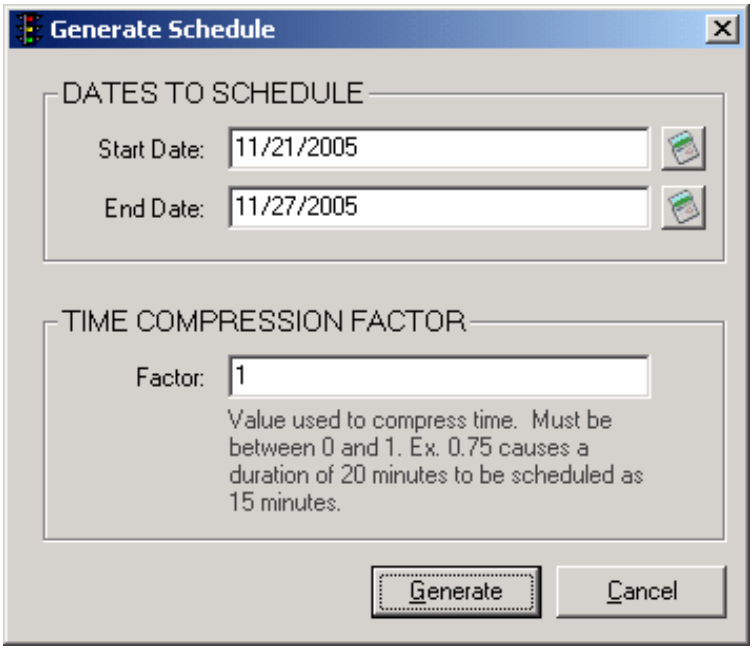


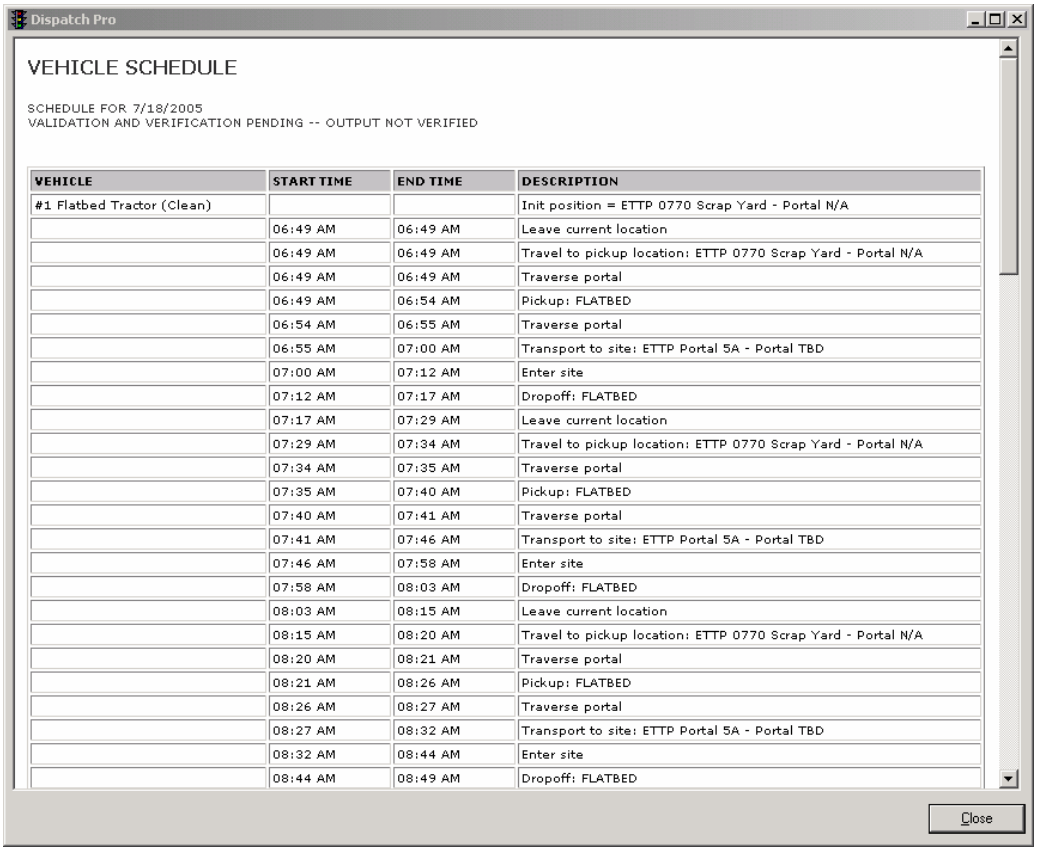
Fig. 4. Dispatch Pro Schedule Generation Screen

Table V. Dispatch Pro Schedule Generation Screen Definitions

FIELD	DESCRIPTION
Start Date	The first date to schedule. All requests between the Start and End date will be scheduled.
End Date	The last date to schedule. All requests between the Start and End date will be scheduled.
Time Compression Factor	This value is used to globally compress durations of time throughout the scheduling process. This parameter is used to extend the availability of vehicles to service more requests.

COMPLETED SCHEDULE

Once generated, schedules may be viewed on-line through Dispatch Pro in either tabular or graphical format (Figure 5). All schedule data may also be exported to another system. The length of time to generate a schedule depends on the complexity of what is being modeled, but typically schedules take approximately five minutes per day of requests included in the scheduling process.



VEHICLE	START TIME	END TIME	DESCRIPTION
#1 Flatbed Tractor (Clean)			Init position = ETTP 0770 Scrap Yard - Portal N/A
	06:49 AM	06:49 AM	Leave current location
	06:49 AM	06:49 AM	Travel to pickup location: ETTP 0770 Scrap Yard - Portal N/A
	06:49 AM	06:49 AM	Traverse portal
	06:49 AM	06:54 AM	Pickup: FLATBED
	06:54 AM	06:55 AM	Traverse portal
	06:55 AM	07:00 AM	Transport to site: ETTP Portal 5A - Portal TBD
	07:00 AM	07:12 AM	Enter site
	07:12 AM	07:17 AM	Dropoff: FLATBED
	07:17 AM	07:29 AM	Leave current location
	07:29 AM	07:34 AM	Travel to pickup location: ETTP 0770 Scrap Yard - Portal N/A
	07:34 AM	07:35 AM	Traverse portal
	07:35 AM	07:40 AM	Pickup: FLATBED
	07:40 AM	07:41 AM	Traverse portal
	07:41 AM	07:46 AM	Transport to site: ETTP Portal 5A - Portal TBD
	07:46 AM	07:58 AM	Enter site
	07:58 AM	08:03 AM	Dropoff: FLATBED
	08:03 AM	08:15 AM	Leave current location
	08:15 AM	08:20 AM	Travel to pickup location: ETTP 0770 Scrap Yard - Portal N/A
	08:20 AM	08:21 AM	Traverse portal
	08:21 AM	08:26 AM	Pickup: FLATBED
	08:26 AM	08:27 AM	Traverse portal
	08:27 AM	08:32 AM	Transport to site: ETTP Portal 5A - Portal TBD
	08:32 AM	08:44 AM	Enter site
	08:44 AM	08:49 AM	Dropoff: FLATBED

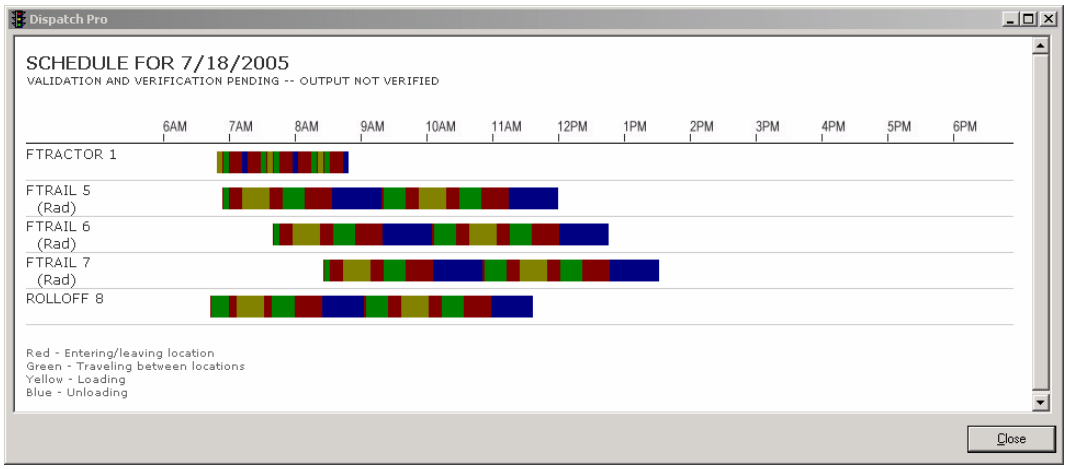


Fig. 5. Dispatch Pro Final Schedule Screen

CONCLUSION

Using modeling and algorithms, this tool provides a practical and efficient method for waste management transportation scheduling and integrates effectively with existing systems. Total dollar cost savings for Bechtel Jacobs have not been calculated as the program is in its first year of use; however, initial man hour savings point to very positive results. Future applications include use at other onsite location cleanup areas that have a need to schedule multiple vehicles

to different disposal sites. The program can also be integrated with existing onsite applications and can be used as a reporting tool to determine if a project is adhering to scheduled timelines. By using an automated system, waste transporters can eliminate man hours spent creating transportation schedules, make cost effective decisions, and improve overall productivity of the site cleanup process.