TRANSPORTATION MODELING OF
REMOTE RADAR SITES AND SUPPORT DEPOTS

THESIS

Sonia E. Leach, Captain, USAF

AFIT/GOR/ENS/97M-13

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THESIS

Presented to the Faculty of the Graduate School of Engineering

Air Education and Training Command

In Partial Fulfillment of the

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Sonia E. Leach, B.S.

Captain, USAF

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THESIS APPROVAL

Student: Sonia E. Leach, Captain, USAF Class: GOR-97M

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Committee:	Name/Title/Department	Signature
Advisor	Richard F. Deckro Professor Department of Operational Sciences Air Force Institute of Technology	Richard F. Deckro
Readers	James T. Moore, Lieutenant Colonel, USAF Associate Professor Department of Operational Sciences Air Force Institute of Technology	James T. Moore
	Lee J. Lehmkuhl, Major, USAF Assistant Professor Department of Mathematical Sciences United States Air Force Academy	Lee J. Lehmkuhl

Disclaimer

The views expressed in this thesis are those of the author and do not reflect the official policy or position of the North Warning System, the United States Air Force, the Department of Defense, the Royal Canadian Air Force, or the Department of National Defence.

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Sonia Eileen Leach

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Abstract

The North Warning System (NWS), a joint program of the United Stated Air Force (USAF) and the Royal Canadian Air Force (RCAF), is responsible for the maintenance of 47 remote radar sites across northern Canada. NWS's current airlift operations, which support the radar maintenance activities, consist of both helicopters and fixed wing aircraft positioned at five support depots. This thesis considers whether a reconfiguration of these support depots and the assignment of radar sites to them can result in either an airlift or total cost savings for NWS.

Mixed integer linear programming models were formulated to address the questions surrounding a reconfiguration of the NWS which might gain airlift cost savings. Several operational scenarios were considered. The analysis identifies that cost savings may be realized through a number of possible actions.

TRANSPORTATION MODELING OF REMOTE RADAR SITES AND SUPPORT DEPOTS

I. Introduction

In the past several years, the United States Armed Forces have experienced declining budgets while maintaining and in some cases even increasing the level of operational activity. It is likely that these budget declines will continue in the immediate future. In the face of such reductions, decision makers must possess sound and reasonable justification for their programs and their operating budgets. An appropriate mathematical model of key aspects of a process often provides valuable information and insight to the decision maker for this purpose.

The United States Air Force (USAF) Air Combat Command (ACC) Detachment Commander assigned to the North Warning System (NWS) has asked for assistance in modeling their airlift activities in an attempt to gain additional insight into their system. The NWS is a joint operation of the USAF and the Royal Canadian Air Force (RCAF) which maintains 47 remote radar sites across northern Canada. The funding of NWS operations is divided such that the RCAF is responsible for the maintenance activities and the USAF is responsible for the airlift support for those maintenance activities. Based upon this division of responsibility, the USAF ACC Detachment Commander is interested in learning how the airlift operations and budget can be streamlined while maintaining the level of support required by the maintenance activities and other operational activities.

Background

The North Warning System (NWS), a joint program of the USAF and RCAF, is a relatively new operation that grew out of the Distant Early Warning (DEW) program. Commonly referred to as the DEW Line, the Distant Early Warning program was established in the 1950s. The background information given here provides a description of the operations and transportation implemented to support the DEW Line and their transition to the current NWS.

DEW Line Operation. Eleven of NWS's current radar sites are long range radar (LRR) established in the 1950s as part of the original DEW Line. These radar sites were designed and equipped as fully manned operating facilities. Along with reasonably equipped living quarters, each site possessed adequate supply storage facilities, as well as a fully operational airfield and aircraft hangar. All of the operations and maintenance activities for the LRRs were contracted activities. The contracted support personnel, which included the radar operators, radar technicians, cooks, cleaners and airfield management crews, were on site 24 hours a day during their tours of duty.

DEW Line Transportation Concept. The transportation concept of personnel and supplies during the operation of the DEW Line was a vertical/lateral supply chain. The vertical aspect consisted of supplies and personnel originating from two hubs located in Winnipeg and Montreal. (See map at Appendix A) These supplies and personnel would travel via 727-type aircraft to a LRR site on the DEW Line. The Winnipeg aircraft would fly once a week to both the Cambridge Bay and Hall Beach sites, and the Montreal aircraft would fly once a week to the community of Iqaluit. Once the supplies and personnel were positioned on the DEW Line, a 748-type aircraft would laterally supply the other LRR sites with the appropriate supplies and personnel.

NWS Operation. The operational concept of the DEW Line changed during the late 1980s. A decision was made to unman the 11 LRR sites and to add 36 short range radar (SRR) sites. The SRR sites, which were built between 1990 and 1993, were designed and constructed as unmanned facilities. The combined operations of the LRR and SRR radar sites was designated as the North Warning System (NWS) and marked the end of the DEW Line. The changes in the operation leading to the establishment of the NWS precipitated a change in the maintenance activities and transportation concepts as well. Maintenance activities that were performed by the full-time crew at each of the 11 LRRs of the DEW Line must now be handled by personnel who are flown to each radar site as needed. In addition, the weekly stream of food and supplies being flown to DEW Line personnel is no longer required.

NWS Transportation Concept. The change in operational concept forced a change in the method of transportation. The extensive fixed-wing flight operations needed for the DEW Line were in place to supply food and other sundry items, as well as to conduct shift changes of manned sites in a severe environment. Under the new, unmanned operational structure, the only airlift missions which remain are the required visits to each radar site for preventative and corrective maintenance. The unmanning of the sites and the associated decrease in requirements included the removal of the airfield support personnel, rendering the airfields unusable for fixed-wing aircraft during the winter months.

The helicopter was chosen to serve as the primary mode of transportation for the NWS. This decision stemmed from the need for maintenance crews to be able to reach a radar site at any time during the year for maintenance. A helicopter is able to land at each radar site regardless of whether or not there is snow on the ground, while a fixed-wing aircraft would require a snow-cleared airstrip. Each of the SRRs were equipped with only helicopter pads based upon this new transportation concept.

While the helicopter is the primary method of transportation, fixed-wing aircraft are also available. During the summer months, fixed-wing Twin Otters are able to use community airstrips and the unmaintained airstrips that are in place at some of the LRRs to stage maintenance supplies for both an LRR and its surrounding SRRs.

Logistic Support Sites (LSS). Upon initiation of NWS activities, five logistic support sites (LSS) were put into operation as home bases for the contracted maintenance personnel. These LSS locations were determined geographically to cover the 47 radar sites. Two of the LSSs are collocated at LRR sites. One of the primary factors in determining the location of each LSS was the availability of a commercial airstrip and hangar facilities which did not require the dedication of contracted airstrip support personnel. Five zones, designated I through V, were established as an LSS and the radar sites it supports. The LSSs, by zone, are located at the following five sites (See map at Appendix A): Zone I - Inuvik; Zone II - Cambridge Bay (collocated with LRR Cambridge Bay); Zone III - Hall Beach (collocated with LRR Hall Beach); Zone IV - Iqaluit; Zone V - Goose Bay. The Zone I, IV and V LSSs are community based facilities in which the contractor personnel maintain private residences within the communities. The only supply issues for these three facilities are those of radar maintenance equipment and material. The Zone II and III LSSs are live-in stations and utilize the existing personnel facilities at the collocated LRRs. In addition to the radar maintenance supplies, these two facilities require personnel shift changes and bi-weekly personnel support supplies. Commercial air support handles these supply and personnel needs.

NWS Maintenance Activities. The airlift support required is driven by the activities of the NWS. The primary activities involve the maintenance of the 47 radar sites. There are different types of maintenance missions which require different levels of airlift support.

Preventative maintenance inspections (PMIs) involve routine maintenance issues and are the only required maintenance missions. These missions occur four times annually at all 47 sites. The PMI is the most extensive operation in terms of airlift support. This mission generally requires multiple helicopter trips over several days between the LSS and the radar site in order to move the required maintenance personnel, equipment and materials. The fixed-wing aircraft may also be used to place some of the maintenance personnel, equipment and materials at the LRR, or nearby communities, in an effort to alleviate some of the helicopter trips.

Corrective maintenance missions are those that involve an unexpected maintenance issue. This type of problem needs to be attended to before the next scheduled PMI at that site, but it does not affect the operation of the radar or security equipment.

Emergency maintenance missions, on the other hand, are those that involve an unexpected maintenance issue which needs to be addressed immediately. A maintenance mission of this type is likely to involve a problem that disables the radar equipment or the security of the facility and must be attended to within 72 hours of notification of the problem.

Additional NWS Activities. In addition to the maintenance activities addressed above, the NWS must also accommodate missions of other origin. These are referred to as third party support (TPS) trips. The TPS category is a catch all to represent anything other than the maintenance of the radar system. The most common of these types of trips are alternate work requests (AWRs) in which items other than the radar or security systems require attention. This type of activity may involve additions or upgrades to the structures at the site which are necessary but not directly related to the operation of the radar itself. An additional type of TPS trip involves visiting dignitaries. As with any operation, there are visits from commanding officers and other interested parties.

Airlift Contracting. For each of the five zones, there are two airlift contracts available, one for helicopter support and a second for fixed-wing support. These ten contracts are all priced and fulfilled separately.

Because the helicopter is the primary mode of transportation for the operations, all five helicopter contracts call for a dedicated helicopter to be located with each LSS. The Zone I, II, III and V contracts are fulfilled by Bell-212 helicopters. The Zone IV contract is fulfilled by a Sikorsky-61N (S-61N) helicopter. The S-61N helicopter is used in Zone IV because the long travel distances between the LSS and some radar sites do not have refueling opportunities. While more expensive than the Bell-212, the larger capacity of the S-61N reduces the number of flights required between sites to position material and provides additional comfort for the crews during the long trips.

For fixed-wing support, each zone has a contract fulfilled by a Twin Otter. Rather than a dedicated support role, the fixed-wing aircraft is called to provide service given a few days notice. Zones I, II, IV and V have fixed-wing support available within their communities. Zone III must depend on an aircraft being brought forward from another community.

Airlift Pricing. The differing roles of the two types of aircraft dictate different pricing within their contracts.

The fixed-wing support, used only on an as needed basis, affords the contracting agency the opportunity to use that aircraft for other business. This arrangement produces contract pricing at a flat cost per operating hour.

Unlike the fixed-wing contracts, each helicopter is contracted as a dedicated resource for the NWS only. (Permission must be obtained even to release these assets in support of non-radar related emergency situations.) The opportunity to derive other income from the helicopter does not exist for the contracting agency. When NWS began its operations, the helicopter contracts were adjusted for this factor by establishing a monthly basing cost just for dedicating the helicopter to NWS. In addition to this charge, an hourly rate was applied to each hour of operation used on the helicopter. Following the first year of operation, the helicopter contracting was changed and now resembles the fixed-wing contracts in which a flat cost per operating hour is imposed. To cover the cost for the dedication of the resource, the hourly rate is higher than that associated with the monthly basing charge rate and the contracting agencies require compensation for a minimum number of operating hours regardless of whether or not the actual operations fall short of that number. Exceeding the minimum set by the contracting agency, though, does not reduce the cost of the additional operating hours. This minimum hour requirement creates a bias against the use of the fixed-wing aircraft until one is sure the helicopter minimum will be met.

The maximum number of hours used on each aircraft, while not limited by the contracting agency, is limited by the budget. The maximum hours allowed in each zone is determined by NWS.

Severe Environmental Conditions. The location of the radar sites and LSSs in or near the Arctic play a very important role in the ability of the contractors to accomplish their tasks. Weather conditions and the availability of daylight hours in the Arctic drive the schedule of operations.

Seasons. The Arctic year has two basic seasons, summer and winter. Summer occurs from May through September and winter occurs from October through April.

Temperatures. Temperatures range from a high of about 50 degrees Fahrenheit in the summer to lows of minus 50 degrees Fahrenheit in the winter, not including wind chill.

Daylight Hours. Daylight hours range from 24 hours of daylight in the height of summer to 24 hours of darkness at the depth of winter.

Precipitation. Snowfall and atmospheric conditions pose severe operational limitations with a potential of over ten feet of snow, coupled with the consistent occurrence of fog and other precipitation.

These harsh environmental conditions limit the activity of both personnel and equipment. As would be expected, snow limits the use of fixed-wing aircraft on unmanned airfields. The helicopters, however, are able to land on top of well-packed snow cover. For safety reasons, an additional pilot is required for flights during the winter months. This increase in the helicopter crew, as well as the need for bulky personnel survival equipment in the winter months, considerably limits the space and weight allowance for cargo available on the smaller Bell-212 helicopter. This space limitation affects the ability to simultaneously move personnel and supplies. The decreased daylight hours, as well as the extremely low temperatures, limit the outdoor activity of the maintenance personnel during winter months. In addition, winter flights are severely limited because the helicopters are required to fly VFR (visual flight references) to meet USAF safety requirements.

Oligopolistic Nature. These operations take place in and near the Arctic, a uniquely demanding environment. Every piece of modern equipment, structure, or supply which exists in the Arctic was brought in either by airlift or by sealift, and must be removed by the same means. To a much greater degree than found in less remote and more populated areas, operations in the Arctic are extremely dependent on support transportation. However, the low population density and severe conditions create a limited total demand that dictates an oligopolistic transportation environment. This oligopolistic structure severely affects the availability of competitive contracts and the prices at which services can be acquired.

Research Goal

The purpose of this research is to develop a model of the NWS remote radar operations airlift activities that can be used to determine if it is cost effective to reconfigure the existing system of five LSSs to lower the costs of the airlift contracts. This model provides the ability to conduct 'what-if' analysis on possible changes of the system requirements and their effect on airlift costs. The model presented also provides the flexibility needed to create new scenarios of operation. Once developed, the model was utilized to address specific research questions regarding the current structure of the system and a series of proposed alternative structures and modes of operation.

Overview

The remainder of this thesis is organized in the following manner. Chapter II gives an overview of literature pertinent to the use of mixed integer linear programs in the modeling and solution of transportation and facility location problems. Chapter III presents the mixed integer linear programming model formulations of the NWS airlift activities. Chapter IV discusses the analysis completed to interpret the data on current operations provided by NWS and the results of the mixed integer linear programming modeling effort. Chapter V presents a summary of research results, the limitations of this study and recommendations for future data collection. Information available in the appendices includes the following: a map of the NWS operation; a key to the variable indices used in the formulation; variable lists, formulations and solution output for the mixed integer linear programs used to consider the research questions; and an investigation into different pricing options for the helicopter support.

II. Literature Review

Introduction

This section summarizes the literature pertinent to this research. This review introduces mathematical programming and covers the modeling techniques of the linear and mixed integer linear programs and the methodologies that may be used to solve and analyze the facility location problem. This section also mentions the various solution techniques, both exact and approximate, that are presented in the literature. The use of the CPLEX Linear Optimizer Software is also discussed.

Mathematical Programming

Mathematical programming, while often utilizing computers, is not simply computer modeling in the strict sense. Programming in this context developed from the British usage, indicating planning. More specifically, mathematical programming deals with the optimization of an objective, subject to a set of constraints. Mathematical programming has been applied to military airlift problems since the birth of modern operations research in World War II. Following World War II, mathematical programming grew in use for the solution of economic and military planning activities [Dantzig, 1963].

Linear Programming

Linear programming (LP) is a subclass of mathematical programming whose objective function and constraints are expressed as continuous linear functions. The constructs of a linear program include decision variables, an objective function, constraints, and sign restrictions.

In general, a linear program may be expressed as follows:

(A) $$\text{(Maximize or Minimize)}\ Z = \sum_{j=1 \text{ to } n} c_j x_j$$

subject to

(1) $$\sum_{j=1 \text{ to } n} a_{ij} x_j \ (\leq, =, \geq)\ b_i, \qquad i = 1, \ldots, m,$$

(2) $$x_j \geq 0, \qquad j = 1, \ldots, n.$$

1) Each constraint of the model may have only one direction to the inequality/equality ($\leq$, $=$, $\geq$), but the direction can vary from one constraint to another in the same model.
2) The decision variables x_j are nonnegative.
3) The values of the parameters c_j, b_i and a_{ij} are assumed constant for a given model.

The model attempts to find values of the decision variables, x_j, that optimize the objective function, while not violating any of the model constraints.

For example, suppose x_j are the hours flown by aircraft j and c_j are the cost per hour for aircraft j. We might wish to minimize the total cost of flights. An obvious solution would appear to be 'do not fly,' i.e. $x_j = 0$ for all j. However, we might have some requirements that b_i tons of cargo be moved per hour to meet our transport requirements. If a_{ij} is the tons of cargo i aircraft j can move per hour, we would need to assign values to x_j that assure $\Sigma\ a_{ij}x_j \geq b_i$.

Linear programming is a flexible modeling technique which has been applied to a wide variety of operational settings. It does require, however, that the operational problem can be reasonably modeled given the assumptions of linear programming.

The linear aspect of the linear program relates to its assumptions of proportionality and additivity. Proportionality dictates that the contribution of any decision variable to the objective function is directly proportional to the value of that decision variable. The additivity of the linear program indicates that the value of a decision variable has no effect on the contribution of another decision variable to the objective function. Additional properties of the linear program are that the values of the decision variables can take on any fractional quantities, and that the coefficients acting upon the decision variables in the objective function and in the constraints are known with certainty.

Mixed Integer Linear Programming

The introduction of binary decision variables and general integer decision variables while maintaining continuous decision variables (those that are not binary or integer) transforms the linear program into a mixed integer linear program. A binary decision variable is one which takes on only values of zero or one. If a value of one indicates that you are in a certain state, a value of zero indicates that you are not in that state. A general integer decision variable indicates that infinite divisibility of that item is not feasible.

Solving the mixed integer linear program is more difficult than solving the linear program. There is no guarantee that there exists a solution which meets all of the binary and integer requirements. The method of solution begins with relaxing the mixed integer linear program into a linear program by dropping the integrality condition. If the solution to the relaxed problem results in assigning appropriate values to all of the integer and binary decision variables, the relaxed solution is also the solution to the mixed integer linear program. If the integer and binary requirements are not met by the relaxed solution, a branch and bound technique may be employed. This technique involves choosing an integer decision variable which is not yet integer, and forcing it to assume either the next largest or next smallest integer value. The problem is then re-solved. The branch and bound process proceeds until either establishing the best integer solution has been found or all of the possibilities have been implicitly or explicitly exhausted and no solution can be found [Land and Doig, 1960].

The mixed integer linear programming model has been used as the basis for solving a wide variety of classes of problems. The fixed charge problem and the plant location problem are two of these classes of problems which have application to this research project.

Fixed Charge Problem

The fixed charge problem is a mixed integer linear program that forms the foundation for the application of facility location. Its formulation presents a way to model the distribution of products from a set of facilities identified as warehouses to a set of destinations referred to as customers. This type of problem is similar to locating a LSS site given a number of potential locations. The fixed charge is assessed when a warehouse is utilized in the distribution of products. The fixed charge problem is presented as follows [Taha, 1975: pg. 285]:

Given,

x_j = a quantity of goods available at location j,

$y_j = 1$ if location j is open and 0 if location j is closed,

k_j = the cost of operating location j,

c_j = the cost of placing goods at location j,

b_i = customer i demand for goods,

the problem is to:

(B) $$\text{Minimize } \sum_{j=1 \text{ to } n} (k_j y_j + c_j x_j)$$

subject to

(3) $$\sum_{j=1 \text{ to } n} a_{ij} x_j \geq b_i, \qquad i = 1, \ldots, m,$$

(4) $$x_j \geq 0, \qquad j = 1, \ldots, n,$$

(5) $$y_j = 0 \text{ if } x_j = 0, \qquad j = 1, \ldots, n,$$

$$y_j = 1 \text{ if } x_j > 0, \qquad j = 1, \ldots, n.$$

Several authors have suggested solution techniques to the fixed charge problem. Cooper and Drebes (1967) and Denzler (1969) offer heuristic techniques, while Steinberg (1970) presents a branch and bound algorithm for the fixed charge problem.

Plant Location Problem

Taha (1975) adapts the fixed charge formulation (B) to the plant location problem in the following way [Taha, 1975: pg. 298]:

Given,

x_{ij} is a quantity of goods available at source i to be shipped to destination j,

y_i is 1 if source i is open and 0 if source i is closed,

c_{ij} is the cost of transporting one unit of product from source $i = 1, \ldots, m$ to destination $j = 1, \ldots, n$,

k_i is the fixed charge incurred if source $i = 1, \ldots, m$ provides a positive quantity of product to any destination $j = 1, \ldots, m$,

a_i is the supply limitation at source $i = 1, \ldots, m$,

b_j is the demand requirement at destination $j = 1, \ldots, n$,

(C) $$\text{Minimize } \sum_{i=1 \text{ to m}} \sum_{j=1 \text{ to n}} c_{ij}x_{ij} + \sum_{i=1 \text{ to m}} k_i y_i,$$

subject to

(6) $$\sum_{j=1 \text{ to n}} x_{ij} = a_i, \qquad i=1, \ldots, m,$$

(7) $$\sum_{i=1 \text{ to m}} x_{ij} = b_j, \qquad j=1, \ldots, n,$$

(8) $$x_{ij} \geq 0, \qquad \forall\ i \text{ and } j,$$

(9) $$y_i = 1 \text{ if } \sum_{j=1 \text{ to n}} x_{ij} > 0, \text{ and } y_i = 0 \text{ otherwise}, \qquad \forall\ i \text{ and } j.$$

The use of a mixed-integer program to solve a facility location problem was first introduced by Baumol and Wolfe (1958). Their formulation describes the situation in which there exists a two-tiered distribution system of a single product type. The origination of a product occurs at plants whose locations are known. These products are then shipped through a number of warehouses to the customers. The objective is to determine where the warehouses should be located to minimize the total cost of the system.

Baumol and Wolfe recognized this facility location problem as a modification to the standard transportation problem. The differences occur when the objective function of the facility location problem is non-linear, there are constraints on the capacity of the warehouses, and when the third subscript is needed to denote the routing of items through a warehouse [Baumol and Wolfe, 1958].

Baumol and Wolfe suggest that the objective function can generally be expected to be a concave function. While this does not necessarily make the problem simpler to solve, this attribute of the objective function combined with the convex constraint set indicates that the solution to the problem will exist at an extreme point of the convex constraint set [Baumol and Wolfe, 1958: pp. 262-263]. If a feasible basic solution is obtained, the solver can proceed to the next extreme point in a direction which reduces the objective function. Improvements to the solution are made until the objective function cannot be reduced any further. The only problem with this technique, as indicated by Baumol and Wolfe (1958), is that one is only guaranteed to reach a local minimum. It is necessary to enumerate all feasible extreme points to ensure the approach has reached the global minimum.

Since Baumol and Wolfe introduced their mixed-integer representation of the facility location problem, several others have contributed to the study of this problem. The works available in the literature cover various types of problems. Some consider locating only one facility while others place many. Some simplify facility location on a continuous space to a decision from among a discrete number of potential sites. There is also the possibility that the facilities to be located are limited in the amount of product they are able to supply to their customers. Each different slant on the problem alters the mixed-integer program to some degree, but more importantly, changes the recommended way in which the solution can be reached.

Spielberg (1969) simplifies his facility location problem even further by formulating a 'simple' facility location problem in which any one of the potential warehouses can supply all of the demand in the system if needed. Spielberg admits that this is an unrealistic requirement that greatly simplifies the model, but he uses this simplification to exhibit the use of side constraints in the problem. These side constraints can take the form of requiring that the system have a maximum number of open warehouses, or insisting that if a particular warehouse is open, another specific warehouse must be closed [Spielberg, 1969]. Each of the works reviewed here deals with the capacitated facility location problem in which several facilities are selected from a discrete list of potential sites.

Kuehn and Hamburger (1963) provide a heuristic in which warehouse locations are added one at a time based upon the overall minimum cost to the system. The authors found success with their heuristic when the number of warehouses to be located was less than half the number of potential sites. They suggest that when this is not the case, a procedure be used where the facilities are removed from use by the system one at a time [Kuehn and Hamburger, 1963].

Several other authors have contributed to solution techniques through heuristics and algorithms. A branch and bound heuristic is provided by Khumawala (1974). Algorithms are suggested by Efroymson and Ray (1966), Sa (1969), Spielberg (1969), Davis and Ray (1969), Ellwein and Gray (1971), Geoffrion and Graves (1974), and Kaufman, Eede and Hansen (1977). Davis and Ray (1969) present a decomposition algorithm. Ellwein and Gray (1971) suggest an enumerative search algorithm. Efroymson and Ray (1966), Sa (1969), Akinc and Khumawala (1977) and Kaufman, Eede and Hansen (1977) present branch and bound algorithms.

As indicated above, each of the problem formulations given by these authors differs slightly from the next. Baumol and Wolfe (1958) presented a triple subscripted formulation, (D), which would reduce to a double subscripted formulation only under the circumstance of a linear objective function. Kuehn and Hamburger (1963) employ a four subscripted system, using the fourth subscript to identify the type of product traveling along the route specified.

Most formulations, like (C) as presented by Taha (1975), uses only a double subscripted system. These systems are only concerned with the activities between the warehouses and the customers.

BRAC Study

The Department of Defense 1995 base realignment and closure committee (BRAC) was given the enormous task of modeling the current installation structure of the military services to determine a proposal for the closure of installations and the realignment of activities. This committee employed the use of a mixed integer linear program for this complex allocation problem [BRAC 95]. The model served to identify, through the use of cross-service alternatives, the trade-offs between different factors (military value, excess capacity, and functional assignments). The BRAC 95 model dealt with a multiple level hierarchy involving sites, activities and functions. This model also dealt with generating suitable alternatives in terms of sites and activities retained.

CPLEX Linear Optimizing Software

A review of the linear optimizing software performed by Sharda in 1995 identified several quality software packages. The CPLEX Optimizing Software possesses several qualities that are useful in solving the problem identified in this research.

CPLEX has the ability to accept a linear program in several different formulation languages. Similarly, it enables the user to output the linear programming code in any of the forms that CPLEX recognizes. The software is capable of handling an unlimited number of constraints and variables, regardless of whether they are continuous or not. CPLEX can be used on several different workstations which gives the linear program added flexibility in terms of hardware. The CPLEX solver is also able to take advantage of the structure of a linear program to presolve and eliminate unnecessary constraints and to exploit underlying features such as networks and special ordered sets.

Overview

This chapter has introduced several topics which are drawn upon in the research. The use of mathematical programming is reviewed, highlighting its use in determining facility locations within a transportation network. The modeling and solution techniques have their basis in the literature as reviewed here. Chapter III establishes the mixed integer linear program that is used to answer the research questions posed in Chapter I.

III. Model Formulation

Introduction

The previous chapter suggests the use of a mixed integer linear program (MILP) for modeling facility location problems. This chapter develops a modeling formulation, based on MILP, to address the NWS airlift operations. A review of the physical aspects of the current NWS remote radar system is presented to characterize the appropriate variables and constraints of the MILP model.

Zone Designations. There are currently five distinct geographic zones of operation. The radar sites in each zone are maintained by the LSS designated for that zone. The operations of each zone are independent of all other zones. When the sites were unmanned in 1993, these zones were established based on expert judgment and existing operations.

Transportation Options. Two modes of transportation are currently available in each zone: one rotary-wing option and one fixed-wing option. Each zone has a primary rotary-wing aircraft designated for full-time use and a secondary fixed-wing Twin Otter on call.

Radar Sites. Each LSS has the responsibility to maintain a certain number of the unmanned LRR and SRR sites. The number and the type of the radar sites currently managed in each zone are listed in Table 3.1. Recall that the LSSs at Inuvik, Iqaluit and Goose Bay are community based while the LSSs at Cambridge Bay and Hall Beach are live-in facilities collocated with a LRR.

Airlift Routings. Within the NWS, there are specific airlift routings that are used to accomplish the maintenance activities at the radar sites. The basic activities, outlined in Chapter I, included preventative maintenance inspections (PMIs), corrective maintenance, emergency maintenance and third party support (TPS). The corrective maintenance, emergency maintenance and TPS trips are generally carried out by a single out and back trip from the LSS to the radar site destination. The PMI trips, on the other hand, are composed of several trips, possibly over many days. A PMI can either take place for an individual radar site or for a combined group of sites. A radar site group consists of an LRR surrounded closely by a few SRR sites. The PMI routings for these sites take advantage of staging the maintenance personnel, equipment and materials at the LRR facility. Although the itinerary of these trips does not always follow the same exact route, there is a predictable pattern to the airlift necessary to accomplish the PMI for these groups of sites. If a radar site is not part of a grouping, it is maintained through a PMI trip of its own. While the PMI trip involves travel directly from the LSS to the radar site and back, it usually requires more than one trip to accomplish all required activities. The actual number of trips required in FY96 is contained in the actual data provided by NWS.

Table 3.1 Current Configuration of NWS Operations

Zone	LSS Name	# LRR	# SRR
I	Inuvik	2	9
II	Cambridge Bay	2	9
III	Hall Beach	2	8
IV	Iqaluit	3	6
V	Goose Bay	2	4

Model Description

The MILP model is constructed to represent the airlift activities of the NWS remote radar system. The airlift activities depicted are the flights between the 50 locations of the NWS (47 radar sites and 3 LSSs not collocated with an LRR) by either a helicopter or fixed-wing aircraft, in support of the maintenance activities required for the remote radar sites. The model objective is to minimize the total cost of operating the system while meeting all of the maintenance requirements of the NWS remote radar system. The total cost of the system involves both the fixed charge of having an LSS in operation plus the variable cost of the airlift operations.

It is necessary to construct two models in order to properly address the airlift operations. These models are named and described according to the following:

1) Base Model -- models current aircraft operations within the established zone structure,

2) Expanded Model -- models current aircraft operations with the option of changing the zone structure.

The Base Model was initially developed to validate that the MILP is appropriately representing the actual operations of the system as indicated by the data available from NWS.

Once the MILP model has been validated against actual operations, the Base Model may then be altered to provide insight into how the cost of the actual system may change with respect to changes in the system requirements.

The Expanded Model builds upon the Base Model by allowing the boundaries of the zones to change. The choice of which LSS supports which radar sites is made in the Expanded Model based upon the lowest total cost of operating the system while satisfying all constraints. The Expanded Model also accommodates investigation of the effects of utilizing less than five LSSs. This model provides insight into a possible reconfiguration of the operating zones and the impact of that reconfiguration on total cost of the system.

Model Assumptions

In the formulation of both the Base and Expanded Models, the following assumptions are made:

1) The airlift activity duration times are known and constant. Though it is understood that the time required to fly between two locations is dependent on factors such as weather, cargo load and wind conditions, this model uses a fixed estimate of flight times. To account for the variations in the possible flight times, the model is solved with different estimates of flight times. These estimates indicate the high, medium and low possible flight times as based upon the actual data provided by the NWS.

2) The cost per hour associated with each transportation activity is known and constant. The costs used for these models are taken directly from the NWS contracts for airlift operations.

Each contract is executed at a constant hourly rate for a full year before being renegotiated. An estimated value for the fixed cost for each LSS was provided by NWS.

3) All variables are nonnegative.

Model Notation

The five indices (i, j, k, m, n) used in the model are designed to indicate the following information. (Refer to Appendix B for the detailed assignments of the indices.)

1) *i*, LSS site/zone of operation. Index designation: A through E. There is an LSS in each zone, numbered I through V. The LSS sites in Zones II and III are collocated with an LRR. The index *i* refers to the LSS site, as well as the zone in which it is located. This is because the zone is defined as the LSS and the radar sites the LSS supports.

2) *j*, radar site. Index designation: 01 through 45. These 45 radar sites include all 36 SRR sites and the nine LRR sites which are not collocated with an LSS. The two LRR sites collocated with the LSS sites are accounted for in the index *i* above.

3) *k*, any of the 50 sites. This index is needed for use with variables which apply to either an LSS site or a radar site. Therefore, the index designation for *k* is A through E and 01 through 45.

4) *m*, transportation mode. Index designation: 1, 2 or 3. The three modes of transportation are the Bell-212 helicopter, index $m = 1$, the Sikorsky-61N helicopter, index $m = 2$, and the Twin Otter airplane, index $m = 3$.

5) n, numerical counter. Index designation: 01, 02, ... This index is needed to distinguish, within each zone, a combined PMI trip to a group of radar sites. For example, the PMI routing which includes visits to SRR Komokuk Beach/Bar-1, index $j = 01$, SRR Stokes Point/Bar-B, index $j = 02$, and LRR Shingle Point/Bar-2, index $j = 03$, is given the designation within zone I as $n = 01$. These routes are distinguished by the zone, index i, with which it is associated in its variable name.

Due to the severe conditions encountered during the winter, the intensity of transportation activities changes depending on the time of year. Summer maintenance trips involve a more extensive list of repairs and can last for several days. Maintenance visits in the winter involve fewer repairs and are shortened to single day trips to accommodate safety factors in the cold weather and limited daylight hours. The difference between trips taken in the summer and winter are designated in the variable names as 'W' for winter (October through April) and 'S' for summer (May through September).

The variables must also be able to designate the type of maintenance trip being conducted. The transportation activities of NWS are based upon two types of maintenance strategies, staging and direct support, designated by 's' and 'd,' respectively.

Staging. Staging, designated as 's' in the variables indicating trips, involves the pre-placement of maintenance supplies at a location, usually an LRR, for use during future maintenance visits. The staging of these maintenance supplies occurs either by helicopter directly to the staging location from the LSS, or by Twin Otter from the LSS to the nearest suitable airstrip and then by helicopter from the airstrip to the LRR, as necessary. The scheduled maintenance activities then use the LRR staging location as a base for maintenance visits to the SRR locations in the vicinity.

Direct Support. Direct support, designated as 'd' in the variables indicating trips, involves a single scope activity in which one location is singled out for maintenance. The required maintenance supplies and personnel are transported directly from the LSS to the radar site. For this type of support, a helicopter may require more than one trip to the site from the LSS due to cargo space limitations. The number of trips is determined based upon the specific items needed for the maintenance being accomplished.

Variable Definition

There are several entities involved in the NWS system that must be accounted for in the model. For clarity of presentation, the associated indices are presented in the variable definitions enclosed by parentheses and in the order in which they are used. The parentheses are not valid for the syntax of mathematical programming languages, and therefore, drop out of the variable names when formulated in the software code. The entities used in this solution of the NWS problem and their associated variables in the model are presented next.

The model objective of minimizing the total cost of system transportation is measured by the number of hours used on each aircraft. These hours are captured by the following continuous variable:

Hours(m, i) = hours flown by aircraft type m in zone i.

In order to determine the number of hours required, the number of one-way trips, or legs, between any two sites must be known. These trips are counted using the following continuous variable:

Lg(m, k, j) = number of one-way trips in either direction between site k and site j by aircraft type m.

Counting the number of legs required is measured by breaking down the different types of preventative maintenance inspection (PMI) trips into the travel legs that make up the trip. A PMI trip can be made either as a direct support mission or as a staged mission. The direct support mission involves travel between the LSS and the single radar site being maintained. The staged mission involves a coordinated string of trips in which the crew camps at an LRR and accomplishes the maintenance at the nearby SRRs. These staged missions may be supported by use of either the fixed-wing or rotary-wing aircraft to place required maintenance equipment at the LRR prior to the planned maintenance activity. Delivery of these materials to the SRR is by helicopter. These trips are modeled by the general integer variables listed below, where m, i, j, and n are as described above. Figure 3.2 provides a reference for the variables. The specific routings associated with these variables can be found in the variable lists located in Appendix C for the Base Model and Appendix F for the Expanded Model.

Dr(m, i, j) = one (i.e. direct) trip out and back between the LSS in zone i and site j, by aircraft type m.

Sd(m, i, j) = direct support summer PMI trip in zone i to radar site j by aircraft type m, where m = 1 or 2, and staging is accomplished by helicopter.

Ss(m, i, n) = staged summer PMI trip number n in zone i by aircraft type m, where m = 1 or 2, and staging is accomplished by helicopter.

TOSd(m, i, j) = direct support summer PMI trip in zone i to radar site j by aircraft type m, where m = 1 or 2, and staging is accomplished by Twin Otter.

TOSs(m, i, n) = staged summer PMI trip number n in zone i by aircraft type m, where m = 1 or 2, and staging is accomplished by Twin Otter.

Wd(m, i, j) = direct support winter PMI trip in zone i to radar site j by aircraft type m, where m = 1 or 2, and staging is accomplished by helicopter.

Ws(m, i, n) = staged winter PMI trip number n in zone i by aircraft type m, where m = 1 or 2, and staging is accomplished by helicopter.

TOWd(m, i, j) = direct support winter PMI trip in zone i to radar site j by aircraft type m, where m = 1 or 2, and staging is accomplished by Twin Otter.

TOWs(m, i, n) = staged winter PMI trip number n in zone i by aircraft type m, where m = 1 or 2, and staging is accomplished by Twin Otter.

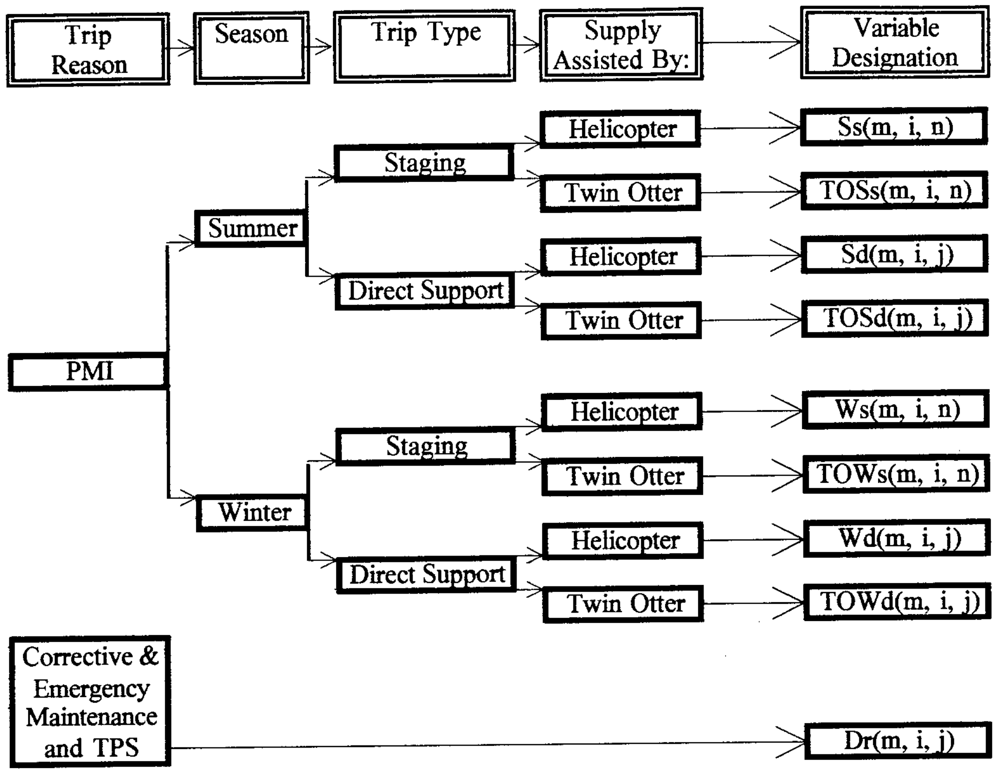


Figure 3.2 Variable Designations for Different Trips Available

The model must also have the ability to indicate whether or not the fixed-wing aircraft is being used in each zone. This event is identified with the following binary indicator variable:

ON(*3, i*) = 1, if the Twin Otter aircraft is used in zone *i*, and 0 otherwise.

Finally, there must exist a binary variable to indicate if an LSS is operating. The variable designation of this event is:

OPEN(*i*) = 1, if LSS *i* is operating, and 0 otherwise.

Parameters

There are several parameters of the system that remain constant throughout both the Base and Expanded Models. These parameters are identified and explained below.

The model objective of minimizing the transportation cost of the system requires the cost associated with each hour flown on each type of aircraft and the fixed cost of operating each LSS. The airlift costs are determined by contractual negotiation and vary by the aircraft type and by zone. The fixed cost of operating each LSS is provided by NWS based upon their annual estimates. These parameters are designated as:

C_{mi} = the cost per flying hour of aircraft type *m* in zone *i*,

F_i = the cost of operating LSS *i*.

The total number of times each radar site is visited is needed in each model in order to ensure that each site is visited at least that many times. This quantity is designated as:

T_j = the number of times radar site *j* must be visited.

The flight times between pairs of locations in the radar system are determined from the data provided or, where necessary, are calculated using distance and average ground speed of each aircraft. These constants are designated as:

H_{mkj} = the flight time in hours between sites *k* and *j* using aircraft *m*.

Within each zone, there is designated a minimum number of flying hours required to fulfill the helicopter contract requirements. A maximum number of flying hours are designated as determined by the budget. These requirements are designated as follows:

MIN_{mi} = minimum operating hours required in zone i on aircraft type m = 1 or 2,

MAX_{mi} = maximum operating hours allowed in zone i on aircraft type m = 1, 2 or 3.

Each site can be visited through the use of several different types of trips. For each radar site, these trips can be grouped as follows:

R_j = the set of all trips that visit radar site j.

Knowing the radar sites each trip visits, we can quantify the number of times a trip flies a leg between pairs of sites. Designate r as any trip, then the number of trips is designated as follows:

L_{mrkj} = the number of times a single trip type r flies the leg between sites k and j using aircraft m, where r is a trip of the variable type given in Figure 3.2.

Based upon the routings determined from the actual operation of the system, each zone has a finite set of legs that are to be flown to accomplish its maintenance trips. This set is designated as:

P_i = the set of flight legs that are used in zone i.

Base Model

The Base Model allocates transportation hours, subject to a set of constraints that capture the system's current operational environment, while minimizing overall transportation costs. The Base Model is constrained according to the current system structure of zone and aircraft choices. Each helicopter is subject to meeting the minimum number of operating hours as designated in each contract.

Objective Function. The Base Model's objective is to minimize the total cost of transportation in the system. This value is calculated by summing the cost of each type of flying hour times the number of hours of that type used, respectively. Given the variables and parameters defined above, the objective function is stated as follows:

$$\text{Minimize } Z = \Sigma_m \Sigma_i C_{mi} \bullet \text{Hours}(m, i) + \Sigma_i F_i \bullet \text{OPEN}(i).$$

Minimum Maintenance Requirement Constraint. NWS estimates that each radar site will require at least 11 maintenance visits per year. Four of these visits are required to be preventative maintenance inspections (PMIs), two of which are accomplished in the arctic summer and two are accomplished in the arctic winter. The seven other visits are identified as corrective maintenance, logistical or discretionary trips. Each site may be visited in one of up to nine ways, as shown in Figure 3.2. The sum over each possible trip type must be greater than or equal to the minimum requirement of trips to that site. The minimum maintenance requirement constraint is of the following form:

$$\Sigma_m \Sigma_i \{\text{Dr}(m, i, j) + \text{Sd}(m, i, j) + \text{TOSd}(m, i, j) + \text{Wd}(m, i, j) + \text{TOWd}(m, i, j)$$
$$+ \Sigma_{n \ni j \in n} [\text{Ss}(m, i, n) + \text{TOSs}(m, i, n) + \text{Ws}(m, i, n) + \text{TOWs}(m, i, n)]\} \geq \text{T}_j, \ \forall\, j.$$

PMI Requirement Constraints. According to the current requirements, each radar site must be visited for a PMI at least twice during both the summer and the winter. This requirement is represented by the following two constraints, one each for summer and winter:

$$\Sigma_m \Sigma_i \{\text{Sd}(m, i, j) + \text{TOSd}(m, i, j) + \Sigma_{n \ni j \in n} [\text{Ss}(m, i, n) + \text{TOSs}(m, i, n)]\} \geq 2, \ \forall\, j,$$

$$\Sigma_m \Sigma_i \{\text{Wd}(m, i, j) + \text{TOWd}(m, i, j) + \Sigma_{n \ni j \in n} [\text{Ws}(m, i, n) + \text{TOWs}(m, i, n)]\} \geq 2, \ \forall\, j.$$

Legs Flown Constraint. Each aircraft is used to fly the trips as designated by the constraints formed above. Consider that a round trip flown between two sites is simply the composition of flying the leg between the sites twice. If we extend this notion to longer trips, we can represent each trip by the legs of which it is composed. Given that *r* is a trip type variable as given in Figure 3.2, the total number of times that a leg is flown is calculated in the following constraint:

$$\text{Lg}(m, k, j) = \Sigma_{r \in Rj} \text{L}_{mrkj} \bullet r, \quad \forall\, m, k, \text{ and } j.$$

Hours Used Constraint. The hours used on each aircraft in each area, a continuous variable, is determined by the number of times each leg flown and the speed of the aircraft. The speed of each aircraft determines how long it takes each aircraft to complete each of the different legs needed for its trips. Given that p denotes a flight leg, the hours required in zone i using aircraft type m is calculated by the following constraint:

$$\text{Hours}(m,\ i) = \Sigma_{p \in \text{P}i}\, \Sigma_k\, \Sigma_j\, \text{H}_{mkj} \bullet \text{Lg}(m,\ k,\ j), \qquad \forall\, m \text{ and } i.$$

Minimum/Maximum Flying Hour Requirement Constraint. A minimum flying hour constraint exists for the helicopter in each zone as imposed by the contract, and maximum flying hour requirements exist for each type of aircraft as designated by the budget. The constraints to ensure that these requirements are being met are as follows:

$$\text{Hours}(m,\ i) \leq \text{MAX}_{mi}, \qquad \forall\, m \text{ and } i,$$

$$\text{Hours}(m,\ i) \geq \text{MIN}_{mi}, \qquad \forall\, m = 1 \text{ or } 2 \text{ and } \forall\, i.$$

Contractual Minimum Flying Hours Constraint. Due to the relatively low cost per hour and higher cargo capacity of the Twin Otter over the helicopter options, this constraint is needed to assure that the contracted helicopter flying hour minimums are met. This constraint is formulated as:

$$\text{Hours}(m,\ i) - \text{MIN}_{mi} \bullet \text{ON}(3,\ i) \geq 0, \qquad \forall\, i, \text{ and } m = 1 \text{ or } 2.$$

Open LSS Constraint. In the Base Model, all of the LSSs are in operation. This constraint is expressed as:

Σ_i OPEN(i) = 5.

Nonnegativity, Integer and Binary Constraints. These constraints ensure the variables take on the proper value type when solved.

Hours(m, i) ≥ 0, $\forall$ m and i,

Lg(m, k, j) ≥ 0, $\forall$ m, k and j,

Dr(m, i, j) ≥ 0 and integer, $\forall$ m, i and j,

Sd(m, i, j), Ss(m, i, n), Wd(m, i, j), Ws(m, i, n) ≥ 0 and integer, $\forall$ m, i, j and n,

TOSd(m, i, j), TOSs(m, i, n), TOWd(m, i, j), TOWs(m, i, n) ≥ 0 and integer,

$\forall$ m, i, j and n,

ON(3, i) $\in \{0, 1\}$, $\forall$ i,

OPEN(i) $\in \{0, 1\}$, $\forall$ i.

The Entire Base Model. Given the variables, parameters and constraints developed above, the Base Model may be presented. The variable and parameter definitions are repeated followed by the complete model.

Given,

Hours(m, i) = hours flown by aircraft type m in zone i,

Lg(m, k, j) = number of one-way trips in either direction between site k and site j by aircraft type m,

Dr(m, i, j) = one (i.e. direct) trip out and back between the LSS in zone i and site j, by aircraft type m,

Sd(m, i, j) = direct support summer PMI trip in zone i to radar site j by aircraft type m, where m = 1 or 2, and staging is accomplished by helicopter,

Ss(m, i, n) = staged summer PMI trip number n in zone i by aircraft type m, where m = 1 or 2, and staging is accomplished by helicopter,

TOSd(m, i, j) = direct support summer PMI trip in zone i to radar site j by aircraft type m, where m = 1 or 2, and staging is accomplished by Twin Otter,

TOSs(m, i, n) = staged summer PMI trip number n in zone i by aircraft type m, where m = 1 or 2, and staging is accomplished by Twin Otter,

Wd(m, i, j) = direct support winter PMI trip in zone i to radar site j by aircraft type m, where m = 1 or 2, and staging is accomplished by helicopter,

Ws(m, i, n) = staged winter PMI trip number n in zone i by aircraft type m, where m = 1 or 2, and staging is accomplished by helicopter,

TOWd(m, i, j) = direct support winter PMI trip in zone i to radar site j by aircraft type m, where m = 1 or 2, and staging is accomplished by Twin Otter,

TOWs(m, i, n) = staged winter PMI trip number n in zone i by aircraft type m, where

$m = 1$ or 2, and staging is accomplished by Twin Otter,

$ON(3, i) = 1$, if the Twin Otter aircraft is used in zone i, and 0 otherwise,

$OPEN(i) = 1$, if LSS i is operating, and 0 otherwise,

C_{mi} = the cost per flying hour of aircraft type m in zone i,

F_i = the cost of operating LSS i,

T_j = the number of times radar site j must be visited,

H_{mkj} = the flight time in hours between sites k and j on aircraft m,

MIN_{mi} = minimum operating hours required in zone i on aircraft type $m = 1$ or 2,

MAX_{mi} = maximum operating hours allowed in zone i on aircraft type $m = 1, 2$ or 3,

R_j = the set of all trips that visit radar site j,

L_{mrkj} = the number of times a single trip type r flies the leg between sites k and j using aircraft m, where r is a trip of variable type given in Figure 3.2,

P_i = the set of flight legs that are possible in zone i,

the problem is to,

$$\text{Minimize } Z = \Sigma_m \Sigma_i C_{mi} \bullet \text{Hours}(m, i) + \Sigma_i F_i \bullet \text{OPEN}(i).$$

subject to

$$\Sigma_m \Sigma_i \{\text{Dr}(m, i, j) + \text{Sd}(m, i, j) + \text{TOSd}(m, i, j) + \text{Wd}(m, i, j) + \text{TOWd}(m, i, j)$$
$$+ \Sigma_{n \ni j \in n} [\text{Ss}(m, i, n) + \text{TOSs}(m, i, n) + \text{Ws}(m, i, n) + \text{TOWs}(m, i, n)]\} \geq T_j, \ \forall j,$$

$$\Sigma_m \Sigma_i \{\text{Sd}(m, i, j) + \text{TOSd}(m, i, j) + \Sigma_{n \ni j \in n} [\text{Ss}(m, i, n) + \text{TOSs}(m, i, n)]\} \geq 2, \ \forall j,$$

$$\Sigma_m \Sigma_i \{\text{Wd}(m, i, j) + \text{TOWd}(m, i, j) + \Sigma_{n \ni j \in n} [\text{Ws}(m, i, n) + \text{TOWs}(m, i, n)]\} \geq 2, \ \forall j,$$

$Lg(m, k, j) = \Sigma_{r \in Rj} L_{mrkj} \bullet r, \quad \forall\, m, k,$ and j,

$Hours(m, i) = \Sigma_{p \in P_i} \Sigma_k \Sigma_j H_{mkj} \bullet Lg(m, k, j), \qquad \forall\, m$ and i,

$Hours(m, i) \leq MAX_{mi}, \qquad \forall\, m$ and i,

$Hours(m, i) \geq MIN_{mi}, \qquad \forall\, m = 1$ or 2 and $\forall\, i$,

$Hours(m, i) - MIN_{mi} \bullet ON(3, i) \geq 0, \qquad \forall\, i$, and $m = 1$ or 2,

$\Sigma_i\, OPEN(i) = 5$,

$Hours(m, i) \geq 0, \qquad \forall\, m$ and i,

$Lg(m, k, j) \geq 0, \qquad \forall\, m, k$ and j,

$Dr(m, i, j) \geq 0$ and integer, $\quad \forall\, m, i$ and j,

$Sd(m, i, j), Ss(m, i, n), Wd(m, i, j), Ws(m, i, n) \geq 0$ and integer, $\qquad \forall\, m, i, j$ and n,

$TOSd(m, i, j), TOSs(m, i, n), TOWd(m, i, j), TOWs(m, i, n) \geq 0$ and integer,

$\forall\, m, i, j$ and n,

$ON(3, i) \in \{0, 1\}, \qquad \forall\, i$

$OPEN(i) \in \{0, 1\}, \qquad \forall\, i.$

Size of the Base Model. Preprocessing based upon known information about the system allows for a reduction in the number of variables and constraints. For instance, it is known that radar site $j = 12$ is assigned to LSS $i = B$. Therefore, the constraints corresponding to $j = 12$ and $i = A, C, D$ or E can be eliminated from the formulation. The Base Model, as described above, to represent the current NWS system structure contains 206 constraints and 230 variables, of which 10 are binary, 122 are general integer and 98 are continuous.

Modeling the Current Pricing Scheme

Previous and current contracts provide the information used to determine the cost of operating the current system. The five current helicopter contracts, one for each zone, are billed according to the flying time of the helicopter and are priced by the hour.

Flying time. Flying time is considered to be the time between engine start-up and shut-down. The contract in each zone designates an annual minimum number of guaranteed flying hours. The contractor is compensated for *at least* the annual minimum number of hours, even if the actual flying time is less than that minimum. Essentially, the contracts have a 'fixed' cost for the minimum number of hours and each hour in excess of that minimum is an additional cost. The transportation for each zone is contracted independently; therefore, each zone operates under different rates and minimums.

Dedicated equipment. Each zone contracts for a fully dedicated helicopter and flight crew. This arrangement is required due to the remote nature of the operations and the need to be able to respond to any site within 72 hours. Because of the dedication of equipment, the contract supplier has insisted on a minimum number of flying hours in the contracts to ensure the helicopter agency is adequately compensated for providing full-time services. On the other hand, the Twin Otter aircraft is not dedicated. Since this aircraft type is used as a transportation supplement to assist in staging larger shipments of maintenance supplies and equipment, these contracts are priced simply at a cost per flying hour without any required minimums. Use of the Twin Otter, however, is indirectly affected by the helicopter minimums. NWS is reluctant to authorize the use of a Twin Otter until they are confident a zone will approach its annual minimum hour usage.

Expanded Model

The Expanded Model differs from the Base Model in that the zones are not predefined. The helicopters being used in each zone remain the same as those currently in operation, but the zones may be expanded or contracted subject to a five hour travel limitation. For example, SRR Harding River, subscript $j=12$, is within a five hour travel time of either Zone I, LSS Inuvik, or Zone II, LSS Cambridge Bay. The Expanded Model chooses the lower cost option of the two in determining which zone SRR Harding River should be assigned.

Variables and Parameters. The additional variable needed for this model is a binary indicator variable which identifies what radar sites have been assigned to each zone. These additional variables are defined as follows:

ASSIGN(i, j) = 1, if site j is assigned to zone i, and 0 otherwise.

Objective Function and Constraints. The objective function and constraints formulated for the Base Model are used in the Extended Model with the following changes and additions:

Minimum Maintenance Requirement Constraint. For the Expanded Model, this constraint is modified with the use of the binary indicator variables which identify which LSS supports each radar site. The two modified constraints below require that if the LSS in zone i is chosen to support radar site j, the total number of trips taken to that radar site from the LSS in zone i is at least T_j, but not more than 50. Alternatively, if the LSS in zone i is not chosen to support radar site j, then these two constraints require that no trips be made to that radar site from the LSS in zone i. The value of 50 as an upper bound was chosen large enough to avoid precluding any reasonable number of trips. It is expected that because this mixed integer linear program has a minimization objective function, the lower bound of T_j should never be exceeded. Together the constraints prevent any trips when the 'Assign' binary variable is zero.

$$\begin{aligned}\Sigma_m \Sigma_i \{&\mathrm{Dr}(m, i, j) + \mathrm{Sd}(m, i, j) + \mathrm{TOSd}(m, i, j) + \mathrm{Wd}(m, i, j) + \mathrm{TOWd}(m, i, j)\\ &+ \Sigma_{n \ni j \in n} [\mathrm{Ss}(m, i, n) + \mathrm{TOSs}(m, i, n) + \mathrm{Ws}(m, i, n) + \mathrm{TOWs}(m, i, n)]\}\\ &\geq T_j \bullet \mathrm{ASSIGN}(i, j), \qquad \forall j,\end{aligned}$$

$$\begin{aligned}\Sigma_m \Sigma_i \{&\mathrm{Dr}(m, i, j) + \mathrm{Sd}(m, i, j) + \mathrm{TOSd}(m, i, j) + \mathrm{Wd}(m, i, j) + \mathrm{TOWd}(m, i, j)\\ &+ \Sigma_{n \ni j \in n} [\mathrm{Ss}(m, i, n) + \mathrm{TOSs}(m, i, n) + \mathrm{Ws}(m, i, n) + \mathrm{TOWs}(m, i, n)]\}\\ &\leq 50\mathrm{ASSIGN}(i, j), \qquad \forall j.\end{aligned}$$

PMI Requirement Constraints. In a similar fashion to the Minimum Maintenance Requirement Constraint, the PMI Requirement Constraints are modified with the same binary indicator variables. The value of 50 as an upper bound is also used as above.

$$\Sigma_m \Sigma_i \{\mathrm{Sd}(m, i, j) + \mathrm{TOSd}(m, i, j) + \Sigma_{n \ni j \in n} [\mathrm{Ss}(m, i, n) + \mathrm{TOSs}(m, i, n)]\} \geq 2\mathrm{ASSIGN}(i, j), \quad \forall j,$$

$$\Sigma_m \Sigma_i \{\mathrm{Sd}(m, i, j) + \mathrm{TOSd}(m, i, j) + \Sigma_{n \ni j \in n} [\mathrm{Ss}(m, i, n) + \mathrm{TOSs}(m, i, n)]\} \leq 50\mathrm{ASSIGN}(i, j), \quad \forall j,$$

$$\Sigma_m \Sigma_i \{\mathrm{Wd}(m, i, j) + \mathrm{TOWd}(m, i, j) + \Sigma_{n \ni j \in n} [\mathrm{Ws}(m, i, n) + \mathrm{TOWs}(m, i, n)]\} \geq 2\mathrm{ASSIGN}(i, j), \quad \forall j,$$

$$\Sigma_m \Sigma_i \{\mathrm{Wd}(m, i, j) + \mathrm{TOWd}(m, i, j) + \Sigma_{n \ni j \in n} [\mathrm{Ws}(m, i, n) + \mathrm{TOWs}(m, i, n)]\} \leq 50\mathrm{ASSIGN}(i, j), \quad \forall j.$$

One Zone Assignment Constraint. Each radar site is required to be serviced by a single zone. While several radar sites are within the five hour travel radius of two LSS facilities, only one LSS can be assigned for service, i.e. servicing may not be split between two zones. The constraint that exactly one zone services each radar site is formulated as follows:

$$\Sigma_i \mathrm{ASSIGN}(i, j) = 1, \quad \forall j.$$

Minimum/Maximum Flying Hour Requirement Constraint. A minimum flying hour constraint exists for the helicopter in each zone as imposed by the contract, and maximum flying hour requirements exist for each type of aircraft as designated by the budget. For the Expanded Model, these constraints are needed if the corresponding LSS is operating. The constraints from the Base Model are modified in the following way to ensure that these requirements are met:

Start with the constraint as given in the Base Model:

$$\text{Hours}(m, i) \leq \text{MAX}_{mi}, \qquad \forall\, m \text{ and } i.$$

Since the requirement is only enforced if LSS i is open, or OPEN(i) = 1, the constraint must be altered to:

$$\text{Hours}(m, i) \leq \text{MAX}_{mi} \bullet \text{OPEN}(i), \qquad \forall\, m \text{ and } i,$$

which can be rewritten as:

$$\text{Hours}(m, i) - \text{MAX}_{mi} \bullet \text{OPEN}(i) \leq 0, \qquad \forall\, m \text{ and } i.$$

The same reasoning applies to meeting the minimum constraint. The two constraint types for the Expanded Model are:

$$\text{Hours}(m, i) - \text{MAX}_{mi} \bullet \text{OPEN}(i) \leq 0, \qquad \forall\, m \text{ and } i,$$

$$\text{Hours}(m, i) - \text{MIN}_{mi} \bullet \text{OPEN}(i) \geq 0, \qquad \forall\, m = 1 \text{ or } 2, \text{ and } \forall\, i.$$

Open LSS Constraint. A constraint is needed to control the number of LSS sites which are in operation. Similarly, a constraint must ensure that if an LSS is not in operation, no radar sites are serviced from that LSS. The constraints follow:

$$\Sigma_i \text{ OPEN}(i) \leq 5,$$

$$\Sigma_j \text{ ASSIGN(i, j)} \leq 47 \bullet \text{OPEN}(i), \qquad \forall\, i.$$

Nonnegativity, Integer and Binary Constraints. An additional binary variable constraint is required for the variable introduced for the Expanded Model. This constraint is:

$$\text{ASSIGN}(i, j) \in \{0, 1\}, \qquad \forall\, i \text{ and } j.$$

The Entire Expanded Model. Given variables, parameters and constraints developed above, the Expanded Model may be presented. The variable and parameter definitions are repeated followed by the complete model.

Given,

Hours(m, i) = hours flown by aircraft type m in zone i,

Lg(m, k, j) = number of one-way trips in either direction between site k and site j by aircraft type m,

Dr(m, i, j) = one (i.e. direct) trip out and back between the LSS in zone i and site j, by aircraft type m,

Sd(m, i, j) = direct support summer PMI trip in zone i to radar site j by aircraft type m, where $m = 1$ or 2, and staging is accomplished by helicopter,

$Ss(m, i, n)$ = staged summer PMI trip number n in zone i by aircraft type m, where $m = 1$ or 2, and staging is accomplished by helicopter,

$TOSd(m, i, j)$ = direct support summer PMI trip in zone i to radar site j by aircraft type m, where $m = 1$ or 2, and staging is accomplished by Twin Otter,

$TOSs(m, i, n)$ = staged summer PMI trip number n in zone i by aircraft type m, where $m = 1$ or 2, and staging is accomplished by Twin Otter,

$Wd(m, i, j)$ = direct support winter PMI trip in zone i to radar site j by aircraft type m, where $m = 1$ or 2, and staging is accomplished by helicopter,

$Ws(m, i, n)$ = staged winter PMI trip number n in zone i by aircraft type m, where $m = 1$ or 2, and staging is accomplished by helicopter,

$TOWd(m, i, j)$ = direct support winter PMI trip in zone i to radar site j by aircraft type m, where $m = 1$ or 2, and staging is accomplished by Twin Otter,

$TOWs(m, i, n)$ = staged winter PMI trip number n in zone i by aircraft type m, where $m = 1$ or 2, and staging is accomplished by Twin Otter,

$ON(3, i) = 1$, if the Twin Otter aircraft is used in zone i, and 0 otherwise,

$OPEN(i) = 1$, if LSS i is operating, and 0 otherwise,

$ASSIGN(i, j) = 1$, if site j is assigned to zone i, and 0 otherwise,

C_{mi} = the cost per flying hour of aircraft type m in zone i,

F_i = the cost of operating LSS i,

T_j = the number of times radar site j must be visited,

H_{mkj} = the flight time in hours between sites k and j on aircraft m,

MIN_{mi} = minimum operating hours required in zone i on aircraft type $m = 1$ or 2,

MAX_{mi} = maximum operating hours allowed in zone i on aircraft type $m = 1$, 2 or 3,

R_j = the set of all trips that visit radar site j,

L_{mrkj} = the number of times a single trip type r flies the leg between sites k and j using aircraft m, where r is a trip of variable type given in Figure 3.2,

P_i = the set of flight legs that are possible in zone i,

the problem is to,

$$\text{Minimize } Z = \Sigma_m \Sigma_i C_{mi} \bullet \text{Hours}(m, i) + \Sigma_i F_i \bullet \text{OPEN}(i),$$

subject to

$$\Sigma_m \Sigma_i \{\text{Dr}(m, i, j) + \text{Sd}(m, i, j) + \text{TOSd}(m, i, j) + \text{Wd}(m, i, j) + \text{TOWd}(m, i, j)$$
$$+ \Sigma_{n \ni j \in n} [\text{Ss}(m, i, n) + \text{TOSs}(m, i, n) + \text{Ws}(m, i, n) + \text{TOWs}(m, i, n)]\}$$
$$\geq T_j \bullet \text{ASSIGN}(i, j), \qquad \forall j,$$

$$\Sigma_m \Sigma_i \{\text{Dr}(m, i, j) + \text{Sd}(m, i, j) + \text{TOSd}(m, i, j) + \text{Wd}(m, i, j) + \text{TOWd}(m, i, j)$$
$$+ \Sigma_{n \ni j \in n} [\text{Ss}(m, i, n) + \text{TOSs}(m, i, n) + \text{Ws}(m, i, n) + \text{TOWs}(m, i, n)]\}$$
$$\leq 50\text{ASSIGN}(i, j), \qquad \forall j,$$

$$\Sigma_m \Sigma_i \{\text{Sd}(m, i, j) + \text{TOSd}(m, i, j) + \Sigma_{n \ni j \in n} [\text{Ss}(m, i, n) + \text{TOSs}(m, i, n)]\} \geq 2\text{ASSIGN}(i, j),$$
$$\forall j,$$

$$\Sigma_m \Sigma_i \{\text{Sd}(m, i, j) + \text{TOSd}(m, i, j) + \Sigma_{n \ni j \in n} [\text{Ss}(m, i, n) + \text{TOSs}(m, i, n)]\}$$

$\leq 50\text{ASSIGN}(i, j), \ \forall j,$

$\Sigma_m \Sigma_i \{\text{Wd}(m, i, j) + \text{TOWd}(m, i, j) + \Sigma_{n \ni j \in n} [\text{Ws}(m, i, n) + \text{TOWs}(m, i, n)]\}$

$\geq 2\text{ASSIGN}(i, j), \quad \forall j,$

$\Sigma_m \Sigma_i \{\text{Wd}(m, i, j) + \text{TOWd}(m, i, j) + \Sigma_{n \ni j \in n} [\text{Ws}(m, i, n) + \text{TOWs}(m, i, n)]\}$

$\leq 50\text{ASSIGN}(i, j), \quad \forall j,$

$\text{Lg}(m, k, j) = \Sigma_{r \in Rj} \text{L}_{mrkj} \bullet r, \quad \forall\, m, k,$ and j,

$\text{Hours}(m, i) = \Sigma_{p \in \text{P}i} \Sigma_k \Sigma_j \text{H}_{mkj} \bullet \text{Lg}(m, k, j), \qquad \forall\, m$ and i,

$\text{Hours}(m, i) - \text{MAX}_{mi} \bullet \text{OPEN}(i) \leq 0, \qquad \forall\, m$ and i,

$\text{Hours}(m, i) - \text{MIN}_{mi} \bullet \text{OPEN}(i) \geq 0, \qquad \forall\, m = 1$ or 2, and $\forall\, i$.

$\text{Hours}(m, i) - \text{MIN}_{mi} \bullet \text{ON}(3, i) \geq 0, \qquad \forall\, i$, and $m = 1$ or 2,

$\Sigma_i \text{ASSIGN}(i, j) = 1, \quad \forall j,$

$\Sigma_i \text{OPEN}(i) \leq 5,$

$\Sigma_j \text{ASSIGN}(\text{i}, \text{j}) \leq 47 \bullet \text{OPEN}(i), \qquad \forall\, i,$

$\text{Hours}(m, i) \geq 0, \qquad \forall\, m$ and i,

$\text{Lg}(m, k, j) \geq 0, \qquad \forall\, m, k$ and j,

$\text{Dr}(m, i, j) \geq 0$ and integer, $\quad \forall\, m, i$ and j,

$\text{Sd}(m, i, j), \text{Ss}(m, i, n), \text{Wd}(m, i, j), \text{Ws}(m, i, n) \geq 0$ and integer, $\qquad \forall\, m, i, j$ and n,

$\text{TOSd}(m, i, j), \text{TOSs}(m, i, n), \text{TOWd}(m, i, j), \text{TOWs}(m, i, n) \geq 0$ and integer,

$\forall\, m, i, j$ and n,

$ON(m, i) \in \{0, 1\}$, $\forall$ m and i,

$OPEN(i) \in \{0, 1\}$, $\forall$ i,

$ASSIGN(i, j) \in \{0, 1\}$, $\forall$ i and j.

Size of the Expanded Model. The Expanded Model as described above contains 610 constraints and 453 variables, of which 83 are binary, 221 are general integer and 149 are continuous. Preprocessing and elimination of unnecessary constraints and variables was accomplished for the Expanded Model as it was for the Base Model.

In some instances, fewer variables could have been used with the same effect in the model. For instance, the One Zone Assignment Constraint involves the sum of binary variables equaling one. For cases in which there are only two possibilities of assignment, one of the binary variables is unnecessary. The single remaining variable would then have taken on the meaning of the radar site being assigned to one zone if the variable equals one, and the other zone if the variable equals zero. Additional constraints would then be needed, though, to ensure that the variable takes on the proper value depending on whether or not an LSS is operating. While modeling the system this way would have reduced the number of binary variables, it would have made the model less straightforward. In addition, the inclusion of the detailed variables allows for greater flexibility in modeling additional requirements.

Several constraints could be eliminated from the model due to the nature of the minimization problem. The added constraints in the Minimum Maintenance Requirement Constraint and in the PMI Requirement Constraint which restrict the choice of those variables to be less than 50 are not necessary. Currently, the minimization objective function tries to keep those constraints as close as possible to their lower bounds. A very high upper bound should not affect the outcome of the model. These added constraints, though, were included in this model in the event that the model is changed and a goal is identified which involves a maximization objective. The inclusion of these constraints does not affect the current solution, and should eliminate extensive editing if changes in the problem require alteration of the model.

Solution of the MILP Models

Following the determination of the values of the parameters, these models were solved using the CPLEX Linear Optimization 3.0 software. The analysis of the data provided by NWS that determined the choice of the parameters for these models is addressed in the next chapter, along. The next chapter also presents and analyzes the solutions of the two models.

IV. Analysis and Results

Introduction

In Chapter II, the use of the mixed integer linear program (MILP) was established for transportation and facility location problems. Chapter III details the physical aspects of the North Warning System (NWS), and uses these aspects to form two MILP models. The MILP model formulations, however, rely on the model parameters developed from the actual operation of the current system. Analysis of the data available from NWS on the operation of the system during fiscal year 1996 (FY96) provides guidance for the proper choice of those parameters. Recall that the system has only operated ten months under its present contract. Once the Base Model has been created and validated against the FY96 operations, variations on both the Base and the Expanded Models can be analyzed to give insight into the current and potential future operations of the system.

The first half of this chapter examines the data provided on the airlift operations of the NWS for FY96. These results are translated into proper choices of the parameters used for the different variations of the models. The results of varying the Base and Expanded Models are addressed in the second half of this chapter.

Data Format

Since the NWS has only been operating in its current configuration since December 1994, there is limited data available on its operation. An additional consideration in evaluating the raw data is that the contract and pricing schedules are subject to change with each fiscal year. The context of the MILP model is also a full year of operation. Given these conditions, FY96 is the only full year of operation for which data is available. It should be noted that this single year of data, mitigated by the seasonality effect, provides a sample size of one. Caution, therefore, should be taken in evaluating and implementing the results of this study. This data, though, coupled with the NWS operations plan, adequately structures the model formulation and its parameters such that the model is useful in determining trends and relative magnitudes of cost and performance.

The data provided by NWS were in their raw format as received from the contracting agency. There were no data collection activities designed specifically for this research effort. The two reports released for use with this research were:

1) Daily Air Reports. This report is published for each day of airlift activity. Each report details the travel legs flown by each aircraft. The time required by each travel leg is given, as well as a brief description of the purpose of the travel. Additional administrative information concerning each flight is provided through this report as well.

2) Monthly Activity Summaries. This report details the total monthly airlift activity by zone. Since this research effort focuses on the operations of an entire year, the last report for FY96, September 1996, was the only monthly summary report needed for analysis.

As the data were compiled from both types of reports, it was observed that the numbers did not always exactly match. The totals from the Daily Air Reports fell short of the reported numbers from the annual summary in the Monthly Activity Summary from September 1996. A list of these differences is given in Appendix K. It was assumed that both the total annual figures reported in the September 1996 Monthly Activity Summary and the total PMI hours reported through the Daily Air Reports were precise enough for the purposes of this research. In instances when the data did not provide the information needed, a conservative estimate was made based upon either a calculated theoretical value or through interaction with knowledgeable NWS personnel.

Data Extraction and Analysis.

The information from the Daily Air Reports was extracted and compiled by zone (five zones) and by each contracted aircraft -- helicopter and fixed-wing. These ten subsets of information were then examined for two purposes: travel times and mission composition.

Travel Times. The travel times between sites are a necessary part of the solution method. Theoretical values for these times were determined based solely upon the distances and approximate ground speed of the aircraft. An examination of the flight data, though, provides a better representation of actual flight time performance. These actual flight time performances were used in the model when available. The flight data provided was grouped together by travel leg. As would be expected, some of the travel legs were flown more frequently than others.

Statistical Evaluation. The flight information for each of the travel legs was examined to determine the most likely time interval necessary to complete the travel between the two sites. The larger populations of data were evaluated using the software package BestFit, Version 1.0, to determine if there exists an underlying statistical distribution to the flight times. This examination, accomplished through the use of the Chi-Square, Kolmogorov-Smirnov and Anderson-Darling tests, ended inconclusively across the populations tested. The flight times between sites are clearly continuous, but the times reported and billed by the contractor are truncated at tenths of an hour. This aspect of the data is believed to have contributed to the inability to link the flight times to a specific distribution.

Difference in Means t-Test. The absence of any determined underlying statistical behavior of the flight times led to an investigation into a similarity between the theoretical travel times, determined by the distance divided by the approximate ground speed of the aircraft, and the mean travel times from the data. This test attempted to determine if the population mean travel times by leg significantly differed from the calculated theoretical flight times. This effort proved inconclusive at 95%, 97.5% and 99% confidence levels across all of the flight times tested. When the theoretical flight times differed significantly from the actual data population mean, the theoretical values were consistently larger than the population means. This observation established that the theoretical values provide an upper bound in cases in which there is an absence of reported data.

Triangular Distribution. Following the inconclusive results of the statistical evaluation and the t-test, the triangular distribution was chosen for further analysis of the flight times. Law and Kelton (1991) suggest the use of the triangular distribution in the event that a large number of distributions are needed and there is not sufficient time to collect the necessary data. This distribution was also chosen because of the assumption that actual flight times are bounded above and below. An initial examination of the data also revealed that the mean and mode of the flight times are not always the same, and the triangular distribution accounts for this key aspect. The triangular distribution was formed for each travel leg using as its parameters the minimum, maximum and mode values from the data, if data for the travel leg is available.

Three data points from each flight leg's triangular distribution are used in the variation of the mixed integer linear programs. These values are referred to as Low, Medium and High. The Low value is the 5% cumulative density function (CDF) value from each triangular distribution. The Medium value is the flight time which occurred most often in the reported data. The High value is the 95% CDF value from the triangular distribution for each flight leg. As noted above, data is not available for all of the travel legs used in the model. In the case of no data, the theoretical value calculated is substituted for all three data points, resulting in a point estimate. In the case of a single flight time reported, this value is used for all three data points. For cases in which there exist two or more data samples in which there is no clear mode, the minimum and maximum values were used and the mean of the population was substituted for the mode.

Mission Composition. The second examination of the Daily Air Reports consisted of categorizing the types and composition of the flights made during the year. The types of flights are as follows:

1) Preventative Maintenance Inspections (PMI). Four PMI trips to each radar site are

required annually.

2) Corrective Maintenance (CM). CM trips occur between the PMIs when a problem arises that must be attended to prior to the next scheduled PMI.

3) Logistics trip. A trip involving the movement of supplies or personnel.

4) Emergency. An emergency trip involves a problem which must be attended to immediately.

5) Third Party Support (TPS). TPS trips consist of any trip not directly related to the operation or maintenance of the radar sites. Examples of such trips include dignitary visits and work items involving the radar site structures not directly related to the operation of the radar.

Fulfillment of the PMI Requirement. In order to properly formulate the models, it was necessary to identify how the PMI trips to each site were organized and carried out. Adequate preparation time is available for these required trips, allowing the opportunity for these activities to be planned well in advance. The execution of these PMI trips was not always consistent, though. The number of travel legs and the total flight time required to accomplish both the summer and winter PMIs for each site was extracted from the data. The travel routes for each PMI are at the discretion of the maintenance team based upon the refueling and personnel requirements of the trip. The resulting inconsistencies had to be translated into a consistent travel pattern in order to incorporate them into the model. The total number of hours required to accomplish the actual PMI trips was matched with a consistent travel pattern devised for the model. This provides for the relative nature of the PMI trip to be quantified and compared within the model. This method was repeated for the PMIs to each site.

Number of visits per site. NWS expects that in the course of a year, a radar site is visited approximately 11 times. These 11 trips consist of four PMIs, four CMs, one logistics trip, and two discretionary trips. These numbers are used for planning purposes only, and do not necessarily reflect the actual operations. In order to capture the actual operations as they were executed in FY96, the number of each type of visit to each site was counted and can be found in Appendix K. These numbers are used in the variation of the Base Model intended to establish a baseline of operations for the system. This baseline is then varied to provide 'what-if' analysis, which is discussed in a later section of this chapter.

Determination of Model Parameters

For each of the several variations of both the Base Model and Expanded Model, model parameters must be chosen. Several of the parameters are dictated by the contractual agreements, such as the cost per flying hour of each aircraft. Other parameters, such as the travel times between pairs of sites and the number of times a site is visited, must be identified through the available data.

Travel times. The model parameter, H_{mkj}, represents the time required for travel between two sites, k and j, in the system as flown by transportation mode m. This parameter appears in the Hours Used Constraints to provide the total number of flying hours required by each aircraft in the system. Due to the single sample of data available, each model is run with three sets of travel time values. These three sets are referred to as High, Medium and Low. It is expected that the actual performance falls between the High and Low extremes. The Medium values are the mode value for each travel leg. These values are the most likely flight times of each travel leg and are the values used in the validation model. The Low values are the 5% CDF values of the triangular distributions calculated for each travel leg. Similarly, the High values are the 95% CDF values of the triangular distributions calculated for each travel leg.

Number of visits per site. While NWS plans for 11 visits per site annually, the actual execution of the FY96 contract did not exactly meet 11 visits for every site. The actual number of visits per site in FY96, as could best be determined from the data provided, is provided in Table K.1 of Appendix K. The number of visits per site varied from as few as seven visits to as many as 21. The variations of the Base and Expanded Model which attempt to match the execution of the FY96 operations use these values in the Minimum Maintenance Requirement Constraints. Variations which are based on the NWS plans are modeled with 11 visits for each site.

PMI Requirements. An aspect of the current operations which is under discussion is the need for four PMI visits annually. To study how a reduction in this requirement would affect the cost of operations, variations of the Base Model were solved with a reduced PMI requirement. A reduction is assumed to affect winter PMI, due to the severe weather conditions and the winter PMI's smaller scope. Based upon this assumption, two variations of the reduced PMI requirements are considered. The first reduced the annual requirement for PMIs to three, with two summer and one winter PMI. This variation changes the two PMI Requirement Constraints to ≥ 2 and ≥ 1 respectively for summer and winter, and the Minimum Maintenance Requirement Constraints to be decreased by one for each site (due to one less trip required each year). The second variation of a reduced PMI concept decreases the annual PMI requirement to only two summer visits. The PMI Requirement constraints then become ≥ 2 and ≥ 0 respectively for summer and winter, with the Minimum Maintenance Requirement Constraints decreased by two visits each from the current operations. Other variations can be considered as needed based upon the results of these two variations and future developments.

Estimated Cost of Operating Each LSS Facility. In addition to the costs associated with the airlift operations to maintain the radar sites, there is a cost associated with operating each LSS facility. The exact cost of this activity was not releasable due to its proprietary nature, but a general estimate was suggested for use solely with this research project. The results of this research, though dependent on these figures for the relative impact on cost, need to be reevaluated by the sponsor agency based upon their actual costs. The estimates used for the cost of operating each LSS depend on the type of facility being operated. Zones I, IV, and V are community based facilities in which the maintenance personnel maintain private residences within the community. Each of the community based LSS facilities has an estimated operating cost of $1 million per year. Zones II and III are live-in facilities in which living accommodations are provided for the maintenance crew. The estimated cost for each live-in LSS facility is $3.5 million per year. These figures give a total fixed cost of $10 million to operate all five LSS facilities. While this value is not a transportation cost, the fixed cost is a driver in considering potential closures of LSSs.

Cost per Operating Hour. The costs per operating hour as established by the FY96 contracts are given below in Table 4.1. Note that the helicopters have a much greater cost associated with their hourly use than the Twin Otters. In addition, the helicopters are dedicated resources requiring a minimum hour guarantee, while the Twin Otters are provided only on an as needed basis.

The S-61N helicopter, which is flown only in Zone IV, has a substantially greater hourly operating cost than the Bell-212 helicopter. The advantages of the S-61N helicopter are its larger capacity, approximately twice that of the Bell-212, and greater comfort for the passengers. The physical orientation of the sites in Zone IV warrant the use of the more expensive helicopter. The radar sites in Zone IV form a semi-circle, rather than a straight line as is the case in the other four zones. This semi-circular arrangement requires the crew in Zone IV to travel longer distances between possible refueling stops. The additional cargo space reduces the number of trips out and back between sites, and the more comfortable accommodations on the helicopter ease the affect that the long trips have on the crew.

The higher cost of the Twin Otter in Zone III is due to the fact that the aircraft must be flown in from an alternate community for use. Each of the other four LSS communities have commercial Twin Otters available for use, while the Zone III LSS community does not.

Table 4.1 Cost per Operating Hour by Zone and Aircraft

Zone	Bell-212	S-61N	Twin Otter
I	$2,660	-	$950
II	$2,740	-	$945
III	$2,740	-	$1,260
IV	-	$4,542	$945
V	$2,480	-	$950

Contractual Minimum and Maximum Flying Hours. This parameter is established by contractual negotiations each year. For the FY96 contract execution, these minimums and maximums were set as shown in Table 4.2 below.

The minimum helicopter hours are driven by the contracting agency requiring compensation for a minimum number of hours in return for the dedication of the helicopter. The minimum number of hours must be paid for regardless of the actual usage. Additional hours are paid for according to the costs shown in Table 4.1. The Twin Otter usage is not subject to a minimum threshold of required hours because it is not a dedicated support item.

The maximums given in Table 4.2 are driven by budgetary concerns and are subject to change based upon governmental decisions. The maximum figures given are those reported at the end of FY96.

Table 4.2 Contractual Minimum and Maximum Flying Hours Established for FY96

	Helicopter Minimum	Helicopter Maximum	Twin Otter Maximum
I	400	437	178
II	400	400	102
III	400	525	53
IV	475	570	193
V	417	526	122

Validation Model

In order to examine the effect of changes to the current system, a validation model must be created to represent the current state of operations. This validation model is the Base Model using the known set of data covering FY96, including the travel times and the number of visits per site. As has been previously discussed, this single set of data is limited but represents the entire population of data for operations under the current contract.

Two measures were used to determine the suitability of the proposed validation model as compared with the actual operations of FY96. These measures are the total hours and PMI missions hours used by each aircraft in each zone. These figures represent the foundation of the operation. Given that the model properly predicts the execution of these hours, there exists confidence that the model reasonably predicts the effect that variations in the operation have on actual performance.

The routings for the model were chosen to closely match the actual performance of operation from FY96 as represented in the data set provided. The information extracted from these data on the number of visits per site in FY96, as given in Appendix K, was used as the required visits for the validation model. The Medium values for travel legs were used because these are the most likely travel times. Note that the minimum hourly constraints were relaxed because they were not met during NWS FY96 operations. The results of the validation model as compared to the actual FY96 values are presented below in Table 4.3.

Table 4.3 Comparison of Validation Model Estimates and Actual FY96 Results

	Helicopter Performance				Twin Otter Performance			
	Total Hours		PMI Hours		Total Hours		PMI Hours	
Zone	Validation	FY96	Validation	FY96	Validation	FY96	Validation	FY96
I	395.66	390.80	189.20	183.30	152.00	156.80	60.80	53.10
II	385.40	368.60	199.20	178.70	73.57	64.60	20.60	26.80
III	489.68	493.60	238.96	229.60	52.00	49.40	36.40	43.20
IV	554.76	558.50	320.70	312.50	160.93	179.10	69.20	64.50
V	488.74	509.90	227.04	233.40	120.00	105.10	63.60	59.40
Totals:	2314.24	2321.40	1175.10	1137.50	558.50	555.00	250.60	247.00

As can be seen in Table 4.3 above, the results of the validation model are only representative of the actual operation during FY96. The MILP is not able to exactly duplicate the results given the choice of parameters, nor is it likely any other model would provide an exact one to one correspondence for each value. The difficulty in reproducing exact results lies in the linear nature of the modeling technique as well as the nature of the routings involved and the estimates of the travel times. In order to maintain a consistent pattern between the summer and winter PMI trips, the alteration of just a single travel leg in one summer PMI trip carries over to its winter PMI counterpart. For instance, if a routing changed by just a single travel leg, the total hourly outcome of the model would change by eight times the travel time of that leg (twice the time for an out and back trip for a single PMI times the four PMIs per year). In addition, the travel times for each leg were taken as the most likely values from the data, and therefore, it is expected that the solutions are close but not exact. The validation model was also created so that it would not perform better than the actual operations. For example, the usage of airlift hours is on the whole slightly larger in the validation model, which in turn produces a larger cost of the system. This aspect of the model allows a conservative estimate of cost saving. Overall, the model does appear to capture the reality of the NWS airlift operations for FY96.

Having established the validation model and accepting it as representative of actual operations as accomplished in FY96, it is possible to evaluate potential changes in the system and the effect those changes may have on total cost and total airlift hours of the system.

Effect of Travel Time Variation

The solution of the Base Model with the Medium travel times provides information about what we would most likely expect based upon the data available. Understanding how the variation of the travel times affects the system is equally important. Three sets of values for the travel times were chosen based upon the triangular distribution. These values were defined as Low, Medium and High, reflecting the 5% CDF, mode, and 95% CDF values as calculated from the actual data provided. The Medium set of values were used in the execution of the validation model. The Low and High sets of values were also run with the Base Model to investigate the effect of the potential change in travel times on the system. The 'Difference' column shows the change in estimated costs of the airlift produced by the Low and High values from the cost of airlift produced by the Medium value. Note that the estimated fixed cost for the five LSSs is not reported for the Base Model variations. This is because it costs $10 million for all variations since all of the LSSs are operated. The results of all three sets of travel times are displayed below. Table 4.4 provides the estimated costs. These costs account for the usage of the airlift, and do not include the payment for unused hours below the minimum contractual guarantee. Figure 4.5 represents the hours estimated to accomplish the annual requirements. The number of airlift hours can be found in Table K.2 of Appendix K.

Table 4.4 Estimated Annual Costs of Airlift Associated with Travel Time Variations of the Validation Model (basing costs are excluded)

	Cost	Difference
Low	$7,002,366	($724,528)
Medium	$7,726,894	-
High	$9,586,612	$1,859,718

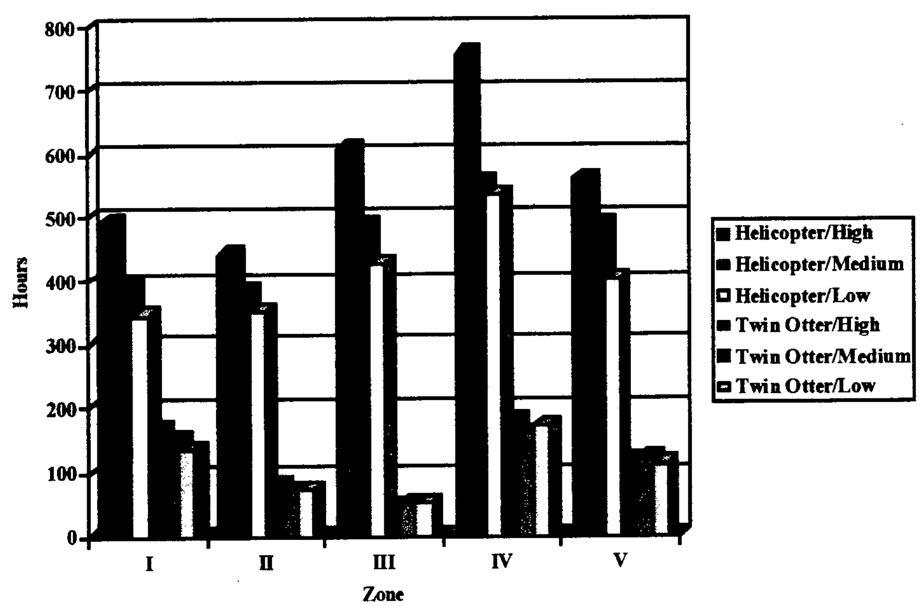


Figure 4.5 Estimated Annual Hours Associated with Travel Time Variations of the Validation Model

The results of these three variations of the Base Model establish a baseline of performance. The variations presented here were chosen based upon the High, Medium and Low values calculated for the travel times. These figures, then, represent what can reasonably be expected to be the range of possible airlift usage for the current operating system. Since it is unlikely that during the course of a year all of the travel times would be at their lowest (Low values) or highest (High values), these values provide a viable range for what might actually be experienced.

Effect of a Change in PMI Requirements

The variation of travel leg times presented above, provided insight into the possible costs and airlift hours flown necessary to accomplish the annual requirements. Suppose these requirements change. At present, the only trips strictly required are the preventative maintenance inspections (PMIs) which are currently set at four per site per year. The other visits to each site are attributed to corrective maintenance, emergency and logistics visits. Additionally, there are several third party support (TPS) and alternate work requests (AWRs) that are supported by NWS airlift. These demands on airlift are not necessarily known in advance of their occurrence, which makes them difficult to manage and control. The known PMI missions, though, are established procedures which are fully planned and executed according to a predetermined schedule.

The four required PMI trips occur as two summer and two winter visits annually to each site. The composition of the winter PMI trip is potentially quite different from the summer

PMI trip due to the severe winter weather conditions. These conditions generally translate into winter PMI trips that are generally less extensive than their summer counterpart. Based upon this information, it is assumed that a reduction in the number of PMI trips required annually would focus first on the winter schedule.

Two cases regarding a reduction in annual PMI trips were investigated: three annual PMI trips to each site and two annual PMI trips to each site. This reduction in the annual number of PMI trips to each site similarly reduces the total number of expected trips to each site. These two cases correspond to a reduction in the total number of visits to each site by one and two, respectively. Both of these cases were examined by modifying the Base Model of the FY96 operations. A comparison of these two cases and the Base Model, based upon the Medium set of values for travel legs are presented below. These variations were solved without the minimum contractual helicopter constraints to understand how an unrestricted system would operate. The comparison of estimated costs for each variation is presented in Table 4.6, and the estimated hours for each aircraft are shown in Figure 4.7, with the values provided in Table K.3 of Appendix K.

Table 4.6 Estimated Annual Costs Associated with the Reduction of the Annual PMI Requirement Based Upon the Medium Travel Leg Values

	Cost	Difference
4 PMIs	\$7,726,894	\$0
3 PMIs	\$6,821,980	(\$904,914)
2 PMIs	\$5,928,101	(\$1,798,793)

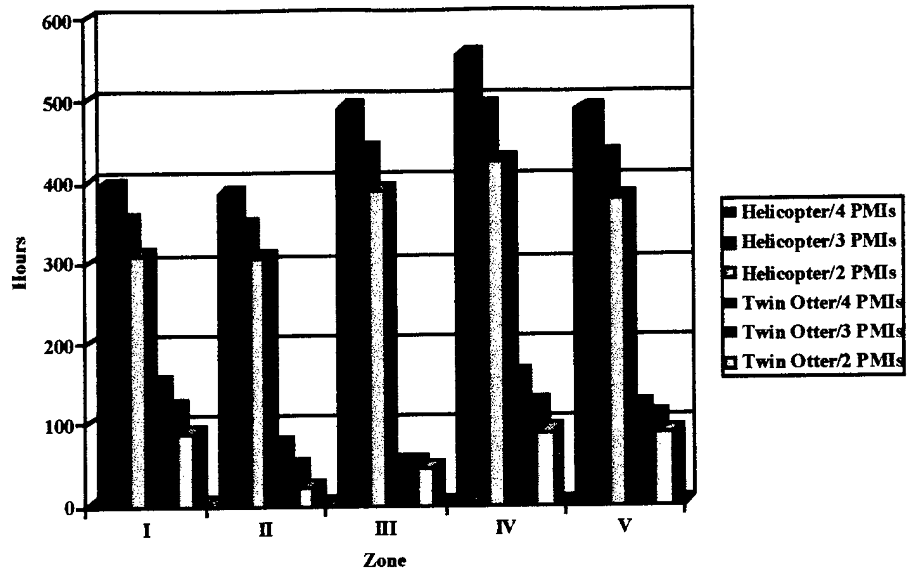


Figure 4.7 Estimated Annual Hours Associated with the Reduction of the Annual PMI Requirement Based Upon the Medium Travel Leg Values

As expected with a requirements decrease, the costs and hours needed to meet those requirements are also decreased. The information above shows that the impact of reducing the annual PMI requirement to three and two PMIs annually results in a decreased annual cost of approximately $900,000 and $1,800,000, respectively. This reduction in cost is similarly reflected in the required flight hours for both the helicopter and Twin Otter in each zone. Because the reduction of the PMI requirement is fulfilled by reducing the winter PMI trips, as well as the total trips to each site, the cost and hour decreases between four and three PMIs is approximately the same as the cost and hour decreases between three and two PMIs. In addition to the cost savings experienced through decreased airlift operations, a decrease in the manpower necessary to accomplish the reduced PMI requirements may also be experienced, although this question is beyond the scope of this study.

Investigating the Contractual Minimum Helicopter Hour Requirement

As can be seen in Figure 4.7, if not enforced, the required number of helicopter hours in each zone falls below the FY 96 contractual minimum hours given in Table 4.2. When this happens, the NWS must pay for the unused hours in compensating the contractor for the airlift. This situation raises the question of whether it is worth the management trouble to force the operations to forego the use of the Twin Otter until the helicopter minimums are sure to be met, or to allow operations to proceed as desired and compensate for the unused hours. An investigation into the trade-offs of these two option is appropriate.

The cost savings involved is relative to how far below the minimums the unrestricted operations fall. Both the fixed-wing Twin Otter and the S-61N helicopter are estimated to have twice the cargo capacity of the Bell-212. This translates into requiring the use of the Bell-212 for twice as long as the Twin Otter to deliver the same amount of cargo. These estimates contribute directly to the trade-off factor resulting in the opportunity cost of using the fixed-wing aircraft prior to ensuring that the helicopter minimums are met. For instance, suppose that the use of the S-61N in Zone IV falls short of its contractual minimum hourly usage by one hour. Then, the equivalent hour of fixed-wing use which replaced that unused helicopter hour results in an actual operating cost of $945 for the billed fixed-wing usage plus $4542 for the hour of helicopter shortage that must be paid to the contractor, totaling $5487. The same reasoning can be extended to the Bell-212 helicopter, remembering that one hour of the fixed-wing Twin Otter is equivalent to two hours of the Bell-212 because of the Twin Otter's greater capacity.

A variation of the Base Model is used to show the effect of the trade-offs for the two management options. The first option is to accept the unrestricted hourly usage of aircraft and simply compensate the contractor for the shortfall of hours. The second option would be to enforce the airlift activities to meet all contractual minimums and incur only the cost of the hourly usage. For each of the PMI requirement scenarios, a cost and hourly usage comparison is made between these two options. The cost comparisons are given in Table 4.8. The corresponding hourly usage comparisons are provided in Figures 4.9, 4.10 and 4.11, respectively for the four, three and two PMI requirements. The values of the hourly usage figures are given in Table K.4 of Appendix K.

Table 4.8 Cost Comparison of Guarantee Options
for the Different PMI Requirements

	Option One: Pay for Shortage	Option Two: Enforce Minimums	Difference (One - Two)
4 PMIs	$7,778,442	$7,760,032	$18,410
3 PMIs	$7,096,428	$6,991,433	$104,995
2 PMIs	$6,775,622	$6,632,579	$143,043

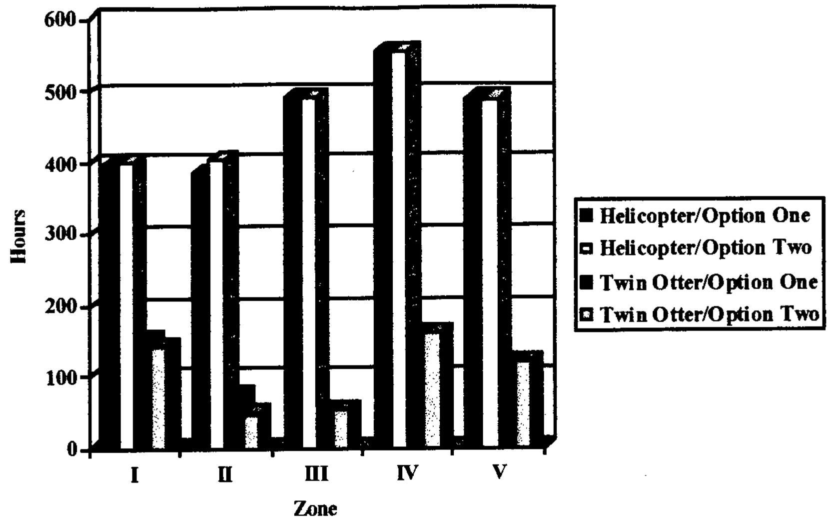


Figure 4.9 Hourly Usage Comparison of Guarantee Options for the Four PMI Requirement

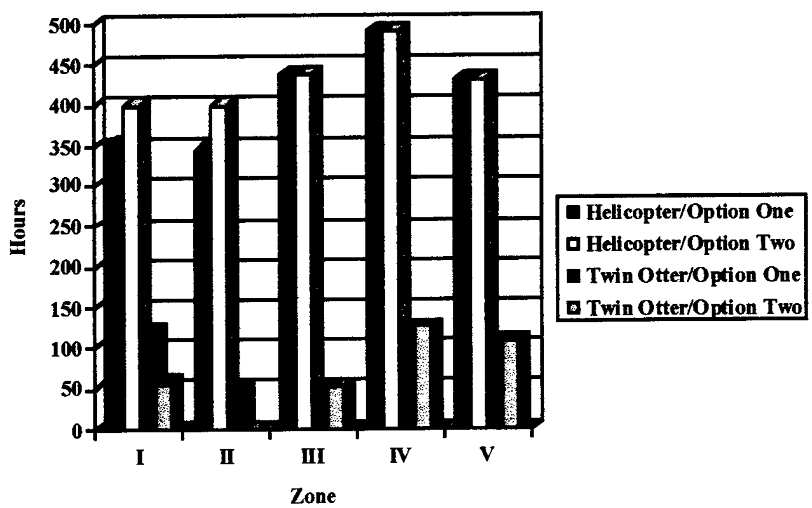


Figure 4.10 Hourly Usage Comparison of Guarantee Options for the Three PMI Requirement

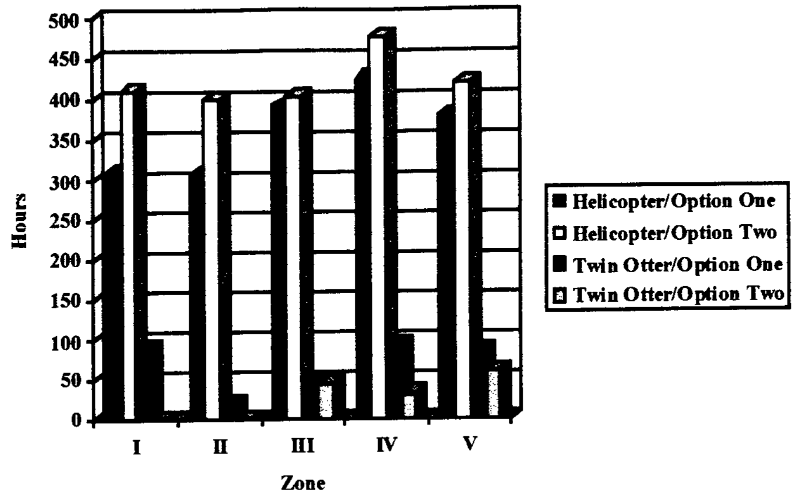


Figure 4.11 Hourly Usage Comparison of Guarantee Options
for the Two PMI Requirement

As can be seen by the cost comparisons in Table 4.8, forcing the minimum helicopter hours to be flown instead of trading them off to fixed-wing hours yields a cost savings. The costs for Option One were calculated as the costs for the unrestricted hourly usage models plus the cost of each unused hour under the minimum contractual guarantee.

From Figures 4.9, 4.10 and 4.11 above, we can see the trade-offs between the two options based upon the hourly usage in each zone. For the four and three PMI requirement scenarios, the level of hourly usage in Zones III, IV and V do not change. The unrestricted operations in those zones already met the contractual minimums. Attention, then, should be focused upon the operations in Zones I and II. The trade-off for the four PMI requirement scenario does not affect the overall cost of the system drastically, but it does change the allocation of hourly use from the fixed-wing Twin Otter to the helicopter in Zones I and II. The three and two PMI requirement scenarios, though, do experience a large difference in operating costs between the two options. The effect of meeting the minimums also noticeably impacts the hourly usage.

While forcing the minimum helicopter hours to be met before employing the use of the fixed-wing Twin Otter results in a lower cost than simply paying for an unmet guarantee, there may be some intrinsic value associated with the use of the Twin Otter that is not captured in the numbers. For instance, the cargo capacity of the Twin Otter enables the movement of large quantities of material much more quickly than the Bell-212. This argument, though, would not be valid for the S-61N since the S-61N and the Twin Otter have equivalent cargo capacity. The actual trade-off will ultimately be dictated by management decision as the situation arises. A reduction in required PMIs, assuming that it does not cause an increase in corrective maintenance and/or emergency maintenance, should create an airlift cost saving.

Expanded Model

The Base Model and its variations examined above provide insight into the operations within the current zone structure. The boundaries of the five zones were not altered for any analysis reported thus far. The initial zone boundaries were established based upon informed judgment and reliable community centers. An examination of potentially changing the zone structure is a logical area for analysis.

The Expanded Model is established based upon the routings determined in the validation model. A covering set was determined for each of the five current LSSs and includes all sites within approximately a five hour travel radius of the LSS. The potential assignments are depicted in Figure 4.12 by the dotted lines. The shaded areas represent the current zone assignment configuration.

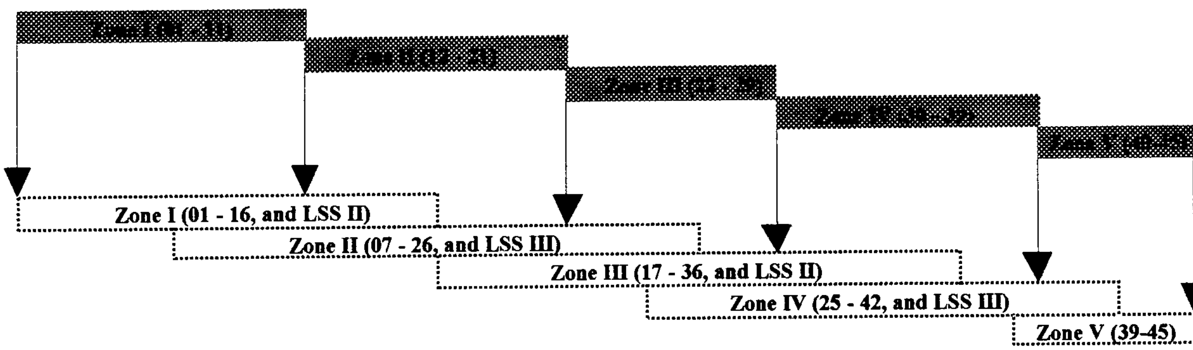


Figure 4.12 Possible Assignments of Radar Sites to Zones
(an approximate five hour travel radius)

It is important to note that there are a handful of radar sites which cannot be covered by more than one possible LSS. Specifically, these are sites 01 - 06 in Zone I, sites 37 and 38 in Zone IV, and sites 43 - 45 in Zone V. Given the current equipment, travel distance from the other LSSs prevents these sites from being covered by more than one LSS. The approximate five hour radius of coverage prevents these sites from being reassigned. Of course, should the five hour radius be either extended or reduced, these possible zone assignments would change and the model would have to be modified to account for the new covering sets. Given the five hour radius, it is known prior to solving the Expanded Model that Zones I, IV and V are not candidates for closure. Notice that even before cost has been explored, the two candidates for closure are the two live-in LSS sites which are also the two more expensive sites to operate. If either of these two LSSs are not chosen to operate, the collocated LRR is assigned to an operating LSS.

Before considering the possible closure of an LSS, the current structure should be investigated further. The Expanded Model was initially solved requiring all five LSSs to be in operation. The model, though, must determine the assignments of the sites to each LSS. Two variations of this situation were studied. The first variation did not require the operations at each LSS to meet the minimum contractual helicopter hours, while the second variation did. The costs associated with the Base Model and these two variations of the Expanded Model are provided in Table 4.13. The airlift hourly usage for each variation is given in Figure 4.14, with the numbers shown in Table K.8 in Appendix K. The unrestricted variation of the Expanded Model does not enforce the contractual minimum hourly usage or account for the payment of unused hours. The restricted variation of the Expanded Model requires the contractual minimum hourly usage be met, but does not enforce the maximum hourly usage set by the NWS budget. The zone assignments for each variation are provided in Figures 4.15 and 4.16. The zone assignments chosen by the models are shown outlined in solid lines, the possible assignments are given with the dotted lines, and the current assignments are provided in the shaded areas.

Table 4.13 Estimated Annual Costs Associated with the Base Model and the Unrestricted and Restricted Five Zone Variations of the Expanded Model

	Total Costs	Fixed Costs	Variable Costs	Difference
Base Model	$17,726,894	$10,000,000	$7,726,894	-
Expanded Model/Unrestricted	$17,291,501	$10,000,000	$7,291,501	($435,393)
Expanded Model/Restricted	$17,786,863	$10,000,000	$7,786,863	$59,969

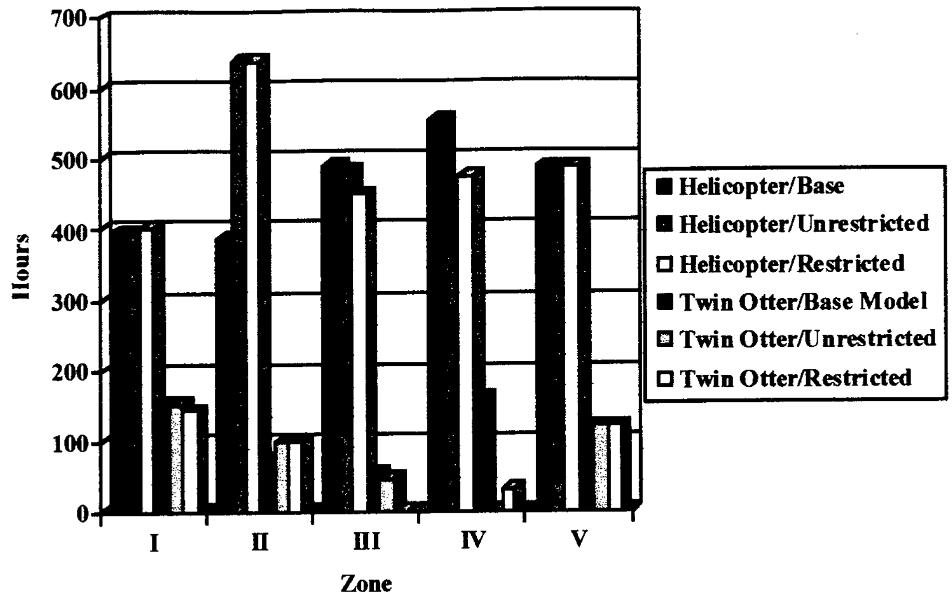


Figure 4.14 Estimated Annual Hourly Usage Associated with the Base Model and the Unrestricted and Restricted Five Zone Variations of the Expanded Model

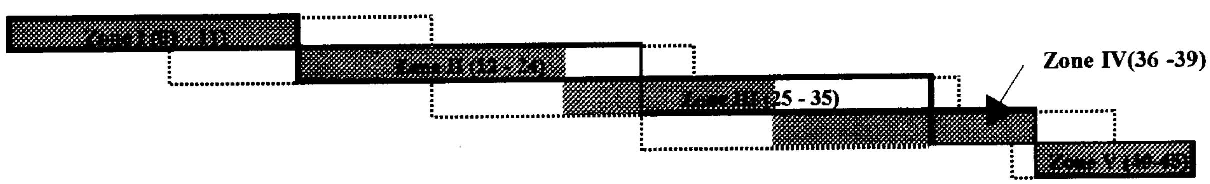


Figure 4.15 Zone Assignments for the Unrestricted Five Zone Variation of the Expanded Model

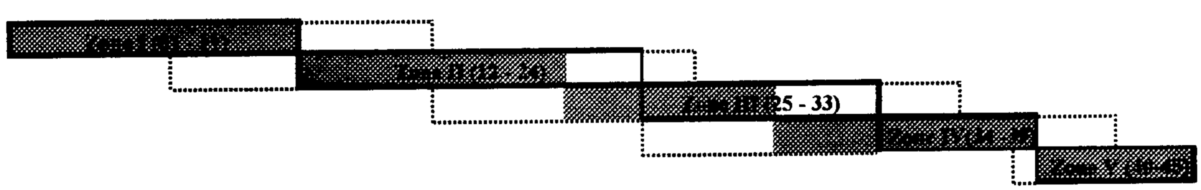


Figure 4.16 Zone Assignments for the Restricted Five Zone Variation of the Expanded Model

It can be seen in the solution information that the minimum contractual helicopter hour requirement has an impact on the radar site assignments, the estimated cost of the system and the hourly usage at each LSS. An unrestricted use of the airlift hours shows a large decrease in the hourly usage and assignment of radar sites to the Zone IV LSS. The contractual minimum brings an increase in activity to the Zone III LSS, and that responsibility is transferred primarily from the Zone IV LSS. Unrestricted use of the airlift hours results in a cost approximately \$435,393 less than the operation in the current zone structure as indicated by the Base Model. The restricted variation requiring each zone to meet its minimum contractual helicopter hour guarantee results in a cost increase of approximately \$59,969. Given this information, a reassignment of radar sites to the five LSSs is not likely to yield a significant cost savings unless the minimum hour guarantees can be reduced or eliminated.

Though the restricted Expanded Model variation does not indicate that a cost savings can be achieved with five LSSs, there may be a cost savings involved with reducing the number of LSSs in operation. An Expanded Model variation allowing the closure of an LSS was examined with the Medium travel leg times. An additional factor involved with this model is that the estimated fixed costs of operating an LSS are incorporated into the objective function. This gives the model the ability to determine the trade-offs between the fixed costs of keeping an LSS open with the variable costs of assigning all of its current radar sites to other LSSs. In the Base Model, the fixed costs were constant because it was known that all of the LSSs would continue to operate. An additional \$10 million needs to be incorporated into the costs of the Base Model variations above to adequately compare them to the results obtained through the Expanded

Model variations. An additional consideration when comparing these figures is the source of each type of expense. The trade-offs between the fixed and variable costs within the system may reduce the total costs, but could result in an overall increase in the variable costs of airlift which are offset by a decrease in the fixed costs.

The results of the Expanded Model are presented below. The estimated annual costs associated with the Expanded Model variation are given in Table 4.17, and the estimated annual hours associated with the Expanded Model variation are provided in Figure 4.18. The associated values for the hourly usage are given in Table K.5 in Appendix K.

Table 4.17 Estimated Annual Airlift and Operating Costs Associated with Travel Time Variations of the Expanded Model

	Total Cost	Fixed Costs	Airlift Costs	Difference
Low	$15,831,585	$6,500,000	$9,331,585	-
Medium	$16,452,680	$6,500,000	$9,952,680	$621,095
High	$17,151,359	$6,500,000	$10,651,359	$1,319,774

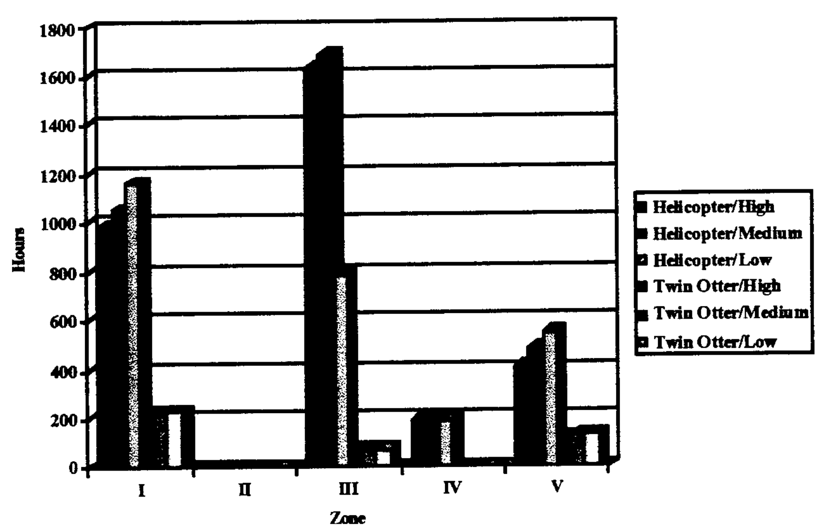


Figure 4.18 Estimated Annual Hours Associated with Travel Time Variations of the Expanded Model

The Expanded Model does not utilize the LSS at Zone II. The $3.5 million estimated cost of operating the LSS at Zone II exceeds the increase in airlift costs of servicing the Zone II sites from the Zone I and Zone III LSSs. The requirements of additional sites and airlift hours on the Zone I and Zone III LSSs must be evaluated in terms of their operational and managerial feasibility. As can be seen from Figure 4.18, the estimated number of helicopter hours required for the new Zone I operations is more than twice its original workload, and the new Zone III operations experience more than three times the original workload. With the Zone II LSS closed, the helicopter flight hours in Zone I increase to 1053 hours, while the flight hours in Zone III increase to 1685 hours. Given that the basing charges associated (fixed charge or contractual minimum) with placing a helicopter at an LSS will be met at this traffic volume, it may be possible to place additional helicopters at the Zone I and III LSSs to accommodate the additional flight requirements. Further analysis could determine if this configuration would precipitate an increase in the fixed charge associated with operating the Zone I and III LSSs given the increased span of control of sites. These costs could result from additional personnel and supplies. While Zones I and III have increased operations, Zone IV's operations decrease to almost half of their current level. This is not surprising given the high cost of helicopter operations in Zone IV, but this needs to be investigated further since this level does not meet the contractual helicopter minimum hour guarantee.

The Expanded Model has chosen to reduce the operations at the Zone II LSS to zero. The proposed assignments chosen by the model are provided in Figure 4.19 below. The dotted lines show what the possible zone assignments could be and the shaded areas depict the current radar site assignments, with the bold lines highlight the assignments chosen by the model.

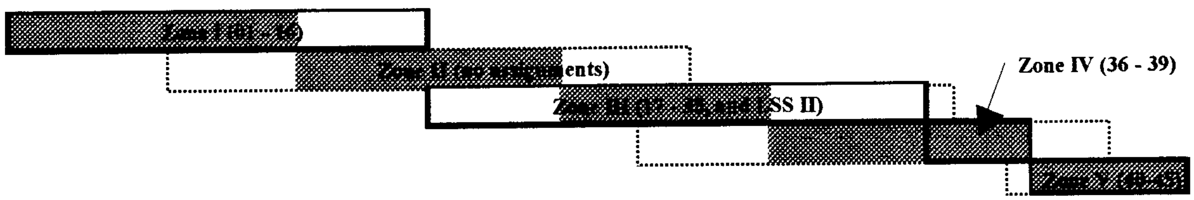


Figure 4.19 Radar Site Assignments for the
Expanded Model Variation Allowing Closure of an LSS

Because the Expanded Model chose to close the LSS in Zone II, the LRR collocated with the LSS in Zone II must be supported by another LSS. The current zone structure inherently covers the maintenance needs for the two LRRs collocated with LSSs because the maintenance personnel are available at those sites full-time. The Expanded Model, therefore, required that should either the Zone II or Zone III LSS be closed, the maintenance of its collocated LRR would be provided by another LSS. In this case, Zone III takes on the responsibility of supporting the Zone II collocated LRR.

The Expanded Model has chosen the particular radar site assignments indicated in Figure 4.19 based solely on the costs associated with the feasible alternative configurations. It is important to review these radar site assignments based upon the maximum ranges and estimated workloads for each LSS. The operating assignments and ranges given by the Expanded Model are provided in Table 4.20 below. Information on the current configuration is also provided.

Table 4.20 Operating Conditions: Current Vs. Proposed Configuration

	Current Configuration					Proposed Configuration					
	LSS Status	# Sites Assigned	Max Range (S. Miles) West	East	Span	LSS Status	# Sites Assigned	Max Range (S. Miles) West	East	Span	Increase in Range
I	Open	11	189	362	551	Open	16	189	642	831	280
II	Open	11*	295	233	528	Closed	0	0	0	0	(528)
III	Open	9*	305	161	466	Open	21*	570	538	1108	642
IV	Open	10	360	194	554	Open	4	170	194	364	(190)
V	Open	6	482	149	631	Open	6	482	149	631	0

* the collocated LRR is included in the assignment

These operating conditions show that the responsibilities assigned to Zone III in the proposed new configuration are significantly increased. Zone I also experiences an increase in its responsibilities, although not as dramatic as Zone III's increase. Zone I's increase in the range of its operations is approximately 50%, with a total span 831 statute miles. Zone III, on the other hand, experiences an increase of about 137% in its range of operations to a span of 1108 statute miles. This large increase to an already large zone could introduce additional concerns such as an increase in average and maximum response times.

Given the solution shown above, and the knowledge that there is only one other possible LSS that the model could eliminate from operation with the five hour travel radius restriction, it seems reasonable to investigate this alternate configuration. The Expanded Model was modified to keep the LSS in Zone II in operation and suspend operations from the LSS in Zone III. Because this configuration was not identified with the original solution of the model, we expect to see a larger cost for the system. This alternate model was also solved using the Medium travel time values. The new assignments with Zone III LSS operations prohibited is given in

Figure 4.21. The original span of possible assignments are again depicted by the dotted lines, and the current zone assignments shown in the shaded areas. The costs and the flying hours, as compared with the Zone II LSS suspended solution, are displayed in Table 4.22 and Figure 4.23, respectively. The values of hourly usage are also given in Table K.6 of Appendix K.

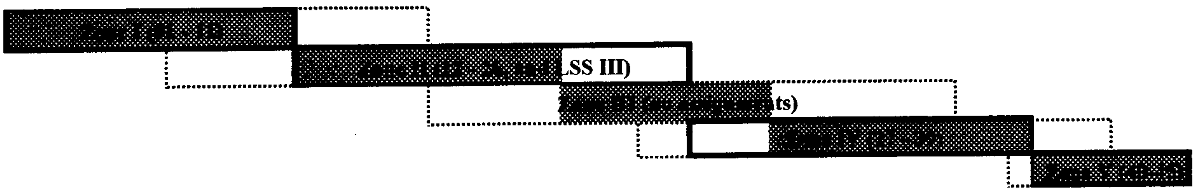


Figure 4.21 Radar Site Assignments for the Expanded Model with the Zone III LSS Suspended

Table 4.22 Estimated Annual Costs Associated with the Zone II LSS and Zone III LSS Suspended Expanded Model Solutions

	Total Costs	Fixed Costs	Airlift Costs	Difference
Zone II LSS Suspended	$16,452,680	$6,500,000	$9,952,680	-
Zone III LSS Suspended	$16,729,800	$6,500,000	$10,229,800	$277,120

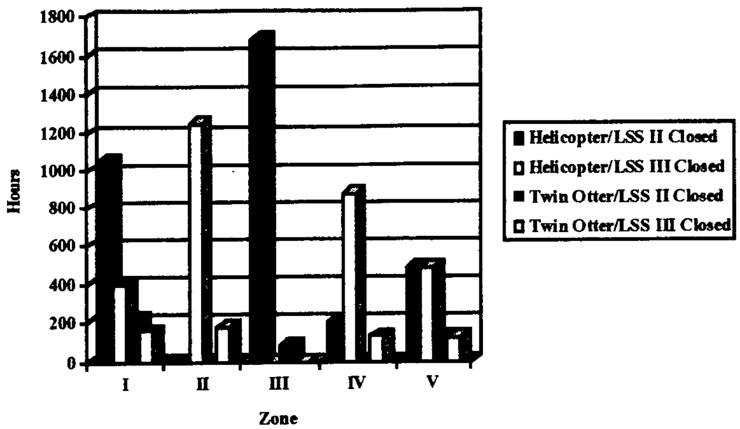


Figure 4.23 Estimated Annual Hours Associated with the Zone II LSS and Zone III LSS Suspended Expanded Model Solutions

Based upon the data available, the difference in cost between the two variations of the Expanded Model is only \$277,120, a 1.7% increase. This relatively small increase in cost, though, has associated with it fewer total number of hours flown across all zones. The operations with the Zone II LSS suspended involved a total of 3,427 helicopter and 424 Twin Otter hours, as opposed to the Zone III LSS suspended operations in which a total of 3,014 helicopter and 577 Twin Otter hours were estimated.

The zone spans should also be considered when comparing the two solutions. The companion information to that for the original solution found in Table 4.20 is located below in Table 4.24.

Table 4.24 Operating Conditions: Current vs. Zone III LSS Suspended Configuration

	Current Configuration					LSS III Suspended Configuration					
	LSS	# Sites	Max Range (S. Miles)			LSS	# Sites	Max Range (S. Miles)			Increase
	Status	Assigned	West	East	Span	Status	Assigned	West	East	Span	in Range
I	Open	11	189	362	551	Open	11	189	362	551	0
II	Open	11*	295	233	528	Open	17*	295	590	885	357
III	Open	9*	305	161	466	Closed	0	0	0	0	(466)
IV	Open	10	360	194	554	Open	13	492	194	686	132
V	Open	6	482	149	631	Open	6	482	149	631	0

* the collocated LRR is included in the assignment

Table 4.25 gives the Zone III LSS suspended and the Zone II LSS suspended operating conditions. Comparing the operating conditions of the Zone II LSS suspended solution with that for the Zone III LSS suspended solution shows that the maximum range is 223 statute miles lower in the Zone III LSS suspended configuration. The net increase in the size of any zone is a 642 statute mile increase for Zone III in the Zone II LSS suspended solution, as compared to the 357 statute mile increase for Zone II in the Zone III LSS suspended solution. The trade-offs in operating conditions, costs and hourly usage between the two configurations are important factors for consideration by the decision makers if deciding to alter the current five zone configuration.

Table 4.25 Operating Conditions: Zone II LSS Suspended vs. Zone III LSS Suspended Configuration

	LSS II Suspended Configuration					LSS III Suspended Configuration				
	LSS	# Sites	Max Range (S. Miles)			LSS	# Sites	Max Range (S. Miles)		
	Status	Assigned	West	East	Span	Status	Assigned	West	East	Span
I	Open	16	189	642	831	Open	11	189	362	551
II	Closed	0	0	0	0	Open	17*	295	590	885
III	Open	21*	570	538	1108	Closed	0	0	0	0
IV	Open	4	170	194	364	Open	13	492	194	686
V	Open	6	482	149	631	Open	6	482	149	631

Execution Results

The mixed integer linear programming models solved for this research effort were accomplished on a SUN SPARCstation 20 using the CPLEX Linear Optimizer 3.0. The Base Model variations investigating the current method of operations required a maximum pre-solve time of 0.08 seconds and maximum solution time of 216.55 seconds. The most iterations required were 48,325, and the maximum nodes visited was 20,000. The Expanded Model variations required a maximum pre-solve time of 0.22 seconds and maximum solution time of 3.50 seconds. The most iterations required were 714, and the maximum nodes visited was 37.

The longer execution times correlate to variation of the Base Model in which only two PMIs are required annually. The longer execution times result from the scenario being less restrictive on the solution space. These execution results are given in Table K.7 of Appendix K.

Conclusion

The scenarios chosen for investigation as previously discussed are only a few of the possible variations. These investigations were motivated through observations of current procedures as well as by discussion with NWS regarding possible scenarios and decisions that are likely to be of importance in the near future. This model can be used to investigate other options. The analysis presented here provides a baseline for studying the system. The analysis reported here does address the airlift operations for the research goal.

V. Conclusions and Recommendations

Introduction

This chapter summarizes the conclusions of this research, identifies the potential limitations of this analysis, and provides recommendations for future data collection by NWS.

Research Results

In order to successfully address the goals of this research project, two mixed integer linear programming (MILP) models were formulated. Several variations of these two models were solved in an effort to understand how the operations of the North Warning System (NWS) may react to changes in the maintenance requirements or in the configurations of the logistic support sites (LSSs).

Validation. The Base Model addressed the current operations. A model was formulated according to the operations of FY96. This model was solved for three variations on the travel leg times, High, Medium and Low. This group of solutions identified that the airlift cost for the system may vary from $7,002,366 up to $9,586,612, with the most likely cost being $7,726,894. This range indicates that total airlift cost is sensitive to the flight time estimates. The solutions to these variations established a baseline of activity from the FY96 operations.

Changing Maintenance Requirements. Using the Base Model, an investigation was made into the effect of reducing the number of required annual preventative maintenance inspections (PMIs) on the cost of the system and the performance of airlift activity was accomplished. The analyst established that based on the most likely travel leg times, an estimated $904,914 would be saved by reducing the PMI requirement from four to three annually. Similarly, a larger reduction from four to two annual PMIs has an estimated airlift cost savings of $1,798,793. These results, though, do not account for the possibility of additional corrective or emergency maintenance that may be needed as a result of fewer PMIs. These results simply identify a relative magnitude of the airlift cost savings associated with an overall reduction in requirements. The number of hours of airlift required is similarly reduced across all five zones. The actual accuracy of the input data will affect the specific hour and cost savings.

Effect of the Minimum Helicopter Hour Guarantee. The investigation of the reduced PMI requirement revealed that the minimum number of contractual helicopter hours was not always met in the solution of the reduced PMI model. This discovery prompted a look at the trade-off between operating without restriction and paying for the unused hours versus forcing the helicopter hours meet the minimum hour guarantee before using the fixed-wing Twin Otter. At first glance, the fixed-wing hourly costs appear to be more attractive because of their relative low cost as compared to the helicopters. The 'hidden' cost is associated with each hour of helicopter time under the contractual minimum that goes unused because a mission was carried out by the fixed-wing Twin Otter. Those replacement hours conducted by the fixed-wing Twin Otter, when the helicopter minimum is not satisfied, essentially take on the Twin Otter's own cost plus the equivalent helicopter cost.

These trade-off results were evident when the model was re-solved imposing the minimum contractual helicopter hour constraint. It was shown that for the current four annual PMI requirement, the difference between paying for unused hours and forcing the minimums is only $18,410. It would seem, in relation to the total cost of the system, that this may not be a material savings. Alternatively, for the three and two annual PMI requirement scenarios, enforcing the minimum helicopter hours be met saved $104,995 and $143,043, respectively, over the alternative of paying for the unused hours.

Exploring a Change in the Configuration. After gaining an understanding into how the current operations may be affected by changes in requirements and travel times, the Expanded Model was developed. This model follows the formulation of the Base Model but without the predefined zones of operation. The model was formulated so that it would not be required to choose all of the LSSs for operations if a lower total cost would result. The original solution of this model, maintaining a five hour travel radius, indicates that only four of the existing LSSs would be in operation. The cost of airlift using the most likely travel times was $9,952,680. Clearly, this airlift cost is greater than that identified above for the current five LSS configuration. The cost savings comes from reducing the operating costs of the LSS facilities. For the current configuration, the five LSSs cost an estimated $10,000,000 to operate. The three community based LSS facilities each cost an estimated $1,000,000 annually, and the two live-in LSS facilities each have a fixed cost estimated at $3,500,000. This variation of the Expanded Model chose not to operate the Zone II LSS, one of the live-in facilities, saving the $3,500,000 operating cost.

Based on the Expanded Model choice to close one of the LSSs in the optimal solution, closing the other possible LSS candidate for closure was investigated. The original variation closed the Zone II LSS. The alternate variation kept the Zone II LSS open and closed the Zone III LSS. The alternate solution revealed that this configuration would result in an increase in airlift costs of $277,120 over the LSS II suspended variation. Because both the Zone II and Zone III LSSs are live-in sites, the cost of operating the LSSs was not changed between the two solutions. While the operating conditions were similar, closing the Zone III LSS results in a smaller maximum range of flights in each zone. What may be more interesting than the cost and operating condition differences, though, is that the LSS II suspended variation requires over 300 more helicopter hours across the entire system. The increase in hours required results from the Zone I and Zone III LSSs not being geographically centered in the assigned areas.

Limitations of This Study

The results of this research effort are promising. There is definite evidence that cost savings can be achieved through altering NWS's current airlift system. As with any modeling effort, though, it is important to recognize the modeling assumptions and the limitations of the data on which the model results were based.

Relationship of Factors. This model was created to study only the airlift operations and how a change in current requirements may affect those airlift operations. In reality, interrelated activities seldom act independently. For example, a decrease in the PMI visits may precipitate the need for additional corrective and emergency maintenance. At the present time, information on such an effect is not available and was not considered.

Increased Responsibilities. The Expanded Model explored a change in the system configuration. The operating costs, as they were estimated for this research, are based upon the operation of five LSSs. It is expected that should there be a reduction in the number of LSSs, the remaining LSSs would likely incur additional costs associated with the increased responsibility. There is not currently any non-proprietary data available on this issue. Therefore, it was assumed that the operating costs of the LSSs would remain unchanged in the event of a reconfiguration.

Intrinsic Value. The oversight of any program generally involves numerous individuals. Any change being examined may affect several interested parties. While cost savings is a clear cut objective, there will always be the 'politically' or 'intrinsically' valued objectives which cannot be adequately represented in any model. The models presented here are no exception. The objective of this research was to reduce costs, while meeting established performance requirements.

Recommendations for Future Data Collection

In the course of this research, it became quite clear that the results of this modeling effort rely heavily on the available data. In most cases, the data come directly from an existing database that was not collected to be used for research. This section includes some recommendations concerning future data collection to better support similar research.

While the reporting of data in terms of the individual travel legs is quite useful, the mission composition is lost. An additional section could be added to these reports which details each full mission upon its completion. This summary would only need to identify the total flying hours required to accomplish the mission and sites included in the mission. This would aid in the ability to identify the exact number of times a site was visited for each type of mission. This information would also account for the hours used in weather aborts and third party support (TPS) flights.

The maintenance of a comprehensive electronic database would prove quite useful for future research efforts. Of the twelve months of data used in this research effort, only eight of those months were available in electronic format; the other four months were retrieved as hard copies from the files. While data availability is the overriding concern, it is important to consider not only the usefulness of the information being collected, but the accessibility of that information. Error is likely to be introduced to the information if large amounts of it must be hand-keyed for each research effort.

The availability of additional data would allow the update of the parameters of the models developed here to obtain refined analysis on the possible system performance. The additional information would provide increased confidence that the parameters chosen accurately reflect the system.

Recommendations for Future Research

During this research effort, questions surfaced that were not within the scope of this study. The nature of these issues provide information to possibly enhance the models presented here and improve the operations of the NWS. These issues involve the use and payment of airlift operations for Third Party Support (TPS) missions, the current helicopter contract pricing, the possibility of obtaining increased capability aircraft, and the effect of reduced PMIs on the corrective and emergency maintenance frequency. The recommendations for future study suggested below could be used to enhance the capabilities of the models developed in the study, but also suggest specific areas of investigation to improve aspects of the NWS operations.

Third Party Support Trips. The analysis of mission composition to obtain the annual number of visits per site for FY96 revealed a significant portion of the missions as TPS. These TPS missions accounted for approximately 40% of the helicopter hours and 50% of the Twin Otter hours. This high level of TPS activity is a concern for two reasons. First, since FY96 was the only year of data available for this study, the results provided here reflect this level of TPS activity in its predictions. Should the level of TPS activity change, the analysis presented here must be adapted to reflect those changes. Secondly, it should be identified if the NWS is the producing agency of these trips or if outside organizations are responsible. In the case that outside organizations are the source, it may be important to reflect the airlift charges associated with those TPS trips in an effort to acquire subsidy for the non-NWS related activities.

Helicopter Contract Pricing. Another area of possible cost savings for NWS may be found in the choice of helicopter contract pricing. An initial investigation of the current helicopter pricing versus an annual basing contract was accomplished. The annual basing costs were obtained from page 5-2 of the North Warning System Post 1995 Concept of Operations Study Final Report. The results of this analysis are given in Appendix L. The analysis identified that the two contract pricing options have approximately the same performance for hourly usage near the minimum contractual hour guarantee, with the exception of Zone IV. The comparison of the two contract pricing options in Zone IV reveal that the minimum contractual hour guarantee is not better than the annual basing contract for any level of usage. In fact, the closest difference between the two contracts occurs at 475 hours of usage in which the minimum contractual hour guarantee costs approximately $50,000 more than the annual basing contract. In addition, across all of the zones, once the hours exceed the minimums set forth, the minimum contractual hour guarantee pricing option becomes much more expensive than the annual basing contract. This difference is an important factor to consider should the operations in any one zone increase. Prior to that, though, the annual basing contract option should be investigated further as a source of cost savings for the current configuration of operations.

Aircraft Performance. Consideration of the aircraft available for use to the NWS should be made. Helicopters with increased payload and speed could greatly improve the performance of mission as well as reduce costs. While this model strictly deals with the helicopter equipment currently in use, the model is capable of addressing a change in aircraft capabilities through a change in the model parameters. Of course, a more capable helicopter is likely to have with it a larger cost, but this factor is appropriately addressed in the model.

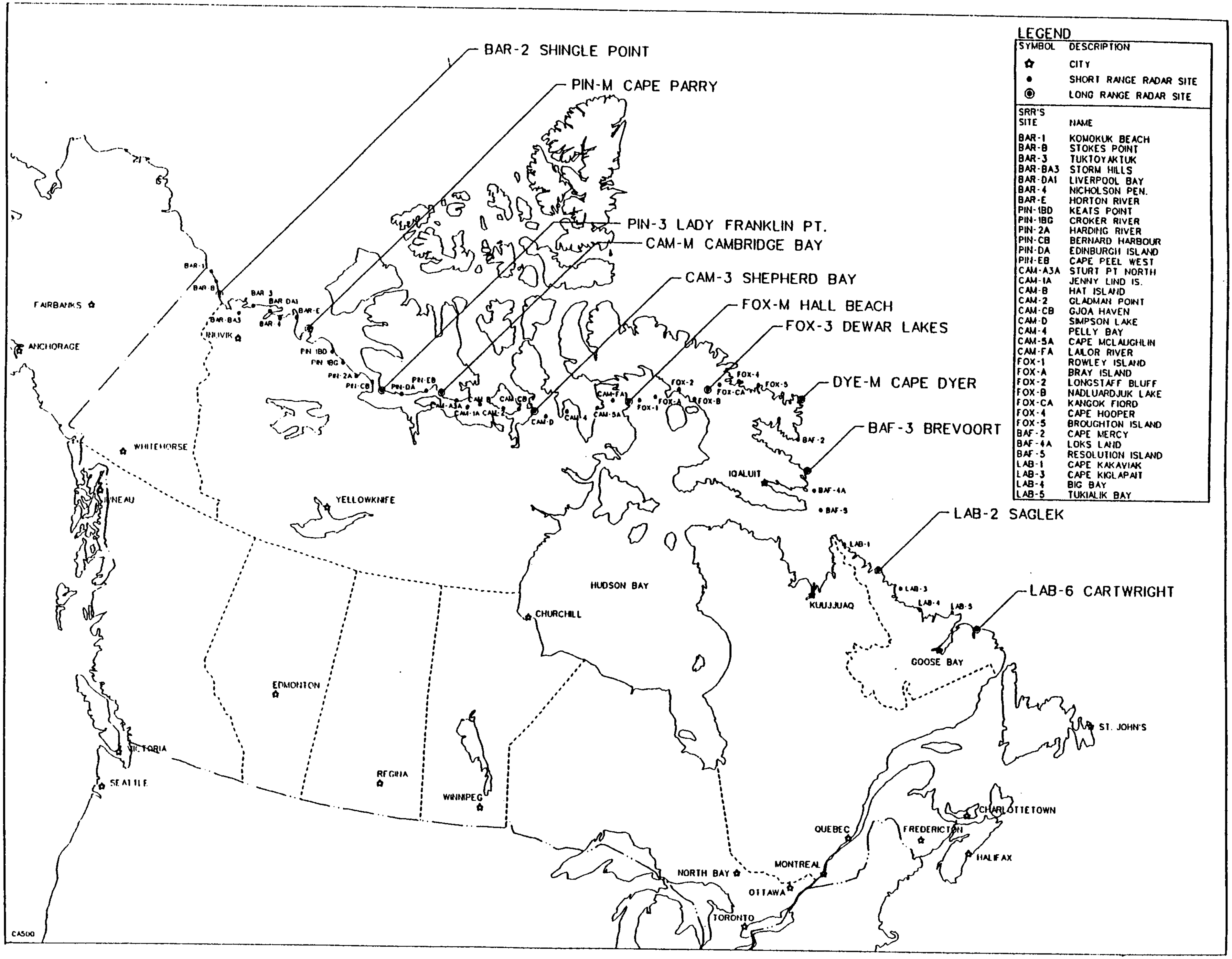
PMI Reduction. The considerations made here as to a reduction of PMIs did not reflect an increase in the expected number of corrective or emergency maintenance trips to each site that may be required. In order to address this issue, information would need to be collected as to the likelihood of this occurrence.

Conclusion

The airlift activities of the North Warning System were investigated through the use of mixed integer linear programming models. Several variations of the models were analyzed. The possibility of cost savings has been identified and can be achieved through a variety of actions.

Appendix A

This appendix provides a map of the North Warning System (NWS).


LEGEND
SYMBOL DESCRIPTION
CITY
SHORT RANGE RADAR SITE
LONG RANGE RADAR SITE
SRR'S SITE NAME
BAR-1 KOMOKUK BEACH
BAR-B STOKES POINT
BAR-3 TUKTOYAKTUK
BAR-BA3 STORM HILLS
BAR-DA1 LIVERPOOL BAY
BAR-4 NICHOLSON PEN.
BAR-E HORTON RIVER
PIN-1BD KEATS POINT
PIN-1BG CROKER RIVER
PIN-2A HARDING RIVER
PIN-CB BERNARD HARBOUR
PIN-DA EDINBURGH ISLAND
PIN-EB CAPE PEEL WEST
CAM-A3A STURT PT NORTH
CAM-1A JENNY LIND IS.
CAM-B HAT ISLAND
CAM-2 GLADMAN POINT
CAM-CB GJOA HAVEN
CAM-D SIMPSON LAKE
CAM-4 PELLY BAY
CAM-5A CAPE MCLAUGHLIN
CAM-FA LAILOR RIVER
FOX-1 ROWLEY ISLAND
FOX-A BRAY ISLAND
FOX-2 LONGSTAFF BLUFF
FOX-B NADLUARDJUK LAKE
FOX-CA KANGOK FIORD
FOX-4 CAPE HOOPER
FOX-5 BROUGHTON ISLAND
BAF-2 CAPE MERCY
BAF-4A LOKS LAND
BAF-5 RESOLUTION ISLAND
LAB-1 CAPE KAKAVIAK
LAB-3 CAPE KIGLAPAIT
LAB-4 BIG BAY
LAB-5 TUKIALIK BAY
BAR-2 SHINGLE POINT
PIN-M CAPE PARRY
PIN-3 LADY FRANKLIN PT.
CAM-M CAMBRIDGE BAY
CAM-3 SHEPHERD BAY
FOX-M HALL BEACH
FOX-3 DEWAR LAKES
DYE-M CAPE DYER
BAF-3 BREVOORT
LAB-2 SAGLEK
LAB-6 CARTWRIGHT
FAIRBANKS
ANCHORAGE
INUVIK
WHITEHORSE
YELLOWKNIFE
EDMONTON
REGINA
WINNIPEG
CHURCHILL
HUDSON BAY
IQALUIT
KUUJJUAQ
GOOSE BAY
ST. JOHN'S
CHARLOTTETOWN
FREDERICTON
HALIFAX
QUEBEC
MONTREAL
OTTAWA
NORTH BAY
TORONTO
VICTORIA
SEATTLE
CA500

Appendix B

This appendix provides a key to the indices used in the mixed integer linear programming formulations.

Zone Designations, i

This subscript represents the zone of operation and the LSS location established in that zone.

Subscript	Zone	LSS Name
A	I	Inuvik
B	II	Cambridge Bay
C	III	Hall Beach
D	IV	Iqaluit
E	V	Goose Bay

Radar Site Designations, j

Subscript j represents the SRR and LRR Only radar sites.

Subscript	Radar Site Type and Name
01	SRR Komokuk Beach/Bar-1
02	SRR Stokes Point/Bar-B
03	LRR Shingle Point/Bar-2
04	SRR Storm Hills/Bar-BA3
05	SRR Tuktoyaktuk/Bar-3
06	SRR Liverpool Bay/Bar-DA1
07	SRR Nicholson Island/Bar-4
08	SRR Horton River/Bar-E
09	LRR Cape Parry/Pin-M
10	SRR Keats Point/Pin-1BD
11	SRR Croker River/Pin-1BG
12	SRR Harding River/Pin-2A
13	SRR Bernard Harbour/Pin-CB
14	LRR Lady Franklin Point/Pin-3
15	SRR Edinburgh Island/Pin-DA
16	SRR Cape Peel West/Pin-EB
17	SRR Sturt Point North/CAM-A3A

18	SRR Jenny Lind Island/Cam-1A
19	SRR Hat Island/Cam-B
20	SRR Gladman Point/Cam-2
21	SRR Gjoa Haven/Cam-CB
22	LRR Sheperd Bay/Cam-3
23	SRR Simpson Lake/Cam-D
24	SRR Pelly Bay/Cam-4
25	SRR Cape McLoughlin/Cam-5A
26	SRR Lailor River/Cam-FA
27	SRR Rowley Island/Fox-1
28	SRR Bray Island/Fox-A
29	SRR Longstaff Bluff/Fox-2
30	SRR Nadluardjuk Lake/Fox-B
31	LRR Dewar Lakes/Fox-3
32	SRR Kangok Fiord/Fox-CA
33	SRR Cape Hooper/Fox-4
34	SRR Broughton Island/Fox-5
35	LRR Cape Dyer/Dye-M
36	SRR Cape Mercy/Baf-2
37	LRR Brevoort Island/Baf-3
38	SRR Loks Land/Baf-4A
39	SRR Resolution Island/Baf-5
40	SRR Cape Kakiviak/Lab-1
41	LRR Saglek Bay/Lab-2
42	SRR Cape Kiglapait/Lab-3
43	SRR Big Bay/Lab-4
44	SRR Tukialik Bay/Lab-5
45	SRR Cartwright/Lab-6

Aircraft Designation, *m*

This subscript designates the aircraft.

Subscript	Aircraft Type
1	Bell-212
2	S-61N
3	Twin Otter

Appendix C

This appendix provides the variable listing and definitions for the Base Model formulation.

Base Model Formulation -- Variable List

This is the base formulation using current zone structure and aircraft.

General Variable Definition:

Hours(m,i): The number of hours flown by transportation mode *m* in zone *i*.

Lg(m,i/j,j): A one-way trip between two sites using transportation mode *m*.

Sd(m,i,j): A summer routing from LSS *i* to site j using transportation mode *m* in order to accomplish a summer PMI.

Ss(m,i,n): A summer routing originating from LSS *i* using transportation mode *m* which visits an LRR and several SRRs to accomplish a summer PMI.

TOSs(m,i,n): A summer routing aided by the use of the fixed-wing Twin Otter originating from LSS *i* using transportation mode *m* which visits an LRR and several SRRs to accomplish a summer PMI

TOSd(m,i,j): A summer routing from LSS *i* to site *j* using transportation mode *m* aided by the use of the fixed-wing Twin Otter.

Wd(m,i,j): A winter routing from LSS *i* to site *j* using transportation mode *m* in order to accomplish a winter PMI.

Ws(m,i,n): A winter routing originating from LSS *i* using transportation mode *m* which visits an LRR and several SRRs to accomplish a winter PMI.

TOWs(m,i,n): A winter routing aided by the use of the fixed-wing Twin Otter originating from LSS *i* using transportation mode *m* which visits an LRR and several SRRs to accomplish a summer PMI

TOWd(m,i,j): A winter routing from LSS *i* to site *j* using transportation mode *m* aided by the use of the fixed-wing Twin Otter.

Dr(m,i/j,j): A routing between two sites using transportation mode *m*.

o/b: out and back

Indices

m:	1	Bell-212
	2	S-61N
	3	Twin Otter
j:	01	SRR Komokuk Beach/Bar-1
	02	SRR Stokes Point/Bar-B
	03	LRR Shingle Point/Bar-2
	04	SRR Storm Hills/Bar-BA3
	05	SRR Tuktoyaktuk/Bar-3
	06	SRR Liverpool Bay/Bar-DA1
	07	SRR Nicholson Island/Bar-4
	08	SRR Horton River/Bar-E
	09	LRR Cape Parry/Pin-M
	10	SRR Keats Point/Pin-1BD

i:	A	Inuvik
	B	Cambridge Bay
	C	Hall Beach
	D	Iqaluit
	E	Goose Bay

11	SRR Croker River/Pin-1BG
12	SRR Harding River/Pin-2A
13	SRR Bernard Harbour/Pin-CB
14	LRR Lady Franklin Point/Pin-3
15	SRR Edinburgh Island/Pin-DA
16	SRR Cape Peel West/Pin-EB
17	SRR Sturt Point North/CAM-A3A
18	SRR Jenny Lind Island/Cam-1A
19	SRR Hat Island/Cam-B
20	SRR Gladman Point/Cam-2
21	SRR Gjoa Haven/Cam-CB
22	LRR Sheperd Bay/Cam-3
23	SRR Simpson Lake/Cam-D
24	SRR Pelly Bay/Cam-4
25	SRR Cape McLoughlin/Cam-5A
26	SRR Lailor River/Cam-FA
27	SRR Rowley Island/Fox-1
28	SRR Bray Island/Fox-A
29	SRR Longstaff Bluff/Fox-2
30	SRR Nadluardjuk Lake/Fox-B
31	LRR Dewar Lakes/Fox-3
32	SRR Kangok Fiord/Fox-CA
33	SRR Cape Hooper/Fox-4
34	SRR Broughton Island/Fox-5
35	LRR Cape Dyer/Dye-M
36	SRR Cape Mercy/Baf-2
37	LRR Brevoort Island/Baf-3
38	SRR Loks Land/Baf-4A
39	SRR Resolution Island/Baf-5
40	SRR Cape Kakiviak/Lab-1
41	LRR Saglek Bay/Lab-2
42	SRR Cape Kiglapait/Lab-3
43	SRR Big Bay/Lab-4
44	SRR Tukialik Bay/Lab-5
45	SRR Cartwright/Lab-6

Zone One -- Inuvik

Dr1A01:	A routing between LSS Inuvik and SRR Komokuk Beach/Bar-1
Dr1A02:	A routing between LSS Inuvik and SRR Stokes Point/Bar-B
Dr1A03:	A routing between LSS Inuvik and LRR Shingle Point/Bar-2
Dr1A04:	A routing between LSS Inuvik and SRR Storm Hills/Bar-BA3
Dr1A05:	A routing between LSS Inuvik and SRR Tuktoyaktuk/Bar-3
Dr1A06:	A routing between LSS Inuvik and SRR Liverpool Bay/Bar-DA1
Dr1A07:	A routing between LSS Inuvik and SRR Nicholson Island/Bar-4
Dr1A08:	A routing between LSS Inuvik and SRR Horton River/Bar-E
Dr1A09:	A routing between LSS Inuvik and LRR Cape Parry/Pin-M
Dr1A10:	A routing between LSS Inuvik and SRR Keats Point/Pin-1BD
Dr1A11:	A routing between LSS Inuvik and SRR Croker River/Pin-1BG

Lg1A01:	A one-way trip between LSS Inuvik and SRR Komokuk Beach/Bar-1
Lg1A02:	A one-way trip between LSS Inuvik and SRR Stokes Point/Bar-B
Lg1A03:	A one-way trip between LSS Inuvik and LRR Shingle Point/Bar-2
Lg1A04:	A one-way trip between LSS Inuvik and SRR Storm Hills/Bar-BA3
Lg1A05:	A one-way trip between LSS Inuvik and SRR Tuktoyaktuk/Bar-3
Lg1A06:	A one-way trip between LSS Inuvik and SRR Liverpool Bay/Bar-DA1
Lg1A07:	A one-way trip between LSS Inuvik and SRR Nicholson Island/Bar-4
Lg1A08:	A one-way trip between LSS Inuvik and SRR Horton River/Bar-E
Lg1A09:	A one-way trip between LSS Inuvik and LRR Cape Parry/Pin-M
Lg1A10:	A one-way trip between LSS Inuvik and SRR Keats Point/Pin-1BD
Lg1A11:	A one-way trip between LSS Inuvik and SRR Croker River/Pin-1BG

Lg1A0103:	A one-way trip between SRR Komokuk Beach/Bar-1 and LRR Shingle Point/Bar-2
Lg1A0203:	A one-way trip between SRR Stokes Point/Bar-B and LRR Shingle Point/Bar-2
Lg1A0709:	A one-way trip between SRR Nicholson Island/Bar-4 and LRR Cape Parry/Pin-M
Lg1A0809:	A one-way trip between SRR Horton River/Bar-E and LRR Cape Parry/Pin-M

Lg1A0910: A one-way trip between LRR Cape Parry/Pin-M and SRR Keats Point/Pin-1BD
Lg1A0911: A one-way trip between LRR Cape Parry/Pin-M and SRR Croker River/Pin-1BG

Lg3A03: A one-way TO trip between LSS Inuvik and LRR Shingle Point/Bar-2
Lg3A09: A one-way TO trip between LSS Inuvik and LRR Cape Parry/Pin-M

Ss1A01: A summer routing which includes --
6 trips o/b between LSS Inuvik and LRR Shingle Point/Bar-2 (A/03)
3 trips o/b between LRR Shingle Point/Bar-2 and SRR Stokes Point/Bar-B (02/03)
3 trips o/b between LRR Shingle Point/Bar-2 and SRR Komokuk Beach/Bar-1 (01/03)

Ss1A02: A summer routing which includes --
8 trips o/b between LSS Inuvik and LRR Cape Parry/Pin-M (A/09)
3 trips o/b between LRR Cape Parry/Pin-M and SRR Nicholson Island/Bar-4 (07/09)
3 trips o/b between LRR Cape Parry/Pin-M and SRR Horton River/Bar-E (08/09)
3 trips o/b between LRR Cape Parry/Pin-M and SRR Keats Point/Pin-1BD (09/10)
3 trips o/b between LRR Cape Parry/Pin-M and SRR Croker River/Pin-1BG (09/11)

TOSs1A01: A summer routing which includes --
3 TO trips o/b between LSS Inuvik and LRR Shingle Point/Bar-2 (TO A/03)
2 trips o/b between LSS Inuvik and LRR Shingle Point/Bar-2 (A/03)
3 trips o/b between LRR Shingle Point/Bar-2 and SRR Stokes Point/Bar-B (02/03)
3 trips o/b between LRR Shingle Point/Bar-2 and SRR Komokuk Beach/Bar-1 (01/03)

TOSs1A02: A summer routing which includes --
4 TO trips o/b between LSS Inuvik and LRR Cape Parry/Pin-M (TO A/09)
2 trips o/b between LSS Inuvik and LRR Cape Parry/Pin-M (A/09)
3 trips o/b between LRR Cape Parry/Pin-M and SRR Nicholson Island/Bar-4 (07/09)
3 trips o/b between LRR Cape Parry/Pin-M and SRR Horton River/Bar-E (08/09)
3 trips o/b between LRR Cape Parry/Pin-M and SRR Keats Point/Pin-1BD (09/10)
3 trips o/b between LRR Cape Parry/Pin-M and SRR Croker River/Pin-1BG (09/11)

Sd1A04: A summer routing which includes --
2 trips o/b between LSS Inuvik and SRR Storm Hills/Bar-BA3 (A/04)

Sd1A05: A summer routing which includes --
2 trips o/b between LSS Inuvik and SRR Tuktoyaktuk/Bar-3 (A/05)

Sd1A06: A summer routing which includes --
2 trips o/b between LSS Inuvik and SRR Liverpool Bay/Bar-DA1 (A/06)

Ws1A01: A winter routing which includes --
4 trips o/b between LSS Inuvik and LRR Shingle Point/Bar-2 (A/03)
2 trips o/b between LRR Shingle Point/Bar-2 and SRR Stokes Point/Bar-B (02/03)
2 trips o/b between LRR Shingle Point/Bar-2 and SRR Komokuk Beach/Bar-1 (01/03)

Ws1A02: A winter routing which includes --
5 trips o/b between LSS Inuvik and LRR Cape Parry/Pin-M (A/09)
3 trips o/b between LRR Cape Parry/Pin-M and SRR Nicholson Island/Bar-4 (07/09)
3 trips o/b between LRR Cape Parry/Pin-M and SRR Horton River/Bar-E (08/09)
3 trips o/b between LRR Cape Parry/Pin-M and SRR Keats Point/Pin-1BD (09/10)
3 trips o/b between LRR Cape Parry/Pin-M and SRR Croker River/Pin-1BG (09/11)

TOWs1A01: A winter routing which includes --
2 TO trips o/b between LSS Inuvik and LRR Shingle Point/Bar-2 (TO A/03)
2 trips o/b between LSS Inuvik and LRR Shingle Point/Bar-2 (A/03)
2 trips o/b between LRR Shingle Point/Bar-2 and SRR Stokes Point/Bar-B (02/03)
2 trips o/b between LRR Shingle Point/Bar-2 and SRR Komokuk Beach/Bar-1 (01/03)

TOWs1A02: A winter routing which includes --
3 TO trips o/b between LSS Inuvik and LRR Cape Parry/Pin-M (TO A/09)
1 trip o/b between LSS Inuvik and LRR Cape Parry/Pin-M (A/09)
3 trips o/b between LRR Cape Parry/Pin-M and SRR Nicholson Island/Bar-4 (07/09)
3 trips o/b between LRR Cape Parry/Pin-M and SRR Horton River/Bar-E (08/09)
3 trips o/b between LRR Cape Parry/Pin-M and SRR Keats Point/Pin-1BD (09/10)
3 trips o/b between LRR Cape Parry/Pin-M and SRR Croker River/Pin-1BG (09/11)

Wd1A04: A winter routing which includes --
2 trips o/b between LSS Inuvik and SRR Storm Hills/Bar-BA3 (A/04)

Wd1A05: A winter routing which includes --
1 trip o/b between LSS Inuvik and SRR Tuktoyaktuk/Bar-3 (A/05)

Wd1A06: A winter routing which includes --
2 trips o/b between LSS Inuvik and SRR Liverpool Bay/Bar-DA1 (A/06)

Zone Two -- Cambridge Bay

Dr1B12: A routing between LSS Cambridge Bay and SRR Harding River/Pin-2A
Dr1B13: A routing between LSS Cambridge Bay and SRR Bernard Harbour/Pin-CB
Dr1B14: A routing between LSS Cambridge Bay and LRR Lady Franklin Point/Pin-3
Dr1B15: A routing between LSS Cambridge Bay and SRR Edinburgh Island/Pin-DA
Dr1B16: A routing between LSS Cambridge Bay and SRR Cape Peel West/Pin-EB
Dr1B17: A routing between LSS Cambridge Bay and SRR Sturt Point North/CAM-A3A
Dr1B18: A routing between LSS Cambridge Bay and SRR Jenny Lind Island/Cam-1A
Dr1B19: A routing between LSS Cambridge Bay and SRR Hat Island/Cam-B
Dr1B20: A routing between LSS Cambridge Bay and SRR Gladman Point/Cam-2
Dr1B21: A routing between LSS Cambridge Bay and SRR Gjoa Haven/Cam-CB
Dr1B22: A routing between LSS Cambridge Bay and LRR Sheperd Bay/Cam-3

Lg1B12: A one-way trip between LSS Cambridge Bay and SRR Harding River/Pin-2A
Lg1B13: A one-way trip between LSS Cambridge Bay and SRR Bernard Harbour/Pin-CB
Lg1B14: A one-way trip between LSS Cambridge Bay and LRR Lady Franklin Point/Pin-3
Lg1B15: A one-way trip between LSS Cambridge Bay and SRR Edinburgh Island/Pin-DA
Lg1B16: A one-way trip between LSS Cambridge Bay and SRR Cape Peel West/Pin-EB
Lg1B17: A one-way trip between LSS Cambridge Bay and SRR Sturt Point North/CAM-A3A
Lg1B18: A one-way trip between LSS Cambridge Bay and SRR Jenny Lind Island/Cam-1A
Lg1B19: A one-way trip between LSS Cambridge Bay and SRR Hat Island/Cam-B
Lg1B20: A one-way trip between LSS Cambridge Bay and SRR Gladman Point/Cam-2
Lg1B21: A one-way trip between LSS Cambridge Bay and SRR Gjoa Haven/Cam-CB
Lg1B22: A one-way trip between LSS Cambridge Bay and LRR Sheperd Bay/Cam-3

Lg1B1214: A one-way trip between SRR Harding River/Pin-2A and LRR Lady Franklin Point/Pin-3
Lg1B1314: A one-way trip between SRR Bernard Harbour/Pin-CB and LRR Lady Franklin Point/Pin-2A
Lg1B1415: A one-way trip between LRR Lady Franklin Point/Pin-2A and SRR Edinburgh Island/Pin-DA
Lg1B2022: A one-way trip between SRR Gladman Point/Cam-2 and LRR Sheperd Bay/Cam-3
Lg1B2122: A one-way trip between SRR Gjoa Haven/Cam-CB and LRR Sheperd Bay/Cam-3

Lg1B14Cp: A one-way trip between LRR Lady Franklin Point/Pin-3 and Coppermine
Lg1B22Gj: A one-way trip between LRR Sheperd Bay/Cam-3 and Gjoa Haven

Lg3B14: A one-way TO trip between LSS Cambridge Bay and LRR Lady Franklin Point/Pin-3
Lg3BCopp: A one-way TO trip between LSS Cambridge Bay and Coppermine
Lg3BGjoa: A one-way TO trip between LSS Cambridge Bay and Gjoa Haven

Ss1B01: A summer routing which includes --
6 trips o/b between LSS Cambridge Bay and LRR Lady Franklin Point/Pin-3 (B/14)
3 trips o/b between LRR Lady Franklin Point/Pin-3 and SRR Harding River/Pin-2A (12/14)
3 trips o/b between LRR Lady Franklin Point/Pin-3 and SRR Bernard Harbour/Pin-CB (13/14)
3 trips o/b between LRR Lady Franklin Point/Pin-3 and SRR Edinburg Island/Pin-DA (14/15)

Ss1B02: A summer routing which includes --
3 trips o/b between LSS Cambridge Bay and LRR Sheperd Bay/Cam-3 (B/22)
1 trip o/b between LRR Sheperd Bay/Cam-3 and SRR Gladman Point/Cam-2 (20/22)
1 trip o/b between LRR Sheperd Bay/Cam-3 and SRR Gjoa Haven/Cam-CB (21/22)

TOSs1B01: A summer routing which includes --
- 2 TO trips o/b between LSS Cambridge Bay and LRR Lady Franklin Point/Pin-3 (TO B/14)
- 1 TO trip o/b between LSS Cambridge Bay and Coppermine (TO B/Cp)
- 2 trips o/b between LRR Lady Franklin Point/Pin-3 and Coppermine (14/Cp)
- 3 trips o/b between LSS Cambridge Bay and LRR Lady Franklin Point/Pin-3 (B/14)
- 3 trips o/b between LRR Lady Franklin Point/Pin-3 and SRR Harding River/Pin-2A (12/14)
- 3 trips o/b between LRR Lady Franklin Point/Pin-3 and SRR Bernard Harbour/Pin-CB (13/14)
- 3 trips o/b between LRR Lady Franklin Point/Pin-3 and SRR Edinburg Island/Pin-DA (14/15)

TOSs1B02: A summer routing which includes --
- 1 TO trip o/b between LSS Cambridge Bay and Gjoa Haven (TO B/Gj)
- 1 trip o/b between LRR Sheperd Bay/Cam-3 and Gjoa Haven (22/Gj)
- 1 trip o/b between LSS Cambridge Bay and LRR Sheperd Bay/Cam-3 (B/22)
- 1 trip o/b between LRR Sheperd Bay/Cam-3 and SRR Gladman Point/Cam-2 (20/22)
- 1 trip o/b between LRR Sheperd Bay/Cam-3 and SRR Gjoa Haven/Cam-CB (21/22)

Sd1B16: A summer routing which includes --
- 3 trips o/b between LSS Cambridge Bay and SRR Cape Peel West/Pin-EB (B/16)

Sd1B17: A summer routing which includes --
- 3 trips o/b between LSS Cambridge Bay and LRR Sturt Point North/Cam-A3A (B/17)

Sd1B18: A summer routing which includes --
- 3 trips o/b between LSS Cambridge Bay and SRR Jenny Lind Island/Cam-1A (B/18)

Sd1B19: A summer routing which includes --
- 3 trips o/b between LSS Cambridge Bay and SRR Hat Island/Cam-B (B/19)

Ws1B01: A winter routing which includes --
- 6 trips o/b between LSS Cambridge Bay and LRR Lady Franklin Point/Pin-3 (B/14)
- 2 trips o/b between LRR Lady Franklin Point/Pin-3 and SRR Harding River/Pin-2A (12/14)
- 2 trips o/b between LRR Lady Franklin Point/Pin-3 and SRR Bernard Harbour/Pin-CB (13/14)
- 2 trips o/b between LRR Lady Franklin Point/Pin-3 and SRR Edinburg Island/Pin-DA (14/15)

Ws1B02: A winter routing which includes --
- 3 trips o/b between LSS Cambridge Bay and LRR Sheperd Bay/Cam-3 (B/22)
- 1 trip o/b between LRR Sheperd Bay/Cam-3 and SRR Gladman Point/Cam-2 (20/22)
- 1 trip o/b between LRR Sheperd Bay/Cam-3 and SRR Gjoa Haven/Cam-CB (21/22)

TOWs1B01: A winter routing which includes --
- 1 TO trip o/b between LSS Cambridge Bay and LRR Lady Franklin Point/Pin-3 (TO B/14)
- 1 TO trip o/b between LSS Cambridge Bay and Coppermine (TO B/Cp)
- 2 trips o/b between LRR Lady Franklin Point/Pin-3 and Coppermine (14/Cp)
- 2 trips o/b between LSS Cambridge Bay and LRR Lady Franklin Point/Pin-3 (B/14)
- 2 trips o/b between LRR Lady Franklin Point/Pin-3 and SRR Harding River/Pin-2A (12/14)
- 2 trips o/b between LRR Lady Franklin Point/Pin-3 and SRR Bernard Harbour/Pin-CB (13/14)
- 2 trips o/b between LRR Lady Franklin Point/Pin-3 and SRR Edinburg Island/Pin-DA (14/15)

TOWs1B02: A winter routing which includes --
- 1 TO trip o/b between LSS Cambridge Bay and Gjoa Haven (TO B/Gj)
- 1 trip o/b between LRR Sheperd Bay/Cam-3 and Gjoa Haven (22/Gj)
- 1 trip o/b between LSS Cambridge Bay and LRR Sheperd Bay/Cam-3 (B/22)
- 1 trip o/b between LRR Sheperd Bay/Cam-3 and SRR Gladman Point/Cam-2 (20/22)
- 1 trip o/b between LRR Sheperd Bay/Cam-3 and SRR Gjoa Haven/Cam-CB (21/22)

Wd1B16: A winter routing which includes --
- 2 trips o/b between LSS Cambridge Bay and SRR Cape Peel West/Pin-EB (B/16)

Wd1B17: A winter routing which includes --
- 2 trips o/b between LSS Cambridge Bay and LRR Sturt Point North/Cam-A3A (B/17)

Wd1B18: A winter routing which includes --
- 2 trips o/b between LSS Cambridge Bay and SRR Jenny Lind Island/Cam-1A (B/18)

Wd1B19: A winter routing which includes --
- 2 trips o/b between LSS Cambridge Bay and SRR Hat Island/Cam-B (B/19)

Zone Three -- Hall Beach

Dr1C22: A routing between LSS Hall Beach and LRR Sheperd Bay/Cam-3
Dr1C23: A routing between LSS Hall Beach and SRR Simpson Lake/Cam-D
Dr1C24: A routing between LSS Hall Beach and SRR Pelly Bay/Cam-4
Dr1C25: A routing between LSS Hall Beach and SRR Cape McLoughlin/Cam-5A
Dr1C26: A routing between LSS Hall Beach and SRR Lailor River/Cam-FA
Dr1C27: A routing between LSS Hall Beach and SRR Rowley Island/Fox-1
Dr1C28: A routing between LSS Hall Beach and SRR Bray Island/Fox-A
Dr1C29: A routing between LSS Hall Beach and SRR Longstaff Bluff/Fox-2
Dr1C31: A routing between LSS Hall Beach and LRR Dewar Lakes/Fox-3

Lg1C22: A one-way trip between LSS Hall Beach and LRR Sheperd Bay/Cam-3
Lg1C23: A one-way trip between LSS Hall Beach and SRR Simpson Lake/Cam-D
Lg1C24: A one-way trip between LSS Hall Beach and SRR Pelly Bay/Cam-4
Lg1C25: A one-way trip between LSS Hall Beach and SRR Cape McLoughlin/Cam-5A
Lg1C26: A one-way trip between LSS Hall Beach and SRR Lailor River/Cam-FA
Lg1C27: A one-way trip between LSS Hall Beach and SRR Rowley Island/Fox-1
Lg1C28: A one-way trip between LSS Hall Beach and SRR Bray Island/Fox-A
Lg1C29: A one-way trip between LSS Hall Beach and SRR Longstaff Bluff/Fox-2
Lg1C31: A one-way trip between LSS Hall Beach and LRR Dewar Lakes/Fox-3

Lg1C2223: A one-way trip between LRR Sheperd Bay/Cam-3 and SRR Simpson Lake/Cam-D
Lg1C2224: A one-way trip between LRR Sheperd Bay/Cam-3 and SRR Pelly Bay/Cam-4
Lg1C2931: A one-way trip between SRR Longstaff Bluff/Fox-2 and LRR Dewar Lakes/Fox-3

Lg1C22Pl: A one-way trip between LRR Sheperd Bay/Cam-3 and Pelly Bay

Lg3CPell: A one-way TO trip between LSS Hall Beach and Pelly Bay

Ss1C01: A summer routing which includes --
11 trips o/b between LSS Hall Beach and LRR Sheperd Bay/Cam-3 (C/22)
4 trips o/b between LRR Sheperd Bay/Cam-3 and SRR Simpson Lake/Cam-D (22/23)
4 trips o/b between LRR Sheperd Bay/Cam-3 and SRR Pelly Bay/Cam-4 (22/24)

Ss1C02: A summer routing which includes --
1 trip o/b between LSS Hall Beach and LRR Dewar Lakes/Fox-3 (C/31)
4 trips o/b between LRR Dewar Lakes/Fox-3 and SRR Longstaff Bluff/Fox-2 (29/31)

TOSs1C01: A summer routing which includes --
6 TO trips o/b between LSS Hall Beach and Pelly Bay (TO C/Pl)
10 trips o/b between LRR Sheperd Bay/Cam-3 and Pelly Bay (22/Pl)
1 trip o/b between LSS Hall Beach and LRR Sheperd Bay/Cam-3 (C/22)
4 trips o/b between LRR Sheperd Bay/Cam-3 and SRR Simpson Lake/Cam-D (22/23)
4 trips o/b between LRR Sheperd Bay/Cam-3 and SRR Pelly Bay/Cam-4 (22/24)

Sd1C25: A summer routing which includes --
3 trips o/b between LSS Hall Beach and SRR Cape McLoughlin/Cam-5A (C/25)

Sd1C26: A summer routing which includes --
3 trips o/b between LSS Hall Beach and SRR Lailor River/Cam-FA (C/26)

Sd1C27: A summer routing which includes --
3 trips o/b between LSS Hall Beach and SRR Rowley Island/Fox-1 (C/27)
Sd1C28: A summer routing which includes --
3 trips o/b between LSS Hall Beach and SRR Bray Island/Fox-A (C/28)

Ws1C01: A winter routing which includes --
3 trip o/b between LSS Hall Beach and LRR Sheperd Bay/Cam-3 (C/22)
4 trips o/b between LRR Sheperd Bay/Cam-3 and SRR Simpson Lake/Cam-D (22/23)
4 trips o/b between LRR Sheperd Bay/Cam-3 and SRR Pelly Bay/Cam-4 (22/24)

Ws1C02: A winter routing which includes --
1 trip o/b between LSS Hall Beach and LRR Dewar Lakes/Fox-3 (C/31)
4 trips o/b between LRR Dewar Lakes/Fox-3 and SRR Longstaff Bluff/Fox-2 (29/31)

TOWs1C01: A winter routing which includes --
2 TO trips o/b between LSS Hall Beach and Pelly Bay (TO C/Pl)
2 trips o/b between LRR Sheperd Bay/Cam-3 and Pelly Bay (22/Pl)
1 trip o/b between LSS Hall Beach and LRR Sheperd Bay/Cam-3 (C/22)
4 trips o/b between LRR Sheperd Bay/Cam-3 and SRR Simpson Lake/Cam-D (22/23)
4 trips o/b between LRR Sheperd Bay/Cam-3 and SRR Pelly Bay/Cam-4 (22/24)

Wd1C25: A winter routing which includes --
2 trips o/b between LSS Hall Beach and SRR Cape McLoughlin/Cam-5A (C/25)

Wd1C26: A winter routing which includes --
2 trips o/b between LSS Hall Beach and SRR Lailor River/Cam-FA (C/26)

Wd1C27: A winter routing which includes --
2 trips o/b between LSS Hall Beach and SRR Rowley Island/Fox-1 (C/27)

Wd1C28: A winter routing which includes --
2 trips o/b between LSS Hall Beach and SRR Bray Island/Fox-A (C/28)

Zone Four -- Iqaluit

Dr2D30: A routing between LSS Iqaluit and SRR Nadluardjuk Lake/Fox-B
Dr2D31: A routing between LSS Iqaluit and LRR Dewar Lakes/Fox-3
Dr2D32: A routing between LSS Iqaluit and SRR Kangok Fiord/Fox-CA
Dr2D33: A routing between LSS Iqaluit and SRR Cape Hooper/Fox-4
Dr2D34: A routing between LSS Iqaluit and SRR Broughton Island/Fox-5
Dr2D35: A routing between LSS Iqaluit and LRR Cape Dyer/Dye-M
Dr2D36: A routing between LSS Iqaluit and SRR Cape Mercy/Baf-2
Dr2D37: A routing between LSS Iqaluit and LRR Brevoort Island/Baf-3
Dr2D38: A routing between LSS Iqaluit and SRR Loks Land/Baf-4A
Dr2D39: A routing between LSS Iqaluit and SRR Resolution Island/Baf-5

Lg2D30: A one-way trip between LSS Iqaluit and SRR Nadluardjuk Lake/Fox-B
Lg2D31: A one-way trip between LSS Iqaluit and LRR Dewar Lakes/Fox-3
Lg2D32: A one-way trip between LSS Iqaluit and SRR Kangok Fiord/Fox-CA
Lg2D33: A one-way trip between LSS Iqaluit and SRR Cape Hooper/Fox-4
Lg2D34: A one-way trip between LSS Iqaluit and SRR Broughton Island/Fox-5
Lg2D35: A one-way trip between LSS Iqaluit and LRR Cape Dyer/Dye-M
Lg2D36: A one-way trip between LSS Iqaluit and SRR Cape Mercy/Baf-2
Lg2D37: A one-way trip between LSS Iqaluit and LRR Brevoort Island/Baf-3
Lg2D38: A one-way trip between LSS Iqaluit and SRR Loks Land/Baf-4A
Lg2D39: A one-way trip between LSS Iqaluit and SRR Resolution Island/Baf-5

Lg2D3031: A one-way trip between SRR Nadjuardjuk Lake/Fox-B and LRR Dewar Lakes/Fox-3
Lg2D3132: A one-way trip between LRR Dewar Lakes/Fox-3 and SRR Kangok Fiord/Fox-CA
Lg2D3133: A one-way trip between LRR Dewar Lakes/Fox-3 and SRR Cape Hooper/Fox-4
Lg2D3435: A one-way trip between SRR Broughton Island/Fox-5 and LRR Cape Dyer/Dye-M

Lg3D31: A one-way trip between LSS Iqaluit and LRR Dewar Lakes/Fox-3
Lg3DBrou: A one-way trip between LSS Iqaluit and Broughton Island

Ss2D01: A summer routing which includes --
5 trips o/b between LSS Iqaluit and LRR Dewar Lakes/Fox-3 (D/31)
8 trips o/b between LRR Dewar Lakes/Fox-3 and SRR Cape Hooper/Fox-4 (30/31)
8 trips o/b between LRR Dewar Lakes/Fox-3 and SRR Kankgok Fiord/Fox-CA (31/32)
8 trips o/b between LRR Dewar Lakes/Fox-3 and SRR Nadjuardjuk Lake/Fox-B (31/33)

Ss2D02: A summer routing which includes --
7 trips o/b between LSS Iqaluit and LRR Cape Dyer/Dye-M (D/35)
6 trips o/b between LRR Cape Dyer/Dye-M and SRR Broughton Island/Fox-5 (34/35)

TOSs2D01: A summer routing which includes --
3 TO trips o/b between LSS Iqaluit and LRR Dewar Lakes/Fox-3 (TO D/31)
1 trip o/b between LSS Iqaluit and LRR Dewar Lakes/Fox-3 (D/31)
8 trips o/b between LRR Dewar Lakes/Fox-3 and SRR Cape Hooper/Fox-4 (30/31)
8 trips o/b between LRR Dewar Lakes/Fox-3 and SRR Kankgok Fiord/Fox-CA (31/32)
8 trips o/b between LRR Dewar Lakes/Fox-3 and SRR Nadjuardjuk Lake/Fox-B (31/33)

TOSs2D02: A summer routing which includes --
2 TO trips o/b between LSS Iqaluit and Broughton Island (TO D/Br)
4 trips o/b between SRR Broughton Island/Fox-5 and Broughton Island (34/Br)
3 trips o/b between LSS Iqaluit and LRR Cape Dyer/Dye-M (D/35)
6 trips o/b between LRR Cape Dyer/Dye-M and SRR Broughton Island/Fox-5 (34/35)

Sd2D36: A summer routing which includes --
3 trips o/b between LSS Iqaluit and SRR Cape Mercy/Baf-2 (D/36)

Sd2D37: A summer routing which includes --
5 trips o/b between LSS Iqaluit and LRR Brevoort Island/Baf-3 (C/37)

Sd2D38: A summer routing which includes --
3 trips o/b between LSS Iqaluit and SRR Loks Land/Baf-4A (C/38)

Sd2D39: A summer routing which includes --
3 trips o/b between LSS Iqaluit and SRR Resolution Island/Baf-5 (C/39)

Ws2D01: A winter routing which includes --
5 trips o/b between LSS Iqaluit and LRR Dewar Lakes/Fox-3 (D/31)
6 trips o/b between LRR Dewar Lakes/Fox-3 and SRR Cape Hooper/Fox-4 (30/31)
6 trips o/b between LRR Dewar Lakes/Fox-3 and SRR Kankgok Fiord/Fox-CA (31/32)
6 trips o/b between LRR Dewar Lakes/Fox-3 and SRR Nadjuardjuk Lake/Fox-B (31/33)

Ws2D02: A winter routing which includes --
7 trips o/b between LSS Iqaluit and LRR Cape Dyer/Dye-M (D/35)
4 trips o/b between LRR Cape Dyer/Dye-M and SRR Broughton Island/Fox-5 (34/35)

TOWs2D01: A winter routing which includes --
2 TO trips o/b between LSS Iqaluit and LRR Dewar Lakes/Fox-3 (TO D/31)
1 trip o/b between LSS Iqaluit and LRR Dewar Lakes/Fox-3 (D/31)
6 trips o/b between LRR Dewar Lakes/Fox-3 and SRR Cape Hooper/Fox-4 (30/31)
6 trips o/b between LRR Dewar Lakes/Fox-3 and SRR Kankgok Fiord/Fox-CA (31/32)
6 trips o/b between LRR Dewar Lakes/Fox-3 and SRR Nadjuardjuk Lake/Fox-B (31/33)

TOWs2D02: A winter routing which includes --
2 TO trips o/b between LSS Iqaluit and Broughton Island (TO D/Br)
1 trip o/b between SRR Broughton Island/Fox-5 and Broughton Island (34/Br)
3 trips o/b between LSS Iqaluit and LRR Cape Dyer/Dye-M (D/35)
4 trips o/b between LRR Cape Dyer/Dye-M and SRR Broughton Island/Fox-5 (34/35)

Wd2D36: A winter routing which includes --
2 trips o/b between LSS Iqaluit and SRR Cape Mercy/Baf-2 (D/36)

Wd2D37: A winter routing which includes --
2 trips o/b between LSS Iqaluit and LRR Brevoort Island/Baf-3 (D/37)

Wd2D38: A winter routing which includes --
2 trips o/b between LSS Iqaluit and SRR Loks Land/Baf-4A (D/38)

Wd2D39: A winter routing which includes --
2 trips o/b between LSS Iqaluit and SRR Resolution Island/Baf-5 (D/39)

<u>Zone Five -- Goose Bay</u>

Dr1E40: A routing between LSS Goose Bay and SRR Cape Kakiviak/Lab-1
Dr1E41: A routing between LSS Goose Bay and LRR Saglek Bay/Lab-2
Dr1E42: A routing between LSS Goose Bay and SRR Cape Kiglapait/Lab-3
Dr1E43: A routing between LSS Goose Bay and SRR Big Bay/Lab-4
Dr1E44: A routing between LSS Goose Bay and SRR Tukialik Bay/Lab-5

DrlE45: A routing between LSS Goose Bay and LRR Cartwright/Lab-6

LglE40: A one-way trip between LSS Goose Bay and SRR Cape Kakiviak/Lab-1
LglE41: A one-way trip between LSS Goose Bay and LRR Saglek Bay/Lab-2
LglE42: A one-way trip between LSS Goose Bay and SRR Cape Kiglapait/Lab-3
LglE43: A one-way trip between LSS Goose Bay and SRR Big Bay/Lab-4
LglE44: A one-way trip between LSS Goose Bay and SRR Tukialik Bay/Lab-5
LglE45: A one-way trip between LSS Goose Bay and LRR Cartwright/Lab-6

LglE4041: A one-way trip between SRR Cape Kakiviak/Lab-1 and LRR Saglek Bay/Lab-2
LglE4142: A one-way trip between LRR Saglek Bay/Lab-2 and SRR Cape Kiglapait/Lab-3
LglE4445: A one-way trip between SRR Tukialik Bay/Lab-5 and SRR Cartwright/Lab-6

LglE41Na: A one-way trip between LRR Saglek Bay/Lab-2 and Nain
LglE43Ho: A one-way trip between SRR Big Bay/Lab-4 and Hopedale
LglE44Ma: A one-way trip between SRR Tukialik Bay/Lab-5 and Makkovik
Lg3ENain: A one-way TO trip between LSS Goose Bay and Nain
Lg3EHope: A one-way TO trip between LSS Goose Bay and Hopedale
Lg3EMakk: A one-way TO trip between LSS Goose Bay and Makkovik
Lg3ECart: A one-way TO trip between LSS Goose Bay and Cartwright

SslE01: A summer routing which includes --
10 trips o/b between LSS Goose Bay and LRR Saglek Bay/Lab-2 (E/41)
3 trips o/b between LRR Saglek Bay/Lab-2 and SRR Cape Kakiviak/Lab-1 (40/41)
3 trips o/b between LRR Saglek Bay/Lab-2 and SRR Cape Kiglapait/Lab-3 (41/42)

TOSslE01: A summer routing which includes --
4 TO trips between LSS Goose Bay and Nain (TO E/Na)
5 trips o/b between LRR Saglek Bay/Lab-2 and Nain (41/Na)
3 trips o/b between LSS Goose Bay and LRR Saglek Bay/Lab-2 (E/41)
3 trips o/b between LRR Saglek Bay/Lab-2 and SRR Cape Kakiviak/Lab-1 (40/41)
3 trips o/b between LRR Saglek Bay/Lab-2 and SRR Cape Kiglapait/Lab-3 (41/42)

SdlE43: A summer routing which includes --
6 trips o/b between LSS Goose Bay and SRR Big Bay/Lab-4 (E/43)

TOSdlE43: A summer routing which includes --
2 TO trips o/b between LSS Goose Bay and Hopedale (E/Ho)
1 trip o/b between SRR Big Bay/Lab-4 and Hopedale (43/Ho)
1 trips o/b between LSS Goose Bay and SRR Big Bay/Lab-4 (E/43)

SdlE44: A summer routing which includes --
6 trips o/b between LSS Goose Bay and SRR Tukialik Bay/Lab-5 (E/44)

TOSdlE44: A summer routing which includes --
3 TO trip o/b between LSS Goose Bay and Makkovik (TO E/Ma)
1 trip o/b between SRR Tukialik Bay/Lab-5 and Makkovik (44/Ma)
1 trip o/b between LSS Goose Bay and SRR Tukialik Bay/Lab-5 (E/44)

SdlE45: A summer routing which includes --
6 trips o/b between LSS Goose Bay and LRR Cartwright/Lab-6 (E/45)

TOSdlE45: A summer routing which includes --
2 TO trips o/b between LSS Goose Bay and Cartwright (TO E/Ca)
1 trip o/b between LSS Goose Bay and LRR Cartwright/Lab-6 (E/45)

WslE01: A winter routing which includes --
6 trips o/b between LSS Goose Bay and LRR Saglek Bay/Lab-2 (E/41)
2 trips o/b between LRR Saglek Bay/Lab-2 and SRR Cape Kakiviak/Lab-1 (40/41)
2 trips o/b between LRR Saglek Bay/Lab-2 and SRR Cape Kiglapait/Lab-3 (41/42)

TOWs1E01: A winter routing which includes --
2 TO trips o/b between LSS Goose Bay and Nain (TO E/Na)
3 trips o/b between LRR Saglek Bay/Lab-2 and Nain (41/Na)
3 trips o/b between LSS Goose Bay and LRR Saglek Bay/Lab-2 (E/41)
2 trips o/b between LRR Saglek Bay/Lab-2 and SRR Cape Kakiviak/Lab-1 (40/41)
2 trips o/b between LRR Saglek Bay/Lab-2 and SRR Cape Kiglapait/Lab-3 (41/42)

Wd1E43: A winter routing which includes --
3 trips o/b between LSS Goose Bay and SRR Big Bay/Lab-4 (E/43)

TOWd1E43: A winter routing which includes --
2 TO trips o/b between LSS Goose Bay and Hopedale (TO E/Ho)
1 trip o/b between SRR Big Bay/Lab-4 and Hopedale (43/Ho)
1 trip o/b between LSS Goose Bay and SRR Big Bay/Lab-4 (E/43)

Wd1E44: A winter routing which includes --
3 trips o/b between LSS Goose Bay and SRR Tukialik Bay/Lab-5

TOWd1E44: A winter routing which includes --
2 TO trips o/b between LSS Goose Bay and Makkovik (TO E/Ma)
1 trip o/b between SRR Tukialik Bay/Lab-5 and Makkovik (44/Ma)
1 trip o/b between LSS Goose Bay and SRR Tukialik Bay/Lab-5 (E/44)

Wd1E45: A winter routing which includes --
3 trips o/b between LSS Goose Bay and LRR Cartwright/Lab-6 (E/45)

TOWd1E45: A winter routing which includes --
2 TO trips o/b between LSS Goose Bay and Cartwright (TO E/Ca)
1 trip o/b between LSS Goose Bay and LRR Cartwright/Lab-6 (E/45)

Appendix D

This appendix provides the formulation of the Base Model mixed integer linear programming model. This formulation is written in LP code understood by the CPLEX Linear Optimizer. This variation of the Base Model formulation depicts the NWS as it operated during FY96.

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\Base Model formulation using current zone structure and aircraft.
\The objective function is to minimize total cost of the system
MINIMIZE 2660Hours1A + 950Hours3A + 2740Hours1B + 945Hours3B + 2740Hours1C + 1260Hours3C
+ 4542Hours2D + 945Hours3D + 2480Hours1E + 945Hours3E + 1000000OPENA + 3500000OPENB
+ 3500000OPENC + 1000000OPEND + 1000000OPENE
SUBJECT TO
\Min. Maintenance Req. Constraint 1:  SRR Komokuk Beach/Bar-1
Dr1A01 + Ss1A01 + TOSs1A01 + Ws1A01 + TOWs1A01 >= 7
\Min. Maintenance Req. Constraint 2:  SRR Stokes Point/Bar-B
Dr1A02 + Ss1A01 + TOSs1A01 + Ws1A01 + TOWs1A01 >= 11
\Min. Maintenance Req. Constraint 3:  LRR Shingle Point/Bar-2
Dr1A03 + Ss1A01 + TOSs1A01 + Ws1A01 + TOWs1A01 >= 19
\Min. Maintenance Req. Constraint 4:  SRR Storm Hills/Bar-BA3
Dr1A04 + Sd1A04 + Wd1A04 >= 11
\Min. Maintenance Req. Constraint 5:  SRR Tuktoyaktuk/Bar-3
Dr1A05 + Sd1A05 + Wd1A05 >= 13
\Min. Maintenance Req. Constraint 6:  SRR Liverpool Bay/Bar-DA1
Dr1A06 + Sd1A06 + Wd1A06 >= 11
\Min. Maintenance Req. Constraint 7:  SRR Nicholson Island/Bar-4
Dr1A07 + Ss1A02 + TOSs1A02 + Ws1A02 + TOWs1A02 >= 11
\Min. Maintenance Req. Constraint 8:  SRR Horton River/Bar-E
Dr1A08 + Ss1A02 + Ws1A02 + TOSs1A02 + TOWs1A02 >= 7
\Min. Maintenance Req. Constraint 9:  LRR Cape Parry/Pin-M
Dr1A09 + Ss1A02 + Ws1A02 + TOSs1A02 + TOWs1A02 >= 12
\Min. Maintenance Req. Constraint 10:  SRR Keats Point/Pin-1BD
Dr1A10 + Ss1A02 + Ws1A02 + TOSs1A02 + TOWs1A02 >= 10
\Min. Maintenance Req. Constraint 11:  SRR Croker River/Pin-1BG
Dr1A11 + Ss1A02 + Ws1A02 + TOSs1A02 + TOWs1A02 >= 8
\Min. Maintenance Req. Constraint 12:  SRR Harding River/Pin-2A
Dr1B12 + Ss1B01 + TOSs1B01 + Ws1B01 + TOWs1B01 >= 9
\Min. Maintenance Req. Constraint 13:  SRR Bernard Harbour/Pin-CB
Dr1B13 + Ss1B01 + TOSs1B01 + Ws1B01 + TOWs1B01 >= 9
\Min. Maintenance Req. Constraint 14:  LRR Lady Franklin Point/Pin-3
Dr1B14 + Ss1B01 + TOSs1B01 + Ws1B01 + TOWs1B01 >= 17
\Min. Maintenance Req. Constraint 15:  SRR Edinburgh Island/Pin-DA
Dr1B15 + Ss1B01 + TOSs1B01 + Ws1B01 + TOWs1B01 >= 10
\Min. Maintenance Req. Constraint 16:  SRR Cape Peel West/Pin-EB
Dr1B16 + Sd1B16 + Wd1B16 >= 10
\Min. Maintenance Req. Constraint 17:  SRR Sturt Point North/Cam-A3A
Dr1B17 + Sd1B17 + Wd1B17 >= 9
\Min. Maintenance Req. Constraint 18:  SRR Jenny Lind Island/Cam-1A
Dr1B18 + Sd1B18 + Wd1B18 >= 11
\Min. Maintenance Req. Constraint 19:  SRR Hat Island/Cam-B
Dr1B19 + Sd1B19 + Wd1B19 >= 9
\Min. Maintenance Req. Constraint 20:  SRR Gladman Point/Cam-2
Dr1B20 + Ss1B02 + TOSs1B02 + Ws1B02 + TOWs1B02 >= 10
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\Min. Maintenance Req. Constraint 21:  SRR Gjoa Haven/Cam-CB
Dr1B21 + Ss1B02 + TOSs1B02 + Ws1B02 + TOWs1B02 >= 9
\Min. Maintenance Req. Constraint 22:  LRR Sheperd Bay/Cam-3
Dr1C22 + Ss1C01 + TOSs1C01 + Ws1C01 + TOWs1C01 >= 21
\Min. Maintenance Req. Constraint 23:  SRR Simpson Lake/Cam-D
Dr1C23 + Ss1C01 + TOSs1C01 + Ws1C01 + TOWs1C01 >= 12
\Min. Maintenance Req. Constraint 24:  SRR Pelly Bay/Cam-4
Dr1C24 + Ss1C01 + TOSs1C01 + Ws1C01 + TOWs1C01 >= 12
\Min. Maintenance Req. Constraint 25:  SRR Cape McLoughlin/Cam-5A
Dr1C25 + Sd1C25 + Wd1C25 >= 20
\Min. Maintenance Req. Constraint 26:  SRR Lailor River/Cam-FA
Dr1C26 + Sd1C26 + Wd1C26 >= 14
\Min. Maintenance Req. Constraint 27:  SRR Rowley Island/Fox-1
Dr1C27 + Sd1C27 + Wd1C27 >= 12
\Min. Maintenance Req. Constraint 28:  SRR Bray Island/Fox-A
Dr1C28 + Sd1C28 + Wd1C28 >= 11
\Min. Maintenance Req. Constraint 29:  SRR Longstaff Bluff/Fox-2
Dr1C29 + Ss1C02 + Ws1C02 >= 12
\Min. Maintenance Req. Constraint 30:  SRR Nakluardjuk Lake/Fox-B
Dr2D30 + Ss2D01 + TOSs2D01 + Ws2D01 + TOWs2D01 >= 8
\Min. Maintenance Req. Constraint 31:  LRR Dewar Lakes/Fox-3
Dr2D31 + Ss2D01 + TOSs2D01 + Ws2D01 + TOWs2D01 >= 13
\Min. Maintenance Req. Constraint 32:  SRR Kankgok Fiord/Fox-CA
Dr2D32 + Ss2D01 + TOSs2D01 + Ws2D01 + TOWs2D01 >= 8
\Min. Maintenance Req. Constraint 33:  SRR Cape Hooper/Fox-4
Dr2D33 + Ss2D01 + TOSs2D01 + Ws2D01 + TOWs2D01 >= 8
\Min. Maintenance Req. Constraint 34:  SRR Broughton Island/Fox-5
Dr2D34 + Ss2D02 + TOSs2D02 + Ws2D02 + TOWs2D02 >= 7
\Min. Maintenance Req. Constraint 35:  LRR Cape Dyer/Dye-M
Dr2D35 + Ss2D02 + TOSs2D02 + Ws2D02 + TOWs2D02 >= 12
\Min. Maintenance Req. Constraint 36:  SRR Cape Mercy/Baf-2
Dr2D36 + Sd2D36 + Wd2D36 >= 9
\Min. Maintenance Req. Constraint 37:  LRR Brevoort Island/Baf-3
Dr2D37 + Sd2D37 + Wd2D37 >= 18
\Min. Maintenance Req. Constraint 38:  SRR Loks Land/Baf-4A
Dr2D38 + Sd2D38 + Wd2D38 >= 9
\Min. Maintenance Req. Constraint 39:  SRR Resolution Island/Baf-5
Dr2D39 + Sd2D39 + Wd2D39 >= 9
\Min. Maintenance Req. Constraint 40:  SRR Cape Kakiviak/Lab-1
Dr1E40 + Ss1E01 + TOSs1E01 + Ws1E01 + TOWs1E01 >= 9
\Min. Maintenance Req. Constraint 41:  LRR Saglek Bay/Lab-2
Dr1E41 + Ss1E01 + TOSs1E01 + Ws1E01 + TOWs1E01 >= 19
\Min. Maintenance Req. Constraint 42:  SRR Cape Kiglapait/Lab-3
Dr1E42 + Ss1E01 + TOSs1E01 + Ws1E01 + TOWs1E01 >= 10
\Min. Maintenance Req. Constraint 43:  SRR Big Bay/Lab-4
Dr1E43 + Sd1E43 + TOSd1E43 + Wd1E43 + TOWd1E43 >= 17
\Min. Maintenance Req. Constraint 44:  SRR Tukialik Bay/Lab-5
Dr1E44 + Sd1E44 + TOSd1E44 + Wd1E44 + TOWd1E44 >= 11
\Min. Maintenance Req. Constraint 45:  SRR Cartwright
Dr1E45 + Sd1E45 + TOSd1E45 + Wd1E45 + TOWd1E45 >= 11
\Summer PMI Requirement Constraints
\Sites 01/02/03
Ss1A01 + TOSs1A01 >= 2
Sd1A04 >= 2
Sd1A05 >= 2
Sd1A06 >= 2
\Sites 07/08/09/10/11
Ss1A02 + TOSs1A02 >= 2
\Sites 12/13/14/15
Ss1B01 + TOSs1B01 >= 2
Sd1B16 >= 2
Sd1B17 >= 2
Sd1B18 >= 2
Sd1B19 >= 2
\Sites 20/21
Ss1B02 + TOSs1B02 >= 2
```

```
\Sites 22/23/24
Ss1C01 + TOSs1C01 >= 2
Sd1C25 >= 2
Sd1C26 >= 2
Sd1C27 >= 2
Sd1C28 >= 2
\Site 29
Ss1C02 >= 2
\Sites 30/31/32/33
Ss2D01 + TOSs2D01 >= 2
\Sites 34/35
Ss2D02 + TOSs2D02 >= 2
Sd2D36 >= 2
Sd2D37 >= 2
Sd2D38 >= 2
Sd2D39 >= 2
\Sites 40/41/42
Ss1E01 + TOSs1E01 >= 2
Sd1E43 + TOSd1E43 >= 2
Sd1E44 + TOSd1E44 >= 2
Sd1E45 + TOSd1E45 >= 2
\Winter PMI Requirement Constraints
\Sites 01/02/03
Ws1A01 + TOWs1A01 >= 2
Wd1A04 >= 2
Wd1A05 >= 2
Wd1A06 >= 2
\Sites 07/08/09/10/11
Ws1A02 + TOWs1A02 >= 2
\Sites 12/13/14
Ws1B01 + TOWs1B01 >= 2
Ws1B01 + TOWs1B01 >= 2
Wd1B16 >= 2
Wd1B17 >= 2
Wd1B18 >= 2
Wd1B19 >= 2
\Sites 20/21
Ws1B02 + TOWs1B02 >= 2
\Sites 22/23/24
Ws1C01 + TOWs1C01 >= 2
Wd1C25 >= 2
Wd1C26 >= 2
Wd1C27 >= 2
Wd1C28 >= 2
\Site 29
Ws1C02 >= 2
\Sites 30/31/32/33
Ws2D01 + TOWs2D01 >= 2
\Sites 34/35
Ws2D02 + TOWs2D02 >= 2
Wd2D36 >= 2
Wd2D37 >= 2
Wd2D38 >= 2
Wd2D39 >= 2
\Sites 40/41/42
Ws1E01 + TOWs1E01 >= 2
Wd1E43 + TOWd1E43 >= 2
Wd1E44 + TOWd1E44 >= 2
Wd1E45 + TOWd1E45 >= 2
\Legs Flown Constraints: Bell-212
Lg1A01 - 2Dr1A01 = 0
Lg1A02 - 2Dr1A02 = 0
Lg1A03 - 2Dr1A03 - 12Ss1A01 - 4TOSs1A01 - 8Ws1A01 - 4TOWs1A01 = 0
Lg1A04 - 2Dr1A04 - 4Sd1A04 - 4Wd1A04 = 0
Lg1A05 - 2Dr1A05 - 4Sd1A05 - 2Wd1A05 = 0
Lg1A06 - 2Dr1A06 - 4Sd1A06 - 4Wd1A06 = 0
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Lg1A07 - 2Dr1A07 = 0
Lg1A08 - 2Dr1A08 = 0
Lg1A09 - 2Dr1A09 - 16Ss1A02 - 4TOSs1A02 - 10Ws1A02 - 2TOWs1A02= 0
Lg1A10 - 2Dr1A10 = 0
Lg1A11 - 2Dr1A11 = 0
Lg1A0103 - 6Ss1A01 - 6TOSs1A01 - 4Ws1A01 - 4TOWs1A01 = 0
Lg1A0203 - 6Ss1A01 - 6TOSs1A01 - 4Ws1A01 - 4TOWs1A01 = 0
Lg1A0709 - 6Ss1A02 - 6TOSs1A02 - 6Ws1A02 - 6TOWs1A02 = 0
Lg1A0809 - 6Ss1A02 - 6TOSs1A02 - 6Ws1A02 - 6TOWs1A02 = 0
Lg1A0910 - 6Ss1A02 - 6TOSs1A02 - 6Ws1A02 - 6TOWs1A02 = 0
Lg1A0911 - 6Ss1A02 - 6TOSs1A02 - 6Ws1A02 - 6TOWs1A02 = 0
Lg1B12 - 2Dr1B12 = 0
Lg1B13 - 2Dr1B13 = 0
Lg1B14 - 2Dr1B14 - 12Ss1B01 - 8TOSs1B01 - 12Ws1B01 - 4TOWs1B02 = 0
Lg1B15 - 2Dr1B15 = 0
Lg1B16 - 2Dr1B16 - 6Sd1B16 - 4Wd1B16 = 0
Lg1B17 - 2Dr1B17 - 6Sd1B17 - 4Wd1B17 = 0
Lg1B18 - 2Dr1B18 - 6Sd1B18 - 4Wd1B18 = 0
Lg1B19 - 2Dr1B19 - 6Sd1B19 - 4Wd1B19 = 0
Lg1B20 - 2Dr1B20 = 0
Lg1B21 - 2Dr1B21 = 0
Lg1B22 - 2Dr1B22 - 6Ss1B02 - 2TOSs1B02 - 6Ws1B02 - 2TOWs1B02 = 0
Lg1B1214 - 6Ss1B01 - 6TOSs1B01 - 4Ws1B01 - 4TOWs1B01 = 0
Lg1B1314 - 6Ss1B01 - 6TOSs1B01 - 4Ws1B01 - 4TOWs1B01 = 0
Lg1B1415 - 6Ss1B01 - 6TOSs1B01 - 4Ws1B01 - 4TOWs1B01 = 0
Lg1B2022 - 2Ss1B02 - 2TOSs1B02 - 2Ws1B02 - 2TOWs1B02 = 0
Lg1B2122 - 2Ss1B02 - 2TOSs1B02 - 2Ws1B02 - 2TOWs1B02 = 0
Lg1B14Cp - 4TOSs1B01 - 4TOWs1B01 = 0
Lg1B22Gj - 2TOSs1B02 - 2TOWs1B02 = 0
Lg1C22 - 2Dr1C22 - 22Ss1C01 - 2TOSs1C01 - 6Ws1C01 - 2TOWs1C01 = 0
Lg1C23 - 2Dr1C23 = 0
Lg1C24 - 2Dr1C24 = 0
Lg1C25 - 2Dr1C25 - 6Sd1C25 - 4Wd1C25 = 0
Lg1C26 - 2Dr1C26 - 6Sd1C26 - 4Wd1C26 = 0
Lg1C27 - 2Dr1C27 - 6Sd1C27 - 4Wd1C27 = 0
Lg1C28 - 2Dr1C28 - 6Sd1C28 - 4Wd1C28 = 0
Lg1C29 - 2Dr1C29 = 0
Lg1C31 - 2Ss1C02 - 2Ws1C02 = 0
Lg1C2223 - 8Ss1C01 - 8TOSs1C01 - 8Ws1C01 - 8TOWs1C01 = 0
Lg1C2224 - 8Ss1C01 - 8TOSs1C01 - 8Ws1C01 - 8TOWs1C01 = 0
Lg1C2931 - 8Ss1C02 - 8Ws1C02 = 0
Lg1C22Pl - 20TOSs1C01 - 4TOWs1C01 = 0
Lg1E40 - 2Dr1E40 = 0
Lg1E41 - 2Dr1E41 - 20Ss1E01 - 6TOSs1E01 - 12Ws1E01 - 6TOWs1E01 = 0
Lg1E42 - 2Dr1E42 = 0
Lg1E43 - 2Dr1E43 - 12Sd1E43 - 2TOSd1E43 - 6Wd1E43 - 2TOWd1E43 = 0
Lg1E44 - 2Dr1E44 - 12Sd1E44 - 2TOSd1E44 - 6Wd1E44 - 2TOWd1E44 = 0
Lg1E45 - 2Dr1E45 - 12Sd1E45 - 2TOSd1E45 - 6Wd1E45 - 2TOWd1E45 = 0
Lg1E4041 - 6Ss1E01 - 6TOSs1E01 - 4Ws1E01 - 4TOWs1E01 = 0
Lg1E4142 - 6Ss1E01 - 6TOSs1E01 - 4Ws1E01 - 4TOWs1E01 = 0
Lg1E41Na - 10TOSs1E01 - 6TOWs1E01 = 0
Lg1E43Ho - 4TOSd1E43 - 4TOWd1E43 = 0
Lg1E44Ma - 4TOSd1E44 - 4TOWd1E44 = 0
\Legs Flown Constraints:  S-61
Lg2D30 - 2Dr2D30 = 0
Lg2D31 - 2Dr2D31 - 10Ss2D01 - 2TOSs2D01 - 10Ws2D01 - 2TOWs2D01 = 0
Lg2D32 - 2Dr2D32 = 0
Lg2D33 - 2Dr2D33 = 0
Lg2D34 - 2Dr2D34 = 0
Lg2D35 - 2Dr2D35 - 14Ss2D02 - 6TOSs2D02 - 14Ws2D02 - 6TOWs2D02 = 0
Lg2D36 - 2Dr2D36 - 6Sd2D36 - 4Wd2D36 = 0
Lg2D37 - 2Dr2D37 - 10Sd2D37 - 4Wd2D37 = 0
Lg2D38 - 2Dr2D38 - 6Sd2D38 - 4Wd2D38 = 0
Lg2D39 - 2Dr2D39 - 6Sd2D39 - 4Wd2D39 = 0
Lg2D3031 - 16Ss2D01 - 16TOSs2D01 - 12Ws2D01 - 12TOWs2D01 = 0
Lg2D3133 - 16Ss2D01 - 16TOSs2D01 - 12Ws2D01 - 12TOWs2D01 = 0
```

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Lg2D3233 - 16Ss2D01 - 16TOSs2D01 - 12Ws2D01 - 12TOWs2D01 = 0
Lg2D3435 - 12Ss2D02 - 12TOSs2D02 - 8Ws2D02 - 8TOWs2D02 = 0
Lg2D34Br - 8TOSs2D02 - 2TOWs2D02 = 0
\Legs Flown Constraint: Twin Otter
Lg3A03 - 6TOSs1A01 - 4TOWs1A01 = 0
Lg3A09 - 8TOSs1A02 - 6TOWs1A02 = 0
Lg3B14 - 4TOSs1B01 - 2TOWs1B01 = 0
Lg3BCopp - 2TOSs1B01 - 2TOWs1B01 = 0
Lg3BGjoa - 2TOSs1B02 - 2TOWs1B02 = 0
Lg3CPell - 12TOSs1C01 - 4TOWs1C01 = 0
Lg3D31 - 6TOSs2D01 - 4TOWs2D01 = 0
Lg3DBrou - 4TOSs2D02 - 4TOWs2D02 = 0
Lg3ENain - 8TOSs1E01 - 4TOWs1E01 = 0
Lg3EHope - 4TOSd1E43 - 4TOWd1E43 = 0
Lg3EMakk - 6TOSd1E44 - 6TOWd1E44 = 0
Lg3ECart - 4TOSd1E45 - 4TOWd1E45 = 0
\Hours Used Constraint:  Bell-212
1.40Lg1A01 + 1.30Lg1A02 + 1.00Lg1A03 + 0.40Lg1A04 + 0.70Lg1A05 + 1.00Lg1A06 + 1.30Lg1A07
+ 1.93Lg1A08 + 2.10Lg1A09 + 2.35Lg1A10 + 3.51Lg1A11 + 0.80Lg1A0103 + 0.40Lg1A0203
+ 1.10Lg1A0709 + 0.50Lg1A0809 + 0.80Lg1A0910 + 1.40Lg1A0911 - Hours1A = 0
2.86Lg1B12 + 2.36Lg1B13 + 1.80Lg1B14 + 1.30Lg1B15 + 0.60Lg1B16 + 0.30Lg1B17 + 0.80Lg1B18
+ 1.10Lg1B19 + 1.60Lg1B20 + 2.00Lg1B21 + 2.50Lg1B22 + 0.90Lg1B1214 + 0.50Lg1B1314
+ 0.60Lg1B1415 + 1.00Lg1B2022 + 0.60Lg1B2122 + 0.60Lg1B14Cp + 0.60Lg1B22Gj - Hours1B = 0
2.40Lg1C22 + 2.62Lg1C23 + 1.80Lg1C24 + 1.20Lg1C25 + 0.70Lg1C26 + 0.60Lg1C27 + 1.00Lg1C28
+ 1.40Lg1C29 + 2.42Lg1C31 + 0.50Lg1C2223 + 0.90Lg1C2224 + 1.00Lg1C2931 + 1.00Lg1C22Pl
- Hours1C = 0
4.67Lg1E40 + 3.56Lg1E41 + 2.40Lg1E42 + 1.60Lg1E43 + 1.30Lg1E44 + 1.40Lg1E45 +
1.10Lg1E4041
+ 1.00Lg1E4142 + 1.30Lg1E41Na + 0.30Lg1E43Ho + 0.40Lg1E44Ma - Hours1E = 0
\Hours Used Constraint:  S-61
2.88Lg2D30 + 2.60Lg2D31 + 3.07Lg2D32 + 2.47Lg2D33 + 2.50Lg2D34 + 2.30Lg2D35 + 1.50Lg2D36
+ 1.20Lg2D37 + 1.30Lg2D38 + 1.60Lg2D39 + 0.45Lg2D3031 + 0.50Lg2D3132 + 0.90Lg2D3133
+ 0.90Lg2D3435 + 0.10Lg2D34Br - Hours2D = 0
\Hours Used Constraint:  Twin Otter
0.80Lg3A03 + 1.60Lg3A09 - 0.40Hours3A = 0
1.20Lg3B14 + 2.45Lg3BCopp + 1.50Lg3BGjoa - 0.28Hours3B = 0
1.30Lg3CPell - 0.70Hours3C = 0
2.10Lg3D31 + 1.70Lg3DBrou - 0.43Hours3D = 0
1.60Lg3ENain + 1.10Lg3EHope + 1.00Lg3EMakk - 0.53Hours3E = 0
\Max Flying Hour Req. Constraint:  Twin Otter
Hours3A - 178ON3A <= 0
Hours3B - 102ON3B <= 0
Hours3C - 53ON3C <= 0
Hours3D - 193ON3D <=0
Hours3E - 122ON3E <= 0
\Contractual Min Flying Hours Constraint
Hours1A - 300ON3A >= 0
Hours1B - 300ON3B >= 0
Hours1C - 300ON3C >= 0
Hours2D - 375ON3D >= 0
Hours1E - 300ON3E >= 0
\Open LSS Constraint
OPENA + OPENB + OPENC + OPEND + OPENE =5
BOUNDS
\Min/Max Flying Hour Req. Constraint:  Bell-212
\400 <= Hours1A <= 437
\400 <= Hours1B <= 400
\400 <= Hours1C <= 525
\417 <= Hours1E <= 526
\Min/Max Flying Hour Requirement Constraint:  S-61
\475 <= Hours2D <= 570
\The following constraints are needed only to establish an upper bound such that CPLEX
\recognizes these variables as general integer and not binary.
Dr1A01 <= 100
Dr1A02 <= 100
Dr1A03 <= 100
```

```
Dr1A04 <= 100
Dr1A05 <= 100
Dr1A06 <= 100
Dr1A07 <= 100
Dr1A08 <= 100
Dr1A09 <= 100
Dr1A10 <= 100
Dr1A11 <= 100
Ss1A01 <= 100
Ss1A02 <= 100
TOSs1A01 <= 100
TOSs1A02 <= 100
Sd1A04 <= 100
Sd1A05 <= 100
Sd1A06 <= 100
Ws1A01 <= 100
Ws1A02 <= 100
TOWs1A01 <= 100
TOWs1A02 <= 100
Wd1A04 <= 100
Wd1A05 <= 100
Wd1A06 <= 100
Dr1B12 <= 100
Dr1B13 <= 100
Dr1B14 <= 100
Dr1B15 <= 100
Dr1B16 <= 100
Dr1B17 <= 100
Dr1B18 <= 100
Dr1B19 <= 100
Dr1B20 <= 100
Dr1B21 <= 100
Ss1B01 <= 100
Ss1B02 <= 100
TOSs1B01 <= 100
TOSs1B02 <= 100
Sd1B16 <= 100
Sd1B17 <= 100
Sd1B18 <= 100
Sd1B19 <= 100
Ws1B01 <= 100
Ws1B02 <= 100
TOWs1B01 <= 100
TOWs1B02 <= 100
Wd1B16 <= 100
Wd1B17 <= 100
Wd1B18 <= 100
Wd1B19 <= 100
Dr1C22 <= 100
Dr1C23 <= 100
Dr1C24 <= 100
Dr1C25 <= 100
Dr1C26 <= 100
Dr1C27 <= 100
Dr1C28 <= 100
Dr1C29 <= 100
Ss1C01 <= 100
Ss1C02 <= 100
TOSs1C01 <= 100
Sd1C25 <= 100
Sd1C26 <= 100
Sd1C27 <= 100
Sd1C28 <= 100
Ws1C01 <= 100
Ws1C02 <= 100
TOWs1C01 <= 100
```

```
Wd1C25 <= 100
Wd1C26 <= 100
Wd1C27 <= 100
Wd1C28 <= 100
Dr2D30 <= 100
Dr2D31 <= 100
Dr2D32 <= 100
Dr2D33 <= 100
Dr2D34 <= 100
Dr2D35 <= 100
Dr2D36 <= 100
Dr2D37 <= 100
Dr2D38 <= 100
Dr2D39 <= 100
Ss2D01 <= 100
Ss2D02 <= 100
TOSs2D01 <= 100
TOSs2D02 <= 100
Sd2D36 <= 100
Sd2D37 <= 100
Sd2D38 <= 100
Sd2D39 <= 100
Ws2D01 <= 100
Ws2D02 <= 100
TOWs2D01 <= 100
TOWs2D02 <= 100
Wd2D36 <= 100
Wd2D37 <= 100
Wd2D38 <= 100
Wd2D39 <= 100
Dr1E40 <= 100
Dr1E41 <= 100
Dr1E42 <= 100
Dr1E43 <= 100
Dr1E44 <= 100
Dr1E45 <= 100
Ss1E01 <= 100
TOSs1E01 <= 100
Sd1E43 <= 100
TOSd1E43 <= 100
Sd1E44 <= 100
TOSd1E44 <= 100
Sd1E45 <= 100
TOSd1E45 <= 100
Ws1E01 <= 100
TOWs1E01 <= 100
Wd1E43 <= 100
TOWd1E43 <= 100
Wd1E44 <= 100
TOWd1E44 <= 100
Wd1E45 <= 100
TOWd1E45 <= 100
INTEGERS
ON3A ON3B ON3C ON3D ON3E OPENA OPENB OPENC OPEND OPENE
Dr1A01 Dr1A02 Dr1A03 Dr1A04 Dr1A05 Dr1A06 Dr1A07 Dr1A08 Dr1A09 Dr1A10 Dr1A11 Ss1A01
Ss1A02 TOSs1A01 TOSs1A02 Sd1A04 Sd1A05 Sd1A06 Ws1A01 Ws1A02 TOWs1A01 TOWs1A02 Wd1A04
Wd1A05 Wd1A06 Dr1B12 Dr1B13 Dr1B14 Dr1B15 Dr1B16 Dr1B17 Dr1B18 Dr1B19 Dr1B20 Dr1B21
Ss1B01 Ss1B02 TOSs1B01 TOSs1B02 Sd1B16 Sd1B17 Sd1B18 Sd1B19 Ws1B01 Ws1B02 TOWs1B01
TOWs1B02 Wd1B16 Wd1B17 Wd1B18 Wd1B19 Dr1C22 Dr1C23 Dr1C24 Dr1C25 Dr1C26 Dr1C27 Dr1C28
Dr1C29 Ss1C01 Ss1C02 TOSs1C01 Sd1C25 Sd1C26 Sd1C27 Sd1C28 Ws1C01 Ws1C02 TOWs1C01 Wd1C25
Wd1C26 Wd1C27 Wd1C28 Dr2D30 Dr2D31 Dr2D32 Dr2D33 Dr2D34 Dr2D35 Dr2D36 Dr2D37 Dr2D38
Dr2D39 Ss2D01 Ss2D02 TOSs2D01 TOSs2D02 Sd2D36 Sd2D37 Sd2D38 Sd2D39 Ws2D01 Ws2D02 TOWs2D01
TOWs2D02 Wd2D36 Wd2D37 Wd2D38 Wd2D39 Dr1E40 Dr1E41 Dr1E42 Dr1E43 Dr1E44 Dr1E45 Ss1E01
TOSs1E01 Sd1E43 TOSd1E43 Sd1E44 TOSd1E44 Sd1E45 TOSd1E45 Ws1E01 TOWs1E01 Wd1E43 TOWd1E43
Wd1E44 TOWd1E44 Wd1E45 TOWd1E45
END
```

Appendix E

This appendix provides the solution output for the Base Model mixed integer linear programming formulation provided in Appendix D.

```
PROBLEM NAME      BModeNow4
DATA     NAME
OBJECTIVE VALUE   1.772689E+07
STATUS            OPTIMAL SOLN
ITERATION         0

OBJECTIVE         obj                     (MIN)
RHS               rhs
RANGES
BOUNDS
```

SECTION 1 - ROWS

NUMBER	......ROW.......	AT	...ACTIVITY...	SLACK ACTIVITY	..LOWER LIMIT.	..UPPER LIMIT.	.DUAL ACTIVITY
1	obj	BS	1.772689E+07	-1.772689E+07	NONE	NONE	1
2	c1	LL	7	0	7	NONE	-7448
3	c2	LL	11	0	11	NONE	-6916
4	c3	LL	19	0	19	NONE	-5320
5	c4	LL	11	0	11	NONE	-2128
6	c5	LL	13	0	13	NONE	-3724
7	c6	LL	11	0	11	NONE	-5320
8	c7	LL	11	0	11	NONE	-6916
9	c8	LL	7	0	7	NONE	-10267.6
10	c9	LL	12	0	12	NONE	-11172
11	c10	LL	10	0	10	NONE	-12502
12	c11	LL	8	0	8	NONE	-18673.2
13	c12	LL	9	0	9	NONE	-15672.8
14	c13	LL	9	0	9	NONE	-12932.8
15	c14	LL	17	0	17	NONE	-9864
16	c15	LL	10	0	10	NONE	-7124
17	c16	LL	10	0	10	NONE	-3288
18	c17	LL	9	0	9	NONE	-1644
19	c18	LL	11	0	11	NONE	-4384
20	c19	LL	9	0	9	NONE	-6028
21	c20	LL	10	0	10	NONE	-8768
22	c21	LL	9	0	9	NONE	-10960
23	c22	LL	21	0	21	NONE	-13152
24	c23	LL	12	0	12	NONE	-14357.6
25	c24	LL	12	0	12	NONE	-9864
26	c25	LL	20	0	20	NONE	-6576
27	c26	LL	14	0	14	NONE	-3836
28	c27	LL	12	0	12	NONE	-3288
29	c28	LL	11	0	11	NONE	-5480
30	c29	LL	12	0	12	NONE	-7672
31	c30	LL	8	0	8	NONE	-26161.92
32	c31	LL	13	0	13	NONE	-23618.4
33	c32	LL	8	0	8	NONE	-27887.88
34	c33	LL	8	0	8	NONE	-22437.48
35	c34	LL	7	0	7	NONE	-22710
36	c35	LL	12	0	12	NONE	-20893.2
37	c36	LL	9	0	9	NONE	-13626
38	c37	LL	18	0	18	NONE	-10900.8
39	c38	LL	9	0	9	NONE	-11809.2
40	c39	LL	9	0	9	NONE	-14534.4
41	c40	LL	9	0	9	NONE	-23163.2

	42	c41	LL	19	0	19	NONE	-17657.6
	43	c42	LL	10	0	10	NONE	-11904
	44	c43	LL	17	0	17	NONE	-7936
	45	c44	LL	11	0	11	NONE	-6448
	46	c45	LL	11	0	11	NONE	-6944
	47	c46	LL	2	0	2	NONE	-21508
	48	c47	LL	2	0	2	NONE	-2128
	49	c48	LL	2	0	2	NONE	-3724
	50	c49	LL	2	0	2	NONE	-5320
	51	c50	LL	2	0	2	NONE	-53861.2
	52	c51	LL	2	0	2	NONE	-46470.4
	53	c52	LL	2	0	2	NONE	-6576
	54	c53	LL	2	0	2	NONE	-3288
	55	c54	LL	2	0	2	NONE	-8768
	56	c55	LL	2	0	2	NONE	-12056
	57	c56	LL	2	0	2	NONE	-16153
	58	c57	LL	2	0	2	NONE	-89346.4
	59	c58	LL	2	0	2	NONE	-13152
	60	c59	LL	2	0	2	NONE	-7672
	61	c60	LL	2	0	2	NONE	-6576
	62	c61	LL	2	0	2	NONE	-10960
	63	c62	LL	2	0	2	NONE	-27509.6
	64	c63	LL	2	0	2	NONE	-49310.62
	65	c64	LL	2	0	2	NONE	-86707.79
	66	c65	LL	2	0	2	NONE	-27252
	67	c66	LL	2	0	2	NONE	-43603.2
	68	c67	LL	2	0	2	NONE	-23618.4
	69	c68	LL	2	0	2	NONE	-29068.8
	70	c69	LL	2	0	2	NONE	-86558.64
	71	c70	LL	2	0	2	NONE	-10821.28
	72	c71	LL	2	0	2	NONE	-14666.11
	73	c72	BS	9	-7	2	NONE	0
	74	c73	LL	2	0	2	NONE	-11324
	75	c74	LL	2	0	2	NONE	-2128
A	76	c75	LL	2	0	2	NONE	-0
	77	c76	LL	2	0	2	NONE	-5320
	78	c77	LL	2	0	2	NONE	-35089.2
	79	c78	BS	2	-0	2	NONE	0
	80	c79	LL	2	0	2	NONE	-7539.9
	81	c80	LL	2	0	2	NONE	-3288
	82	c81	LL	2	0	2	NONE	-1644
	83	c82	LL	2	0	2	NONE	-4384
	84	c83	LL	2	0	2	NONE	-6028
	85	c84	LL	2	0	2	NONE	-30140
	86	c85	LL	2	0	2	NONE	-26786.4
	87	c86	LL	2	0	2	NONE	-6576
	88	c87	LL	2	0	2	NONE	-3836
	89	c88	LL	2	0	2	NONE	-3288
	90	c89	LL	2	0	2	NONE	-5480
	91	c90	LL	2	0	2	NONE	-27509.6
	92	c91	LL	2	0	2	NONE	-15553.59
	93	c92	LL	2	0	2	NONE	-67631.39
	94	c93	LL	2	0	2	NONE	-13626
	95	c94	LL	2	0	2	NONE	-10900.8
	96	c95	LL	2	0	2	NONE	-11809.2
	97	c96	LL	2	0	2	NONE	-14534.4
	98	c97	LL	2	0	2	NONE	-51835.32
	99	c98	LL	2	0	2	NONE	-10821.28
	100	c99	LL	2	0	2	NONE	-12896
A	101	c100	LL	2	0	2	NONE	-0
	102	c101	EQ	0	0	0	0	-3724
	103	c102	EQ	0	0	0	0	-3458
	104	c103	EQ	0	0	0	0	-2660
	105	c104	EQ	0	0	0	0	-1064
	106	c105	EQ	0	0	0	0	-1862
	107	c106	EQ	0	0	0	0	-2660
	108	c107	EQ	0	0	0	0	-3458
	109	c108	EQ	0	0	0	0	-5133.8
	110	c109	EQ	0	0	0	0	-5586
	111	c110	EQ	0	0	0	0	-6251
	112	c111	EQ	0	0	0	0	-9336.6
	113	c112	EQ	0	0	0	0	-2128
	114	c113	EQ	0	0	0	0	-1064
	115	c114	EQ	0	0	0	0	-2926

	116	c115	EQ	0	0	0	0	-1330
	117	c116	EQ	0	0	0	0	-2128
	118	c117	EQ	0	0	0	0	-3724
	119	c118	EQ	0	0	0	0	-7836.4
	120	c119	EQ	0	0	0	0	-6466.4
	121	c120	EQ	0	0	0	0	-4932
	122	c121	EQ	0	0	0	0	-3562
	123	c122	EQ	0	0	0	0	-1644
	124	c123	EQ	0	0	0	0	-822
	125	c124	EQ	0	0	0	0	-2192
	126	c125	EQ	0	0	0	0	-3014
	127	c126	EQ	0	0	0	0	-4384
	128	c127	EQ	0	0	0	0	-5480
	129	c128	EQ	0	0	0	0	-6850
	130	c129	EQ	0	0	0	0	-2466
	131	c130	EQ	0	0	0	0	-1370
	132	c131	EQ	0	0	0	0	-1644
	133	c132	EQ	0	0	0	0	-2740
	134	c133	EQ	0	0	0	0	-1644
	135	c134	EQ	0	0	0	0	-1644
	136	c135	EQ	0	0	0	0	-1644
	137	c136	EQ	0	0	0	0	-6576
	138	c137	EQ	0	0	0	0	-7178.8
	139	c138	EQ	0	0	0	0	-4932
	140	c139	EQ	0	0	0	0	-3288
	141	c140	EQ	0	0	0	0	-1918
	142	c141	EQ	0	0	0	0	-1644
	143	c142	EQ	0	0	0	0	-2740
	144	c143	EQ	0	0	0	0	-3836
	145	c144	EQ	0	0	0	0	-6630.8
	146	c145	EQ	0	0	0	0	-1370
	147	c146	EQ	0	0	0	0	-2466
	148	c147	EQ	0	0	0	0	-2740
	149	c148	EQ	0	0	0	0	-2740
	150	c149	EQ	0	0	0	0	-11581.6
	151	c150	EQ	0	0	0	0	-8828.8
	152	c151	EQ	0	0	0	0	-5952
	153	c152	EQ	0	0	0	0	-3968
	154	c153	EQ	0	0	0	0	-3224
	155	c154	EQ	0	0	0	0	-3472
	156	c155	EQ	0	0	0	0	-2728
	157	c156	EQ	0	0	0	0	-2480
	158	c157	EQ	0	0	0	0	-3224
	159	c158	EQ	0	0	0	0	-744
	160	c159	EQ	0	0	0	0	-992
	161	c160	EQ	0	0	0	0	-13080.96
	162	c161	EQ	0	0	0	0	-11809.2
	163	c162	EQ	0	0	0	0	-13943.94
	164	c163	EQ	0	0	0	0	-11218.74
	165	c164	EQ	0	0	0	0	-11355
	166	c165	EQ	0	0	0	0	-10446.6
	167	c166	EQ	0	0	0	0	-6813
	168	c167	EQ	0	0	0	0	-5450.4
	169	c168	EQ	0	0	0	0	-5904.6
	170	c169	EQ	0	0	0	0	-7267.2
	171	c170	EQ	0	0	0	0	-2043.9
	172	c171	EQ	0	0	0	0	-4087.8
A	173	c172	EQ	0	0	0	0	-0
	174	c173	EQ	0	0	0	0	-4087.8
	175	c174	EQ	0	0	0	0	-454.2
	176	c175	EQ	0	0	0	0	-1900
	177	c176	EQ	0	0	0	0	-3800
	178	c177	EQ	0	0	0	0	-4050
	179	c178	EQ	0	0	0	0	-8268.75
	180	c179	EQ	0	0	0	0	-5062.5
	181	c180	EQ	0	0	0	0	-2340
	182	c181	EQ	0	0	0	0	-4615.116
	183	c182	EQ	0	0	0	0	-3736.047
	184	c183	EQ	0	0	0	0	-2852.83
	185	c184	EQ	0	0	0	0	-1961.321
	186	c185	EQ	0	0	0	0	-1783.019
A	187	c186	EQ	0	0	0	0	-0
	188	c187	EQ	0	0	0	0	2660
	189	c188	EQ	0	0	0	0	2740

190	c189	EQ	0	0	0	0	2740
191	c190	EQ	0	0	0	0	2480
192	c191	EQ	0	0	0	0	4542
193	c192	EQ	0	0	0	0	2375
194	c193	EQ	0	0	0	0	3375
195	c194	EQ	0	0	0	0	1800
196	c195	EQ	0	0	0	0	2197.674
197	c196	EQ	0	0	0	0	1783.019
198	c197	BS	-26	26	NONE	0	-0
199	c198	BS	-28.42857	28.42857	NONE	0	-0
200	c199	BS	-1	1	NONE	0	-0
201	c200	BS	-32.06977	32.06977	NONE	0	-0
202	c201	BS	-2	2	NONE	0	-0
203	c202	BS	95.66	-95.66	0	NONE	0
204	c203	BS	85.4	-85.4	0	NONE	0
205	c204	BS	189.68	-189.68	0	NONE	0
206	c205	BS	179.76	-179.76	0	NONE	0
207	c206	BS	188.74	-188.74	0	NONE	0
208	c207	BS	5	0	5	5	-0

SECTION 2 - COLUMNS

NUMBER	.....COLUMN.....	AT	...ACTIVITY...	..INPUT COST..	..LOWER LIMIT.	..UPPER LIMIT.	.REDUCED COST.
209	Hours1A	BS	395.66	2660	0	NONE	0
210	Hours3A	BS	152	950	0	NONE	0
211	Hours1B	BS	385.4	2740	0	NONE	0
212	Hours3B	BS	73.57143	945	0	NONE	0
213	Hours1C	BS	489.68	2740	0	NONE	0
214	Hours3C	BS	52	1260	0	NONE	0
215	Hours2D	BS	554.76	4542	0	NONE	0
216	Hours3D	BS	160.9302	945	0	NONE	0
217	Hours1E	BS	488.74	2480	0	NONE	0
218	Hours3E	BS	120	945	0	NONE	0
219	OPENA	EQ	1	1000000	1	1	1000000
220	OPENB	EQ	1	3500000	1	1	3500000
221	OPENC	EQ	1	3500000	1	1	3500000
222	OPEND	EQ	1	1000000	1	1	1000000
223	OPENE	EQ	1	1000000	1	1	1000000
224	Dr1A01	BS	3	0	3	3	0
225	Ss1A01	EQ	0	0	0	0	9880
226	TOSs1A01	BS	2	0	2	2	0
227	Ws1A01	EQ	0	0	0	0	3040
228	TOWs1A01	BS	2	0	2	2	0
229	Dr1A02	BS	7	0	7	7	0
230	Dr1A03	BS	15	0	15	15	0
231	Dr1A04	BS	7	0	7	7	0
232	Sd1A04	BS	2	0	2	2	0
233	Wd1A04	BS	2	0	2	2	0
234	Dr1A05	BS	9	0	9	9	0
235	Sd1A05	BS	2	0	2	2	0
236	Wd1A05	BS	2	0	2	2	0
237	Dr1A06	BS	7	0	7	7	0
238	Sd1A06	BS	2	0	2	2	0
239	Wd1A06	BS	2	0	2	2	0
240	Dr1A07	BS	7	0	7	7	0
241	Ss1A02	EQ	0	0	0	0	36632
242	TOSs1A02	BS	2	0	2	2	0
243	Ws1A02	EQ	0	0	0	0	21888
244	TOWs1A02	BS	2	0	2	2	0
245	Dr1A08	BS	3	0	3	3	0
246	Dr1A09	BS	8	0	8	8	0
247	Dr1A10	BS	6	0	6	6	0
248	Dr1A11	BS	4	0	4	4	0
249	Dr1B12	BS	5	0	5	5	0
250	Ss1B01	BS	2	0	2	2	0
251	TOSs1B01	EQ	0	0	0	0	19585.5
252	Ws1B01	EQ	0	0	0	0	27970.5
253	TOWs1B01	BS	2	0	2	2	0
254	Dr1B13	BS	5	0	5	5	0
255	Dr1B14	BS	13	0	13	13	0
256	Dr1B15	BS	6	0	6	6	0
257	Dr1B16	BS	6	0	6	6	0
258	Sd1B16	BS	2	0	2	2	0

259	Wd1B16	BS	2	0	2	2	0
260	Dr1B17	BS	5	0	5	5	0
261	Sd1B17	BS	2	0	2	2	0
262	Wd1B17	BS	2	0	2	2	0
263	Dr1B18	BS	7	0	7	7	0
264	Sd1B18	BS	2	0	2	2	0
265	Wd1B18	BS	2	0	2	2	0
266	Dr1B19	BS	5	0	5	5	0
267	Sd1B19	BS	2	0	2	2	0
268	Wd1B19	BS	2	0	2	2	0
269	Dr1B20	BS	6	0	6	6	0
270	Ss1B02	EQ	0	0	0	0	13987
271	TOSs1B02	BS	2	0	2	2	0
272	Ws1B02	BS	2	0	2	2	0
273	TOWs1B02	EQ	0	0	0	0	5741
274	Dr1B21	BS	5	0	5	5	0
275	Dr1C22	BS	17	0	17	17	0
276	Ss1C01	EQ	0	0	0	0	48640
277	TOSs1C01	BS	2	0	2	2	0
278	Ws1C01	EQ	1	0	1	1	5984
279	TOWs1C01	BS	1	0	1	1	0
280	Dr1C23	BS	8	0	8	8	0
281	Dr1C24	BS	8	0	8	8	0
282	Dr1C25	BS	16	0	16	16	0
283	Sd1C25	BS	2	0	2	2	0
284	Wd1C25	BS	2	0	2	2	0
285	Dr1C26	BS	10	0	10	10	0
286	Sd1C26	BS	2	0	2	2	0
287	Wd1C26	BS	2	0	2	2	0
288	Dr1C27	BS	8	0	8	8	0
289	Sd1C27	BS	2	0	2	2	0
290	Wd1C27	BS	2	0	2	2	0
291	Dr1C28	BS	7	0	7	7	0
292	Sd1C28	BS	2	0	2	2	0
293	Wd1C28	BS	2	0	2	2	0
294	Dr1C29	BS	8	0	8	8	0
295	Ss1C02	BS	2	0	2	2	0
296	Ws1C02	BS	2	0	2	2	0
297	Dr2D30	BS	4	0	4	4	0
298	Ss2D01	EQ	0	0	0	0	66782.9
299	TOSs2D01	BS	2	0	2	2	0
300	Ws2D01	EQ	0	0	0	0	76013.13
301	TOWs2D01	BS	2	0	2	2	0
302	Dr2D31	BS	9	0	9	9	0
303	Dr2D32	BS	4	0	4	4	0
304	Dr2D33	BS	4	0	4	4	0
305	Dr2D34	BS	3	0	3	3	0
306	Ss2D02	EQ	0	0	0	0	64995.01
307	TOSs2D02	BS	2	0	2	2	0
308	Ws2D02	EQ	0	0	0	0	67720.21
309	TOWs2D02	BS	2	0	2	2	0
310	Dr2D35	BS	8	0	8	8	0
311	Dr2D36	BS	5	0	5	5	0
312	Sd2D36	BS	2	0	2	2	0
313	Wd2D36	BS	2	0	2	2	0
314	Dr2D37	BS	14	0	14	14	0
315	Sd2D37	BS	2	0	2	2	0
316	Wd2D37	BS	2	0	2	2	0
317	Dr2D38	BS	5	0	5	5	0
318	Sd2D38	BS	2	0	2	2	0
319	Wd2D38	BS	2	0	2	2	0
320	Dr2D39	BS	5	0	5	5	0
321	Sd2D39	BS	2	0	2	2	0
322	Wd2D39	BS	2	0	2	2	0
323	Dr1E40	BS	5	0	5	5	0
324	Ss1E01	EQ	0	0	0	0	68540.56
325	TOSs1E01	BS	2	0	2	2	0
326	Ws1E01	EQ	0	0	0	0	22217.48
327	TOWs1E01	BS	2	0	2	2	0
328	Dr1E41	BS	15	0	15	15	0
329	Dr1E42	BS	6	0	6	6	0
330	Dr1E43	BS	13	0	13	13	0
331	Sd1E43	EQ	0	0	0	0	28858.72
332	TOSd1E43	BS	2	0	2	2	0

	333	Wd1E43	EQ	1	0	1	1	5050.717
	334	TOWd1E43	BS	1	0	1	1	0
	335	Dr1E44	BS	7	0	7	7	0
	336	Sd1E44	EQ	0	0	0	0	17573.89
	337	TOSd1E44	BS	2	0	2	2	0
	338	Wd1E44	BS	2	0	2	2	0
	339	TOWd1E44	EQ	0	0	0	0	1770.113
A	340	Dr1E45	EQ	0	0	0	0	0
	341	Sd1E45	EQ	0	0	0	0	34720
	342	TOSd1E45	BS	9	0	9	9	0
	343	Wd1E45	EQ	0	0	0	0	13888
	344	TOWd1E45	BS	2	0	2	2	0
	345	Lg1A01	BS	6	0	0	NONE	0
	346	Lg1A02	BS	14	0	0	NONE	0
	347	Lg1A03	BS	46	0	0	NONE	0
	348	Lg1A04	BS	30	0	0	NONE	0
	349	Lg1A05	BS	30	0	0	NONE	0
	350	Lg1A06	BS	30	0	0	NONE	0
	351	Lg1A07	BS	14	0	0	NONE	0
	352	Lg1A08	BS	6	0	0	NONE	0
	353	Lg1A09	BS	28	0	0	NONE	0
	354	Lg1A10	BS	12	0	0	NONE	0
	355	Lg1A11	BS	8	0	0	NONE	0
	356	Lg1A0103	BS	20	0	0	NONE	0
	357	Lg1A0203	BS	20	0	0	NONE	0
	358	Lg1A0709	BS	24	0	0	NONE	0
	359	Lg1A0809	BS	24	0	0	NONE	0
	360	Lg1A0910	BS	24	0	0	NONE	0
	361	Lg1A0911	BS	24	0	0	NONE	0
	362	Lg1B12	BS	10	0	0	NONE	0
	363	Lg1B13	BS	10	0	0	NONE	0
	364	Lg1B14	BS	50	0	0	NONE	0
	365	Lg1B15	BS	12	0	0	NONE	0
	366	Lg1B16	BS	32	0	0	NONE	0
	367	Lg1B17	BS	30	0	0	NONE	0
	368	Lg1B18	BS	34	0	0	NONE	0
	369	Lg1B19	BS	30	0	0	NONE	0
	370	Lg1B20	BS	12	0	0	NONE	0
	371	Lg1B21	BS	10	0	0	NONE	0
	372	Lg1B22	BS	16	0	0	NONE	0
	373	Dr1B22	LL	0	0	0	NONE	13700
	374	Lg1B1214	BS	20	0	0	NONE	0
	375	Lg1B1314	BS	20	0	0	NONE	0
	376	Lg1B1415	BS	20	0	0	NONE	0
	377	Lg1B2022	BS	8	0	0	NONE	0
	378	Lg1B2122	BS	8	0	0	NONE	0
	379	Lg1B14Cp	BS	8	0	0	NONE	0
	380	Lg1B22Gj	BS	4	0	0	NONE	0
	381	Lg1C22	BS	46	0	0	NONE	0
	382	Lg1C23	BS	16	0	0	NONE	0
	383	Lg1C24	BS	16	0	0	NONE	0
	384	Lg1C25	BS	52	0	0	NONE	0
	385	Lg1C26	BS	40	0	0	NONE	0
	386	Lg1C27	BS	36	0	0	NONE	0
	387	Lg1C28	BS	34	0	0	NONE	0
	388	Lg1C29	BS	16	0	0	NONE	0
	389	Lg1C31	BS	8	0	0	NONE	0
	390	Lg1C2223	BS	32	0	0	NONE	0
	391	Lg1C2224	BS	32	0	0	NONE	0
	392	Lg1C2931	BS	32	0	0	NONE	0
	393	Lg1C22Pl	BS	44	0	0	NONE	0
	394	Lg1E40	BS	10	0	0	NONE	0
	395	Lg1E41	BS	54	0	0	NONE	0
	396	Lg1E42	BS	12	0	0	NONE	0
	397	Lg1E43	BS	38	0	0	NONE	0
	398	Lg1E44	BS	30	0	0	NONE	0
	399	Lg1E45	BS	22	0	0	NONE	0
	400	Lg1E4041	BS	20	0	0	NONE	0
	401	Lg1E4142	BS	20	0	0	NONE	0
	402	Lg1E41Na	BS	32	0	0	NONE	0
	403	Lg1E43Ho	BS	12	0	0	NONE	0
	404	Lg1E44Ma	BS	8	0	0	NONE	0
	405	Lg2D30	BS	8	0	0	NONE	0
	406	Lg2D31	BS	26	0	0	NONE	0

	407	Lg2D32	BS	8	0	0	NONE	0
	408	Lg2D33	BS	8	0	0	NONE	0
	409	Lg2D34	BS	6	0	0	NONE	0
	410	Lg2D35	BS	40	0	0	NONE	0
	411	Lg2D36	BS	30	0	0	NONE	0
	412	Lg2D37	BS	56	0	0	NONE	0
	413	Lg2D38	BS	30	0	0	NONE	0
	414	Lg2D39	BS	30	0	0	NONE	0
	415	Lg2D3031	BS	56	0	0	NONE	0
	416	Lg2D3133	BS	56	0	0	NONE	0
	417	Lg2D3233	BS	56	0	0	NONE	0
	418	Lg2D3435	BS	40	0	0	NONE	0
	419	Lg2D34Br	BS	20	0	0	NONE	0
	420	Lg3A03	BS	20	0	0	NONE	0
	421	Lg3A09	BS	28	0	0	NONE	0
	422	Lg3B14	BS	4	0	0	NONE	0
	423	Lg3BCopp	BS	4	0	0	NONE	0
	424	Lg3BGjoa	BS	4	0	0	NONE	0
	425	Lg3CPell	BS	28	0	0	NONE	0
	426	Lg3D31	BS	20	0	0	NONE	0
	427	Lg3DBrou	BS	16	0	0	NONE	0
	428	Lg3ENain	BS	24	0	0	NONE	0
	429	Lg3EHope	BS	12	0	0	NONE	0
	430	Lg3EMakk	BS	12	0	0	NONE	0
	431	Lg3ECart	BS	44	0	0	NONE	0
	432	Lg2D3132	LL	0	0	0	NONE	2271
A	433	ON3A	EQ	1	0	1	1	0
A	434	ON3B	EQ	1	0	1	1	0
A	435	ON3C	EQ	1	0	1	1	0
A	436	ON3D	EQ	1	0	1	1	0
A	437	ON3E	EQ	1	0	1	1	0

Appendix F

This appendix provides the variable listing and definitions for the Expanded Model formulation.

Expanded Model Formulation -- Variable List

This is the base formulation using current aircraft and allowing zone expansion.

General Variable Definition:

Hours(m,i): The number of hours flown by transportation mode *m* in zone *i*.

Lg(m,i/j,j): A one-way trip between two sites using transportation mode *m*.

Sd(m,i,j): A summer routing from LSS *i* to site j using transportation mode *m* in order to accomplish a summer PMI.

Ss(m,i,n): A summer routing originating from LSS *i* using transportation mode *m* which visits an LRR and several SRRs to accomplish a summer PMI.

TOSs(m,i,n): A summer routing aided by the use of the fixed-wing Twin Otter originating from LSS *i* using transportation mode *m* which visits an LRR and several SRRs to accomplish a summer PMI

TOSd(m,i,j): A summer routing from LSS *i* to site *j* using transportation mode *m* aided by the use of the fixed-wing Twin Otter.

Wd(m,i,j): A winter routing from LSS *i* to site *j* using transportation mode *m* in order to accomplish a winter PMI.

Ws(m,i,n): A winter routing originating from LSS *i* using transportation mode *m* which visits an LRR and several SRRs to accomplish a winter PMI.

TOWs(m,i,n): A winter routing aided by the use of the fixed-wing Twin Otter originating from LSS *i* using transportation mode *m* which visits an LRR and several SRRs to accomplish a summer PMI

TOWd(m,i,j): A winter routing from LSS *i* to site *j* using transportation mode *m* aided by the use of the fixed-wing Twin Otter.

Dr(m,i/j,j): A routing between two sites using transportation mode *m*.

ON(m,i): A binary variable to signify the use of transportation mode *m* in zone *i*.

ASSIGN(i, j): A binary variable to signify that site j is being serviced in zone i.

o/b: out and back

Indices

m:	1	Bell-212
	2	S-61N
	3	Twin Otter
j:	01	SRR Komokuk Beach/Bar-1
	02	SRR Stokes Point/Bar-B
	03	LRR Shingle Point/Bar-2
	04	SRR Storm Hills/Bar-BA3
	05	SRR Tuktoyaktuk/Bar-3

i:	A	Inuvik
	B	Cambridge Bay
	C	Hall Beach
	D	Iqaluit
	E	Goose Bay

06 SRR Liverpool Bay/Bar-DA1
07 SRR Nicholson Island/Bar-4
08 SRR Horton River/Bar-E
09 LRR Cape Parry/Pin-M
10 SRR Keats Point/Pin-1BD
11 SRR Croker River/Pin-1BG
12 SRR Harding River/Pin-2A
13 SRR Bernard Harbour/Pin-CB
14 LRR Lady Franklin Point/Pin-3
15 SRR Edinburgh Island/Pin-DA
16 SRR Cape Peel West/Pin-EB
17 SRR Sturt Point North/CAM-A3A
18 SRR Jenny Lind Island/Cam-1A
19 SRR Hat Island/Cam-B
20 SRR Gladman Point/Cam-2
21 SRR Gjoa Haven/Cam-CB
22 LRR Sheperd Bay/Cam-3
23 SRR Simpson Lake/Cam-D
24 SRR Pelly Bay/Cam-4
25 SRR Cape McLoughlin/Cam-5A
26 SRR Lailor River/Cam-FA
27 SRR Rowley Island/Fox-1
28 SRR Bray Island/Fox-A
29 SRR Longstaff Bluff/Fox-2
30 SRR Nadluardjuk Lake/Fox-B
31 LRR Dewar Lakes/Fox-3
32 SRR Kangok Fiord/Fox-CA
33 SRR Cape Hooper/Fox-4
34 SRR Broughton Island/Fox-5
35 LRR Cape Dyer/Dye-M
36 SRR Cape Mercy/Baf-2
37 LRR Brevoort Island/Baf-3
38 SRR Loks Land/Baf-4A
39 SRR Resolution Island/Baf-5
40 SRR Cape Kakiviak/Lab-1
41 LRR Saglek Bay/Lab-2
42 SRR Cape Kiglapait/Lab-3
43 SRR Big Bay/Lab-4
44 SRR Tukialik Bay/Lab-5
45 SRR Cartwright/Lab-6

Zone One -- Inuvik

Dr1A01: A routing between LSS Inuvik and SRR Komokuk Beach/Bar-1
Dr1A02: A routing between LSS Inuvik and SRR Stokes Point/Bar-B
Dr1A03: A routing between LSS Inuvik and LRR Shingle Point/Bar-2
Dr1A04: A routing between LSS Inuvik and SRR Storm Hills/Bar-BA3
Dr1A05: A routing between LSS Inuvik and SRR Tuktoyaktuk/Bar-3
Dr1A06: A routing between LSS Inuvik and SRR Liverpool Bay/Bar-DA1
Dr1A07: A routing between LSS Inuvik and SRR Nicholson Island/Bar-4
Dr1A08: A routing between LSS Inuvik and SRR Horton River/Bar-E
Dr1A09: A routing between LSS Inuvik and LRR Cape Parry/Pin-M
Dr1A10: A routing between LSS Inuvik and SRR Keats Point/Pin-1BD
Dr1A11: A routing between LSS Inuvik and SRR Croker River/Pin-1BG
Dr1A12: A routing between LSS Inuvik and SRR Harding River/Pin-2A
Dr1A13: A routing between LSS Inuvik and SRR Bernard Harbour/Pin-CB
Dr1A14: A routing between LSS Inuvik and LRR Lady Frankling Point/Pin-3
Dr1A15: A routing between LSS Inuvik and SRR Edingburgh Island/Pin-DA
Dr1A16: A routing between LSS Inuvik and SRR Cape Peel West/Pin-EB
Dr1AB: A routing between LSS Inuvik and LRR Cambridge Bay/Cam-M

Lg1A01: A one-way trip between LSS Inuvik and SRR Komokuk Beach/Bar-1
Lg1A02: A one-way trip between LSS Inuvik and SRR Stokes Point/Bar-B
Lg1A03: A one-way trip between LSS Inuvik and LRR Shingle Point/Bar-2
Lg1A04: A one-way trip between LSS Inuvik and SRR Storm Hills/Bar-BA3
Lg1A05: A one-way trip between LSS Inuvik and SRR Tuktoyaktuk/Bar-3

Lg1A06: A one-way trip between LSS Inuvik and SRR Liverpool Bay/Bar-DA1
Lg1A07: A one-way trip between LSS Inuvik and SRR Nicholson Island/Bar-4
Lg1A08: A one-way trip between LSS Inuvik and SRR Horton River/Bar-E
Lg1A09: A one-way trip between LSS Inuvik and LRR Cape Parry/Pin-M
Lg1A10: A one-way trip between LSS Inuvik and SRR Keats Point/Pin-1BD
Lg1A11: A one-way trip between LSS Inuvik and SRR Croker River/Pin-1BG
Lg1A12: A one-way trip between LSS Inuvik and SRR Harding River/Pin-2A
Lg1A13: A one-way trip between LSS Inuvik and SRR Bernard Harbour/Pin-CB
Lg1A14: A one-way trip between LSS Inuvik and LRR Lady Frankling Point/Pin-3
Lg1A15: A one-way trip between LSS Inuvik and SRR Edingburgh Island/Pin-DA
Lg1A16: A one-way trip between LSS Inuvik and SRR Cape Peel West/Pin-EB
Lg1AB: A one-way trip between LSS Inuvik and LRR Cambridge Bay/Cam-M

Lg1A0103: A one-way trip between SRR Komokuk Beach/Bar-1 and LRR Shingle Point/Bar-2
Lg1A0203: A one-way trip between SRR Stokes Point/Bar-B and LRR Shingle Point/Bar-2
Lg1A0709: A one-way trip between SRR Nicholson Island/Bar-4 and LRR Cape Parry/Pin-M
Lg1A0809: A one-way trip between SRR Horton River/Bar-E and LRR Cape Parry/Pin-M
Lg1A0910: A one-way trip between LRR Cape Parry/Pin-M and SRR Keats Point/Pin-1BD
Lg1A0911: A one-way trip between LRR Cape Parry/Pin-M and SRR Croker River/Pin-1BG
Lg1A1214: A one-way trip between LRR Lady Franklin Point/Pin-3 and SRR Harding River/Pin-2A
Lg1A1314: A one-way trip between SRR Bernard Harbour/Pin-CB and LRR Lady Franklin Point/Pin-2A
Lg1A1415: A one-way trip between LRR Lady Franklin Point/Pin-2A and SRR Edinburgh Island/Pin-DA

Lg1A14Cp: A one-way trip between LRR Lady Franklin Point/Pin-3 and Coppermine

Lg3A03: A one-way TO trip between LSS Inuvik and LRR Shingle Point/Bar-2
Lg3A09: A one-way TO trip between LSS Inuvik and LRR Cape Parry/Pin-M
Lg3ACopp: A one-way TO trip between LSS Inuvik and Coppermine

Ss1A01: A summer routing which includes --
6 trips o/b between LSS Inuvik and LRR Shingle Point/Bar-2 (A/03)
3 trips o/b between LRR Shingle Point/Bar-2 and SRR Stokes Point/Bar-B (02/03)
3 trips o/b between LRR Shingle Point/Bar-2 and SRR Komokuk Beach/Bar-1 (01/03)

Ss1A02: A summer routing which includes --
8 trips o/b between LSS Inuvik and LRR Cape Parry/Pin-M (A/09)
3 trips o/b between LRR Cape Parry/Pin-M and SRR Nicholson Island/Bar-4 (07/09)
3 trips o/b between LRR Cape Parry/Pin-M and SRR Horton River/Bar-E (08/09)
3 trips o/b between LRR Cape Parry/Pin-M and SRR Keats Point/Pin-1BD (09/10)
3 trips o/b between LRR Cape Parry/Pin-M and SRR Croker River/Pin-1BG (09/11)

Ss1A03: A summer routing which includes --
6 trips o/b between LSS Inuvik and LRR Lady Franklin Point/Pin-3 (A/14)
3 trips o/b between LRR Lady Franklin Point/Pin-3 and SRR Harding River/Pin-2A (12/14)
3 trips o/b between LRR Lady Franklin Point/Pin-3 and SRR Bernard Harbour/Pin-CB (13/14)
3 trips o/b between LRR Lady Franklin Point/Pin-3 and SRR Edinburgh Island/Pin-DA (14/15)

TOSs1A01: A summer routing which includes --
3 TO trips o/b between LSS Inuvik and LRR Shingle Point/Bar-2 (TO A/03)
2 trips o/b between LSS Inuvik and LRR Shingle Point/Bar-2 (A/03)
3 trips o/b between LRR Shingle Point/Bar-2 and SRR Stokes Point/Bar-B (02/03)
3 trips o/b between LRR Shingle Point/Bar-2 and SRR Komokuk Beach/Bar-1 (01/03)

TOSs1A02: A summer routing which includes --
4 TO trips o/b between LSS Inuvik and LRR Cape Parry/Pin-M (TO A/09)
2 trips o/b between LSS Inuvik and LRR Cape Parry/Pin-M (A/09)
3 trips o/b between LRR Cape Parry/Pin-M and SRR Nicholson Island/Bar-4 (07/09)
3 trips o/b between LRR Cape Parry/Pin-M and SRR Horton River/Bar-E (08/09)
3 trips o/b between LRR Cape Parry/Pin-M and SRR Keats Point/Pin-1BD (09/10)
3 trips o/b between LRR Cape Parry/Pin-M and SRR Croker River/Pin-1BG (09/11)

TOSs1A03: A summer routing which includes --
2 TO trips o/b between LSS Inuvik and Coppermine (TO A/Cp)
4 trips o/b between LRR Lady Franklin Point/Pin-3 and Coppermine (14/Cp)
1 trip o/b between LSS Inuvik and LRR Lady Franklin Point/Pin-3 (A/14)
3 trips o/b between LRR Lady Franklin Point/Pin-3 and SRR Harding River/Pin-2A (12/14)
3 trips o/b between LRR Lady Franklin Point/Pin-3 and SRR Bernard Harbour/Pin-CB (13/14)
3 trips o/b between LRR Lady Franklin Point/Pin-3 and SRR Edinburgh Island/Pin-DA (14/15)

Sd1A04: A summer routing which includes --
2 trips o/b between LSS Inuvik and SRR Storm Hills/Bar-BA3 (A/04)

Sd1A05: A summer routing which includes --
2 trips o/b between LSS Inuvik and SRR Tuktoyaktuk/Bar-3 (A/05)

Sd1A06: A summer routing which includes --
2 trips o/b between LSS Inuvik and SRR Liverpool Bay/Bar-DA1 (A/06)

Sd1A16: A summer routing which inlcudes --
3 trips o/b between LSS Inuvik and SRR Cape Peel West/Pin-EB (A/16)

Sd1AB: A summer routing which includes --
3 trips o/b between LSS Inuvik and LRR Cambridge Bay/Cam-M (A/B)

Ws1A01: A winter routing which includes --
4 trips o/b between LSS Inuvik and LRR Shingle Point/Bar-2 (A/03)
2 trips o/b between LRR Shingle Point/Bar-2 and SRR Stokes Point/Bar-B (02/03)
2 trips o/b between LRR Shingle Point/Bar-2 and SRR Komokuk Beach/Bar-1 (01/03)

Ws1A02: A winter routing which includes --
5 trips o/b between LSS Inuvik and LRR Cape Parry/Pin-M (A/09)
3 trips o/b between LRR Cape Parry/Pin-M and SRR Nicholson Island/Bar-4 (07/09)
3 trips o/b between LRR Cape Parry/Pin-M and SRR Horton River/Bar-E (08/09)
3 trips o/b between LRR Cape Parry/Pin-M and SRR Keats Point/Pin-1BD (09/10)
3 trips o/b between LRR Cape Parry/Pin-M and SRR Croker River/Pin-1BG (09/11)

Ws1A03: A winter routing which includes --
6 trips o/b between LSS Inuvik and LRR Lady Franklin Point/Pin-3 (A/14)
2 trips o/b between LRR Lady Franklin Point/Pin-3 and SRR Harding River/Pin-2A (12/14)
2 trips o/b between LRR Lady Franklin Point/Pin-3 and SRR Bernard Harbour/Pin-CB (13/14)
2 trips o/b between LRR Lady Franklin Point/Pin-3 and SRR Edinburgh Island/Pin-DA (14/15)

TOWs1A01: A winter routing which includes --
2 TO trips o/b between LSS Inuvik and LRR Shingle Point/Bar-2 (TO A/03)
2 trips o/b between LSS Inuvik and LRR Shingle Point/Bar-2 (A/03)
2 trips o/b between LRR Shingle Point/Bar-2 and SRR Stokes Point/Bar-B (02/03)
2 trips o/b between LRR Shingle Point/Bar-2 and SRR Komokuk Beach/Bar-1 (01/03)

TOWs1A02: A winter routing which includes --
3 TO trips o/b between LSS Inuvik and LRR Cape Parry/Pin-M (TO A/09)
1 trip o/b between LSS Inuvik and LRR Cape Parry/Pin-M (A/09)
3 trips o/b between LRR Cape Parry/Pin-M and SRR Nicholson Island/Bar-4 (07/09)
3 trips o/b between LRR Cape Parry/Pin-M and SRR Horton River/Bar-E (08/09)
3 trips o/b between LRR Cape Parry/Pin-M and SRR Keats Point/Pin-1BD (09/10)
3 trips o/b between LRR Cape Parry/Pin-M and SRR Croker River/Pin-1BG (09/11)

TOWs1A03: A winter routing which includes --
2 TO trips o/b between LSS Inuvik and Coppermine (TO A/Cp)
4 trips o/b between LRR Lady Franklin Point/Pin-3 and Coppermine (14/Cp)
2 trips o/b between LSS Inuvik and LRR Lady Franklin Point/Pin-3 (A/14)
2 trips o/b between LRR Lady Franklin Point/Pin-3 and SRR Harding River/Pin-2A (12/14)
2 trips o/b between LRR Lady Franklin Point/Pin-3 and SRR Bernard Harbour/Pin-CB (13/14)
2 trips o/b between LRR Lady Franklin Point/Pin-3 and SRR Edinburgh Island/Pin-DA (14/15)

Wd1A04: A winter routing which includes --
2 trips o/b between LSS Inuvik and SRR Storm Hills/Bar-BA3 (A/04)

Wd1A05: A winter routing which includes --
1 trip o/b between LSS Inuvik and SRR Tuktoyaktuk/Bar-3 (A/05)

Wd1A06: A winter routing which includes --
2 trips o/b between LSS Inuvik and SRR Liverpool Bay/Bar-DA1 (A/06)

Wd1A16: A winter routing which includes --
2 trips o/b between LSS Inuvik and SRR Cape Peel West/Pin-EB (A/16)

Wd1AB: A winter routing which includes --
2 trips o/b between LSS Inuvik and LRR Cambridge Bay/Cam-M (A/B)

Zone Two -- Cambridge Bay

Dr1B07: A routing between LSS Cambridge Bay and SRR Nicholson Island/Bar-4
Dr1B08: A routing between LSS Cambridge Bay and SRR Horton River/Bar-E
Dr1B09: A routing between LSS Cambridge Bay and LRR Cape Parry/Pin-M
Dr1B10: A routing between LSS Cambridge Bay and SRR Keats Point/Pin-1BD
Dr1B11: A routing between LSS Cambridge Bay and SRR Croker River/Pin-1BG
Dr1B12: A routing between LSS Cambridge Bay and SRR Harding River/Pin-2A
Dr1B13: A routing between LSS Cambridge Bay and SRR Bernard Harbour/Pin-CB
Dr1B14: A routing between LSS Cambridge Bay and LRR Lady Franklin Point/Pin-3
Dr1B15: A routing between LSS Cambridge Bay and SRR Edinburgh Island/Pin-DA
Dr1B16: A routing between LSS Cambridge Bay and SRR Cape Peel West/Pin-EB
Dr1B17: A routing between LSS Cambridge Bay and SRR Sturt Point North/CAM-A3A
Dr1B18: A routing between LSS Cambridge Bay and SRR Jenny Lind Island/Cam-1A
Dr1B19: A routing between LSS Cambridge Bay and SRR Hat Island/Cam-B
Dr1B20: A routing between LSS Cambridge Bay and SRR Gladman Point/Cam-2
Dr1B21: A routing between LSS Cambridge Bay and SRR Gjoa Haven/Cam-CB
Dr1B22: A routing between LSS Cambridge Bay and LRR Sheperd Bay/Cam-3
Dr1B23: A routing between LSS Cambridge Bay and SRR Simpson Lake/Cam-D
Dr1B24: A routing between LSS Cambridge Bay and SRR Pelly Bay/Cam-4
Dr1B25: A routing between LSS Cambridge Bay and SRR Cape McLoughlin/Cam-5A
Dr1B26: A routing between LSS Cambridge Bay and SRR Lailor River/Cam-FA
Dr1BC: A routing between LSS Cambridge Bay and LRR Hall Beach/Fox-M

Lg1B07: A one-way trip between LSS Cambridge Bay and SRR Nicholson Island/Bar-4
Lg1B08: A one-way trip between LSS Cambridge Bay and SRR Horton River/Bar-E
Lg1B09: A one-way trip between LSS Cambridge Bay and LRR Cape Parry/Pin-M
Lg1B10: A one-way trip between LSS Cambridge Bay and SRR Keats Point/Pin-1BD
Lg1B11: A one-way trip between LSS Cambridge Bay and SRR Croker River/Pin-1BG
Lg1B12: A one-way trip between LSS Cambridge Bay and SRR Harding River/Pin-2A
Lg1B13: A one-way trip between LSS Cambridge Bay and SRR Bernard Harbour/Pin-CB
Lg1B14: A one-way trip between LSS Cambridge Bay and LRR Lady Franklin Point/Pin-3
Lg1B15: A one-way trip between LSS Cambridge Bay and SRR Edinburgh Island/Pin-DA
Lg1B16: A one-way trip between LSS Cambridge Bay and SRR Cape Peel West/Pin-EB
Lg1B17: A one-way trip between LSS Cambridge Bay and SRR Sturt Point North/CAM-A3A
Lg1B18: A one-way trip between LSS Cambridge Bay and SRR Jenny Lind Island/Cam-1A
Lg1B19: A one-way trip between LSS Cambridge Bay and SRR Hat Island/Cam-B
Lg1B20: A one-way trip between LSS Cambridge Bay and SRR Gladman Point/Cam-2
Lg1B21: A one-way trip between LSS Cambridge Bay and SRR Gjoa Haven/Cam-CB
Lg1B22: A one-way trip between LSS Cambridge Bay and LRR Sheperd Bay/Cam-3
Lg1B23: A one-way trip between LSS Cambridge Bay and SRR Simpson Lake/Cam-D
Lg1B24: A one-way trip between LSS Cambridge Bay and SRR Pelly Bay/Cam-4
Lg1B25: A one-way trip between LSS Cambridge Bay and SRR Cape McLoughlin/Cam-5A
Lg1B26: A one-way trip between LSS Cambridge Bay and SRR Lailor River/Cam-FA
Lg1BC: A one-way trip between LSS Cambridge Bay and LRR Hall Beach/Fox-M

Lg1B0709: A one-way trip between SRR Nicholson Island/Bar-4 and LRR Cape Parry/Pin-M
Lg1B0809: A one-way trip between SRR Horton River/Bar-E and LRR Cape Parry/Pin-M
Lg1B0910: A one-way trip between LRR Cape Parry/Pin-M and SRR Keats Point/Pin-1BD
Lg1B0911: A one-way trip between LRR Cape Parry/Pin-M and SRR Croker River/Pin-1BG
Lg1B1214: A one-way trip between SRR Harding River/Pin-2A and LRR Lady Franklin Point/Pin-3
Lg1B1314: A one-way trip between SRR Bernard Harbour/Pin-CB and LRR Lady Franklin Point/Pin-2A
Lg1B1415: A one-way trip between LRR Lady Franklin Point/Pin-2A and SRR Edinburgh Island/Pin-DA
Lg1B2022: A one-way trip between SRR Gladman Point/Cam-2 and LRR Sheperd Bay/Cam-3

Lg1B2122: A one-way trip between SRR Gjoa Haven/Cam-CB and LRR Sheperd Bay/Cam-3
Lg1B2223: A one-way trip between LRR Sheperd Bay/Cam-3 and SRR Simpson Lake/Cam-D
Lg1B2224: A one-way trip between LRR Sheperd Bay/Cam-3 and SRR Pelly Bay/Cam-4

Lg1B14Cp: A one-way trip between LRR Lady Franklin Point/Pin-3 and Coppermine
Lg1B22Gj: A one-way trip between LRR Sheperd Bay/Cam-3 and Gjoa Haven

Lg3B09: A one-way TO trip between LSS Cambridge Bay and LRR Cape Parry/Pin-M
Lg3BCopp: A one-way TO trip between LSS Cambridge Bay and Coppermine
Lg3BGjoa: A one-way TO trip between LSS Cambridge Bay and Gjoa Haven

Ss1B01: A summer routing which includes --
6 trips o/b between LSS Cambridge Bay and LRR Lady Franklin Point/Pin-3 (B/14)
3 trips o/b between LRR Lady Franklin Point/Pin-3 and SRR Harding River/Pin-2A (12/14)
3 trips o/b between LRR Lady Franklin Point/Pin-3 and SRR Bernard Harbour/Pin-CB (13/14)
3 trips o/b between LRR Lady Franklin Point/Pin-3 and SRR Edinburg Island/Pin-DA (14/15)

Ss1B03: A summer routing which includes --
8 trips o/b between LSS Cambridge Bay and LRR Cape Parry/Pin-M (B/09)
2 trips o/b between LRR Cape Parry/Pin-M and SRR Nicholson Island/Bar-4 (07/09)
2 trips o/b between LRR Cape Parry/Pin-M and SRR Horton River/Bar-E (08/09)
2 trips o/b between LRR Cape Parry/Pin-M and SRR Keats Point/Pin-1BD (09/10)
2 trips o/b between LRR Cape Parry/Pin-M and SRR Croker River/Pin-1BG (09/11)

Ss1B04: A summer routing which includes --
5 trips o/b between LSS Cambridge Bay and LRR Sheperd Bay/Cam-3 (B/22)
3 trips o/b between LRR Sheperd Bay/Cam-3 and SRR Gladman Point/Cam-2 (20/22)
3 trips o/b between LRR Sheperd Bay/Cam-3 and SRR Gjoa Haven/Cam-CB (21/22)
3 trips o/b between LRR Sheperd Bay/Cam-3 and SRR Simpson Lake/Cam-D (22/23)
3 trips o/b between LRR Sheperd Bay/Cam-3 and SRR Pelly Bay/Cam-4 (22/24)

TOSs1B01: A summer routing which includes --
2 TO trips o/b between LSS Cambridge Bay and LRR Lady Franklin Point/Pin-3 (TO B/14)
1 TO trip o/b between LSS Cambridge Bay and Coppermine (TO B/Cp)
2 trips o/b between LRR Lady Franklin Point/Pin-3 and Coppermine (14/Cp)
3 trips o/b between LSS Cambridge Bay and LRR Lady Franklin Point/Pin-3 (B/14)
3 trips o/b between LRR Lady Franklin Point/Pin-3 and SRR Harding River/Pin-2A (12/14)
3 trips o/b between LRR Lady Franklin Point/Pin-3 and SRR Bernard Harbour/Pin-CB (13/14)
3 trips o/b between LRR Lady Franklin Point/Pin-3 and SRR Edinburg Island/Pin-DA (14/15)

TOSs1B03: A summer routing which includes --
3 TO trips o/b between LSS Cambridge Bay and LRR Cape Parry/Pin-M (TO B/09)
2 trips o/b between LSS Inuvik and LRR Cape Parry/Pin-M (B/09)
2 trips o/b between LRR Cape Parry/Pin-M and SRR Nicholson Island/Bar-4 (07/09)
2 trips o/b between LRR Cape Parry/Pin-M and SRR Horton River/Bar-E (08/09)
2 trips o/b between LRR Cape Parry/Pin-M and SRR Keats Point/Pin-1BD (09/10)
2 trips o/b between LRR Cape Parry/Pin-M and SRR Croker River/Pin-1BG (09/11)

TOSs1B04: A summer routing which includes --
2 TO trips o/b between LSS Cambridge Bay and Gjoa Haven (TO B/Gj)
4 trips o/b between LRR Sheperd Bay/Cam-3 and Gjoa Haven (22/Gj)
1 trip o/b between LSS Cambridge Bay and LRR Sheperd Bay/Cam-3 (B/22)
3 trips o/b between LRR Sheperd Bay/Cam-3 and SRR Gladman Point/Cam-2 (20/22)
3 trips o/b between LRR Sheperd Bay/Cam-3 and SRR Gjoa Haven/Cam-CB (21/22)
3 trips o/b between LRR Sheperd Bay/Cam-3 and SRR Simpson Lake/Cam-D (22/23)
3 trips o/b between LRR Sheperd Bay/Cam-3 and SRR Pelly Bay/Cam-4 (22/24)

Sd1B16: A summer routing which includes --
3 trips o/b between LSS Cambridge Bay and SRR Cape Peel West/Pin-EB (B/16)

Sd1B17: A summer routing which includes --
3 trips o/b between LSS Cambridge Bay and LRR Sturt Point North/Cam-A3A (B/17)

Sd1B18: A summer routing which includes --
3 trips o/b between LSS Cambridge Bay and SRR Jenny Lind Island/Cam-1A (B/18)

Sd1B19: A summer routing which includes --
3 trips o/b between LSS Cambridge Bay and SRR Hat Island/Cam-B (B/19)

Sd1B25: A summer routing which includes --
3 trips o/b between LSS Cambridge Bay and SRR Cape McLoughlin/Cam-5A (B/25)

Sd1B26: A summer routing which includes --
3 trips o/b between LSS Cambridge Bay and SRR Lailor River/Cam-FA (B/26)

Sd1BC: A summer routing which includes --
3 trips o/b between LSS Cambridge Bay and LRR Hall Beach/Fox-M (B/C)

Ws1B01: A winter routing which includes --
6 trips o/b between LSS Cambridge Bay and LRR Lady Franklin Point/Pin-3 (B/14)
2 trips o/b between LRR Lady Franklin Point/Pin-3 and SRR Harding River/Pin-2A (12/14)
2 trips o/b between LRR Lady Franklin Point/Pin-3 and SRR Bernard Harbour/Pin-CB (13/14)
2 trips o/b between LRR Lady Franklin Point/Pin-3 and SRR Edinburg Island/Pin-DA (14/15)

Ws1B03: A winter routing which includes --
5 trips o/b between LSS Cambridge Bay and LRR Cape Parry/Pin-M (B/09)
2 trips o/b between LRR Cape Parry/Pin-M and SRR Nicholson Island/Bar-4 (07/09)
2 trips o/b between LRR Cape Parry/Pin-M and SRR Horton River/Bar-E (08/09)
2 trips o/b between LRR Cape Parry/Pin-M and SRR Keats Point/Pin-1BD (09/10)
2 trips o/b between LRR Cape Parry/Pin-M and SRR Croker River/Pin-1BG (09/11)

Ws1B04: A winter routing which includes --
3 trips o/b between LSS Cambridge Bay and LRR Sheperd Bay/Cam-3 (B/22)
2 trips o/b between LRR Sheperd Bay/Cam-3 and SRR Gladman Point/Cam-2 (20/22)
2 trips o/b between LRR Sheperd Bay/Cam-3 and SRR Gjoa Haven/Cam-CB (21/22)
2 trips o/b between LRR Sheperd Bay/Cam-3 and SRR Simpson Lake/Cam-D (22/23)
2 trips o/b between LRR Sheperd Bay/Cam-3 and SRR Pelly Bay/Cam-4 (22/24)

TOWs1B01: A winter routing which includes --
1 TO trip o/b between LSS Cambridge Bay and LRR Lady Franklin Point/Pin-3 (TO B/14)
1 TO trip o/b between LSS Cambridge Bay and Coppermine (TO B/Cp)
2 trips o/b between LRR Lady Franklin Point/Pin-3 and Coppermine (14/Cp)
2 trips o/b between LSS Cambridge Bay and LRR Lady Franklin Point/Pin-3 (B/14)
2 trips o/b between LRR Lady Franklin Point/Pin-3 and SRR Harding River/Pin-2A (12/14)
2 trips o/b between LRR Lady Franklin Point/Pin-3 and SRR Bernard Harbour/Pin-CB (13/14)
2 trips o/b between LRR Lady Franklin Point/Pin-3 and SRR Edinburg Island/Pin-DA (14/15)

TOWs1B03: A winter routing which includes --
2 TO trips o/b between LSS Cambridge Bay and LRR Cape Parry/Pin-M (TO B/09)
1 trips o/b between LSS Inuvik and LRR Cape Parry/Pin-M (B/09)
2 trips o/b between LRR Cape Parry/Pin-M and SRR Nicholson Island/Bar-4 (07/09)
2 trips o/b between LRR Cape Parry/Pin-M and SRR Horton River/Bar-E (08/09)
2 trips o/b between LRR Cape Parry/Pin-M and SRR Keats Point/Pin-1BD (09/10)
2 trips o/b between LRR Cape Parry/Pin-M and SRR Croker River/Pin-1BG (09/11)

TOWs1B04: A winter routing which includes --
1 TO trip o/b between LSS Cambridge Bay and Gjoa Haven (TO B/Gj)
2 trips o/b between LRR Sheperd Bay/Cam-3 and Gjoa Haven (22/Gj)
1 trip o/b between LSS Cambridge Bay and LRR Sheperd Bay/Cam-3 (B/22)
2 trips o/b between LRR Sheperd Bay/Cam-3 and SRR Gladman Point/Cam-2 (20/22)
2 trips o/b between LRR Sheperd Bay/Cam-3 and SRR Gjoa Haven/Cam-CB (21/22)
2 trips o/b between LRR Sheperd Bay/Cam-3 and SRR Simpson Lake/Cam-D (22/23)
2 trips o/b between LRR Sheperd Bay/Cam-3 and SRR Pelly Bay/Cam-4 (22/24)

Wd1B16: A winter routing which includes --
2 trips o/b between LSS Cambridge Bay and SRR Cape Peel West/Pin-EB (B/16)

Wd1B17: A winter routing which includes --
2 trips o/b between LSS Cambridge Bay and LRR Sturt Point North/Cam-A3A (B/17)

Wd1B18: A winter routing which includes --
2 trips o/b between LSS Cambridge Bay and SRR Jenny Lind Island/Cam-1A (B/18)

Wd1B19: A winter routing which includes --
2 trips o/b between LSS Cambridge Bay and SRR Hat Island/Cam-B (B/19)

Wd1B25: A winter routing which includes --
2 trips o/b between LSS Cambridge Bay and SRR Cape McLoughlin/Cam-5A (B/25)

Wd1B26: A winter routing which includes --
2 trips o/b between LSS Cambridge Bay and SRR Lailor River/Cam-FA (B/26)

Wd1BC: A winter routing which includes --
2 trips o/b between LSS Cambridge Bay and LRR Hall Beach/Fox-M (B/C)

Zone Three -- Hall Beach

Dr1C17: A routing between LSS Hall Beach and SRR Sturt Point North/CAM-A3A
Dr1C18: A routing between LSS Hall Beach and SRR Jenny Lind Island/Cam-1A
Dr1C19: A routing between LSS Hall Beach and SRR Hat Island/Cam-B
Dr1C20: A routing between LSS Hall Beach and SRR Gladman Point/Cam-2
Dr1C21: A routing between LSS Hall Beach and SRR Gjoa Haven/Cam-CB
Dr1C22: A routing between LSS Hall Beach and LRR Sheperd Bay/Cam-3
Dr1C23: A routing between LSS Hall Beach and SRR Simpson Lake/Cam-D
Dr1C24: A routing between LSS Hall Beach and SRR Pelly Bay/Cam-4
Dr1C25: A routing between LSS Hall Beach and SRR Cape McLoughlin/Cam-5A
Dr1C26: A routing between LSS Hall Beach and SRR Lailor River/Cam-FA
Dr1C27: A routing between LSS Hall Beach and SRR Rowley Island/Fox-1
Dr1C28: A routing between LSS Hall Beach and SRR Bray Island/Fox-A
Dr1C29: A routing between LSS Hall Beach and SRR Longstaff Bluff/Fox-2
Dr1C30: A routing between LSS Hall Beach and SRR Nadluardjuk Lake/Fox-B
Dr1C31: A routing between LSS Hall Beach and LRR Dewar Lakes/Fox-3
Dr1C32: A routing between LSS Hall Beach and SRR Kangok Fiord/Fox-CA
Dr1C33: A routing between LSS Hall Beach and SRR Cape Hooper/Fox-4
Dr1C34: A routing between LSS Hall Beach and SRR Broughton Island/Fox-5
Dr1C35: A routing between LSS Hall Beach and LRR Cape Dyer/Dye-M
Dr1C36: A routing between LSS Hall Beach and SRR Cape Mercy/Baf-2
Dr1CB: A routing between LSS Hall Beach and LRR Cambridge Bay/Cam-M

Lg1C17: A one-way trip between LSS Hall Beach and SRR Sturt Point North/CAM-A3A
Lg1C18: A one-way trip between LSS Hall Beach and SRR Jenny Lind Island/Cam-1A
Lg1C19: A one-way trip between LSS Hall Beach and SRR Hat Island/Cam-B
Lg1C20: A one-way trip between LSS Hall Beach and SRR Gladman Point/Cam-2
Lg1C21: A one-way trip between LSS Hall Beach and SRR Gjoa Haven/Cam-CB
Lg1C22: A one-way trip between LSS Hall Beach and LRR Sheperd Bay/Cam-3
Lg1C23: A one-way trip between LSS Hall Beach and SRR Simpson Lake/Cam-D
Lg1C24: A one-way trip between LSS Hall Beach and SRR Pelly Bay/Cam-4
Lg1C25: A one-way trip between LSS Hall Beach and SRR Cape McLoughlin/Cam-5A
Lg1C26: A one-way trip between LSS Hall Beach and SRR Lailor River/Cam-FA
Lg1C27: A one-way trip between LSS Hall Beach and SRR Rowley Island/Fox-1
Lg1C28: A one-way trip between LSS Hall Beach and SRR Bray Island/Fox-A

Lg1C29: A one-way trip between LSS Hall Beach and SRR Longstaff Bluff/Fox-2
Lg1C30: A one-way trip between LSS Hall Beach and SRR Nadluardjuk Lake/Fox-B
Lg1C31: A one-way trip between LSS Hall Beach and LRR Dewar Lakes/Fox-3
Lg1C32: A one-way trip between LSS Hall Beach and SRR Kangok Fiord/Fox-CA
Lg1C33: A one-way trip between LSS Hall Beach and SRR Cape Hooper/Fox-4
Lg1C34: A one-way trip between LSS Hall Beach and SRR Broughton Island/Fox-5
Lg1C35: A one-way trip between LSS Hall Beach and LRR Cape Dyer/Dye-M
Lg1C36: A one-way trip between LSS Hall Beach and SRR Cape Mercy/Baf-2
Lg1CB: A one-way trip between LSS Hall Beach and LRR Cambridge Bay/Cam-M

Lg1C2022: A one-way trip between SRR Gladman Point/Cam-2 and LRR Sheperd Bay/Cam-3
Lg1C2122: A one-way trip between SRR Gjoa Haven/Cam-CB and LRR Sheperd Bay/Cam-3
Lg1C2223: A one-way trip between LRR Sheperd Bay/Cam-3 and SRR Simpson Lake/Cam-D
Lg1C2224: A one-way trip between LRR Sheperd Bay/Cam-3 and SRR Pelly Bay/Cam-4
Lg1C2931: A one-way trip between SRR Longstaff Bluff/Fox-2 and LRR Dewar Lakes/Fox-3
Lg1C3031: A one-way trip between SRR Nadjuardjuk Lake/Fox-B and LRR Dewar Lakes/Fox-3
Lg1C3132: A one-way trip between LRR Dewar Lakes/Fox-3 and SRR Kangok Fiord/Fox-CA
Lg1C3133: A one-way trip between LRR Dewar Lakes/Fox-3 and SRR Cape Hooper/Fox-4

Lg1C22Pl: A one-way trip between LRR Sheperd Bay/Cam-3 and Pelly Bay
Lg1C34Br: A one-way trip between SRR Broughton Island/Fox-5 and Broughton Island

Lg3CPell: A one-way TO trip between LSS Hall Beach and Pelly Bay
Lg3CBrou: A one-way TO trip between LSS Hall Beach and Broughton Island

Ss1C03: A summer routing which includes --
5 trips o/b between LSS Hall Beach and LRR Sheperd Bay/Cam-3 (C/22)
3 trips o/b between LRR Sheperd Bay/Cam-3 and SRR Gladman Point/Cam-2 (20/22)
3 trips o/b between LRR Sheperd Bay/Cam-3 and SRR Gjoa Haven/Cam-CB (21/22)
3 trips o/b between LRR Sheperd Bay/Cam-3 and SRR Simpson Lake/Cam-D (22/23)
3 trips o/b between LRR Sheperd Bay/Cam-3 and SRR Pelly Bay/Cam-4 (22/24)

Ss1C04: A summer routing which includes --
5 trips o/b between LSS Hall Beach and LRR Dewar Lakes/Fox-3 (C/31)
4 trips o/b between LRR Dewar Lakes/Fox-3 and SRR Longstaff Bluff/Fox-2 (29/31)
6 trips o/b between LRR Dewar Lakes/Fox-3 and SRR Cape Hooper/Fox-4 (30/31)
6 trips o/b between LRR Dewar Lakes/Fox-3 and SRR Kankgok Fiord/Fox-CA (31/32)
6 trips o/b between LRR Dewar Lakes/Fox-3 and SRR Nadjuardjuk Lake/Fox-B (31/33)

Ss1C05: A summer routing which includes --
6 trips o/b between LSS Hall Beach and SRR Broughton Island/Fox-5 (C/34)
7 trips o/b between SRR Broughton Island/Fox-5 and LRR Cape Dyer/Dye-M (34/35)

TOSs1C03: A summer routing which includes --
2 TO trips o/b between LSS Hall Beach and Pelly Bay (TO C/Pl)
4 trips o/b between LRR Sheperd Bay/Cam-3 and Pelly Bay (22/Pl)
1 trip o/b between LSS Hall Beach and LRR Sheperd Bay/Cam-3 (C/22)
3 trips o/b between LRR Sheperd Bay/Cam-3 and SRR Gladman Point/Cam-2 (20/22)
3 trips o/b between LRR Sheperd Bay/Cam-3 and SRR Gjoa Haven/Cam-CB (21/22)
3 trips o/b between LRR Sheperd Bay/Cam-3 and SRR Simpson Lake/Cam-D (22/23)
3 trips o/b between LRR Sheperd Bay/Cam-3 and SRR Pelly Bay/Cam-4 (22/24)

TOSs1C05: A summer routing which includes --
2 TO trips o/b between LSS Hall Beach and Broughton Island (TO C/Br)
3 trips o/b between LSS Hall Beach and SRR Broughton Island/Fox-5 (C/34)
6 trips o/b between SRR Broughton Island/Fox-5 and LRR Cape Dyer/Dye-M (34/35)

Sd1C17: A summer routing which includes --
4 trips o/b between LSS Cambridge Bay and LRR Sturt Point North/Cam-A3A (C/17)

Sd1C18: A summer routing which includes --
4 trips o/b between LSS Cambridge Bay and SRR Jenny Lind Island/Cam-1A (C/18)

Sd1C19: A summer routing which includes --
2 trips o/b between LSS Cambridge Bay and SRR Hat Island/Cam-B (C/19)

Sd1C25: A summer routing which includes --
3 trips o/b between LSS Hall Beach and SRR Cape McLoughlin/Cam-5A (C/25)

Sd1C26: A summer routing which includes --
3 trips o/b between LSS Hall Beach and SRR Lailor River/Cam-FA (C/26)

Sd1C27: A summer routing which includes --
3 trips o/b between LSS Hall Beach and SRR Rowley Island/Fox-1 (C/27)

Sd1C28: A summer routing which includes --
3 trips o/b between LSS Hall Beach and SRR Bray Island/Fox-A (C/28)

Sd1C36: A summer routing which includes --
3 trips o/b between LSS Hall Beach and SRR Cape Mercy/Baf-2 (C/36)

Sd1CB: A summer routing which includes --
3 trips o/b between LSS Hall Beach and LRR Cambridge Bay/Cam-M (C/B)

Ws1C03: A winter routing which includes --
3 trips o/b between LSS Hall Beach and LRR Sheperd Bay/Cam-3 (C/22)
2 trips o/b between LRR Sheperd Bay/Cam-3 and SRR Gladman Point/Cam-2 (20/22)
2 trips o/b between LRR Sheperd Bay/Cam-3 and SRR Gjoa Haven/Cam-CB (21/22)
2 trips o/b between LRR Sheperd Bay/Cam-3 and SRR Simpson Lake/Cam-D (22/23)
2 trips o/b between LRR Sheperd Bay/Cam-3 and SRR Pelly Bay/Cam-4 (22/24)

Ws1C04: A winter routing which includes --
3 trips o/b between LSS Hall Beach and LRR Dewar Lakes/Fox-3 (C/31)
2 trips o/b between LRR Dewar Lakes/Fox-3 and SRR Longstaff Bluff/Fox-2 (29/31)
3 trips o/b between LRR Dewar Lakes/Fox-3 and SRR Cape Hooper/Fox-4 (30/31)
3 trips o/b between LRR Dewar Lakes/Fox-3 and SRR Kankgok Fiord/Fox-CA (31/32)
3 trips o/b between LRR Dewar Lakes/Fox-3 and SRR Nadjuardjuk Lake/Fox-B (31/33)

Ws1C05: A winter routing which includes --
5 trips o/b between LSS Hall Beach and SRR Broughton Island/Fox-5 (C/34)
5 trips o/b between SRR Broughton Island/Fox-5 and LRR Cape Dyer/Dye-M (34/35)

TOWs1C03: A winter routing which includes --
1 TO trips o/b between LSS Hall Beach and Pelly Bay (TO C/Pl)
2 trips o/b between LRR Sheperd Bay/Cam-3 and Pelly Bay (22/Pl)
1 trip o/b between LSS Hall Beach and LRR Sheperd Bay/Cam-3 (C/22)
2 trips o/b between LRR Sheperd Bay/Cam-3 and SRR Gladman Point/Cam-2 (20/22)
2 trips o/b between LRR Sheperd Bay/Cam-3 and SRR Gjoa Haven/Cam-CB (21/22)
2 trips o/b between LRR Sheperd Bay/Cam-3 and SRR Simpson Lake/Cam-D (22/23)
2 trips o/b between LRR Sheperd Bay/Cam-3 and SRR Pelly Bay/Cam-4 (22/24)

TOWs1C05: A winter routing which includes --
2 TO trips o/b between LSS Hall Beach and Broughton Island (TO C/Br)
4 trips o/b between LSS Hall Beach and LRR Cape Dyer/Dye-M (C/34)
7 trips o/b between LRR Cape Dyer/Dye-M and SRR Broughton Island/Fox-5 (34/35)

Wd1C17: A winter routing which includes --
2 trips o/b between LSS Cambridge Bay and LRR Sturt Point North/Cam-A3A (C/17)

Wd1C18: A winter routing which includes --
1 trip o/b between LSS Cambridge Bay and SRR Jenny Lind Island/Cam-1A (C/18)

Wd1C19: A winter routing which includes --
2 trips o/b between LSS Cambridge Bay and SRR Hat Island/Cam-B (C/19)

Wd1C25: A winter routing which includes --
2 trips o/b between LSS Hall Beach and SRR Cape McLoughlin/Cam-5A (C/25)

Wd1C26: A winter routing which includes --
2 trips o/b between LSS Hall Beach and SRR Lailor River/Cam-FA (C/26)

Wd1C27: A winter routing which includes --
2 trips o/b between LSS Hall Beach and SRR Rowley Island/Fox-1 (C/27)

Wd1C28: A winter routing which includes --
2 trips o/b between LSS Hall Beach and SRR Bray Island/Fox-A (C/28)

Wd1C36: A winter routing which includes --
2 trips o/b between LSS Hall Beach and SRR Cape Mercy/Baf-2 (C/36)

Wd1CB: A winter routing which includes --
2 trips o/b between LSS Hall Beach and LRR Cambridge Bay/Cam-M (C/B)

Zone Four -- Iqaluit

Dr2D25: A routing between LSS Iqaluit and SRR Cape McLoughlin/Cam-5A
Dr2D26: A routing between LSS Iqaluit and SRR Lailor River/Cam-FA
Dr2D27: A routing between LSS Iqaluit and SRR Rowley Island/Fox-1
Dr2D28: A routing between LSS Iqaluit and SRR Bray Island/Fox-A
Dr2D29: A routing between LSS Iqaluit and SRR Longstaff Bluff/Fox-2
Dr2D30: A routing between LSS Iqaluit and SRR Nadluardjuk Lake/Fox-B
Dr2D31: A routing between LSS Iqaluit and LRR Dewar Lakes/Fox-3
Dr2D32: A routing between LSS Iqaluit and SRR Kangok Fiord/Fox-CA
Dr2D33: A routing between LSS Iqaluit and SRR Cape Hooper/Fox-4
Dr2D34: A routing between LSS Iqaluit and SRR Broughton Island/Fox-5
Dr2D35: A routing between LSS Iqaluit and LRR Cape Dyer/Dye-M
Dr2D36: A routing between LSS Iqaluit and SRR Cape Mercy/Baf-2
Dr2D37: A routing between LSS Iqaluit and LRR Brevoort Island/Baf-3
Dr2D38: A routing between LSS Iqaluit and SRR Loks Land/Baf-4A
Dr2D39: A routing between LSS Iqaluit and SRR Resolution Island/Baf-5
Dr2D40: A routing between LSS Iqaluit and SRR Cape Kakiviak/Lab-1
Dr2D41: A routing between LSS Iqaluit and LRR Saglek Bay/Lab-2
Dr2D42: A routing between LSS Iqaluit and SRR Cape Kiglapait/Lab-3
Dr2DC: A routing between LSS Iqaluit and LRR Hall Beach/Fox-M

Lg2D25: A one-way trip between LSS Iqaluit and SRR Cape McLoughlin/Cam-5A
Lg2D26: A one-way trip between LSS Iqaluit and SRR Lailor River/Cam-FA
Lg2D27: A one-way trip between LSS Iqaluit and SRR Rowley Island/Fox-1
Lg2D28: A one-way trip between LSS Iqaluit and SRR Bray Island/Fox-A
Lg2D29: A one-way trip between LSS Iqaluit and SRR Longstaff Bluff/Fox-2
Lg2D30: A one-way trip between LSS Iqaluit and SRR Nadluardjuk Lake/Fox-B
Lg2D31: A one-way trip between LSS Iqaluit and LRR Dewar Lakes/Fox-3
Lg2D32: A one-way trip between LSS Iqaluit and SRR Kangok Fiord/Fox-CA
Lg2D33: A one-way trip between LSS Iqaluit and SRR Cape Hooper/Fox-4
Lg2D34: A one-way trip between LSS Iqaluit and SRR Broughton Island/Fox-5
Lg2D35: A one-way trip between LSS Iqaluit and LRR Cape Dyer/Dye-M
Lg2D36: A one-way trip between LSS Iqaluit and SRR Cape Mercy/Baf-2
Lg2D37: A one-way trip between LSS Iqaluit and LRR Brevoort Island/Baf-3
Lg2D38: A one-way trip between LSS Iqaluit and SRR Loks Land/Baf-4A
Lg2D39: A one-way trip between LSS Iqaluit and SRR Resolution Island/Baf-5
Lg2D40: A one-way trip between LSS Iqaluit and SRR Cape Kakiviak/Lab-1
Lg2D41: A one-way trip between LSS Iqaluit and LRR Saglek Bay/Lab-2
Lg2D42: A one-way trip between LSS Iqaluit and SRR Cape Kiglapait/Lab-3
Lg2DC: A one-way trip between LSS Iqaluit and LRR Hall Beach/Fox-M

Lg2D2931: A one-way trip between SRR Longstaff Bluff/Fox-2 and LRR Dewar Lakes/Fox-3
Lg2D3031: A one-way trip between SRR Nadjuardjuk Lake/Fox-B and LRR Dewar Lakes/Fox-3
Lg2D3132: A one-way trip between LRR Dewar Lakes/Fox-3 and SRR Kangok Fiord/Fox-CA
Lg2D3133: A one-way trip between LRR Dewar Lakes/Fox-3 and SRR Cape Hooper/Fox-4
Lg2D3435: A one-way trip between SRR Broughton Island/Fox-5 and LRR Cape Dyer/Dye-M
Lg2D4041: A one-way trip between SRR Cape Kakiviak/Lab-1 and LRR Saglek Bay/Lab-2
Lg2D4142: A one-way trip between LRR Saglek Bay/Lab-2 and SRR Cape Kiglapait/Lab-3

Lg2D34Br: A one-way trip between SRR Broughton Island/Fox-5 and Broughton Island
Lg2D41Na: A one-way trip between LRR Saglek Bay/Lab-2 and Nain

Lg3DBrou: A one-way TO trip between LSS Iqaluit and Broughton Island

Lg3DNain: A one-way TO trip between LSS Iqaluit and Nain

Ss2D02: A summer routing which includes --
- 7 trips o/b between LSS Iqaluit and LRR Cape Dyer/Dye-M (D/35)
- 6 trips o/b between LRR Cape Dyer/Dye-M and SRR Broughton Island/Fox-5 (34/35)

Ss2D03: A summer routing which includes --
- 5 trips o/b between LSS Iqaluit and LRR Dewar Lakes/Fox-3 (D/31)
- 4 trips o/b between LRR Dewar Lakes/Fox-3 and SRR Longstaff Bluff/Fox-2 (29/31)
- 4 trips o/b between LRR Dewar Lakes/Fox-3 and SRR Cape Hooper/Fox-4 (30/31)
- 4 trips o/b between LRR Dewar Lakes/Fox-3 and SRR Kankgok Fiord/Fox-CA (31/32)
- 4 trips o/b between LRR Dewar Lakes/Fox-3 and SRR Nadjuardjuk Lake/Fox-B (31/33)

Ss2D04: A summer routing which includes --
- 5 trips o/b between LSS Iqaluit and LRR Saglek Bay/Lab-2 (D/41)
- 4 trips o/b between LRR Saglek Bay/Lab-2 and SRR Cape Kakiviak/Lab-1 (40/41)
- 4 trips o/b between LRR Saglek Bay/Lab-2 and SRR Cape Kiglapait/Lab-3 (41/42)

TOSs2D02: A summer routing which includes --
- 1 TO trip o/b between LSS Iqaluit and Broughton Island (TO D/Br)
- 4 trips o/b between SRR Broughton Island/Fox-5 and Broughton Island (34/Br)
- 3 trips o/b between LSS Iqaluit and LRR Cape Dyer/Dye-M (D/35)
- 6 trips o/b between LRR Cape Dyer/Dye-M and SRR Broughton Island/Fox-5 (34/35)

TOSs2D03: A summer routing which includes --
- 2 TO trips o/b between LSS Iqaluit and Broughton Island (TO D/Br)
- 2 trips o/b between LRR Dewar Lakes/Fox-3 and Broughton Island (31/Br)
- 1 trip o/b between LSS Iqaluit and LRR Dewar Lakes/Fox-3 (D/31)
- 4 trips o/b between LRR Dewar Lakes/Fox-3 and SRR Longstaff Bluff/Fox-2 (29/31)
- 4 trips o/b between LRR Dewar Lakes/Fox-3 and SRR Cape Hooper/Fox-4 (30/31)
- 4 trips o/b between LRR Dewar Lakes/Fox-3 and SRR Kankgok Fiord/Fox-CA (31/32)
- 4 trips o/b between LRR Dewar Lakes/Fox-3 and SRR Nadjuardjuk Lake/Fox-B (31/33)

TOSs2D04: A summer routing which includes --
- 2 TO trips o/b between LSS Iqaluit and Nain (TO D/Na)
- 2 trips o/b between LRR Saglek Bay/Lab-2 and Nain (41/Na)
- 1 trip o/b between LSS Iqaluit and LRR Saglek Bay/Lab-2 (D/41)
- 4 trips o/b between LRR Saglek Bay/Lab-2 and SRR Cape Kakiviak/Lab-1 (40/41)
- 4 trips o/b between LRR Saglek Bay/Lab-2 and SRR Cape Kiglapàit/Lab-3 (41/42)

Sd2D25: A summer routing which includes --
- 2 trips o/b between LSS Iqaluit and SRR Cape McLoughlin/Cam-5A (D/25)

Sd2D26: A summer routing which includes --
- 2 trips o/b between LSS Iqaluit and SRR Lailor River/Cam-FA (D/26)

Sd2D27: A summer routing which includes --
- 3 trips o/b between LSS Iqaluit and SRR Rowley Island/Fox-1 (D/27)

Sd2D28: A summer routing which includes --
- 2 trips o/b between LSS Iqaluit and SRR Bray Island/Fox-A (D/28)

Sd2D36: A summer routing which includes --
- 3 trips o/b between LSS Iqaluit and SRR Cape Mercy/Baf-2 (D/36)

Sd2D37: A summer routing which includes --
- 5 trips o/b between LSS Iqaluit and LRR Brevoort Island/Baf-3 (D/37)

Sd2D38: A summer routing which includes --
- 3 trips o/b between LSS Iqaluit and SRR Loks Land/Baf-4A (D/38)

Sd2D39: A summer routing which includes --
- 3 trips o/b between LSS Iqaluit and SRR Resolution Island/Baf-5 (D/39)

Sd2DC: A summer routing which includes --
- 3 trips o/b between LSS Iqaluit and LRR Hall Beach/Fox-M (D/C)

Ws2D02: A winter routing which includes --
- 7 trips o/b between LSS Iqaluit and LRR Cape Dyer/Dye-M (D/35)
- 4 trips o/b between LRR Cape Dyer/Dye-M and SRR Broughton Island/Fox-5 (34/35)

Ws2D03: A winter routing which includes --
- 3 trips o/b between LSS Iqaluit and LRR Dewar Lakes/Fox-3 (D/31)
- 2 trips o/b between LRR Dewar Lakes/Fox-3 and SRR Longstaff Bluff/Fox-2 (29/31)
- 2 trips o/b between LRR Dewar Lakes/Fox-3 and SRR Cape Hooper/Fox-4 (30/31)
- 2 trips o/b between LRR Dewar Lakes/Fox-3 and SRR Kankgok Fiord/Fox-CA (31/32)
- 2 trips o/b between LRR Dewar Lakes/Fox-3 and SRR Nadjuardjuk Lake/Fox-B (31/33)

Ws2D04: A winter routing which includes --
- 3 trips o/b between LSS Iqaluit and LRR Saglek Bay/Lab-2 (D/41)
- 2 trips o/b between LRR Saglek Bay/Lab-2 and SRR Cape Kakiviak/Lab-1 (40/41)
- 2 trips o/b between LRR Saglek Bay/Lab-2 and SRR Cape Kiglapait/Lab-3 (41/42)

TOWs2D02: A winter routing which includes --
- 1 TO trip o/b between LSS Iqaluit and Broughton Island (TO D/Br)
- 1 trip o/b between SRR Broughton Island/Fox-5 and Broughton Island (34/Br)
- 3 trips o/b between LSS Iqaluit and LRR Cape Dyer/Dye-M (D/35)
- 4 trips o/b between LRR Cape Dyer/Dye-M and SRR Broughton Island/Fox-5 (34/35)

TOWs2D03: A winter routing which includes --
- 1 TO trip o/b between LSS Iqaluit and Broughton Island (TO D/Br)
- 1 trip o/b between LRR Dewar Lakes/Fox-3 and Broughton Island (31/Br)
- 1 trip o/b between LSS Iqaluit and LRR Dewar Lakes/Fox-3 (D/31)
- 2 trips o/b between LRR Dewar Lakes/Fox-3 and SRR Longstaff Bluff/Fox-2 (29/31)
- 2 trips o/b between LRR Dewar Lakes/Fox-3 and SRR Cape Hooper/Fox-4 (30/31)
- 2 trips o/b between LRR Dewar Lakes/Fox-3 and SRR Kankgok Fiord/Fox-CA (31/32)
- 2 trips o/b between LRR Dewar Lakes/Fox-3 and SRR Nadjuardjuk Lake/Fox-B (32/33)

TOWs2D04: A winter routing which includes --
- 1 TO trip o/b between LSS Iqaluit and Nain (TO D/Na)
- 1 trip o/b between LRR Saglek Bay/Lab-2 and Nain (41/Na)
- 2 trips o/b between LSS Iqaluit and LRR Saglek Bay/Lab-2 (D/41)
- 2 trips o/b between LRR Saglek Bay/Lab-2 and SRR Cape Kakiviak/Lab-1 (40/41)
- 2 trips o/b between LRR Saglek Bay/Lab-2 and SRR Cape Kiglapait/Lab-3 (41/42)

Wd2D25: A winter routing which includes --
- 2 trips o/b between LSS Iqaluit and SRR Cape McLoughlin/Cam-5A (D/25)

Wd2D26: A winter routing which includes --
- 2 trips o/b between LSS Iqaluit and SRR Lailor River/Cam-FA (D/26)

Wd2D27: A winter routing which includes --
- 2 trips o/b between LSS Iqaluit and SRR Rowley Island/Fox-1 (D/27)

Wd2D28: A winter routing which includes --
- 2 trips o/b between LSS Iqaluit and SRR Bray Island/Fox-A (D/28)

Wd2D36: A winter routing which includes --
- 2 trips o/b between LSS Iqaluit and SRR Cape Mercy/Baf-2 (D/36)

Wd2D37: A winter routing which includes --
- 2 trips o/b between LSS Iqaluit and LRR Brevoort Island/Baf-3 (D/37)

Wd2D38: A winter routing which includes --
- 2 trips o/b between LSS Iqaluit and SRR Loks Land/Baf-4A (D/38)

Wd2D39: A winter routing which includes --
- 2 trips o/b between LSS Iqaluit and SRR Resolution Island/Baf-5 (D/39)

Wd2DC: A winter routing which includes --
- 2 trips o/b between LSS Iqaluit and LRR Hall Beach/Fox-M (D/C)

Zone Five -- Goose Bay

DrlE39: A routing between LSS Goose Bay and SRR Resolution Island/Baf-5
DrlE40: A routing between LSS Goose Bay and SRR Cape Kakiviak/Lab-1
DrlE41: A routing between LSS Goose Bay and LRR Saglek Bay/Lab-2
DrlE42: A routing between LSS Goose Bay and SRR Cape Kiglapait/Lab-3
DrlE43: A routing between LSS Goose Bay and SRR Big Bay/Lab-4
DrlE44: A routing between LSS Goose Bay and SRR Tukialik Bay/Lab-5
DrlE45: A routing between LSS Goose Bay and LRR Cartwright/Lab-6

LglE39: A one-way trip between LSS Goose Bay and SRR Resolution Island/Baf-5
LglE40: A one-way trip between LSS Goose Bay and SRR Cape Kakiviak/Lab-1
LglE41: A one-way trip between LSS Goose Bay and LRR Saglek Bay/Lab-2
LglE42: A one-way trip between LSS Goose Bay and SRR Cape Kiglapait/Lab-3
LglE43: A one-way trip between LSS Goose Bay and SRR Big Bay/Lab-4
LglE44: A one-way trip between LSS Goose Bay and SRR Tukialik Bay/Lab-5
LglE45: A one-way trip between LSS Goose Bay and LRR Cartwright/Lab-6

LglE4041: A one-way trip between SRR Cape Kakiviak/Lab-1 and LRR Saglek Bay/Lab-2
LglE4142: A one-way trip between LRR Saglek Bay/Lab-2 and SRR Cape Kiglapait/Lab-3
LglE4445: A one-way trip between SRR Tukialik Bay/Lab-5 and SRR Cartwright/Lab-6

LglE41Na: A one-way trip between LRR Saglek Bay/Lab-2 and Nain
LglE43Ho: A one-way trip between SRR Big Bay/Lab-4 and Hopedale
LglE44Ma: A one-way trip between SRR Tukialik Bay/Lab-5 and Makkovik

Lg3ENain: A one-way TO trip between LSS Goose Bay and Nain
Lg3EHope: A one-way TO trip between LSS Goose Bay and Hopedale
Lg3EMakk: A one-way TO trip between LSS Goose Bay and Makkovik
Lg3Ecart: A one-way TO trip between LSS Goose Bay and Cartwright

SdlE39: A summer routing which includes --
3 trips o/b between LSS Goose Bay and SRR Resolution Island/Baf-5 (E/39)

SslE01: A summer routing which includes --
10 trips o/b between LSS Goose Bay and LRR Saglek Bay/Lab-2 (E/41)
3 trips o/b between LRR Saglek Bay/Lab-2 and SRR Cape Kakiviak/Lab-1 (40/41)
3 trips o/b between LRR Saglek Bay/Lab-2 and SRR Cape Kiglapait/Lab-3 (41/42)

TOSslE01: A summer routing which includes --
4 TO trips between LSS Goose Bay and Nain (TO E/Na)
5 trips o/b between LRR Saglek Bay/Lab-2 and Nain (41/Na)
3 trip o/b between LSS Goose Bay and LRR Saglek Bay/Lab-2 (E/41)
3 trips o/b between LRR Saglek Bay/Lab-2 and SRR Cape Kakiviak/Lab-1 (40/41)
3 trips o/b between LRR Saglek Bay/Lab-2 and SRR Cape Kiglapait/Lab-3 (41/42)

SdlE43: A summer routing which includes --
6 trips o/b between LSS Goose Bay and SRR Big Bay/Lab-4 (E/43)

TOSdlE43: A summer routing which includes --
2 TO trips o/b between LSS Goose Bay and Hopedale (TO E/Ho)
1 trip o/b between SRR Big Bay/Lab-4 and Hopedale (43/Ho)
1 trip o/b between LSS Goose Bay and SRR Big Bay/Lab-4 (E/43)

SdlE44: A summer routing which includes --
6 trips o/b between LSS Goose Bay and SRR Tukialik Bay/Lab-5 (E/44)

TOSdlE44: A summer routing which includes --
3 TO trip o/b between LSS Goose Bay and Makkovik (TO E/Ma)
1 trip o/b between SRR Tukialik Bay/Lab-5 and Makkovik (44/Ma)
1 trip o/b between LSS Goose Bay and SRR Tukialik Bay/Lab-5 (E/44)

SdlE45: A summer routing which includes --
6 trips o/b between LSS Goose Bay and LRR Cartwright/Lab-6 (E/45)

TOSd1E45: A summer routing which includes --
2 TO trips o/b between LSS Goose Bay and Cartwright (TO E/Ca)
1 trip o/b between LSS Goose Bay and LRR Cartwright/Lab-6 (E/45)

Wd1E39: A winter routing which includes --
2 trips o/b between LSS Goose Bay and SRR Resolution Island/Baf-5 (E/39)

Ws1E01: A winter routing which includes --
6 trips o/b between LSS Goose Bay and LRR Saglek Bay/Lab-2 (E/41)
2 trips o/b between LRR Saglek Bay/Lab-2 and SRR Cape Kakiviak/Lab-1 (40/41)
2 trips o/b between LRR Saglek Bay/Lab-2 and SRR Cape Kiglapait/Lab-3 (41/42)

TOWs1E01: A winter routing which includes --
2 TO trips o/b between LSS Goose Bay and Nain (TO E/Na)
3 trips o/b between LRR Saglek Bay/Lab-2 and Nain (41/Na)
3 trips o/b between LSS Goose Bay and LRR Saglek Bay/Lab-2 (E/41)
2 trips o/b between LRR Saglek Bay/Lab-2 and SRR Cape Kakiviak/Lab-1 (40/41)
2 trips o/b between LRR Saglek Bay/Lab-2 and SRR Cape Kiglapait/Lab-3 (41/42)

Wd1E43: A winter routing which includes --
3 trips o/b between LSS Goose Bay and SRR Big Bay/Lab-4 (E/43)

TOWd1E43: A summer routing which includes --
2 TO trips o/b between LSS Goose Bay and Hopedale (TO E/Ho)
1 trip o/b between SRR Big Bay/Lab-4 and Hopedale (43/Ho)
1 trip o/b between LSS Goose Bay and SRR Big Bay/Lab-4 (E/43)

Wd1E44: A winter routing which includes --
3 trips o/b between LSS Goose Bay and SRR Tukialik Bay/Lab-5 (E/44)

TOWd1E44: A summer routing which includes --
3 TO trips o/b between LSS Goose Bay and Makkovik (TO E/Ma)
1 trip o/b between SRR Tukialik Bay/Lab-5 and Makkovik (44/Ma)
1 trip o/b between LSS Goose Bay and SRR Tukialik Bay/Lab-5 (E/44)

Wd1E45: A winter routing which includes --
3 trips o/b between LSS Goose Bay and LRR Cartwright/Lab-6 (E/45)

TOWd1E45: A winter routing which includes --
2 TO trips o/b between LSS Goose Bay and Cartwright (TO E/Ca)
1 trip o/b between LSS Goose Bay and LRR Cartwright/Lab-6 (E/45)

Appendix G

This appendix provides the formulation of the Expanded Model mixed integer linear programming model. This formulation is written as LP code understood by the CPLEX Linear Optimizer. This variation of the Expanded Model formulation depicts the NWS as it operated during FY96 allowing the choice of zone operating boundaries.

```
\This is the CPLEX text for the Expanded Model
\The objective function is to minimize total cost of the system
MINIMIZE 2660Hours1A + 950Hours3A + 2740Hours1B + 945Hours3B + 2740Hours1C + 1260Hours3C
+ 4542Hours2D + 945Hours3D + 2480Hours1E + 945Hours3E + 1000000OPENA + 3500000OPENB
+ 3500000OPENC + 1000000OPEND + 1000000OPENE
SUBJECT TO
\Min. Maintenance Req. Constraint 1A:  SRR Komokuk Beach/Bar-1
Dr1A01 + Ss1A01 + TOSs1A01 + Ws1A01 + TOWs1A01 >= 7
\Min. Maintenance Req. Constraint 2A:  SRR Stokes Point/Bar-B
Dr1A02 + Ss1A01 + TOSs1A01 + Ws1A01 + TOWs1A01 >= 11
\Min. Maintenance Req. Constraint 3A:  LRR Shingle Point/Bar-2
Dr1A03 + Ss1A01 + TOSs1A01 + Ws1A01 + TOWs1A01 >= 19
\Min. Maintenance Req. Constraint 4A:  SRR Storm Hills/Bar-BA3
Dr1A04 + Sd1A04 + Wd1A04 >= 11
\Min. Maintenance Req. Constraint 5A:  SRR Tuktoyaktuk/Bar-3
Dr1A05 + Sd1A05 + Wd1A05 >= 13
\Min. Maintenance Req. Constraint 6A:  SRR Liverpool Bay/Bar-DA1
Dr1A06 + Sd1A06 + Wd1A06 >= 11
\Min. Maintenance Req. Constraint 7A:  SRR Nicholson Island/Bar-4
Dr1A07 + Ss1A02 + TOSs1A02 + Ws1A02 + TOWs1A02 - 11ASSIGNA07 >= 0
Dr1A07 + Ss1A02 + TOSs1A02 + Ws1A02 + TOWs1A02 - 50ASSIGNA07 <= 0
\Min. Maintenance Req. Constraint 8A:  SRR Horton River/Bar-E
Dr1A08 + Ss1A02 + TOSs1A02 + Ws1A02 + TOWs1A02 - 7ASSIGNA08 >= 0
Dr1A08 + Ss1A02 + TOSs1A02 + Ws1A02 + TOWs1A02 - 50ASSIGNA08 <= 0
\Min. Maintenance Req. Constraint 9A:  LRR Cape Parry/Pin-M
Dr1A09 + Ss1A02 + TOSs1A02 + Ws1A02 + TOWs1A02 - 12ASSIGNA09 >= 0
Dr1A09 + Ss1A02 + TOSs1A02 + Ws1A02 + TOWs1A02 - 50ASSIGNA09 <= 0
\Min. Maintenance Req. Constraint 10A:  SRR Keats Point/Pin-1BD
Dr1A10 + Ss1A02 + TOSs1A02 + Ws1A02 + TOWs1A02 - 10ASSIGNA10 >= 0
Dr1A10 + Ss1A02 + TOSs1A02 + Ws1A02 + TOWs1A02 - 50ASSIGNA10 <= 0
\Min. Maintenance Req. Constraint 11A:  SRR Croker River/Pin-1BG
Dr1A11 + Ss1A02 + TOSs1A02 + Ws1A02 + TOWs1A02 - 8ASSIGNA11 >= 0
Dr1A11 + Ss1A02 + TOSs1A02 + Ws1A02 + TOWs1A02 - 50ASSIGNA11 <= 0
\Min. Maintenance Req. Constraint 12A:  SRR Harding River/Pin-2A
Dr1A12 + Ss1A03 + TOSs1A03 + Ws1A03 + TOWs1A03 - 9ASSIGNA12 >= 0
Dr1A12 + Ss1A03 + TOSs1A03 + Ws1A03 + TOWs1A03 - 50ASSIGNA12 <= 0
\Min. Maintenance Req. Constraint 13A:  SRR Bernard Harbour/Pin-CB
Dr1A13 + Ss1A03 + TOSs1A03 + Ws1A03 + TOWs1A03 - 9ASSIGNA13 >= 0
Dr1A13 + Ss1A03 + TOSs1A03 + Ws1A03 + TOWs1A03 - 50ASSIGNA13 <= 0
\Min. Maintenance Req. Constraint 14A:  LRR Lady Franklin Point/Pin-3
Dr1A14 + Ss1A03 + TOSs1A03 + Ws1A03 + TOWs1A03 - 17ASSIGNA14 >= 0
Dr1A14 + Ss1A03 + TOSs1A03 + Ws1A03 + TOWs1A03 - 50ASSIGNA14 <= 0
\Min. Maintenance Req. Constraint 15A:  SRR Edinburgh Island/Pin-DA
Dr1A15 + Ss1A03 + TOSs1A03 + Ws1A03 + TOWs1A03 - 10ASSIGNA15 >= 0
Dr1A15 + Ss1A03 + TOSs1A03 + Ws1A03 + TOWs1A03 - 50ASSIGNA15 <= 0
\Min. Maintenance Req. Constraint 16A:  SRR Cape Peel West/Pin-EB
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Dr1A16 + Sd1A16 + Wd1A16 - 10ASSIGNA16 >= 0
Dr1A16 + Sd1A16 + Wd1A16 - 50ASSIGNA16 <= 0
\Min. Maintenance Req. Constraint 7B:  SRR Nicholson Island/Bar-4
Dr1B07 + Ss1B03 + TOSs1B03 + Ws1B03 + TOWs1B03 - 11ASSIGNB07 >= 0
Dr1B07 + Ss1B03 + TOSs1B03 + Ws1B03 + TOWs1B03 - 50ASSIGNB07 <= 0
\Min. Maintenance Req. Constraint 8B:  SRR Horton River/Bar-E
Dr1B08 + Ss1B03 + TOSs1B03 + Ws1B03 + TOWs1B03 - 7ASSIGNB08 >= 0
Dr1B08 + Ss1B03 + TOSs1B03 + Ws1B03 + TOWs1B03 - 50ASSIGNB08 <= 0
\Min. Maintenance Req. Constraint 9B:  LRR Cape Parry/Pin-M
Dr1B09 + Ss1B03 + TOSs1B03 + Ws1B03 + TOWs1B03 - 12ASSIGNB09 >= 0
Dr1B09 + Ss1B03 + TOSs1B03 + Ws1B03 + TOWs1B03 - 50ASSIGNB09 <= 0
\Min. Maintenance Req. Constraint 10B:  SRR Keats Point/Pin-1BD
Dr1B10 + Ss1B03 + TOSs1B03 + Ws1B03 + TOWs1B03 - 10ASSIGNB10 >= 0
Dr1B10 + Ss1B03 + TOSs1B03 + Ws1B03 + TOWs1B03 - 50ASSIGNB10 <= 0
\Min. Maintenance Req. Constraint 11B:  SRR Croker River/Pin-1BG
Dr1B11 + Ss1B03 + TOSs1B03 + Ws1B03 + TOWs1B03 - 8ASSIGNB11 >= 0
Dr1B11 + Ss1B03 + TOSs1B03 + Ws1B03 + TOWs1B03 - 50ASSIGNB11 <= 0
\Min. Maintenance Req. Constraint 12B:  SRR Harding River/Pin-2A
Dr1B12 + Ss1B01 + TOSs1B01 + Ws1B01 + TOWs1B01 - 9ASSIGNB12 >= 0
Dr1B12 + Ss1B01 + TOSs1B01 + Ws1B01 + TOWs1B01 - 50ASSIGNB12 <= 0
\Min. Maintenance Req. Constraint 13B:  SRR Bernard Harbour/Pin-CB
Dr1B13 + Ss1B01 + TOSs1B01 + Ws1B01 + TOWs1B01 - 9ASSIGNB13 >= 0
Dr1B13 + Ss1B01 + TOSs1B01 + Ws1B01 + TOWs1B01 - 50ASSIGNB13 <= 0
\Min. Maintenance Req. Constraint 14B:  LRR Lady Franklin Point/Pin-3
Dr1B14 + Ss1B01 + TOSs1B01 + Ws1B01 + TOWs1B01 - 17ASSIGNB14 >= 0
Dr1B14 + Ss1B01 + TOSs1B01 + Ws1B01 + TOWs1B01 - 50ASSIGNB14 <= 0
\Min. Maintenance Req. Constraint 15B:  SRR Edinburgh Island/Pin-DA
Dr1B15 + Ss1B01 + TOSs1B01 + Ws1B01 + TOWs1B01 - 10ASSIGNB15 >= 0
Dr1B15 + Ss1B01 + TOSs1B01 + Ws1B01 + TOWs1B01 - 50ASSIGNB15 <= 0
\Min. Maintenance Req. Constraint 16B:  SRR Cape Peel West/Pin-EB
Dr1B16 + Sd1B16 + Wd1B16 - 10ASSIGNB16 >= 0
Dr1B16 + Sd1B16 + Wd1B16 - 50ASSIGNB16 <= 0
\Min. Maintenance Req. Constraint 17B:  SRR Sturt Point North/Cam-A3A
Dr1B17 + Sd1B17 + Wd1B17 - 9ASSIGNB17 >= 0
Dr1B17 + Sd1B17 + Wd1B17 - 50ASSIGNB17 <= 0
\Min. Maintenance Req. Constraint 18B:  SRR Jenny Lind Island/Cam-1A
Dr1B18 + Sd1B18 + Wd1B18 - 11ASSIGNB18 >= 0
Dr1B18 + Sd1B18 + Wd1B18 - 50ASSIGNB18 <= 0
\Min. Maintenance Req. Constraint 19B:  SRR Hat Island/Cam-B
Dr1B19 + Sd1B19 + Wd1B19 - 9ASSIGNB19 >= 0
Dr1B19 + Sd1B19 + Wd1B19 - 50ASSIGNB19 <= 0
\Min. Maintenance Req. Constraint 20B:  SRR Gladman Point/Cam-2
Dr1B20 + Ss1B04 + TOSs1B04 + Ws1B04 + TOWs1B04 - 10ASSIGNB20 >= 0
Dr1B20 + Ss1B04 + TOSs1B04 + Ws1B04 + TOWs1B04 - 50ASSIGNB20 <= 0
\Min. Maintenance Req. Constraint 21B:  SRR Gjoa Haven/Cam-CB
Dr1B21 + Ss1B04 + TOSs1B04 + Ws1B04 + TOWs1B04 - 9ASSIGNB21 >= 0
Dr1B21 + Ss1B04 + TOSs1B04 + Ws1B04 + TOWs1B04 - 50ASSIGNB21 <= 0
\Min. Maintenance Req. Constraint 22B:  LRR Sheperd Bay/Cam-3
Dr1B22 + Ss1B04 + TOSs1B04 + Ws1B04 + TOWs1B04 - 21ASSIGNB22 >= 0
Dr1B22 + Ss1B04 + TOSs1B04 + Ws1B04 + TOWs1B04 - 50ASSIGNB22 <= 0
\Min. Maintenance Req. Constraint 23B:  SRR Simpson Lake/Cam-D
Dr1B23 + Ss1B04 + TOSs1B04 + Ws1B04 + TOWs1B04 - 12ASSIGNB23 >= 0
Dr1B23 + Ss1B04 + TOSs1B04 + Ws1B04 + TOWs1B04 - 50ASSIGNB23 <= 0
\Min. Maintenance Req. Constraint 24B:  SRR Pelly Bay/Cam-4
Dr1B24 + Ss1B04 + TOSs1B04 + Ws1B04 + TOWs1B04 - 12ASSIGNB24 >= 0
Dr1B24 + Ss1B04 + TOSs1B04 + Ws1B04 + TOWs1B04 - 50ASSIGNB24 <= 0
\Min. Maintenance Req. Constraint 25B:  SRR Cape McLoughlin/Cam-5A
Dr1B25 + Sd1B25 + Wd1B25 - 20ASSIGNB25 >= 0
Dr1B25 + Sd1B25 + Wd1B25 - 50ASSIGNB25 <= 0
\Min. Maintenance Req. Constraint 26B:  SRR Lailor River/Cam-FA
Dr1B26 + Sd1B26 + Wd1B26 - 14ASSIGNB26 >= 0
Dr1B26 + Sd1B26 + Wd1B26 - 50ASSIGNB26 <= 0
\Min. Maintenance Req. Constraint 17C:  SRR Sturt Point North/Cam-A3A
Dr1C17 + Sd1C17 + Wd1C17 - 9ASSIGNC17 >= 0
Dr1C17 + Sd1C17 + Wd1C17 - 50ASSIGNC17 <= 0
\Min. Maintenance Req. Constraint 18C:  SRR Jenny Lind Island/Cam-1A
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Dr1C18 + Sd1C18 + Wd1C18 - 11ASSIGNC18 >= 0
Dr1C18 + Sd1C18 + Wd1C18 - 50ASSIGNC18 <= 0
\Min. Maintenance Req. Constraint 19C:  SRR Hat Island/Cam-B
Dr1C19 + Sd1C19 + Wd1C19 - 9ASSIGNC19 >= 0
Dr1C19 + Sd1C19 + Wd1C19 - 50ASSIGNC19 <= 0
\Min. Maintenance Req. Constraint 20C:  SRR Gladman Point/Cam-2
Dr1C20 + Ss1C03 + TOSs1C03 + Ws1C03 + TOSs1C03 - 10ASSIGNC20 >= 0
Dr1C20 + Ss1C03 + TOSs1C03 + Ws1C03 + TOSs1C03 - 50ASSIGNC20 <= 0
\Min. Maintenance Req. Constraint 21C:  SRR Gjoa Haven/Cam-CB
Dr1C21 + Ss1C03 + TOSs1C03 + Ws1C03 + TOSs1C03 - 9ASSIGNC21 >= 0
Dr1C21 + Ss1C03 + TOSs1C03 + Ws1C03 + TOSs1C03 - 50ASSIGNC21 <= 0
\Min. Maintenance Req. Constraint 22C:  LRR Sheperd Bay/Cam-3
Dr1C22 + Ss1C03 + TOSs1C03 + Ws1C03 + TOWs1C03 - 21ASSIGNC22 >= 0
Dr1C22 + Ss1C03 + TOSs1C03 + Ws1C03 + TOWs1C03 - 50ASSIGNC22 <= 0
\Min. Maintenance Req. Constraint 23C:  SRR Simpson Lake/Cam-D
Dr1C23 + Ss1C03 + TOSs1C03 + Ws1C03 + TOWs1C03 - 12ASSIGNC23 >= 0
Dr1C23 + Ss1C03 + TOSs1C03 + Ws1C03 + TOWs1C03 - 50ASSIGNC23 <= 0
\Min. Maintenance Req. Constraint 24C:  SRR Pelly Bay/Cam-4
Dr1C24 + Ss1C03 + TOSs1C03 + Ws1C03 + TOWs1C03 - 12ASSIGNC24 >= 0
Dr1C24 + Ss1C03 + TOSs1C03 + Ws1C03 + TOWs1C03 - 50ASSIGNC24 <= 0
\Min. Maintenance Req. Constraint 25C:  SRR Cape McLoughlin/Cam-5A
Dr1C25 + Sd1C25 + Wd1C25 - 20ASSIGNC25 >= 0
Dr1C25 + Sd1C25 + Wd1C25 - 50ASSIGNC25 <= 0
\Min. Maintenance Req. Constraint 26C:  SRR Lailor River/Cam-FA
Dr1C26 + Sd1C26 + Wd1C26 - 14ASSIGNC26 >= 0
Dr1C26 + Sd1C26 + Wd1C26 - 50ASSIGNC26 <= 0
\Min. Maintenance Req. Constraint 27C:  SRR Rowley Island/Fox-1
Dr1C27 + Sd1C27 + Wd1C27 - 12ASSIGNC27 >= 0
Dr1C27 + Sd1C27 + Wd1C27 - 50ASSIGNC27 <= 0
\Min. Maintenance Req. Constraint 28C:  SRR Bray Island/Fox-A
Dr1C28 + Sd1C28 + Wd1C28 - 11ASSIGNC28 >= 0
Dr1C28 + Sd1C28 + Wd1C28 - 50ASSIGNC28 <= 0
\Min. Maintenance Req. Constraint 29C:  SRR Longstaff Bluff/Fox-2
Dr1C29 + Ss1C04 + Ws1C04 - 12ASSIGNC29 >= 0
Dr1C29 + Ss1C04 + Ws1C04 - 50ASSIGNC29 <= 0
\Min. Maintenance Req. Constraint 30C:  SRR Nadluardjuk Lake/Fox-B
Dr1C30 + Ss1C04 + Ws1C04 - 8ASSIGNC30 >= 0
Dr1C30 + Ss1C04 + Ws1C04 - 50ASSIGNC30 <= 0
\ Min. Maintenance Req. Constraint 31C:  LRR Dewar Lakes/Fox-3
Dr1C31 + Ss1C04 + Ws1C04 - 13ASSIGNC31 >= 0
Dr1C31 + Ss1C04 + Ws1C04 - 50ASSIGNC31 <= 0
\ Min. Maintenance Req. Constraint 32C:  SRR Kangok Fiord/Fox-CA
Dr1C32 + Ss1C04 + Ws1C04 - 8ASSIGNC32 >= 0
Dr1C32 + Ss1C04 + Ws1C04 - 50ASSIGNC32 <= 0
\ Min. Maintenance Req. Constraint 33C:  SRR Cape Hooper/Fox-4
Dr1C33 + Ss1C04 + Ws1C04 - 8ASSIGNC33 >= 0
Dr1C33 + Ss1C04 + Ws1C04 - 50ASSIGNC33 <= 0
\ Min. Maintenance Req. Constraint 34C:  SRR Broughton Island/Fox-5
Dr1C30 + Ss1C05 + TOSs1C05 + Ws1C05 + TOWs1C05 - 7ASSIGNC34 >= 0
Dr1C30 + Ss1C05 + TOSs1C05 + Ws1C05 + TOWs1C05 - 50ASSIGNC34 <= 0
\ Min. Maintenance Req. Constraint 35C:  LRR Cape Dyer/Dye-M
Dr1C35 + Ss1C05 + TOSs1C05 + Ws1C05 + TOWs1C05 - 12ASSIGNC35 >= 0
Dr1C35 + Ss1C05 + TOSs1C05 + Ws1C05 + TOWs1C05 - 50ASSIGNC35 <= 0
\ Min. Maintenance Req. Constraint 36C:  SRR Cape Mercy/Bar-2
Dr1C36 + Sd1C36 + Wd1C36 - 9ASSIGNC36 >= 0
Dr1C36 + Sd1C36 + Wd1C36 - 50ASSIGNC36 <= 0
\Min. Maintenance Req. Constraint 25D:  SRR Cape McLoughlin/Cam-5A
Dr2D25 + Sd2D25 + Wd2D25 - 20ASSIGND25 >= 0
Dr2D25 + Sd2D25 + Wd2D25 - 50ASSIGND25 <= 0
\Min. Maintenance Req. Constraint 26D:  SRR Lailor River/Cam-FA
Dr2D26 + Sd2D26 + Wd2D26 - 14ASSIGND26 >= 0
Dr2D26 + Sd2D26 + Wd2D26 - 50ASSIGND26 <= 0
\Min. Maintenance Req. Constraint 27D:  SRR Rowley Island/Fox-1
Dr2D27 + Sd2D27 + Wd2D27 - 12ASSIGND27 >= 0
Dr2D27 + Sd2D27 + Wd2D27 - 50ASSIGND27 <= 0
\Min. Maintenance Req. Constraint 28D:  SRR Bray Island/Fox-A
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Dr2D28 + Sd2D28 + Wd2D28 - 11ASSIGND28 >= 0
Dr2D28 + Sd2D28 + Wd2D28 - 50ASSIGND28 <= 0
\Min. Maintenance Req. Constraint 29D:  SRR Longstaff Bluff/Fox-2
Dr2D29 + Ss2D03 + TOSs2D03 + Ws2D03 + TOWs2D03 - 12ASSIGND29 >= 0
Dr2D29 + Ss2D03 + TOSs2D03 + Ws2D03 + TOWs2D03 - 50ASSIGND29 <= 0
\Min. Maintenance Req. Constraint 30D:  SRR Nakluardjuk Lake/Fox-B
Dr2D30 + Ss2D03 + TOSs2D03 + Ws2D03 + TOWs2D03 - 8ASSIGND30 >= 0
Dr2D30 + Ss2D03 + TOSs2D03 + Ws2D03 + TOWs2D03 - 50ASSIGND30 <= 0
\Min. Maintenance Req. Constraint 31D:  LRR Dewar Lakes/Fox-3
Dr2D31 + Ss2D03 + TOSs2D03 + Ws2D03 + TOWs2D03 - 13ASSIGND31 >= 0
Dr2D31 + Ss2D03 + TOSs2D03 + Ws2D03 + TOWs2D03 - 50ASSIGND31 <= 0
\Min. Maintenance Req. Constraint 32D:  SRR Kankgok Fiord/Fox-CA
Dr2D32 + Ss2D03 + TOSs2D03 + Ws2D03 + TOWs2D03 - 8ASSIGND32 >= 0
Dr2D32 + Ss2D03 + TOSs2D03 + Ws2D03 + TOWs2D03 - 50ASSIGND32 <= 0
\Min. Maintenance Req. Constraint 33D:  SRR Cape Hooper/Fox-4
Dr2D33 + Ss2D03 + TOSs2D03 + Ws2D03 + TOWs2D03 - 8ASSIGND33 >= 0
Dr2D33 + Ss2D03 + TOSs2D03 + Ws2D03 + TOWs2D03 - 50ASSIGND33 <= 0
\Min. Maintenance Req. Constraint 34D:  SRR Broughton Island/Fox-5
Dr2D34 + Ss2D02 + TOSs2D02 + Ws2D02 + TOWs2D02 - 7ASSIGND34 >= 0
Dr2D34 + Ss2D02 + TOSs2D02 + Ws2D02 + TOWs2D02 - 50ASSIGND34 <= 0
\Min. Maintenance Req. Constraint 35D:  LRR Cape Dyer/Dye-M
Dr2D35 + Ss2D02 + TOSs2D02 + Ws2D02 + TOWs2D02 - 12ASSIGND35 >= 0
Dr2D35 + Ss2D02 + TOSs2D02 + Ws2D02 + TOWs2D02 - 50ASSIGND35 <= 0
\Min. Maintenance Req. Constraint 36D:  SRR Cape Mercy/Baf-2
Dr2D36 + Sd2D36 + Wd2D36 - 9ASSIGND36 >= 0
Dr2D36 + Sd2D36 + Wd2D36 - 50ASSIGND36 <= 0
\Min. Maintenance Req. Constraint 37D:  LRR Brevoort Island/Baf-3
Dr2D37 + Sd2D37 + Wd2D37 >= 18
\Min. Maintenance Req. Constraint 38D:  SRR Loks Land/Baf-4A
Dr2D38 + Sd2D38 + Wd2D38 >= 9
\Min. Maintenance Req. Constraint 39D:  SRR Resolution Island/Baf-5
Dr2D39 + Sd2D39 + Wd2D39 - 9ASSIGND39 >= 0
Dr2D39 + Sd2D39 + Wd2D39 - 50ASSIGND39 <= 0
\Min. Maintenance Req. Constraint 40D:  SRR Cape Kakiviak/Lab-1
Dr2D40 + Ss2D04 + TOSs2D04 + Ws2D04 + TOWs2D04 - 9ASSIGND40 >= 0
Dr2D40 + Ss2D04 + TOSs2D04 + Ws2D04 + TOWs2D04 - 50ASSIGND40 <= 0
\Min. Maintenance Req. Constraint 41D:  LRR Saglek Bay/Lab-2
Dr2D41 + Ss2D04 + TOSs2D04 + Ws2D04 + TOWs2D04 - 19ASSIGND41 >= 0
Dr2D41 + Ss2D04 + TOSs2D04 + Ws2D04 + TOWs2D04 - 50ASSIGND41 <= 0
\Min. Maintenance Req. Constraint 42D:  SRR Cape Kiglapait/Lab-3
Dr2D42 + Ss2D04 + TOSs2D04 + Ws2D04 + TOWs2D04 - 10ASSIGND42 >= 0
Dr2D42 + Ss2D04 + TOSs2D04 + Ws2D04 + TOWs2D04 - 50ASSIGND42 <= 0
\Min. Maintenance Req. Constraint 39E:  SRR Resolution Island/Baf-5
Dr1E39 + Sd1E39 + Wd1E39 - 9ASSIGNE39 >= 0
Dr1E39 + Sd1E39 + Wd1E39 - 50ASSIGNE39 <= 0
\Min. Maintenance Req. Constraint 40E:  SRR Cape Kakiviak/Lab-1
Dr1E40 + Ss1E01 + TOSs1E01 + Ws1E01 + TOWs1E01 - 9ASSIGNE40 >= 0
Dr1E40 + Ss1E01 + TOSs1E01 + Ws1E01 + TOWs1E01 - 50ASSIGNE40 <= 0
\Min. Maintenance Req. Constraint 41E:  LRR Saglek Bay/Lab-2
Dr1E41 + Ss1E01 + TOSs1E01 + Ws1E01 + TOWs1E01 - 19ASSIGNE41 >= 0
Dr1E41 + Ss1E01 + TOSs1E01 + Ws1E01 + TOWs1E01 - 50ASSIGNE41 <= 0
\Min. Maintenance Req. Constraint 42E:  SRR Cape Kiglapait/Lab-3
Dr1E42 + Ss1E01 + TOSs1E01 + Ws1E01 + TOWs1E01 - 10ASSIGNE42 >= 0
Dr1E42 + Ss1E01 + TOSs1E01 + Ws1E01 + TOWs1E01 - 50ASSIGNE42 <= 0
\Min. Maintenance Req. Constraint 43E:  SRR Big Bay/Lab-4
Dr1E43 + Sd1E43 + TOSd1E43 + Wd1E43 + TOWd1E43 >= 17
\Min. Maintenance Req. Constraint 44E:  SRR Tukialik Bay/Lab-5
Dr1E44 + Sd1E44 + TOSd1E44 + Wd1E44 + TOWd1E44 >= 11
\Min. Maintenance Req. Constraint 45E:  SRR Cartwright
Dr1E45 + Sd1E45 + TOSd1E45 + Wd1E45 + TOWd1E45 >= 11
\Min. Maintenance Req. Constraint CB:  LRR Hall Beach/Fox-M
Dr1BC + Sd1BC + Wd1BC - 11ASSIGNBC >= 0
Dr1BC + Sd1BC + Wd1BC - 50ASSIGNBC <= 0
\Min. Maintenance Req. Constraint CD:  LRR Hall Beach/Fox-M
Dr2DC + Sd2DC + Wd2DC - 11ASSIGNDC >= 0
Dr2DC + Sd2DC + Wd2DC - 50ASSIGNDC <= 0
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\Min. Maintenance Req. Constraint BA:  LRR Cambridge Bay/Cam-M
Dr1AB + Sd1AB + Wd1AB - 11ASSIGNAB >= 0
Dr1AB + Sd1AB + Wd1AB - 50ASSIGNAB <= 0
\Min. Maintenance Req. Constraint BC:  LRR Cambridge Bay/Cam-M
Dr1CB + Sd1CB + Wd1CB - 11ASSIGNCB >= 0
Dr1CB + Sd1CB + Wd1CB - 50ASSIGNCB <= 0
\Summer PMI Requirement Constraints
\Sites 01/02/03
Ss1A01 + TOSs1A01 >= 2
Sd1A04 >= 2
Sd1A05 >= 2
Sd1A06 >= 2
\Sites 07/08/09/10/11
Ss1A02 + TOSs1A02 - 2ASSIGNA07 >= 0
Ss1A02 + TOSs1A02 - 2ASSIGNA08 >= 0
Ss1A02 + TOSs1A02 - 2ASSIGNA09 >= 0
Ss1A02 + TOSs1A02 - 2ASSIGNA10 >= 0
Ss1A02 + TOSs1A02 - 2ASSIGNA11 >= 0
Ss1A02 + TOSs1A02 - 50ASSIGNA07 - 50ASSIGNA08 - 50ASSIGNA09 - 50ASSIGNA10 - 50ASSIGNA11 <= 0
\Sites 12/13/14/15
Ss1A03 + TOSs1A03 - 2ASSIGNA12 >= 0
Ss1A03 + TOSs1A03 - 2ASSIGNA13 >= 0
Ss1A03 + TOSs1A03 - 2ASSIGNA14 >= 0
Ss1A03 + TOSs1A03 - 2ASSIGNA15 >= 0
Ss1A03 + TOSs1A03 - 50ASSIGNA12 - 50ASSIGNA13 - 50ASSIGNA14 - 50ASSIGNA15 <= 0
\Site 16
Sd1A16 - 2ASSIGNA16 >= 0
Sd1A16 - 50ASSIGNA16 <= 0
\Sites 07/08/09/10/11
Ss1B03 + TOSs1B03 - 2ASSIGNB07 >= 0
Ss1B03 + TOSs1B03 - 2ASSIGNB08 >= 0
Ss1B03 + TOSs1B03 - 2ASSIGNB09 >= 0
Ss1B03 + TOSs1B03 - 2ASSIGNB10 >= 0
Ss1B03 + TOSs1B03 - 2ASSIGNB11 >= 0
Ss1B03 + TOSs1B03 - 50ASSIGNB07 - 50ASSIGNB08 - 50ASSIGNB09 - 50ASSIGNB10 - 50ASSIGNB11 <= 0
\Sites 12/13/14/15
Ss1B01 + TOSs1B01 - 2ASSIGNB12 >= 0
Ss1B01 + TOSs1B01 - 2ASSIGNB13 >= 0
Ss1B01 + TOSs1B01 - 2ASSIGNB14 >= 0
Ss1B01 + TOSs1B01 - 2ASSIGNB15 >= 0
Ss1B01 + TOSs1B01 - 50ASSIGNB12 - 50ASSIGNB13 - 50ASSIGNB14 - 50ASSIGNB15 <= 0
Sd1B16 - 2ASSIGNB16 >= 0
Sd1B16 - 50ASSIGNB16 <= 0
Sd1B17 - 2ASSIGNB17 >= 0
Sd1B17 - 50ASSIGNB17 <= 0
Sd1B18 - 2ASSIGNB18 >= 0
Sd1B18 - 50ASSIGNB18 <= 0
Sd1B19 - 2ASSIGNB19 >= 0
Sd1B19 - 50ASSIGNB19 <= 0
\Sites 20/21/22/23/24
Ss1B04 + TOSs1B04 - 2ASSIGNB20 >= 0
Ss1B04 + TOSs1B04 - 2ASSIGNB21 >= 0
Ss1B04 + TOSs1B04 - 2ASSIGNB22 >= 0
Ss1B04 + TOSs1B04 - 2ASSIGNB23 >= 0
Ss1B04 + TOSs1B04 - 2ASSIGNB24 >= 0
Ss1B04 + TOSs1B04 - 50ASSIGNB20 - 50ASSIGNB21 - 50ASSIGNB22 - 50ASSIGNB23 - 50ASSIGNB24 <= 0
Sd1B25 - 2ASSIGNB25 >= 0
Sd1B25 - 50ASSIGNB25 <= 0
Sd1B26 - 2ASSIGNB26 >= 0
Sd1B26 - 50ASSIGNB26 <= 0
Sd1C17 - 2ASSIGNC17 >= 0
Sd1C17 - 50ASSIGNC17 <= 0
Sd1C18 - 2ASSIGNC18 >= 0
Sd1C18 - 50ASSIGNC18 <= 0
Sd1C19 - 2ASSIGNC19 >= 0
Sd1C19 - 50ASSIGNC19 <= 0
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\Sites 20/21
Ss1C03 + TOSs1C03 - 2ASSIGNC20 >= 0
Ss1C03 + TOSs1C03 - 2ASSIGNC21 >= 0
Ss1C03 + TOSs1C03 - 2ASSIGNC22 >= 0
Ss1C03 + TOSs1C03 - 2ASSIGNC23 >= 0
Ss1C03 + TOSs1C03 - 2ASSIGNC24 >= 0
Ss1C03 + TOSs1C03 - 50ASSIGNC20 - 50ASSIGNC21 - 50ASSIGNC22 - 50ASSIGNC23 - 50ASSIGNC24 <= 0
Sd1C25 - 2ASSIGNC25 >= 0
Sd1C25 - 50ASSIGNC25 <= 0
Sd1C26 - 2ASSIGNC26 >= 0
Sd1C26 - 50ASSIGNC26 <= 0
Sd1C27 - 2ASSIGNC27 >= 0
Sd1C27 - 50ASSIGNC27 <= 0
Sd1C28 - 2ASSIGNC28 >= 0
Sd1C28 - 50ASSIGNC28 <= 0
\Sites 29/30/31/32/33
Ss1C04 - 2ASSIGNC29 >= 0
Ss1C04 - 2ASSIGNC30 >= 0
Ss1C04 - 2ASSIGNC31 >= 0
Ss1C04 - 2ASSIGNC32 >= 0
Ss1C04 - 2ASSIGNC33 >= 0
Ss1C04 - 50ASSIGNC29 - 50ASSIGNC30 - 50ASSIGNC31- 50ASSIGNC32 - 50ASSIGNC33 <= 0
\Sites 34/35
Ss1C05 + TOSs1C05 - 2ASSIGNC34 >= 0
Ss1C05 + TOSs1C05 - 2ASSIGNC35 >= 0
Ss1C05 + TOSs1C05 - 50ASSIGNC34 - 50 ASSIGNC35 <= 0
Sd1C36 - 2ASSIGNC36 >= 0
Sd1C36 - 50ASSIGNC36 <= 0
Sd2D25 - 2ASSIGND25 >= 0
Sd2D25 - 50ASSIGND25 <= 0
Sd2D26 - 2ASSIGND26 >= 0
Sd2D26 - 50ASSIGND26 <= 0
Sd2D27 - 2ASSIGND27 >= 0
Sd2D27 - 50ASSIGND27 <= 0
Sd2D28 - 2ASSIGND28 >= 0
Sd2D28 - 50ASSIGND28 <= 0
\Site 29/30/31/32/33
Ss2D03 + TOSs2D03 - 2ASSIGND29 >= 0
Ss2D03 + TOSs2D03 - 2ASSIGND30 >= 0
Ss2D03 + TOSs2D03 - 2ASSIGND31 >= 0
Ss2D03 + TOSs2D03 - 2ASSIGND32 >= 0
Ss2D03 + TOSs2D03 - 2ASSIGND33 >= 0
Ss2D03 + TOSs2D03 - 50ASSIGND29 - 50ASSIGND30 - 50ASSIGND31 - 50ASSIGND32 - 50ASSIGND33 <= 0
\Sites 34/35
Ss2D02 + TOSs2D02 - 2ASSIGND34 >= 0
Ss2D02 + TOSs2D02 - 2ASSIGND35 >= 0
Ss2D02 + TOSs2D02 - 50ASSIGND34 - 50ASSIGND35 <= 0
Sd2D36 - 2ASSIGND36 >= 0
Sd2D36 - 50ASSIGND36 <= 0
Sd2D37 >= 2
Sd2D38 >= 2
Sd2D39 - 2ASSIGND39 >= 0
Sd2D39 - 50ASSIGND39 <= 0
\Sites 40/41/42
Ss2D04 + TOSs2D04 - 2ASSIGND40 >= 0
Ss2D04 + TOSs2D04 - 2ASSIGND41 >= 0
Ss2D04 + TOSs2D04 - 2ASSIGND42 >= 0
Ss2D04 + TOSs2D04 - 50ASSIGND40 - 50ASSIGND41 - 50ASSIGND42 <= 0
Sd1E39 - 2ASSIGNE39 >= 0
Sd1E39 - 50ASSIGNE39 <= 0
\Sites 40/41/42
Ss1E01 + TOSs1E01 - 2ASSIGNE40 >= 0
Ss1E01 + TOSs1E01 - 2ASSIGNE41 >= 0
Ss1E01 + TOSs1E01 - 2ASSIGNE42 >= 0
Ss1E01 + TOSs1E01 - 50ASSIGNE40 - 50ASSIGNE41 - 50ASSIGNE42 <= 0
Sd1E43 + TOSd1E43 >= 2
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Sd1E44 + TOSd1E44 >= 2
Sd1E45 + TOSd1E45 >= 2
\Site C
Sd1BC - 2ASSIGNBC >= 0
Sd1BC - 50ASSIGNBC <= 0
Sd2DC - 2ASSIGNDC >= 0
Sd2DC - 50ASSIGNDC <= 0
\Site B
Sd1AB - 2ASSIGNAB >= 0
Sd1AB - 50ASSIGNAB <= 0
Sd1CB - 2ASSIGNCB >= 0
Sd1CB - 50ASSIGNCB <= 0
\Winter PMI Requirement Constraints
\Sites 01/02/03
Ws1A01 + TOWs1A01 >= 2
Wd1A04 >= 2
Wd1A05 >= 2
Wd1A06 >= 2
\Sites 07/08/09/10/11
Ws1A02 + TOWs1A02 - 2ASSIGNA07 >= 0
Ws1A02 + TOWs1A02 - 2ASSIGNA08 >= 0
Ws1A02 + TOWs1A02 - 2ASSIGNA09 >= 0
Ws1A02 + TOWs1A02 - 2ASSIGNA10 >= 0
Ws1A02 + TOWs1A02 - 2ASSIGNA11 >= 0
Ws1A02 + TOWs1A02 - 50ASSIGNA07 - 50ASSIGNA08 - 50ASSIGNA09 - 50ASSIGNA10 - 50ASSIGNA11 <= 0
\Sites 12/13/14/15
Ws1A03 + TOWs1A03 - 2ASSIGNA12 >= 0
Ws1A03 + TOWs1A03 - 2ASSIGNA13 >= 0
Ws1A03 + TOWs1A03 - 2ASSIGNA14 >= 0
Ws1A03 + TOWs1A03 - 2ASSIGNA15 >= 0
Ws1A03 + TOWs1A03 - 50ASSIGNA12 - 50ASSIGNA13 - 50ASSIGNA14 - 50ASSIGNA15 <= 0
\Site 16
Wd1A16 - 2ASSIGNA16 >= 0
Wd1A16 - 50ASSIGNA16 <= 0
\Sites 07/08/09/10/11
Ws1B03 + TOWs1B03 - 2ASSIGNB07 >= 0
Ws1B03 + TOWs1B03 - 2ASSIGNB08 >= 0
Ws1B03 + TOWs1B03 - 2ASSIGNB09 >= 0
Ws1B03 + TOWs1B03 - 2ASSIGNB10 >= 0
Ws1B03 + TOWs1B03 - 2ASSIGNB11 >= 0
Ws1B03 + TOWs1B03 - 50ASSIGNB07 - 50ASSIGNB08 - 50ASSIGNB09 - 50ASSIGNB10 - 50ASSIGNB11 <= 0
\Sites 12/13/14/15
Ws1B01 + TOWs1B01 - 2ASSIGNB12 >= 0
Ws1B01 + TOWs1B01 - 2ASSIGNB13 >= 0
Ws1B01 + TOWs1B01 - 2ASSIGNB14 >= 0
Ws1B01 + TOWs1B01 - 2ASSIGNB15 >= 0
Ws1B01 + TOWs1B01 - 50ASSIGNB12 - 50ASSIGNB13 - 50ASSIGNB14 - 50ASSIGNB15 <= 0
Wd1B16 - 2ASSIGNB16 >= 0
Wd1B16 - 50ASSIGNB16 <= 0
Wd1B17 - 2ASSIGNB17 >= 0
Wd1B17 - 50ASSIGNB17 <= 0
Wd1B18 - 2ASSIGNB18 >= 0
Wd1B18 - 50ASSIGNB18 <= 0
Wd1B19 - 2ASSIGNB19 >= 0
Wd1B19 - 50ASSIGNB20 <= 0
\Sites 20/21/22/23/24
Ws1B04 + TOWs1B04 - 2ASSIGNB20 >= 0
Ws1B04 + TOWs1B04 - 2ASSIGNB21 >= 0
Ws1B04 + TOWs1B04 - 2ASSIGNB22 >= 0
Ws1B04 + TOWs1B04 - 2ASSIGNB23 >= 0
Ws1B04 + TOWs1B04 - 2ASSIGNB24 >= 0
Ws1B04 + TOWs1B04 - 50ASSIGNB20 - 50ASSIGNB21 - 50ASSIGNB22 - 502ASSIGNB23 - 50ASSIGNB24 <=
0
Wd1B25 - 2ASSIGNB25 >= 0
Wd1B25 - 50ASSIGNB25 <= 0
Wd1B26 - 2ASSIGNB26 >= 0
```

```
Wd1B26 - 50ASSIGNB26 <= 0
Wd1C17 - 2ASSIGNC17 >= 0
Wd1C17 - 50ASSIGNC17 <= 0
Wd1C18 - 2ASSIGNC18 >= 0
Wd1C18 - 50ASSIGNC18 <= 0
Wd1C19 - 2ASSIGNC19 >= 0
Wd1C19 - 50ASSIGNC19 <= 0
\Sites 20/21/22/23/24
Ws1C03 + TOWs1C03 - 2ASSIGNC20 >= 0
Ws1C03 + TOWs1C03 - 2ASSIGNC21 >= 0
Ws1C03 + TOWs1C03 - 2ASSIGNC22 >= 0
Ws1C03 + TOWs1C03 - 2ASSIGNC23 >= 0
Ws1C03 + TOWs1C03 - 2ASSIGNC24 >= 0
Ws1C03 + TOWs1C03 - 50ASSIGNC20 - 50ASSIGNC21 - 50ASSIGNC22 - 50ASSIGNC23 - 50ASSIGNC24 <= 0
Wd1C25 - 2ASSIGNC25 >= 0
Wd1C25 - 50ASSIGNC25 <= 0
Wd1C26 - 2ASSIGNC26 >= 0
Wd1C26 - 50ASSIGNC26 <= 0
Wd1C27 - 2ASSIGNC27 >= 0
Wd1C27 - 50ASSIGNC27 <= 0
Wd1C28 - 2ASSIGNC28 >= 0
Wd1C28 - 2ASSIGNC28 <= 0
\Sites 29/30/31/32/33
Ws1C04 - 2ASSIGNC29 >= 0
Ws1C04 - 2ASSIGNC31 >= 0
Ws1C04 - 2ASSIGNC30 >= 0
Ws1C04 - 2ASSIGNC32 >= 0
Ws1C04 - 2ASSIGNC33 >= 0
Ws1C04 - 50ASSIGNC29 - 50ASSIGNC30 - 50ASSIGNC31 - 50ASSIGNC32 - 50ASSIGNC33 <= 0
\Sites 34/35
Ws1C05 + TOWs1C05 - 2ASSIGNC34 >= 0
Ws1C05 + TOWs1C05 - 2ASSIGNC35 >= 0
Ws1C05 + TOWs1C05 - 50ASSIGNC34 - 50ASSIGNC35 <= 0
Wd1C36 - 2ASSIGNC36 >= 0
Wd1C36 - 50ASSIGNC36 <= 0
Wd2D25 - 2ASSIGND25 >= 0
Wd2D25 - 50ASSIGND25 <= 0
Wd2D26 - 2ASSIGND26 >= 0
Wd2D26 - 50ASSIGND26 <= 0
Wd2D27 - 2ASSIGND27 >= 0
Wd2D27 - 50ASSIGND27 <= 0
Wd2D28 - 2ASSIGND28 >= 0
Wd2D28 - 50ASSIGND28 <= 0
\Site 29/30/31/32/33
Ws2D03 + TOWs2D03 - 2ASSIGND29 >= 0
Ws2D03 + TOWs2D03 - 2ASSIGND30 >= 0
Ws2D03 + TOWs2D03 - 2ASSIGND31 >= 0
Ws2D03 + TOWs2D03 - 2ASSIGND32 >= 0
Ws2D03 + TOWs2D03 - 2ASSIGND33 >= 0
Ws2D03 + TOWs2D03 - 50ASSIGND29 - 50ASSIGND30 - 50ASSIGND31 -50ASSIGND32 - 50ASSIGND33 <= 0
\Sites 34/35
Ws2D02 + TOWs2D02 - 2ASSIGND34 >= 0
Ws2D02 + TOWs2D02 - 2ASSIGND35 >= 0
Ws2D02 + TOWs2D02 - 50ASSIGND34 - 50ASSIGND35 <= 0
Wd2D36 - 2ASSIGND36 >= 0
Wd2D36 - 50ASSIGND36 <= 0
Wd2D37 >= 2
Wd2D38 >= 2
Wd2D39 - 2ASSIGND39 >= 0
Wd2D39 - 50ASSIGND39 <= 0
\Sites 40/41/42
Ws2D04 + TOWs2D04 - 2ASSIGND40 >= 0
Ws2D04 + TOWs2D04 - 2ASSIGND41 >= 0
Ws2D04 + TOWs2D04 - 2ASSIGND42 >= 0
Ws2D04 + TOWs2D04 - 50ASSIGND40 - 50ASSIGND41 -50ASSIGND42 <= 0
Wd1E39 - 2ASSIGNE39 >= 0
```

```
Wd1E39 - 50ASSIGNE39 <= 0
\Sites 40/41/42
Ws1E01 + TOWs1E01 - 2ASSIGNE40 >= 0
Ws1E01 + TOWs1E01 - 2ASSIGNE41 >= 0
Ws1E01 + TOWs1E01 - 2ASSIGNE42 >= 0
Ws1E01 + TOWs1E01 - 50ASSIGNE40 - 50ASSIGNE41 - 50ASSIGNE42 <= 0
Wd1E43 + TOWd1E43 >= 2
Wd1E44 + TOWd1E44 >= 2
Wd1E45 + TOWd1E45 >= 2
\Site C
Wd1BC - 2ASSIGNBC >= 0
Wd1BC - 50ASSIGNBC <= 0
Wd2DC - 2ASSIGNDC >= 0
Wd2DC - 50ASSIGNDC <= 0
\Site B
Wd1AB - 2ASSIGNAB >= 0
Wd1AB - 50ASSIGNAB <= 0
Wd1CB - 2ASSIGNCB >= 0
Wd1CB - 50ASSIGNCB <= 0
\Legs Flown Constraints: Bell-212
Lg1A01 - 2Dr1A01 = 0
Lg1A02 - 2Dr1A02 = 0
Lg1A03 - 2Dr1A03 - 12Ss1A01 - 4TOSs1A01 - 8Ws1A01 - 4TOWs1A01 = 0
Lg1A04 - 2Dr1A04 - 4Sd1A04 - 4Wd1A04 = 0
Lg1A05 - 2Dr1A05 - 4Sd1A05 - 2Wd1A05 = 0
Lg1A06 - 2Dr1A06 - 4Sd1A06 - 4Wd1A06 = 0
Lg1A07 - 2Dr1A07 = 0
Lg1A08 - 2Dr1A08 = 0
Lg1A09 - 2Dr1A09 - 16Ss1A02 - 4TOSs1A02 - 10Ws1A02 - 2TOWs1A02= 0
Lg1A10 - 2Dr1A10 = 0
Lg1A11 - 2Dr1A11 = 0
Lg1A12 - 2Dr1A12 = 0
Lg1A13 - 2Dr1A13 = 0
Lg1A14 - 2Dr1A14 - 12Ss1A03 - 2TOSs1A03 - 12Ws1A03 - 4TOWs1A03 = 0
Lg1A15 - 2Dr1A15 = 0
Lg1A16 - 2Dr1A16 - 6Sd1A16 - 4Wd1A16 = 0
Lg1AB - 2Dr1AB - 6Sd1AB - 4Wd1AB = 0
Lg1A0103 - 6Ss1A01 - 6TOSs1A01 - 4Ws1A01 - 4TOWs1A01 = 0
Lg1A0203 - 6Ss1A01 - 6TOSs1A01 - 4Ws1A01 - 4TOWs1A01 = 0
Lg1A0709 - 6Ss1A02 - 6TOSs1A02 - 6Ws1A02 - 6TOWs1A02 = 0
Lg1A0809 - 6Ss1A02 - 6TOSs1A02 - 6Ws1A02 - 6TOWs1A02 = 0
Lg1A0910 - 6Ss1A02 - 6TOSs1A02 - 6Ws1A02 - 6TOWs1A02 = 0
Lg1A0911 - 6Ss1A02 - 6TOSs1A02 - 6Ws1A02 - 6TOWs1A02 = 0
Lg1A1214 - 6Ss1A03 - 6TOSs1A03 - 4Ws1A03 - 4TOWs1A03 = 0
Lg1A1314 - 6Ss1A03 - 6TOSs1A03 - 4Ws1A03 - 4TOWs1A03 = 0
Lg1A1415 - 6Ss1A03 - 6TOSs1A03 - 4Ws1A03 - 4TOWs1A03 = 0
Lg1A14Cp - 8TOSs1A03 - 8TOWs1A03 = 0
Lg1B07 - 2Dr1B07 = 0
Lg1B08 - 2Dr1B08 = 0
Lg1B09 - 2Dr1B09 - 16Ss1B03 - 4TOSs1B03 - 10Ws1B03 - 2TOWs1B03 = 0
Lg1B10 - 2Dr1B10 = 0
Lg1B11 - 2Dr1B11 = 0
Lg1B12 - 2Dr1B12 = 0
Lg1B13 - 2Dr1B13 = 0
Lg1B14 - 2Dr1B14 - 12Ss1B01 - 6TOSs1B01 - 12Ws1B01 - 4TOWs1B01 = 0
Lg1B15 - 2Dr1B15 = 0
Lg1B16 - 2Dr1B16 - 6Sd1B16 - 4Wd1B16 = 0
Lg1B17 - 2Dr1B17 - 6Sd1B17 - 4Wd1B17 = 0
Lg1B18 - 2Dr1B18 - 6Sd1B18 - 4Wd1B18 = 0
Lg1B19 - 2Dr1B19 - 6Sd1B19 - 4Wd1B19 = 0
Lg1B20 - 2Dr1B20 = 0
Lg1B21 - 2Dr1B21 = 0
Lg1B22 - 2Dr1B22 - 10Ss1B04 - 2TOSs1B04 - 6Ws1B04 - 2TOWs1B04 = 0
Lg1B23 - 2Dr1B23 = 0
Lg1B24 - 2Dr1B24 = 0
Lg1B25 - 2Dr1B25 - 6Sd1B25 - 4Wd1B25 = 0
```

```
Lg1B26 - 2Dr1B26 - 6Sd1B26 - 4Wd1B26 = 0
Lg1BC - 2Dr1BC - 6Sd1BC - 4Wd1BC = 0
Lg1B0709 - 4Ss1B03 - 4TOSs1B03 - 4Ws1B03 - 4Ws1B03 = 0
Lg1B0809 - 4Ss1B03 - 4TOSs1B03 - 4Ws1B03 - 4Ws1B03 = 0
Lg1B0910 - 4Ss1B03 - 4TOSs1B03 - 4Ws1B03 - 4Ws1B03 = 0
Lg1B0911 - 4Ss1B03 - 4TOSs1B03 - 4Ws1B03 - 4Ws1B03 = 0
Lg1B1214 - 6Ss1B01 - 6TOSs1B01 - 4Ws1B01 - 4TOWs1B01 = 0
Lg1B1314 - 6Ss1B01 - 6TOSs1B01 - 4Ws1B01 - 4TOWs1B01 = 0
Lg1B1415 - 6Ss1B01 - 6TOSs1B01 - 4Ws1B01 - 4TOWs1B01 = 0
Lg1B2022 - 6Ss1B04 - 6TOSs1B04 - 4Ws1B04 - 4TOWs1B04 = 0
Lg1B2122 - 6Ss1B04 - 6TOSs1B04 - 4Ws1B04 - 4TOWs1B04 = 0
Lg1B2223 - 6Ss1B04 - 6TOSs1B04 - 4Ws1B04 - 4TOWs1B04 = 0
Lg1B2224 - 6Ss1B04 - 6TOSs1B04 - 4Ws1B04 - 4TOWs1B04 = 0
Lg1B14Cp - 4TOSs1B01 - 4TOWs1B01 = 0
Lg1B22Gj - 8TOSs1B04 - 4TOWs1B04 = 0
Lg1C17 - 2Dr1C17 - 8Sd1C17 - 4Wd1C17 = 0
Lg1C18 - 2Dr1C18 - 8Sd1C18 - 2Wd1C18 = 0
Lg1C19 - 2Dr1C19 - 4Sd1C19 - 4Wd1C19 = 0
Lg1C20 - 2Dr1C20 = 0
Lg1C21 - 2Dr1C21 = 0
Lg1C22 - 2Dr1C22 - 10Ss1C03 - 2TOSs1C03 - 6Ws1C03 - 2TOWs1C03 = 0
Lg1C23 - 2Dr1C23 = 0
Lg1C24 - 2Dr1C24 = 0
Lg1C25 - 2Dr1C25 - 6Sd1C25 - 4Wd1C25 = 0
Lg1C26 - 2Dr1C26 - 6Sd1C26 - 4Wd1C26 = 0
Lg1C27 - 2Dr1C27 - 6Sd1C27 - 4Wd1C27 = 0
Lg1C28 - 2Dr1C28 - 6Sd1C28 - 4Wd1C28 = 0
Lg1C29 - 2Dr1C29 = 0
Lg1C30 - 2Dr1C30 = 0
Lg1C31 - 2Dr1C31 - 10Ss1C04 - 6Ws1C04 = 0
Lg1C32 - 2Dr1C32 = 0
Lg1C33 - 2Dr1C33 = 0
Lg1C34 - 2Dr1C34 - 12Ss1C05 - 6TOSs1C05 - 10Ws1C05 - 8TOWs1C05 = 0
Lg1C35 - 2Dr1C35 = 0
Lg1C36 - 2Dr1C36 - 6Sd1C36 - 4Wd1C36 = 0
Lg1CB - 2Dr1CB - 6Sd1CB - 4Wd1CB = 0
Lg1C2022 - 6Ss1C03 - 6TOSs1C03 - 4Ws1C03 - 4TOWs1C03 = 0
Lg1C2122 - 6Ss1C03 - 6TOSs1C03 - 4Ws1C03 - 4TOWs1C03 = 0
Lg1C2223 - 6Ss1C03 - 6TOSs1C03 - 4Ws1C03 - 4TOWs1C03 = 0
Lg1C2224 - 6Ss1C03 - 6TOSs1C03 - 4Ws1C03 - 4TOWs1C03 = 0
Lg1C2931 - 8Ss1C04 - 4Ws1C04 = 0
Lg1C3031 - 12Ss1C04 - 6Ws1C04 = 0
Lg1C3132 - 12Ss1C04 - 6Ws1C04 = 0
Lg1C3133 - 12Ss1C04 - 6Ws1C04 = 0
Lg1C3435 - 14Ss1C05 - 12TOSs1C05 - 10Ws1C05 - 14TOWs1C05 = 0
Lg1C22Pl - 8TOSs1C03 - 4TOWs1C03 = 0
Lg1E39 - 2Dr1E39 - 6Sd1E39 - 2Wd1E39 = 0
Lg1E40 - 2Dr1E40 = 0
Lg1E41 - 2Dr1E41 - 20Ss1E01 - 6TOSs1E01 - 12Ws1E01 - 6TOWs1E01 = 0
Lg1E42 - 2Dr1E42 = 0
Lg1E43 - 2Dr1E43 - 12Sd1E43 - 2TOSd1E43 - 6Wd1E43 - 2TOWd1E43 = 0
Lg1E44 - 2Dr1E44 - 12Sd1E44 - 2TOSd1E44 - 6Wd1E44 - 2TOWd1E44 = 0
Lg1E45 - 2Dr1E45 - 12Sd1E45 - 2TOSd1E45 - 6Wd1E45 - 2TOWd1E45 = 0
Lg1E4041 - 6Ss1E01 - 6TOSs1E01 - 4Ws1E01 - 4TOWs1E01 = 0
Lg1E4142 - 6Ss1E01 - 6TOSs1E01 - 4Ws1E01 - 4TOWs1E01 = 0
Lg1E41Na - 10TOSs1E01 - 6TOWs1E01 = 0
Lg1E43Ho - 4TOSd1E43 - 4TOWd1E43 = 0
Lg1E44Ma - 4TOSd1E44 - 4TOWd1E44 = 0
\Legs Flown Constraints: S-61
Lg2D25 - 2Dr2D25 - 4Sd2D25 - 2Wd2D25 = 0
Lg2D26 - 2Dr2D26 - 4Sd2D26 - 2Wd2D26 = 0
Lg2D27 - 2Dr2D27 - 6Sd2D27 - 2Wd2D27 = 0
Lg2D28 - 2Dr2D28 - 4Sd2D28 - 2Wd2D28 = 0
Lg2D29 - 2Dr2D29 = 0
Lg2D30 - 2Dr2D30 = 0
Lg2D31 - 2Dr2D31 - 10Ss2D03 - 2TOSs2D03 - 10Ws2D03 - 2TOWs2D03 = 0
```

```
Lg2D32 - 2Dr2D32 = 0
Lg2D33 - 2Dr2D33 = 0
Lg2D34 - 2Dr2D34 = 0
Lg2D35 - 2Dr2D35 - 14Ss2D02 - 6TOSs2D02 - 14Ws2D02 - 6TOWs2D02 = 0
Lg2D36 - 2Dr2D36 - 6Sd2D36 - 4Wd2D36 = 0
Lg2D37 - 2Dr2D37 - 10Sd2D37 - 4Wd2D37 = 0
Lg2D38 - 2Dr2D38 - 6Sd2D38 - 4Wd2D38 = 0
Lg2D39 - 2Dr2D39 - 6Sd2D39 - 4Wd2D39 = 0
Lg2D40 - 2Dr2D40 = 0
Lg2D41 - 2Dr2D41 - 10Ss2D04 - 2TOSs2D04 - 6Ws2D04 - 4TOWs2D04 = 0
Lg2D42 - 2Dr2D42 = 0
Lg2DC - 2Dr2DC - 6Sd2DC - 4Wd2DC = 0
Lg2D2931 - 16Ss2D03 - 16TOSs2D03 - 12Ws2D03 - 12TOWs2D03 = 0
Lg2D3031 - 16Ss2D03 - 16TOSs2D03 - 12Ws2D03 - 12TOWs2D03 = 0
Lg2D3133 - 16Ss2D03 - 16TOSs2D03 - 12Ws2D03 - 12TOWs2D03 = 0
Lg2D3233 - 16Ss2D03 - 16TOSs2D03 - 12Ws2D03 - 12TOWs2D03 = 0
Lg2D3435 - 12Ss2D02 - 12TOSs2D02 - 8Ws2D02 - 8TOWs2D02 = 0
Lg2D4041 - 8Ss2D04 - 8TOSs2D04 - 4Ws2D04 - 4TOWs2D04 = 0
Lg2D4142 - 8Ss2D04 - 8TOSs2D04 - 4Ws2D04 - 4TOWs2D04 = 0
Lg2D34Br - 8TOSs2D02 - 2TOWs2D02 = 0
Lg2D41Na - 4TOSs2D04 - 2TOWs2D04 = 0
\Legs Flown Constraint: Twin Otter
Lg3A03 - 6TOSs1A01 - 4TOWs1A01 = 0
Lg3A09 - 8TOSs1A02 - 6TOWs1A02 = 0
Lg3ACopp - 4TOSs1A03 - 4TOWs1A03 = 0
Lg3B09 - 6TOSs1B03 - 4TOWs1B03 = 0
Lg3B14 - 4TOSs1B01 - 2TOWs1B01 = 0
Lg3BCopp - 2TOSs1B01 - 2TOWs1B01 = 0
Lg3BGjoa - 4TOSs1B04 - 2TOWs1B04 = 0
Lg3CPell - 4TOSs1C03 - 2TOWs1C03 = 0
Lg3CBrou - 4TOSs1C05 - 4TOWs1C05 = 0
Lg3DBrou - 4TOSs2D02 - 2TOWs2D02 - 4TOSs2D03 - 2TOWs2D03 = 0
Lg3DNain - 4TOSs2D04 - 2TOWs2D04 = 0
Lg3ENain - 8TOSs1E01 - 4TOWs1E01 = 0
Lg3EHope - 4TOSd1E43 - 4TOWd1E43 = 0
Lg3EMakk - 6TOSd1E44 - 6TOWd1E44 = 0
Lg3ECart - 4TOSd1E45 - 4TOWd1E45 = 0
\Hours Used Constraint:  Bell-212
1.40Lg1A01 + 1.30Lg1A02 + 1.00Lg1A03 + 0.40Lg1A04 + 0.70Lg1A05 + 1.00Lg1A06 + 1.30Lg1A07
+ 1.93Lg1A08 + 2.10Lg1A09 + 2.35Lg1A10 + 3.51Lg1A11 + 4.04Lg1A12 + 4.53Lg1A13 + 4.97Lg1A14
+ 5.54Lg1A15 + 6.00Lg1A16 + 0.80Lg1A0103 +  0.40Lg1A0203 + 1.10Lg1A0709 + 0.50Lg1A0809
+ 0.80Lg1A0910 + 1.40Lg1A0911 + 0.90Lg1A1214 + 0.50Lg1A1314 + 0.60Lg1A1415 + 0.60Lg1A14Cp
+ 6.85Lg1AB - Hours1A = 0
5.57Lg1B07 + 5.10Lg1B08 + 4.59Lg1B09 + 3.91Lg1B10 + 3.47Lg1B11 + 2.86Lg1B12 + 2.36Lg1B13
+ 1.80Lg1B14 + 1.30Lg1B15 + 0.60Lg1B16 + 0.30Lg1B17 + 0.80Lg1B18 + 1.10Lg1B19 + 1.60Lg1B20
+ 2.00Lg1B21 + 2.50Lg1B22 + 3.19Lg1B23 + 3.75Lg1B24 + 4.73Lg1B25 + 5.13Lg1B26 + 1.10Lg1B0709
+ 0.50Lg1B0809 + 0.80Lg1B0910 + 1.40Lg1B0911 + 0.90Lg1B1214 + 0.50Lg1B1314 + 0.60Lg1B1415
+ 1.00Lg1B2022 + 0.60Lg1B2122 + 0.50Lg1B2223 + 0.90Lg1B2224 + 0.60Lg1B14Cp + 0.60Lg1B22Gj
+ 5.72Lg1BC - Hours1B = 0
5.41Lg1C17 + 4.98Lg1C18 + 4.60Lg1C19 + 4.01Lg1C20 + 3.56Lg1C21 + 2.40Lg1C22 + 2.62Lg1C23
+ 1.80Lg1C24 + 1.20Lg1C25 + 0.70Lg1C26 + 0.60Lg1C27 + 1.00Lg1C28 + 1.40Lg1C29 + 1.80Lg1C30
+ 2.42Lg1C31 + 2.95Lg1C32 + 3.53Lg1C33 + 4.41Lg1C34 + 5.21Lg1C35 + 5.27Lg1C36 + 1.00Lg1C2022
+ 0.60Lg1C2122 + 0.50Lg1C2223 + 0.90Lg1C2224 + 1.00Lg1C2931 + 0.50Lg1C3031 + 0.51Lg1C3132
+ 1.09Lg1C3133 + 0.86Lg1C3435 + 1.00Lg1C22Pl + 5.72Lg1CB - Hours1C = 0
5.76Lg1E39 + 4.67Lg1E40 + 3.56Lg1E41 + 2.40Lg1E42 + 1.60Lg1E43 + 1.30Lg1E44 + 1.40Lg1E45
+ 1.10Lg1E4041 + 1.00Lg1E4142 + 1.30Lg1E41Na + 0.30Lg1E43Ho + 0.40Lg1E44Ma + 0.20Lg1E45Ca
- Hours1E = 0
\Hours Used Constraint:  S-61
5.22Lg2D25 + 5.03Lg2D26 + 4.47Lg2D27 + 4.14Lg2D28 + 3.63Lg2D29 + 2.88Lg2D30 + 2.60Lg2D31
+ 3.07Lg2D32 + 2.83Lg2D33 + 2.50Lg2D34 + 2.30Lg2D35 + 1.50Lg2D36 + 1.20Lg2D37 + 1.30Lg2D38
+ 1.60Lg2D39 + 2.78Lg2D40 + 3.60Lg2D41 + 4.70Lg2D42 + 0.50Lg2D2931 + 0.45Lg2D3031
+ 0.50Lg2D3132 + 0.90Lg2D3133 + 0.90Lg2D3435 + 1.07Lg2D4041 + 0.94Lg2D4142 + 0.10Lg2D34Br
+ 1.25Lg2D41Na +4.47Lg2DC - Hours2D = 0
\Hours Used Constraint:  Twin Otter
0.80Lg3A03 + 1.60Lg3A09 + 4.15Lg3ACopp - 0.40Hours3A = 0
2.50Lg3B09 + 1.20Lg3B14 + 2.45Lg3BCopp + 1.50Lg3BGjoa - 0.28Hours3B = 0
```

```
1.30Lg3CPell + 3.91Lg3CBrou - 0.70Hours3C = 0
1.70Lg3DBrou + 2.90Lg3DNain - 0.43Hours3D = 0
1.60Lg3ENain + 1.10Lg3EHope + 1.00Lg3EMakk + 1.00Lg3ECart - 0.53Hours3E = 0
\Min/Max Flying Hour Req. Constraint:  Bell-212
\Hours1A - 437OPENA <= 0
\Hours1A - 400OPENA >= 0
\Hours1B - 400OPENB <= 0
\Hours1B - 400OPENB >= 0
\Hours1C - 525OPENC <= 0
\Hours1C - 400OPENC >= 0
\Hours1E - 526OPENE <= 0
\Hours1E - 417OPENE >= 0
\Min/Max Flying Hour Requirement Constraint:  S-61
\Hours2D - 570OPEND <= 0
\Hours2D - 475OPEND >= 0
\Max Flying Hour Req. Constraint:  Twin Otter
Hours3A - 229ON3A <= 0
Hours3B - 218ON3B <= 0
Hours3C - 201ON3C <= 0
Hours3D - 280ON3D <= 0
Hours3E - 219ON3E <= 0
\Contractual Min Flying Hours Constraint
Hours1A - 300ON3A >= 0
Hours1B - 300ON3B >= 0
Hours1C - 300ON3C >= 0
Hours2D - 375ON3D >= 0
Hours1E - 300ON3E >= 0
\One Zone Assignment Constraints
ASSIGNA07 + ASSIGNB07 = 1
ASSIGNA08 + ASSIGNB08 = 1
ASSIGNA09 + ASSIGNB09 = 1
ASSIGNA10 + ASSIGNB10 = 1
ASSIGNA11 + ASSIGNB11 = 1
ASSIGNA12 + ASSIGNB12 = 1
ASSIGNA13 + ASSIGNB13 = 1
ASSIGNA14 + ASSIGNB14 = 1
ASSIGNA15 + ASSIGNB15 = 1
ASSIGNA16 + ASSIGNB16 = 1
ASSIGNB17 + ASSIGNC17 = 1
ASSIGNB18 + ASSIGNC18 = 1
ASSIGNB19 + ASSIGNC19 = 1
ASSIGNB20 + ASSIGNC20 = 1
ASSIGNB21 + ASSIGNC21 = 1
ASSIGNB22 + ASSIGNC22 = 1
ASSIGNB23 + ASSIGNC23 = 1
ASSIGNB24 + ASSIGNC24 = 1
ASSIGNB25 + ASSIGNC25 + ASSIGND25 = 1
ASSIGNB26 + ASSIGNC26 + ASSIGND26 = 1
ASSIGNC27 + ASSIGND27 = 1
ASSIGNC28 + ASSIGND28 = 1
ASSIGNC29 + ASSIGND29 = 1
ASSIGNC30 + ASSIGND30 = 1
ASSIGNC31 + ASSIGND31 = 1
ASSIGNC32 + ASSIGND32 = 1
ASSIGNC33 + ASSIGND33 = 1
ASSIGNC34 + ASSIGND34 = 1
ASSIGNC35 + ASSIGND35 = 1
ASSIGNC36 + ASSIGND36 = 1
ASSIGND39 + ASSIGNE39 = 1
ASSIGND40 + ASSIGNE40 = 1
ASSIGND41 + ASSIGNE41 = 1
ASSIGND42 + ASSIGNE42 = 1
ASSIGNAB + ASSIGNCB + OPENB =1
ASSIGNBC + ASSIGNDC + OPENC =1
\Open LSS Constraints
OPENA = 1
```

```
ASSIGNB07 + ASSIGNB08 + ASSIGNB09 + ASSIGNB10 + ASSIGNB11 + ASSIGNB12 + ASSIGNB13
+ ASSIGNB14 + ASSIGNB15 + ASSIGNB16 + ASSIGNB17 + ASSIGNB18 + ASSIGNB19 + ASSIGNB20
+ ASSIGNB21 + ASSIGNB22 + ASSIGNB23 + ASSIGNB24 + ASSIGNB25 + ASSIGNB26 + ASSIGNBC
- 45OPENB <= 0
ASSIGNC17 + ASSIGNC18 + ASSIGNC19 + ASSIGNC20 + ASSIGNC21 + ASSIGNC22 + ASSIGNC23
+ ASSIGNC24 + ASSIGNC25 + ASSIGNC26 + ASSIGNC27 + ASSIGNC28 + ASSIGNC29 + ASSIGNC30
+ ASSIGNC31 + ASSIGNC32 + ASSIGNC33 + ASSIGNC34 + ASSIGNC35 + ASSIGNC36 + ASSIGNCB
- 45OPENC <= 0
OPEND = 1
OPENE = 1
\Sites Open Constraint
OPEN A + OPENB + OPENC + OPEND + OPENE <= 5
BOUNDS
\These constraints are needed so that CPLEX will identify these variables as general integer
\and not binary.
Dr1A01 <= 100
Dr1A02 <= 100
Dr1A03 <= 100
Dr1A04 <= 100
Dr1A05 <= 100
Dr1A06 <= 100
Dr1A07 <= 100
Dr1A08 <= 100
Dr1A09 <= 100
Dr1A10 <= 100
Dr1A11 <= 100
Dr1A12 <= 100
Dr1A13 <= 100
Dr1A14 <= 100
Dr1A15 <= 100
Dr1A16 <= 100
Dr1AB <= 100
Sd1A04 <= 100
Sd1A05 <= 100
Sd1A06 <= 100
Sd1A16 <= 100
Sd1AB <= 100
Wd1A04 <= 100
Wd1A05 <= 100
Wd1A06 <= 100
Wd1A16 <= 100
Wd1AB <= 100
Ss1A01 <= 100
Ss1A02 <= 100
Ss1A03 <= 100
TOSs1A01 <= 100
TOSs1A02 <= 100
TOSs1A03 <= 100
Ws1A01 <= 100
Ws1A02 <= 100
Ws1A03 <= 100
TOWs1A01 <= 100
TOWs1A02 <= 100
TOWs1A03 <= 100
Dr1B07 <= 100
Dr1B08 <= 100
Dr1B09 <= 100
Dr1B10 <= 100
Dr1B11 <= 100
Dr1B12 <= 100
Dr1B13 <= 100
Dr1B14 <= 100
Dr1B15 <= 100
Dr1B16 <= 100
Dr1B17 <= 100
Dr1B18 <= 100
```

```
Dr1B19 <= 100
Dr1B20 <= 100
Dr1B21 <= 100
Dr1B22 <= 100
Dr1B23 <= 100
Dr1B24 <= 100
Dr1B25 <= 100
Dr1B26 <= 100
Dr1BC <= 100
Sd1B16 <= 100
Sd1B17 <= 100
Sd1B18 <= 100
Sd1B19 <= 100
Sd1B25  <= 100
Sd1B26 <= 100
Sd1BC <= 100
Wd1B16 <= 100
Wd1B17 <= 100
Wd1B18 <= 100
Wd1B19 <= 100
Wd1B25 <= 100
Wd1B26 <= 100
Wd1BC <= 100
Ss1B01 <= 100
Ss1B03 <= 100
Ss1B04 <= 100
TOSs1B01 <= 100
TOSs1B03 <= 100
TOSs1B04 <= 100
Ws1B01 <= 100
Ws1B03 <= 100
Ws1B04 <= 100
TOWs1B01 <= 100
TOWs1B03 <= 100
TOWs1B04 <= 100
Dr1C17 <= 100
Dr1C18 <= 100
Dr1C19 <= 100
Dr1C20 <= 100
Dr1C21 <= 100
Dr1C22 <= 100
Dr1C23 <= 100
Dr1C24 <= 100
Dr1C25 <= 100
Dr1C26 <= 100
Dr1C27 <= 100
Dr1C28 <= 100
Dr1C29 <= 100
Dr1C30 <= 100
Dr1C31 <= 100
Dr1C32 <= 100
Dr1C33 <= 100
Dr1C34 <= 100
Dr1C35 <= 100
Dr1C35 <= 100
Dr1C36 <= 100
Dr1CB <= 100
Sd1C17 <= 100
Sd1C18 <= 100
Sd1C19 <= 100
Sd1C25 <= 100
Sd1C26 <= 100
Sd1C27 <= 100
Sd1C28 <= 100
Sd1C36 <= 100
Sd1CB <= 100
```

```
Wd1C17 <= 100
Wd1C18 <= 100
Wd1C19 <= 100
Wd1C25 <= 100
Wd1C26 <= 100
Wd1C27 <= 100
Wd1C28 <= 100
Wd1C36 <= 100
Wd1CB <= 100
Ss1C03 <= 100
Ss1C04 <= 100
Ss1C05 <= 100
TOSs1C03 <= 100
TOSs1C05 <= 100
Ws1C03 <= 100
Ws1C04 <= 100
Ws1C05 <= 100
TOWs1C03 <= 100
TOWs1C05 <= 100
Dr2D25 <= 100
Dr2D26 <= 100
Dr2D27 <= 100
Dr2D28 <= 100
Dr2D29 <= 100
Dr2D30 <= 100
Dr2D31 <= 100
Dr2D32 <= 100
Dr2D33 <= 100
Dr2D34 <= 100
Dr2D35 <= 100
Dr2D36 <= 100
Dr2D37 <= 100
Dr2D38 <= 100
Dr2D39 <= 100
Dr2D40 <= 100
Dr2D41 <= 100
Dr2D42 <= 100
Dr2DC <= 100
Sd2D25 <= 100
Sd2D26 <= 100
Sd2D27 <= 100
Sd2D28 <= 100
Sd2D36 <= 100
Sd2D37 <= 100
Sd2D38 <= 100
Sd2D39 <= 100
Sd2DC <= 100
Wd2D25 <= 100
Wd2D26 <= 100
Wd2D27 <= 100
Wd2D28 <= 100
Wd2D36 <= 100
Wd2D37 <= 100
Wd2D38 <= 100
Wd2D39 <= 100
Wd2DC <= 100
Ss2D02 <= 100
Ss2D03 <= 100
Ss2D04 <= 100
TOSs2D02 <= 100
TOSs2D03 <= 100
TOSs2D04 <= 100
Ws2D02 <= 100
Ws2D03 <= 100
Ws2D04 <= 100
TOWs2D02 <= 100
```

```
TOWs2D03 <= 100
TOWs2D04 <= 100
Dr1E39 <= 100
Dr1E40 <= 100
Dr1E41 <= 100
Dr1E42 <= 100
Dr1E43 <= 100
Dr1E44 <= 100
Dr1E45 <= 100
Ss1E01 <= 100
TOSs1E01 <= 100
Sd1E39 <= 100
Sd1E43 <= 100
TOSd1E43 <= 100
Sd1E44 <= 100
TOSd1E44 <= 100
Sd1E45 <= 100
TOSd1E45 <= 100
Ws1E01 <= 100
TOWs1E01 <= 100
Wd1E39 <= 100
Wd1E43 <= 100
TOWd1E43 <= 100
Wd1E44 <= 100
TOWd1E44 <= 100
Wd1E45 <= 100
TOWd1E45 <= 100
INTEGERS
OPENA ON3A ASSIGNA07 ASSIGNA08 ASSIGNA09 ASSIGNA10 ASSIGNA11 ASSIGNA12 ASSIGNA13 ASSIGNA14
ASSIGNA15 ASSIGNA16 ASSIGNAB Dr1A01 Dr1A02 Dr1A03 Dr1A04 Dr1A05 Dr1A06 Dr1A07 Dr1A08 Dr1A09
Dr1A10 Dr1A11 Dr1A12 Dr1A13 Dr1A14 Dr1A15 Dr1A16 Dr1AB Sd1A04 Sd1A05 Sd1A06 Wd1A04 Wd1A05
Wd1A06 Ss1A01 Ss1A02 Ss1A03 Sd1A16 Sd1AB TOSs1A01 TOSs1A02 TOSs1A03 Ws1A01 Ws1A02 Ws1A03
Wd1A16 Wd1AB TOWs1A01 TOWs1A02 TOWs1A03 OPENB ON3B ASSIGNB07 ASSIGNB08 ASSIGNB09 ASSIGNB10
ASSIGNB11 ASSIGNB12 ASSIGNB13 ASSIGNB14 ASSIGNB15 ASSIGNB16 ASSIGNB17 ASSIGNB18 ASSIGNB19
ASSIGNB20 ASSIGNB21 ASSIGNB22 ASSIGNB23 ASSIGNB24 ASSIGNB25 ASSIGNB26 ASSIGNBC Dr1B07 Dr1B08
Dr1B09 Dr1B10 Dr1B11 Dr1B12 Dr1B13 Dr1B14 Dr1B15 Dr1B16 Dr1B17 Dr1B18 Dr1B19 Dr1B20 Dr1B21
Dr1B22 Dr1B23 Dr1B24 Dr1B25 Dr1B26 Dr1BC Sd1B16 Sd1B17 Sd1B18 Sd1B19 Sd1B25 Sd1B26 Sd1BC
Wd1B16 Wd1B17 Wd1B18 Wd1B19 Wd1B25 Wd1B26 Wd1BC Ss1B01 Ss1B03 Ss1B04 TOSs1B01 TOSs1B03
TOSs1B04 Ws1B01 Ws1B03 Ws1B04 TOWs1B01 TOWs1B03 TOWs1B04 OPENC ON3C ASSIGNC17 ASSIGNC18
ASSIGNC19 ASSIGNC20 ASSIGNC21 ASSIGNC22 ASSIGNC23 ASSIGNC24 ASSIGNC25 ASSIGNC26 ASSIGNC27
ASSIGNC28 ASSIGNC29 ASSIGNC30 ASSIGNC31 ASSIGNC32 ASSIGNC33 ASSIGNC34 ASSIGNC35 ASSIGNC36
ASSIGNCB Dr1C17 Dr1C18 Dr1C19 Dr1C20 Dr1C21 Dr1C22 Dr1C23 Dr1C24 Dr1C25 Dr1C26 Dr1C27
Dr1C28 Dr1C29 Dr1C30 Dr1C31 Dr1C32 Dr1C33 Dr1C34 Dr1C35 Dr1C36 Dr1CB Sd1C17 Sd1C18 Sd1C19
Sd1C25 Sd1C26 Sd1C27 Sd1C28 Sd1C36 Sd1CB Wd1C17 Wd1C18 Wd1C19 Wd1C25 Wd1C26 Wd1C27 Wd1C28
Wd1C36 Wd1CB Ss1C03 Ss1C04 Ss1C05 TOSs1C03 TOSs1C05 Ws1C03 Ws1C04 Ws1C05 TOWs1C03 TOWs1C05
OPEND ON3D ASSIGND25 ASSIGND26 ASSIGND27 ASSIGND28 ASSIGND29 ASSIGND30 ASSIGND31 ASSIGND32
ASSIGND33 ASSIGND34 ASSIGND35 ASSIGND36 ASSIGNDC ASSIGND39 ASSIGND40 ASSIGND41 ASSIGND42
Dr2D25 Dr2D26 Dr2D27 Dr2D28 Dr2D29 Dr2D30 Dr2D31 Dr2D32 Dr2D33 Dr2D34 Dr2D35 Dr2D36 Dr2D37
Dr2D38 Dr2D39 Dr2D40 Dr2D41 Dr2D42 Dr2DC Sd2D25 Sd2D26 Sd2D27 Sd2D28 Sd2D36 Sd2D37 Sd2D38
Sd2D39 Sd2DC Wd2D25 Wd2D26 Wd2D27 Wd2D28 Wd2D36 Wd2D37 Wd2D38 Wd2D39 Wd2DC Ss2D02 Ss2D03
Ss2D04 TOSs2D02 TOSs2D03 TOSs2D04 Ws2D02 Ws2D03 Ws2D04 TOWs2D02 TOWs2D03 TOWs2D04 OPENE ON3E
ASSIGNE39 ASSIGNE40 ASSIGNE41 ASSIGNE42 Dr1E39 Dr1E40 Dr1E41 Dr1E42 Dr1E43 Dr1E44 Dr1E45
Ss1E01 TOSs1E01 Sd1E39 Sd1E43 TOSd1E43 Sd1E44 TOSd1E44 Sd1E45 TOSd1E45 Ws1E01 TOWs1E01
Wd1E39 Wd1E43 TOWd1E43 Wd1E44 TOWd1E44 Wd1E45 TOWd1E45
END
```

Appendix H

This appendix provides the solution output for the Expanded Model mixed integer linear programming formulation provided in Appendix G.

```
PROBLEM NAME       EModeNow4
DATA     NAME
OBJECTIVE VALUE    1.645268E+07
STATUS             OPTIMAL SOLN
ITERATION          31

OBJECTIVE          obj                      (MIN)
RHS                rhs
RANGES
BOUNDS
```

SECTION 1 - ROWS

NUMBER	......ROW.......	AT	...ACTIVITY...	SLACK ACTIVITY	..LOWER LIMIT.	..UPPER LIMIT.	.DUAL ACTIVITY
1	obj	BS	1.645268E+07	-1.645268E+07	NONE	NONE	1
2	c1	LL	7	0	7	NONE	-7448
3	c2	LL	11	0	11	NONE	-6916
4	c3	LL	19	0	19	NONE	-5320
5	c4	LL	11	0	11	NONE	-2128
6	c5	LL	13	0	13	NONE	-3724
7	c6	LL	11	0	11	NONE	-5320
8	c7	LL	0	0	0	NONE	-6916
9	c8	BS	-39	39	NONE	0	-0
10	c9	LL	0	0	0	NONE	-10267.6
11	c10	BS	-43	43	NONE	0	-0
12	c11	LL	0	0	0	NONE	-11172
13	c12	BS	-38	38	NONE	0	-0
14	c13	LL	0	0	0	NONE	-12502
15	c14	BS	-40	40	NONE	0	-0
16	c15	LL	0	0	0	NONE	-18673.2
17	c16	BS	-42	42	NONE	0	-0
18	c17	LL	0	0	0	NONE	-78497.14
19	c18	BS	-41	41	NONE	0	-0
20	c19	LL	0	0	0	NONE	-3815.034
21	c20	BS	-41	41	NONE	0	-0
22	c21	LL	0	0	0	NONE	-13742.59
23	c22	BS	-33	33	NONE	0	-0
24	c23	LL	0	0	0	NONE	-14498.63
25	c24	BS	-40	40	NONE	0	-0
26	c25	BS	0	-0	0	NONE	0
27	c26	BS	-40	40	NONE	0	-0
28	c27	LL	0	0	0	NONE	-921.8085
29	c28	BS	0	0	NONE	0	-0
30	c29	BS	0	-0	0	NONE	0
31	c30	BS	0	0	NONE	0	-0
32	c31	LL	0	0	0	NONE	-19587.31
33	c32	BS	0	0	NONE	0	-0
34	c33	LL	0	0	0	NONE	-5908.389
35	c34	BS	0	0	NONE	0	-0
36	c35	BS	0	-0	0	NONE	0
37	c36	BS	0	0	NONE	0	-0
38	c37	LL	0	0	0	NONE	-71170.91
39	c38	BS	0	0	NONE	0	-0
40	c39	BS	0	-0	0	NONE	0
41	c40	BS	0	0	NONE	0	-0
42	c41	LL	0	0	0	NONE	-9864

43	c42	BS	0	0	NONE	0	-0
44	c43	LL	0	0	0	NONE	-7124
45	c44	BS	0	0	NONE	0	-0
46	c45	LL	0	0	0	NONE	-3288
47	c46	BS	0	0	NONE	0	-0
48	c47	LL	0	0	0	NONE	-1644
49	c48	BS	0	0	NONE	0	-0
50	c49	LL	0	0	0	NONE	-4384
51	c50	BS	0	0	NONE	0	-0
52	c51	LL	0	0	0	NONE	-6028
53	c52	BS	0	0	NONE	0	-0
54	c53	BS	0	-0	0	NONE	0
55	c54	BS	0	0	NONE	0	-0
56	c55	BS	0	-0	0	NONE	0
57	c56	BS	0	0	NONE	0	-0
58	c57	LL	0	0	0	NONE	-13700
59	c58	BS	0	0	NONE	0	-0
60	c59	LL	0	0	0	NONE	-29031
61	c60	BS	0	0	NONE	0	-0
62	c61	LL	0	0	0	NONE	-20550
63	c62	BS	0	0	NONE	0	-0
64	c63	LL	0	0	0	NONE	-25920.4
65	c64	BS	0	0	NONE	0	-0
66	c65	LL	0	0	0	NONE	-539.1947
67	c66	BS	0	0	NONE	0	-0
68	c67	LL	0	0	0	NONE	-29646.8
69	c68	BS	-41	41	NONE	0	-0
70	c69	LL	0	0	0	NONE	-27290.4
71	c70	BS	-39	39	NONE	0	-0
72	c71	LL	0	0	0	NONE	-25208
73	c72	BS	-41	41	NONE	0	-0
74	c73	LL	0	0	0	NONE	-14794.32
75	c74	BS	-40	40	NONE	0	-0
76	c75	BS	1	-1	0	NONE	0
77	c76	BS	-40	40	NONE	0	-0
78	c77	LL	0	0	0	NONE	-13152
79	c78	BS	-29	29	NONE	0	-0
80	c79	LL	0	0	0	NONE	-34525.68
81	c80	BS	-38	38	NONE	0	-0
82	c81	LL	0	0	0	NONE	-9864
83	c82	BS	-38	38	NONE	0	-0
84	c83	LL	0	0	0	NONE	-6576
85	c84	BS	-30	30	NONE	0	-0
86	c85	LL	0	0	0	NONE	-3836
87	c86	BS	-36	36	NONE	0	-0
88	c87	LL	0	0	0	NONE	-3288
89	c88	BS	-38	38	NONE	0	-0
90	c89	LL	0	0	0	NONE	-5480
91	c90	BS	-39	39	NONE	0	-0
92	c91	LL	0	0	0	NONE	-4100.793
93	c92	BS	-38	38	NONE	0	-0
94	c93	LL	0	0	0	NONE	-9864
95	c94	BS	-42	42	NONE	0	-0
96	c95	LL	0	0	0	NONE	-13261.6
97	c96	BS	-37	37	NONE	0	-0
98	c97	LL	0	0	0	NONE	-16166
99	c98	BS	-42	42	NONE	0	-0
100	c99	LL	0	0	0	NONE	-41876.41
101	c100	BS	-42	42	NONE	0	-0
102	c101	BS	1	-1	0	NONE	0
103	c102	BS	-42	42	NONE	0	-0
104	c103	LL	0	0	0	NONE	-28550.8
105	c104	BS	-38	38	NONE	0	-0
106	c105	BS	0	-0	0	NONE	0
107	c106	BS	0	0	NONE	0	-0
108	c107	LL	0	0	0	NONE	-28459.73
109	c108	BS	0	0	NONE	0	-0
110	c109	LL	0	0	0	NONE	-5480
111	c110	BS	0	0	NONE	0	-0
112	c111	LL	0	0	0	NONE	-40605.48
113	c112	BS	0	0	NONE	0	-0
114	c113	LL	0	0	0	NONE	-37607.76
115	c114	BS	0	0	NONE	0	-0
116	c115	LL	0	0	0	NONE	-32974.92

	117	c116	BS	0	0	NONE	0	-0
	118	c117	LL	0	0	0	NONE	-9864
	119	c118	BS	0	0	NONE	0	-0
	120	c119	LL	0	0	0	NONE	-13261.6
	121	c120	BS	0	0	NONE	0	-0
	122	c121	LL	0	0	0	NONE	-16166
	123	c122	BS	0	0	NONE	0	-0
	124	c123	LL	0	0	0	NONE	-25707.72
	125	c124	BS	0	0	NONE	0	-0
	126	c125	LL	0	0	0	NONE	-22710
	127	c126	BS	0	0	NONE	0	-0
	128	c127	LL	0	0	0	NONE	-20893.2
	129	c128	BS	0	0	NONE	0	-0
	130	c129	LL	0	0	0	NONE	-13626
	131	c130	BS	-41	41	NONE	0	-0
	132	c131	LL	18	0	18	NONE	-10900.8
	133	c132	LL	9	0	9	NONE	-11809.2
	134	c133	LL	0	0	0	NONE	-14534.4
	135	c134	BS	-41	41	NONE	0	-0
	136	c135	LL	0	0	0	NONE	-41251.4
	137	c136	BS	0	0	NONE	0	-0
A	138	c137	LL	0	0	0	NONE	0
	139	c138	BS	0	0	NONE	0	-0
A	140	c139	LL	0	0	0	NONE	0
	141	c140	BS	0	0	NONE	0	-0
	142	c141	LL	0	0	0	NONE	-24224
	143	c142	BS	0	0	NONE	0	-0
	144	c143	LL	0	0	0	NONE	-23163.2
	145	c144	BS	-41	41	NONE	0	-0
A	146	c145	LL	0	0	0	NONE	0
	147	c146	BS	-31	31	NONE	0	-0
A	148	c147	LL	0	0	0	NONE	0
	149	c148	BS	-40	40	NONE	0	-0
	150	c149	LL	17	0	17	NONE	-7936
	151	c150	LL	11	0	11	NONE	-6448
	152	c151	LL	11	0	11	NONE	-6944
	153	c152	LL	0	0	0	NONE	-312187.6
	154	c153	BS	0	0	NONE	0	-0
	155	c154	LL	0	0	0	NONE	-318181.8
	156	c155	BS	0	0	NONE	0	-0
	157	c156	LL	0	0	0	NONE	-31345.6
	158	c157	BS	0	0	NONE	0	-0
	159	c158	LL	0	0	0	NONE	-31345.6
	160	c159	BS	-39	39	NONE	0	-0
	161	c160	LL	2	0	2	NONE	-21508
	162	c161	LL	2	0	2	NONE	-2128
	163	c162	LL	2	0	2	NONE	-3724
	164	c163	LL	2	0	2	NONE	-5320
	165	c164	BS	0	-0	0	NONE	0
	166	c165	BS	0	-0	0	NONE	0
	167	c166	LL	0	0	0	NONE	-26482.72
	168	c167	BS	0	-0	0	NONE	0
	169	c168	LL	0	0	0	NONE	-27378.48
	170	c169	BS	-248	248	NONE	0	-0
	171	c170	BS	0	-0	0	NONE	0
	172	c171	BS	0	-0	0	NONE	0
	173	c172	BS	0	-0	0	NONE	0
	174	c173	BS	0	-0	0	NONE	0
	175	c174	BS	-198	198	NONE	0	-0
	176	c175	BS	0	-0	0	NONE	0
	177	c176	BS	-48	48	NONE	0	-0
	178	c177	BS	0	-0	0	NONE	0
	179	c178	BS	0	-0	0	NONE	0
	180	c179	BS	0	-0	0	NONE	0
	181	c180	BS	0	-0	0	NONE	0
	182	c181	LL	0	0	0	NONE	-69103.23
	183	c182	BS	0	0	NONE	0	-0
	184	c183	BS	0	-0	0	NONE	0
	185	c184	BS	0	-0	0	NONE	0
	186	c185	BS	0	-0	0	NONE	0
	187	c186	LL	0	0	0	NONE	-3905.092
	188	c187	BS	0	0	NONE	0	-0
	189	c188	LL	0	0	0	NONE	-11143.95
	190	c189	BS	0	0	NONE	0	-0

191	c190	LL	0	0	0	NONE	-3288
192	c191	BS	0	0	NONE	0	-0
193	c192	LL	0	0	0	NONE	-8768
194	c193	BS	0	0	NONE	0	-0
195	c194	LL	0	0	0	NONE	-12056
196	c195	BS	0	0	NONE	0	-0
197	c196	LL	0	0	0	NONE	-41003.57
198	c197	BS	0	-0	0	NONE	0
199	c198	BS	0	-0	0	NONE	0
200	c199	BS	0	-0	0	NONE	0
201	c200	BS	0	-0	0	NONE	0
202	c201	BS	0	0	NONE	0	-0
203	c202	LL	0	0	0	NONE	-51840.8
204	c203	BS	0	0	NONE	0	-0
205	c204	LL	0	0	0	NONE	-1078.389
206	c205	BS	0	0	NONE	0	-0
207	c206	LL	0	0	0	NONE	-88940.4
208	c207	BS	-48	48	NONE	0	-0
209	c208	LL	0	0	0	NONE	-81871.2
210	c209	BS	-48	48	NONE	0	-0
211	c210	LL	0	0	0	NONE	-25208
212	c211	BS	-48	48	NONE	0	-0
213	c212	BS	2	-2	0	NONE	0
214	c213	BS	2	-2	0	NONE	0
215	c214	BS	2	-2	0	NONE	0
216	c215	BS	2	-2	0	NONE	0
217	c216	BS	2	-2	0	NONE	0
218	c217	BS	-246	246	NONE	0	-0
219	c218	LL	0	0	0	NONE	-13152
220	c219	BS	-48	48	NONE	0	-0
221	c220	LL	0	0	0	NONE	-7672
222	c221	BS	-48	48	NONE	0	-0
223	c222	LL	0	0	0	NONE	-6576
224	c223	BS	-48	48	NONE	0	-0
225	c224	LL	0	0	0	NONE	-10960
226	c225	BS	-48	48	NONE	0	-0
227	c226	LL	0	0	0	NONE	-72007.2
228	c227	BS	0	-0	0	NONE	0
229	c228	BS	0	-0	0	NONE	0
230	c229	BS	0	-0	0	NONE	0
231	c230	BS	0	-0	0	NONE	0
232	c231	BS	-248	248	NONE	0	-0
233	c232	BS	0	-0	0	NONE	0
234	c233	LL	0	0	0	NONE	-100378.4
235	c234	BS	-98	98	NONE	0	-0
236	c235	LL	0	0	0	NONE	-61317
237	c236	BS	0	0	NONE	0	-0
238	c237	LL	0	0	0	NONE	-66377.23
239	c238	BS	0	0	NONE	0	-0
240	c239	BS	0	-0	0	NONE	0
241	c240	BS	0	0	NONE	0	-0
242	c241	LL	0	0	0	NONE	-81210.96
243	c242	BS	0	0	NONE	0	-0
244	c243	LL	0	0	0	NONE	-37607.76
245	c244	BS	0	0	NONE	0	-0
246	c245	BS	0	-0	0	NONE	0
247	c246	BS	0	-0	0	NONE	0
248	c247	BS	0	-0	0	NONE	0
249	c248	BS	0	-0	0	NONE	0
250	c249	LL	0	0	0	NONE	-64674.75
251	c250	BS	0	0	NONE	0	-0
252	c251	LL	0	0	0	NONE	-36362.2
253	c252	LL	0	0	0	NONE	-50345.59
254	c253	BS	0	0	NONE	0	-0
255	c254	LL	0	0	0	NONE	-27252
256	c255	BS	-48	48	NONE	0	-0
257	c256	LL	2	0	2	NONE	-43603.2
258	c257	LL	2	0	2	NONE	-23618.4
259	c258	LL	0	0	0	NONE	-29068.8
260	c259	BS	-48	48	NONE	0	-0
261	c260	BS	0	-0	0	NONE	0
262	c261	BS	0	-0	0	NONE	0
263	c262	BS	0	-0	0	NONE	0
264	c263	BS	0	0	NONE	0	-0

	265	c264	BS	0	-0	0	NONE	0
	266	c265	BS	0	0	NONE	0	-0
	267	c266	BS	0	-0	0	NONE	0
	268	c267	BS	0	-0	0	NONE	0
	269	c268	BS	0	-0	0	NONE	0
	270	c269	BS	-148	148	NONE	0	-0
	271	c270	LL	2	0	2	NONE	-10821.28
	272	c271	LL	2	0	2	NONE	-14666.11
A	273	c272	LL	2	0	2	NONE	-0
	274	c273	BS	0	-0	0	NONE	0
	275	c274	BS	0	0	NONE	0	-0
	276	c275	BS	0	-0	0	NONE	0
	277	c276	BS	0	0	NONE	0	-0
	278	c277	LL	0	0	0	NONE	-62691.2
	279	c278	BS	0	0	NONE	0	-0
	280	c279	LL	0	0	0	NONE	-62691.2
	281	c280	BS	-48	48	NONE	0	-0
	282	c281	LL	2	0	2	NONE	-14364
	283	c282	LL	2	0	2	NONE	-2128
	284	c283	BS	11	-9	2	NONE	0
	285	c284	LL	2	0	2	NONE	-5320
	286	c285	BS	0	-0	0	NONE	0
	287	c286	BS	0	-0	0	NONE	0
	288	c287	LL	0	0	0	NONE	-56977.2
	289	c288	BS	0	-0	0	NONE	0
	290	c289	BS	0	-0	0	NONE	0
	291	c290	BS	-248	248	NONE	0	-0
	292	c291	BS	0	-0	0	NONE	0
	293	c292	LL	0	0	0	NONE	-15800.4
	294	c293	BS	0	-0	0	NONE	0
	295	c294	BS	0	-0	0	NONE	0
	296	c295	BS	-198	198	NONE	0	-0
	297	c296	LL	0	0	0	NONE	-63840
	298	c297	BS	-48	48	NONE	0	-0
	299	c298	BS	0	-0	0	NONE	0
	300	c299	LL	0	0	0	NONE	-2968.547
	301	c300	BS	0	-0	0	NONE	0
	302	c301	BS	0	-0	0	NONE	0
	303	c302	BS	0	-0	0	NONE	0
	304	c303	BS	0	0	NONE	0	-0
	305	c304	BS	0	-0	0	NONE	0
	306	c305	BS	0	-0	0	NONE	0
	307	c306	BS	0	-0	0	NONE	0
	308	c307	BS	0	-0	0	NONE	0
	309	c308	BS	0	0	NONE	0	-0
	310	c309	LL	0	0	0	NONE	-3288
	311	c310	BS	0	0	NONE	0	-0
	312	c311	LL	0	0	0	NONE	-1644
	313	c312	BS	0	0	NONE	0	-0
	314	c313	LL	0	0	0	NONE	-4384
	315	c314	BS	0	0	NONE	0	-0
	316	c315	LL	0	0	0	NONE	-6028
	317	c316	BS	0	0	NONE	0	-0
	318	c317	BS	0	-0	0	NONE	0
	319	c318	BS	0	-0	0	NONE	0
	320	c319	BS	0	-0	0	NONE	0
	321	c320	BS	0	-0	0	NONE	0
	322	c321	BS	0	-0	0	NONE	0
	323	c322	BS	0	0	NONE	0	-0
	324	c323	LL	0	0	0	NONE	-25920.4
	325	c324	BS	0	0	NONE	0	-0
	326	c325	LL	0	0	0	NONE	-539.1947
	327	c326	BS	0	0	NONE	0	-0
	328	c327	LL	0	0	0	NONE	-29646.8
	329	c328	BS	-48	48	NONE	0	-0
A	330	c329	LL	0	0	0	NONE	-0
	331	c330	BS	-48	48	NONE	0	-0
	332	c331	LL	0	0	0	NONE	-25208
	333	c332	BS	-48	48	NONE	0	-0
	334	c333	BS	0	-0	0	NONE	0
	335	c334	BS	0	-0	0	NONE	0
	336	c335	BS	0	-0	0	NONE	0
	337	c336	BS	0	-0	0	NONE	0
	338	c337	BS	0	-0	0	NONE	0

	339	c338	BS	-248	248	NONE	0	-0
	340	c339	LL	0	0	0	NONE	-6576
	341	c340	BS	-48	48	NONE	0	-0
	342	c341	LL	0	0	0	NONE	-3836
	343	c342	BS	-48	48	NONE	0	-0
	344	c343	LL	0	0	0	NONE	-3288
	345	c344	BS	-48	48	NONE	0	-0
	346	c345	LL	0	0	0	NONE	-5480
	347	c346	BS	0	0	NONE	0	-0
	348	c347	BS	0	-0	0	NONE	0
	349	c348	BS	0	-0	0	NONE	0
	350	c349	BS	0	-0	0	NONE	0
	351	c350	BS	0	-0	0	NONE	0
	352	c351	BS	0	-0	0	NONE	0
	353	c352	BS	-248	248	NONE	0	-0
	354	c353	LL	0	0	0	NONE	-115847.2
	355	c354	BS	0	-0	0	NONE	0
	356	c355	BS	-98	98	NONE	0	-0
	357	c356	LL	0	0	0	NONE	-40878
	358	c357	BS	0	0	NONE	0	-0
	359	c358	LL	0	0	0	NONE	-18958.75
	360	c359	BS	0	0	NONE	0	-0
A	361	c360	LL	0	0	0	NONE	-0
	362	c361	BS	0	0	NONE	0	-0
A	363	c362	LL	0	0	0	NONE	-0
	364	c363	BS	0	0	NONE	0	-0
A	365	c364	LL	0	0	0	NONE	-0
	366	c365	BS	0	0	NONE	0	-0
	367	c366	BS	0	-0	0	NONE	0
	368	c367	BS	0	-0	0	NONE	0
	369	c368	BS	0	-0	0	NONE	0
	370	c369	BS	0	-0	0	NONE	0
	371	c370	BS	0	-0	0	NONE	0
	372	c371	BS	0	0	NONE	0	-0
	373	c372	BS	0	-0	0	NONE	0
	374	c373	LL	0	0	0	NONE	-60159.29
	375	c374	BS	0	0	NONE	0	-0
	376	c375	LL	0	0	0	NONE	-13626
	377	c376	BS	-48	48	NONE	0	-0
	378	c377	LL	2	0	2	NONE	-10900.8
	379	c378	LL	2	0	2	NONE	-11809.2
	380	c379	LL	0	0	0	NONE	-14534.4
	381	c380	BS	-48	48	NONE	0	-0
	382	c381	BS	0	-0	0	NONE	0
	383	c382	BS	0	-0	0	NONE	0
	384	c383	BS	0	-0	0	NONE	0
	385	c384	BS	0	0	NONE	0	-0
A	386	c385	LL	0	0	0	NONE	-1.455192E-11
	387	c386	BS	0	0	NONE	0	-0
	388	c387	LL	0	0	0	NONE	-81396.92
	389	c388	BS	0	-0	0	NONE	0
	390	c389	BS	0	-0	0	NONE	0
	391	c390	BS	-148	148	NONE	0	-0
	392	c391	LL	2	0	2	NONE	-10821.28
	393	c392	LL	2	0	2	NONE	-12896
A	394	c393	LL	2	0	2	NONE	-0
	395	c394	BS	0	-0	0	NONE	0
	396	c395	BS	0	0	NONE	0	-0
	397	c396	BS	0	-0	0	NONE	0
	398	c397	BS	0	0	NONE	0	-0
	399	c398	LL	0	0	0	NONE	-31345.6
	400	c399	BS	0	0	NONE	0	-0
	401	c400	LL	0	0	0	NONE	-31345.6
	402	c401	BS	-48	48	NONE	0	-0
	403	c402	EQ	0	0	0	0	-3724
	404	c403	EQ	0	0	0	0	-3458
	405	c404	EQ	0	0	0	0	-2660
	406	c405	EQ	0	0	0	0	-1064
	407	c406	EQ	0	0	0	0	-1862
	408	c407	EQ	0	0	0	0	-2660
	409	c408	EQ	0	0	0	0	-3458
	410	c409	EQ	0	0	0	0	-5133.8
	411	c410	EQ	0	0	0	0	-5586
	412	c411	EQ	0	0	0	0	-6251

413	c412	EQ	0	0	0	0	-9336.6
414	c413	EQ	0	0	0	0	-10746.4
415	c414	EQ	0	0	0	0	-12049.8
416	c415	EQ	0	0	0	0	-13220.2
417	c416	EQ	0	0	0	0	-14736.4
418	c417	EQ	0	0	0	0	-15960
419	c418	EQ	0	0	0	0	-15672.8
420	c419	EQ	0	0	0	0	-2128
421	c420	EQ	0	0	0	0	-1064
422	c421	EQ	0	0	0	0	-2926
423	c422	EQ	0	0	0	0	-1330
424	c423	EQ	0	0	0	0	-2128
425	c424	EQ	0	0	0	0	-3724
426	c425	EQ	0	0	0	0	-2394
427	c426	EQ	0	0	0	0	-1330
428	c427	EQ	0	0	0	0	-1596
429	c428	EQ	0	0	0	0	-1596
430	c429	EQ	0	0	0	0	-15261.8
431	c430	EQ	0	0	0	0	-13974
432	c431	EQ	0	0	0	0	-9793.655
433	c432	EQ	0	0	0	0	-10713.4
434	c433	EQ	0	0	0	0	-9507.8
435	c434	EQ	0	0	0	0	-7836.4
436	c435	EQ	0	0	0	0	-6466.4
437	c436	EQ	0	0	0	0	-4932
438	c437	EQ	0	0	0	0	-3562
439	c438	EQ	0	0	0	0	-1644
440	c439	EQ	0	0	0	0	-822
441	c440	EQ	0	0	0	0	-2192
442	c441	EQ	0	0	0	0	-3014
443	c442	EQ	0	0	0	0	-4384
444	c443	EQ	0	0	0	0	-5480
445	c444	EQ	0	0	0	0	-6850
446	c445	EQ	0	0	0	0	-8740.6
447	c446	EQ	0	0	0	0	-10275
448	c447	EQ	0	0	0	0	-12960.2
449	c448	EQ	0	0	0	0	-269.5973
450	c449	EQ	0	0	0	0	-15672.8
451	c450	EQ	0	0	0	0	-3014
452	c451	EQ	0	0	0	0	-1370
453	c452	EQ	0	0	0	0	-2192
454	c453	EQ	0	0	0	0	-3836
455	c454	EQ	0	0	0	0	-2466
456	c455	EQ	0	0	0	0	-1370
457	c456	EQ	0	0	0	0	-1644
458	c457	EQ	0	0	0	0	-2740
459	c458	EQ	0	0	0	0	-1644
460	c459	EQ	0	0	0	0	-1370
461	c460	EQ	0	0	0	0	-2466
462	c461	EQ	0	0	0	0	-1644
463	c462	EQ	0	0	0	0	-1644
464	c463	EQ	0	0	0	0	-14823.4
465	c464	EQ	0	0	0	0	-13645.2
466	c465	EQ	0	0	0	0	-12604
467	c466	EQ	0	0	0	0	-7397.162
468	c467	EQ	0	0	0	0	-9754.4
469	c468	EQ	0	0	0	0	-6576
470	c469	EQ	0	0	0	0	-7178.8
471	c470	EQ	0	0	0	0	-4932
472	c471	EQ	0	0	0	0	-3288
473	c472	EQ	0	0	0	0	-1918
474	c473	EQ	0	0	0	0	-1644
475	c474	EQ	0	0	0	0	-2740
476	c475	EQ	0	0	0	0	-3836
477	c476	EQ	0	0	0	0	-4932
478	c477	EQ	0	0	0	0	-6630.8
479	c478	EQ	0	0	0	0	-8083
480	c479	EQ	0	0	0	0	-9672.2
481	c480	EQ	0	0	0	0	-12083.4
482	c481	EQ	0	0	0	0	-14275.4
483	c482	EQ	0	0	0	0	-10219.5
484	c483	EQ	0	0	0	0	-15672.8
485	c484	EQ	0	0	0	0	-2740
486	c485	EQ	0	0	0	0	-1644

	487	c486	EQ	0	0	0	0	-1370
	488	c487	EQ	0	0	0	0	-2466
	489	c488	EQ	0	0	0	0	-2740
	490	c489	EQ	0	0	0	0	-1370
	491	c490	EQ	0	0	0	0	-1397.4
	492	c491	EQ	0	0	0	0	-2986.6
	493	c492	EQ	0	0	0	0	-2356.4
	494	c493	EQ	0	0	0	0	-2740
	495	c494	EQ	0	0	0	0	-12112
	496	c495	EQ	0	0	0	0	-11581.6
	497	c496	EQ	0	0	0	0	-8828.8
	498	c497	EQ	0	0	0	0	-5952
	499	c498	EQ	0	0	0	0	-3968
	500	c499	EQ	0	0	0	0	-3224
	501	c500	EQ	0	0	0	0	-3472
	502	c501	EQ	0	0	0	0	-2728
	503	c502	EQ	0	0	0	0	-2480
	504	c503	EQ	0	0	0	0	-3224
	505	c504	EQ	0	0	0	0	-744
	506	c505	EQ	0	0	0	0	-992
	507	c506	EQ	0	0	0	0	-23709.24
	508	c507	EQ	0	0	0	0	-2740
	509	c508	EQ	0	0	0	0	-20302.74
	510	c509	EQ	0	0	0	0	-18803.88
	511	c510	EQ	0	0	0	0	-16487.46
	512	c511	EQ	0	0	0	0	-13080.96
	513	c512	EQ	0	0	0	0	-6630.8
	514	c513	EQ	0	0	0	0	-13943.94
	515	c514	EQ	0	0	0	0	-12853.86
	516	c515	EQ	0	0	0	0	-11355
	517	c516	EQ	0	0	0	0	-10446.6
	518	c517	EQ	0	0	0	0	-6813
	519	c518	EQ	0	0	0	0	-5450.4
	520	c519	EQ	0	0	0	0	-5904.6
	521	c520	EQ	0	0	0	0	-7267.2
	522	c521	EQ	0	0	0	0	-12626.76
A	523	c522	EQ	0	0	0	0	0
	524	c523	EQ	0	0	0	0	-21347.4
	525	c524	EQ	0	0	0	0	-20302.74
	526	c525	EQ	0	0	0	0	-2271
	527	c526	EQ	0	0	0	0	-2043.9
	528	c527	EQ	0	0	0	0	-4087.8
A	529	c528	EQ	0	0	0	0	-0
	530	c529	EQ	0	0	0	0	-4087.8
	531	c530	EQ	0	0	0	0	-4859.94
	532	c531	BS	0	0	0	0	-0
	533	c532	EQ	0	0	0	0	-454.2
	534	c533	EQ	0	0	0	0	-5677.5
	535	c534	EQ	0	0	0	0	-1900
	536	c535	EQ	0	0	0	0	-3800
	537	c536	EQ	0	0	0	0	-9856.25
	538	c537	EQ	0	0	0	0	-2449.686
	539	c538	EQ	0	0	0	0	-4050
	540	c539	EQ	0	0	0	0	-8268.75
	541	c540	EQ	0	0	0	0	-5062.5
	542	c541	EQ	0	0	0	0	-2340
	543	c542	EQ	0	0	0	0	-7038
	544	c543	EQ	0	0	0	0	-3736.047
	545	c544	EQ	0	0	0	0	-5228.322
	546	c545	EQ	0	0	0	0	-2852.83
	547	c546	EQ	0	0	0	0	-1961.321
	548	c547	EQ	0	0	0	0	-1783.019
A	549	c548	EQ	0	0	0	0	-0
	550	c549	EQ	0	0	0	0	2660
	551	c550	EQ	0	0	0	0	2740
	552	c551	EQ	0	0	0	0	2740
	553	c552	EQ	0	0	0	0	2480
	554	c553	EQ	0	0	0	0	4542
	555	c554	EQ	0	0	0	0	2375
	556	c555	EQ	0	0	0	0	3375
	557	c556	EQ	0	0	0	0	1800
	558	c557	EQ	0	0	0	0	2197.674
	559	c558	EQ	0	0	0	0	1783.019
	560	c559	BS	-7	7	NONE	0	-0

A	561	c560	UL	0	0	NONE	0	0
	562	c561	BS	-126.6	126.6	NONE	0	-0
A	563	c562	UL	0	0	NONE	0	0
	564	c563	BS	-90.69811	90.69811	NONE	0	-0
	565	c564	BS	753.9	-753.9	0	NONE	0
	566	c565	BS	0	-0	0	NONE	0
	567	c566	BS	1385.94	-1385.94	0	NONE	0
	568	c567	BS	199.2	-199.2	0	NONE	0
	569	c568	BS	183.54	-183.54	0	NONE	0
	570	c569	EQ	1	0	1	1	-76076
	571	c570	EQ	1	0	1	1	-71873.2
	572	c571	EQ	1	0	1	1	-300983.8
	573	c572	EQ	1	0	1	1	-125020
	574	c573	EQ	1	0	1	1	-204142.6
	575	c574	EQ	1	0	1	1	-706474.3
	576	c575	EQ	1	0	1	1	-65936.11
	577	c576	EQ	1	0	1	1	-233624.1
	578	c577	EQ	1	0	1	1	-144986.3
	579	c578	EQ	1	0	1	1	-127680
	580	c579	EQ	1	0	1	1	-90596.11
	581	c580	EQ	1	0	1	1	-140464.1
	582	c581	EQ	1	0	1	1	-156356.1
	583	c582	EQ	1	0	1	1	-147943.2
A	584	c583	EQ	1	0	1	1	-0
	585	c584	EQ	1	0	1	1	-353636.1
	586	c585	EQ	1	0	1	1	-414308.1
	587	c586	EQ	1	0	1	1	-312536.1
	588	c587	EQ	1	0	1	1	-739866.5
	589	c588	EQ	1	0	1	1	-76720
	590	c589	EQ	1	0	1	1	-649687.7
	591	c590	EQ	1	0	1	1	-488900.9
	592	c591	EQ	1	0	1	1	-395699
	593	c592	EQ	1	0	1	1	-78912
	594	c593	EQ	1	0	1	1	-172400.8
	595	c594	EQ	1	0	1	1	-129328
	596	c595	EQ	1	0	1	1	-335011.3
	597	c596	EQ	1	0	1	1	-231694.4
	598	c597	EQ	1	0	1	1	-471728.2
	599	c598	EQ	1	0	1	1	-204390
	600	c599	EQ	1	0	1	1	-218016
	601	c600	EQ	1	0	1	1	-371262.6
	602	c601	BS	1	0	1	1	-0
	603	c602	BS	1	0	1	1	-0
	604	c603	EQ	1	0	1	1	-532875.2
	605	c604	EQ	1	0	1	1	-3500000
	606	c605	EQ	1	0	1	1	-1000000
	607	c606	UL	0	0	NONE	0	65936.11
	608	c607	BS	-25	25	NONE	0	-0
	609	c608	EQ	1	0	1	1	-1000000
	610	c609	EQ	1	0	1	1	-1000000
	611	c610	BS	4	1	NONE	5	-0

SECTION 2 - COLUMNS

NUMBER	.....COLUMN.....	AT	...ACTIVITY...	..INPUT COST..	..LOWER LIMIT.	..UPPER LIMIT.	.REDUCED COST.
612	Hours1A	BS	1053.9	2660	0	NONE	0
613	Hours3A	BS	222	950	0	NONE	0
614	Hours1B	BS	0	2740	0	NONE	0
615	Hours3B	BS	0	945	0	NONE	0
616	Hours1C	BS	1685.94	2740	0	NONE	0
617	Hours3C	BS	74.4	1260	0	NONE	0
618	Hours2D	BS	199.2	4542	0	NONE	0
619	Hours3D	BS	0	945	0	NONE	0
620	Hours1E	BS	483.54	2480	0	NONE	0
621	Hours3E	BS	128.3019	945	0	NONE	0
622	OPENA	BS	1	1000000	1	1	0
623	OPENB	BS	0	3500000	0	0	0
624	OPENC	BS	1	3500000	1	1	0
625	OPEND	BS	1	1000000	1	1	0
626	OPENE	BS	1	1000000	1	1	0
627	Dr1A01	BS	3	0	3	3	0
628	Ss1A01	EQ	2	0	2	2	9880
629	TOSs1A01	BS	0	0	0	0	0

	630	Ws1A01	BS	2	0	2	2	0
	631	TOWs1A01	EQ	0	0	0	0	-3040
	632	Dr1A02	BS	7	0	7	7	0
	633	Dr1A03	BS	15	0	15	15	0
	634	Dr1A04	BS	7	0	7	7	0
	635	Sd1A04	BS	2	0	2	2	0
	636	Wd1A04	BS	2	0	2	2	0
A	637	Dr1A05	EQ	0	0	0	0	0
	638	Sd1A05	BS	2	0	2	2	0
	639	Wd1A05	BS	11	0	11	11	0
	640	Dr1A06	BS	7	0	7	7	0
	641	Sd1A06	BS	2	0	2	2	0
	642	Wd1A06	BS	2	0	2	2	0
	643	Dr1A07	BS	7	0	7	7	0
	644	Ss1A02	EQ	1	0	1	1	36632
	645	TOSs1A02	BS	1	0	1	1	0
	646	Ws1A02	BS	1	0	1	1	0
	647	TOWs1A02	EQ	1	0	1	1	-21888
	648	ASSIGNA07	BS	1	0	1	1	0
	649	Dr1A08	BS	3	0	3	3	0
	650	ASSIGNA08	BS	1	0	1	1	0
	651	Dr1A09	BS	8	0	8	8	0
	652	ASSIGNA09	BS	1	0	1	1	0
	653	Dr1A10	BS	6	0	6	6	0
	654	ASSIGNA10	BS	1	0	1	1	0
	655	Dr1A11	BS	4	0	4	4	0
	656	ASSIGNA11	BS	1	0	1	1	0
	657	Dr1A12	EQ	5	0	5	5	-57004.34
	658	Ss1A03	EQ	0	0	0	0	80009
	659	TOSs1A03	BS	2	0	2	2	0
	660	Ws1A03	EQ	0	0	0	0	53568.6
	661	TOWs1A03	BS	2	0	2	2	0
	662	ASSIGNA12	BS	1	0	1	1	0
	663	Dr1A13	EQ	5	0	5	5	20284.57
	664	ASSIGNA13	BS	1	0	1	1	0
	665	Dr1A14	EQ	13	0	13	13	12697.81
	666	ASSIGNA14	BS	1	0	1	1	0
	667	Dr1A15	EQ	6	0	6	6	14974.17
	668	ASSIGNA15	BS	1	0	1	1	0
	669	Dr1A16	EQ	6	0	6	6	31920
	670	Sd1A16	EQ	2	0	2	2	95760
	671	Wd1A16	BS	2	0	2	2	0
	672	ASSIGNA16	BS	1	0	1	1	0
	673	Dr1B07	EQ	0	0	0	0	29601.79
	674	Ss1B03	EQ	0	0	0	0	102825.7
	675	TOSs1B03	BS	0	0	0	0	0
	676	Ws1B03	EQ	0	0	0	0	151846.5
	677	TOWs1B03	BS	0	0	0	0	0
	678	ASSIGNB07	BS	0	0	0	0	0
	679	Dr1B08	EQ	0	0	0	0	27948
	680	ASSIGNB08	BS	0	0	0	0	0
	681	Dr1B09	BS	0	0	0	0	0
	682	ASSIGNB09	BS	0	0	0	0	0
	683	Dr1B10	EQ	0	0	0	0	15518.41
	684	ASSIGNB10	BS	0	0	0	0	0
	685	Dr1B11	EQ	0	0	0	0	19015.6
	686	ASSIGNB11	BS	0	0	0	0	0
	687	Dr1B12	EQ	0	0	0	0	-55498.11
	688	Ss1B01	BS	0	0	0	0	0
	689	TOSs1B01	EQ	0	0	0	0	9721.5
	690	Ws1B01	EQ	0	0	0	0	-7054.908
	691	TOWs1B01	EQ	0	0	0	0	-15297.41
	692	ASSIGNB12	BS	0	0	0	0	0
	693	Dr1B13	EQ	0	0	0	0	12932.8
	694	ASSIGNB13	BS	0	0	0	0	0
	695	Dr1B14	BS	0	0	0	0	0
	696	ASSIGNB14	BS	0	0	0	0	0
	697	Dr1B15	BS	0	0	0	0	0
	698	ASSIGNB15	BS	0	0	0	0	0
	699	Dr1B16	BS	0	0	0	0	0
	700	Sd1B16	EQ	0	0	0	0	-4567.947
	701	Wd1B16	BS	0	0	0	0	0
	702	ASSIGNB16	BS	0	0	0	0	0
	703	Dr1B17	BS	0	0	0	0	0

704	Sd1B17	BS	0	0	0	0	0
705	Wd1B17	BS	0	0	0	0	0
706	ASSIGNB17	BS	0	0	0	0	0
707	Dr1B18	BS	0	0	0	0	0
708	Sd1B18	BS	0	0	0	0	0
709	Wd1B18	BS	0	0	0	0	0
710	ASSIGNB18	BS	0	0	0	0	0
711	Dr1B19	BS	0	0	0	0	0
712	Sd1B19	BS	0	0	0	0	0
713	Wd1B19	BS	0	0	0	0	0
714	ASSIGNB19	BS	0	0	0	0	0
715	Dr1B20	EQ	0	0	0	0	8768
716	Ss1B04	EQ	0	0	0	0	13535.43
717	TOSs1B04	EQ	0	0	0	0	-7862.569
718	Ws1B04	EQ	0	0	0	0	10699
719	TOWs1B04	BS	0	0	0	0	0
720	ASSIGNB20	BS	0	0	0	0	0
721	Dr1B21	EQ	0	0	0	0	10960
722	ASSIGNB21	EQ	0	0	0	0	65936.11
723	Dr1B22	BS	0	0	0	0	0
724	ASSIGNB22	BS	0	0	0	0	0
725	Dr1B23	EQ	0	0	0	0	-11549.8
726	ASSIGNB23	BS	0	0	0	0	0
727	Dr1B24	BS	0	0	0	0	0
728	ASSIGNB24	BS	0	0	0	0	0
729	Dr1B25	BS	0	0	0	0	0
730	Sd1B25	BS	0	0	0	0	0
731	Wd1B25	BS	0	0	0	0	0
732	ASSIGNB25	BS	0	0	0	0	0
733	Dr1B26	BS	0	0	0	0	0
734	Sd1B26	BS	0	0	0	0	0
735	Wd1B26	BS	0	0	0	0	0
736	ASSIGNB26	BS	0	0	0	0	0
737	Dr1C17	BS	5	0	5	5	0
738	Sd1C17	BS	2	0	2	2	0
739	Wd1C17	BS	2	0	2	2	0
740	ASSIGNC17	EQ	1	0	1	1	413399.5
741	Dr1C18	BS	7	0	7	7	0
742	Sd1C18	BS	2	0	2	2	0
743	Wd1C18	BS	2	0	2	2	0
744	ASSIGNC18	EQ	1	0	1	1	323472.7
745	Dr1C19	BS	5	0	5	5	0
746	Sd1C19	BS	2	0	2	2	0
747	Wd1C19	BS	2	0	2	2	0
748	ASSIGNC19	EQ	1	0	1	1	171347.9
749	Dr1C20	BS	0	0	0	0	0
750	Ss1C03	EQ	0	0	0	0	42744
751	TOSs1C03	EQ	4	0	4	4	6621.676
752	Ws1C03	BS	2	0	2	2	0
753	ASSIGNC20	BS	1	0	1	1	0
754	Dr1C21	EQ	0	0	0	0	19508.8
755	ASSIGNC21	BS	1	0	1	1	0
756	Dr1C22	BS	15	0	15	15	0
757	TOWs1C03	EQ	0	0	0	0	4130.324
758	ASSIGNC22	EQ	1	0	1	1	-77444.11
759	Dr1C23	EQ	6	0	6	6	-20168.08
760	ASSIGNC23	BS	1	0	1	1	0
761	Dr1C24	BS	6	0	6	6	0
762	ASSIGNC24	EQ	1	0	1	1	-194168.1
763	Dr1C25	BS	16	0	16	16	0
764	Sd1C25	BS	2	0	2	2	0
765	Wd1C25	BS	2	0	2	2	0
766	ASSIGNC25	EQ	1	0	1	1	-568890.5
767	Dr1C26	BS	10	0	10	10	0
768	Sd1C26	BS	2	0	2	2	0
769	Wd1C26	BS	2	0	2	2	0
770	ASSIGNC26	BS	1	0	1	1	0
771	Dr1C27	BS	8	0	8	8	0
772	Sd1C27	BS	2	0	2	2	0
773	Wd1C27	BS	2	0	2	2	0
774	ASSIGNC27	EQ	1	0	1	1	-590503.7
775	Dr1C28	BS	7	0	7	7	0
776	Sd1C28	BS	2	0	2	2	0
777	Wd1C28	BS	2	0	2	2	0

778	ASSIGNC28	EQ	1	0	1	1	-395740.9
779	Dr1C29	EQ	8	0	8	8	3571.207
780	Ss1C04	BS	2	0	2	2	0
781	Ws1C04	BS	2	0	2	2	0
782	ASSIGNC29	EQ	1	0	1	1	-202475.1
783	Dr1C30	BS	4	0	4	4	0
784	ASSIGNC30	BS	1	0	1	1	0
785	Dr1C31	BS	9	0	9	9	0
786	ASSIGNC31	BS	1	0	1	1	0
787	Dr1C32	BS	4	0	4	4	0
788	ASSIGNC32	BS	1	0	1	1	0
789	Dr1C33	EQ	4	0	4	4	-22532.01
790	ASSIGNC33	BS	1	0	1	1	0
791	Ss1C05	EQ	0	0	0	0	49061.2
792	TOSs1C05	BS	2	0	2	2	0
793	Ws1C05	BS	2	0	2	2	0
794	TOWs1C05	EQ	0	0	0	0	13410.8
795	ASSIGNC34	BS	1	0	1	1	0
796	Dr1C35	BS	8	0	8	8	0
797	ASSIGNC35	EQ	1	0	1	1	71638.24
798	Dr1C36	EQ	0	0	0	0	20439
799	Sd1C36	BS	0	0	0	0	0
800	Wd1C36	BS	0	0	0	0	0
801	ASSIGNC36	BS	0	0	0	0	0
802	Dr2D25	EQ	0	0	0	0	18958.75
803	Sd2D25	BS	0	0	0	0	0
804	Wd2D25	BS	0	0	0	0	0
805	ASSIGND25	BS	0	0	0	0	0
806	Dr2D26	BS	0	0	0	0	0
807	Sd2D26	EQ	0	0	0	0	5480
808	Wd2D26	BS	0	0	0	0	0
809	ASSIGND26	BS	0	0	0	0	0
810	Dr2D27	BS	0	0	0	0	0
811	Sd2D27	BS	0	0	0	0	0
812	Wd2D27	BS	0	0	0	0	0
813	ASSIGND27	BS	0	0	0	0	0
814	Dr2D28	BS	0	0	0	0	0
815	Sd2D28	BS	0	0	0	0	0
816	Wd2D28	BS	0	0	0	0	0
817	ASSIGND28	BS	0	0	0	0	0
818	Dr2D29	BS	0	0	0	0	0
819	Ss2D03	EQ	0	0	0	0	38102.21
820	TOSs2D03	BS	0	0	0	0	0
821	Ws2D03	EQ	0	0	0	0	69166.16
822	TOWs2D03	EQ	0	0	0	0	23591.85
823	ASSIGND29	BS	0	0	0	0	0
824	Dr2D30	EQ	0	0	0	0	16297.92
825	ASSIGND30	BS	0	0	0	0	0
826	Dr2D31	BS	0	0	0	0	0
827	ASSIGND31	BS	0	0	0	0	0
828	Dr2D32	EQ	0	0	0	0	11721.88
829	ASSIGND32	BS	0	0	0	0	0
830	Dr2D33	BS	0	0	0	0	0
831	ASSIGND33	BS	0	0	0	0	0
832	Dr2D34	BS	0	0	0	0	0
833	Ss2D02	EQ	0	0	0	0	64995.01
834	TOSs2D02	BS	0	0	0	0	0
835	Ws2D02	EQ	0	0	0	0	75192.31
836	TOWs2D02	BS	0	0	0	0	0
837	ASSIGND34	BS	0	0	0	0	0
838	Dr2D35	BS	0	0	0	0	0
839	ASSIGND35	BS	0	0	0	0	0
840	Dr2D36	BS	5	0	5	5	0
841	Sd2D36	BS	2	0	2	2	0
842	Wd2D36	BS	2	0	2	2	0
843	ASSIGND36	BS	1	0	1	1	0
844	Dr2D37	BS	14	0	14	14	0
845	Sd2D37	BS	2	0	2	2	0
846	Wd2D37	BS	2	0	2	2	0
847	Dr2D38	BS	5	0	5	5	0
848	Sd2D38	BS	2	0	2	2	0
849	Wd2D38	BS	2	0	2	2	0
850	Dr2D39	BS	5	0	5	5	0
851	Sd2D39	BS	2	0	2	2	0

852	Wd2D39	BS	2	0	2	2	0
853	ASSIGND39	BS	1	0	1	1	0
854	Dr2D40	EQ	0	0	0	0	-15997.88
855	Ss2D04	EQ	0	0	0	0	-2371.885
856	TOSs2D04	EQ	0	0	0	0	41251.4
857	Ws2D04	EQ	0	0	0	0	-21811.64
858	TOWs2D04	BS	0	0	0	0	0
859	ASSIGND40	BS	0	0	0	0	0
860	Dr2D41	BS	0	0	0	0	0
861	ASSIGND41	BS	0	0	0	0	0
862	Dr2D42	EQ	0	0	0	0	42694.8
863	ASSIGND42	BS	0	0	0	0	0
864	Dr1E39	BS	0	0	0	0	0
865	Sd1E39	EQ	0	0	0	0	48448
866	Wd1E39	BS	0	0	0	0	0
867	ASSIGNE39	BS	0	0	0	0	0
868	Dr1E40	BS	5	0	5	5	0
869	Ss1E01	EQ	0	0	0	0	184660.8
870	TOSs1E01	EQ	2	0	2	2	116120.2
871	Ws1E01	EQ	0	0	0	0	22217.48
872	TOWs1E01	BS	2	0	2	2	0
873	ASSIGNE40	BS	1	0	1	1	0
874	Dr1E41	EQ	15	0	15	15	17657.6
875	ASSIGNE41	BS	1	0	1	1	0
876	Dr1E42	EQ	6	0	6	6	11904
877	ASSIGNE42	BS	1	0	1	1	0
878	Dr1E43	BS	13	0	13	13	0
879	Sd1E43	EQ	0	0	0	0	28858.72
880	TOSd1E43	BS	2	0	2	2	0
881	Wd1E43	EQ	0	0	0	0	5050.717
882	TOWd1E43	BS	2	0	2	2	0
883	Dr1E44	BS	7	0	7	7	0
884	Sd1E44	EQ	0	0	0	0	17573.89
885	TOSd1E44	BS	2	0	2	2	0
886	Wd1E44	BS	2	0	2	2	0
887	TOWd1E44	EQ	0	0	0	0	1770.113
888	Dr1E45	BS	7	0	7	7	0
889	Sd1E45	EQ	0	0	0	0	34720
890	TOSd1E45	BS	2	0	2	2	0
891	Wd1E45	EQ	0	0	0	0	13888
892	TOWd1E45	BS	2	0	2	2	0
893	Dr1BC	EQ	0	0	0	0	-280842
894	Sd1BC	EQ	0	0	0	0	-218150.8
895	Wd1BC	EQ	0	0	0	0	-249496.4
896	ASSIGNBC	BS	0	0	0	0	0
897	Dr2DC	EQ	0	0	0	0	-277576.3
898	Sd2DC	EQ	0	0	0	0	-196365.4
899	Wd2DC	EQ	0	0	0	0	-236970.9
900	ASSIGNDC	BS	0	0	0	0	0
901	Dr1AB	BS	0	0	0	0	0
902	Sd1AB	BS	0	0	0	0	0
903	Wd1AB	BS	0	0	0	0	0
904	ASSIGNAB	BS	0	0	0	0	0
905	Dr1CB	BS	7	0	7	7	0
906	Sd1CB	BS	2	0	2	2	0
907	Wd1CB	BS	2	0	2	2	0
908	ASSIGNCB	BS	1	0	1	1	0
909	Lg1A01	BS	6	0	0	NONE	0
910	Lg1A02	BS	14	0	0	NONE	0
911	Lg1A03	BS	70	0	0	NONE	0
912	Lg1A04	BS	30	0	0	NONE	0
913	Lg1A05	BS	30	0	0	NONE	0
914	Lg1A06	BS	30	0	0	NONE	0
915	Lg1A07	BS	14	0	0	NONE	0
916	Lg1A08	BS	6	0	0	NONE	0
917	Lg1A09	BS	48	0	0	NONE	0
918	Lg1A10	BS	12	0	0	NONE	0
919	Lg1A11	BS	8	0	0	NONE	0
920	Lg1A12	BS	10	0	0	NONE	0
921	Lg1A13	BS	10	0	0	NONE	0
922	Lg1A14	BS	38	0	0	NONE	0
923	Lg1A15	BS	12	0	0	NONE	0
924	Lg1A16	BS	32	0	0	NONE	0
925	Lg1AB	LL	0	0	0	NONE	2548.2

926	Lg1A0103	BS	20	0	0	NONE	0
927	Lg1A0203	BS	20	0	0	NONE	0
928	Lg1A0709	BS	24	0	0	NONE	0
929	Lg1A0809	BS	24	0	0	NONE	0
930	Lg1A0910	BS	24	0	0	NONE	0
931	Lg1A0911	BS	24	0	0	NONE	0
932	Lg1A1214	BS	20	0	0	NONE	0
933	Lg1A1314	BS	20	0	0	NONE	0
934	Lg1A1415	BS	20	0	0	NONE	0
935	Lg1A14Cp	BS	32	0	0	NONE	0
936	Lg1B07	BS	0	0	0	NONE	0
937	Lg1B08	BS	0	0	0	NONE	0
938	Lg1B09	LL	0	0	0	NONE	2782.945
939	Lg1B10	BS	0	0	0	NONE	0
940	Lg1B11	BS	0	0	0	NONE	0
941	Lg1B12	BS	0	0	0	NONE	0
942	Lg1B13	BS	0	0	0	NONE	0
943	Lg1B14	BS	0	0	0	NONE	0
944	Lg1B15	BS	0	0	0	NONE	0
945	Lg1B16	BS	0	0	0	NONE	0
946	Lg1B17	BS	0	0	0	NONE	0
947	Lg1B18	BS	0	0	0	NONE	0
948	Lg1B19	BS	0	0	0	NONE	0
949	Lg1B20	BS	0	0	0	NONE	0
950	Lg1B21	BS	0	0	0	NONE	0
951	Lg1B22	BS	0	0	0	NONE	0
952	Lg1B23	BS	0	0	0	NONE	0
953	Lg1B24	BS	0	0	0	NONE	0
954	Lg1B25	BS	0	0	0	NONE	0
955	Lg1B26	LL	0	0	0	NONE	13786.6
956	Lg1BC	BS	0	0	0	NONE	0
957	Lg1B0709	BS	0	0	0	NONE	0
958	Lg1B0809	BS	0	0	0	NONE	0
959	Lg1B0910	BS	0	0	0	NONE	0
960	Lg1B0911	BS	0	0	0	NONE	0
961	Lg1B1214	BS	0	0	0	NONE	0
962	Lg1B1314	BS	0	0	0	NONE	0
963	Lg1B1415	BS	0	0	0	NONE	0
964	Lg1B2022	BS	0	0	0	NONE	0
965	Lg1B2122	BS	0	0	0	NONE	0
966	Lg1B2223	BS	0	0	0	NONE	0
967	Lg1B2224	BS	0	0	0	NONE	0
968	Lg1B14Cp	BS	0	0	0	NONE	0
969	Lg1B22Gj	BS	0	0	0	NONE	0
970	Lg1C17	BS	34	0	0	NONE	0
971	Lg1C18	BS	34	0	0	NONE	0
972	Lg1C19	BS	26	0	0	NONE	0
973	Lg1C20	LL	0	0	0	NONE	3590.238
974	Lg1C21	BS	0	0	0	NONE	0
975	Lg1C22	BS	50	0	0	NONE	0
976	Lg1C23	BS	12	0	0	NONE	0
977	Lg1C24	BS	12	0	0	NONE	0
978	Lg1C25	BS	52	0	0	NONE	0
979	Lg1C26	BS	40	0	0	NONE	0
980	Lg1C27	BS	36	0	0	NONE	0
981	Lg1C28	BS	34	0	0	NONE	0
982	Lg1C29	BS	16	0	0	NONE	0
983	Lg1C30	BS	8	0	0	NONE	0
984	Lg1C31	BS	50	0	0	NONE	0
985	Lg1C32	BS	8	0	0	NONE	0
986	Lg1C33	BS	8	0	0	NONE	0
987	Lg1C34	BS	32	0	0	NONE	0
988	Dr1C34	EQ	0	0	0	0	24166.8
989	Lg1C35	BS	16	0	0	NONE	0
990	Lg1C36	LL	0	0	0	NONE	4220.3
991	Lg1CB	BS	34	0	0	NONE	0
992	Lg1C2022	BS	32	0	0	NONE	0
993	Lg1C2122	BS	32	0	0	NONE	0
994	Lg1C2223	BS	32	0	0	NONE	0
995	Lg1C2224	BS	32	0	0	NONE	0
996	Lg1C2931	BS	24	0	0	NONE	0
997	Lg1C3031	BS	36	0	0	NONE	0
998	Lg1C3132	BS	36	0	0	NONE	0
999	Lg1C3133	BS	36	0	0	NONE	0

	1000	Lg1C3435	BS	44	0	0	NONE	0
	1001	Lg1C22Pl	BS	32	0	0	NONE	0
	1002	Lg1E39	LL	0	0	0	NONE	2172.8
	1003	Lg1E40	BS	10	0	0	NONE	0
	1004	Lg1E41	BS	54	0	0	NONE	0
	1005	Lg1E42	BS	12	0	0	NONE	0
	1006	Lg1E43	BS	34	0	0	NONE	0
	1007	Lg1E44	BS	30	0	0	NONE	0
	1008	Lg1E45	BS	22	0	0	NONE	0
	1009	Lg1E4041	BS	20	0	0	NONE	0
	1010	Lg1E4142	BS	20	0	0	NONE	0
	1011	Lg1E41Na	BS	32	0	0	NONE	0
	1012	Lg1E43Ho	BS	16	0	0	NONE	0
	1013	Lg1E44Ma	BS	8	0	0	NONE	0
	1014	Lg2D25	BS	0	0	0	NONE	0
	1015	Lg2D26	LL	0	0	0	NONE	20106.26
	1016	Lg2D27	BS	0	0	0	NONE	0
	1017	Lg2D28	BS	0	0	0	NONE	0
	1018	Lg2D29	BS	0	0	0	NONE	0
	1019	Lg2D30	BS	0	0	0	NONE	0
	1020	Lg2D31	LL	0	0	0	NONE	5178.4
	1021	Lg2D32	BS	0	0	0	NONE	0
	1022	Lg2D33	BS	0	0	0	NONE	0
	1023	Lg2D34	BS	0	0	0	NONE	0
	1024	Lg2D35	BS	0	0	0	NONE	0
	1025	Lg2D36	BS	30	0	0	NONE	0
	1026	Lg2D37	BS	56	0	0	NONE	0
	1027	Lg2D38	BS	30	0	0	NONE	0
	1028	Lg2D39	BS	30	0	0	NONE	0
	1029	Lg2D40	BS	0	0	0	NONE	0
	1030	Lg2D41	LL	0	0	0	NONE	16351.2
	1031	Lg2D42	BS	0	0	0	NONE	0
	1032	Lg2DC	BS	0	0	0	NONE	0
	1033	Lg2D2931	BS	0	0	0	NONE	0
	1034	Lg2D3031	BS	0	0	0	NONE	0
	1035	Lg2D3133	BS	0	0	0	NONE	0
	1036	Lg2D3233	BS	0	0	0	NONE	0
	1037	Lg2D3435	BS	0	0	0	NONE	0
	1038	Lg2D4041	BS	0	0	0	NONE	0
	1039	Lg2D4142	LL	0	0	0	NONE	4269.48
	1040	Lg2D34Br	BS	0	0	0	NONE	0
	1041	Lg2D41Na	BS	0	0	0	NONE	0
	1042	Lg3A03	BS	0	0	0	NONE	0
	1043	Lg3A09	BS	14	0	0	NONE	0
	1044	Lg3ACopp	BS	16	0	0	NONE	0
	1045	Lg3B09	LL	0	0	0	NONE	5987.814
	1046	Lg3B14	BS	0	0	0	NONE	0
	1047	Lg3BCopp	BS	0	0	0	NONE	0
	1048	Lg3BGjoa	BS	0	0	0	NONE	0
	1049	Lg3CPell	BS	16	0	0	NONE	0
	1050	Lg3CBrou	BS	8	0	0	NONE	0
	1051	Lg3DBrou	BS	0	0	0	NONE	0
	1052	Lg3DNain	LL	0	0	0	NONE	1144.934
	1053	Lg3ENain	BS	24	0	0	NONE	0
	1054	Lg3EHope	BS	16	0	0	NONE	0
	1055	Lg3EMakk	BS	12	0	0	NONE	0
	1056	Lg3ECart	BS	16	0	0	NONE	0
	1057	Lg1E45Ca	LL	0	0	0	NONE	496
	1058	Lg2D3132	LL	0	0	0	NONE	2271
A	1059	ON3A	EQ	1	0	1	1	0
	1060	ON3B	BS	0	0	0	0	0
A	1061	ON3C	EQ	1	0	1	1	0
	1062	ON3D	BS	0	0	0	0	0
A	1063	ON3E	EQ	1	0	1	1	0

Appendix J

This appendix includes a description of the data analysis tasks completed for this research. Complete listings of the information described in this appendix have been provided to the NWS in electronic format.

Daily Air Reports

The Daily Air Reports for FY96 provide the basic information necessary for this research. Figures J.1 and J.2 provide an example taken directly from the data. The first page of the report gives information concerning each travel leg flown with the appropriate details. Page two of the report describes the reason for each mission flown that day.

Investigation into Travel Times

The data provided from the Daily Air Reports was grouped by aircraft and travel leg flown. The times for each travel leg were then evaluated for the following information: number of data points, minimum value, mean value, mode value, maximum value, standard deviation, 5% cumulative density function (CDF) value of the triangular distribution, and 95% CDF value of the triangular distribution. The value under column C represents the positioning of the mode value relative to the minimum and maximum values and is needed for the triangular distribution calculations. Figure J.3 provides a sample page from the spreadsheet used to accomplish this analysis. This particular page presents information about the Bell-212 flights in Zone I, but the information is not exhaustive. Information concerning the other aircraft and other zones were addressed in the same manner.

Investigation into Mission Composition

The data from the Daily Air Reports was also analyzed to determine the effort needed to accomplish the preventative maintenance inspections (PMIs) as well as to determine approximately how many times a site was visited during the year. Figure J.4 presents a sample page of the spreadsheet used to determine this information. The Julian calendar date was used to chronologically order the data into meaningful groups. The sample page provided represents a partial listing of the Bell-212 missions from Zone I. Information concerning the other aircraft and other zones were compiled in a similar fashion.

Summarized Analysis Information

The information collected on the items described above have been summarized and included at the end of this appendix section. Table J.5 provides the exhaustive list of the information calculated for each travel leg used in FY96. Table J.6 represents the information specifically needed by this research effort. Along with the information described above, the table includes the distance between sites, reported in statute miles, and the theoretically calculated travel time for that leg. These times were based upon ground speeds, reported in statute miles per hour, estimated for the aircraft: Bell-212, 103.2 smph; S-61N, 110 smph; and Twin Otter, 115 smph. Additional information provided are the results from the difference in means t-test as was described in Chapter IV. Information left blank was not available from the data.

FRONTEC ROTARY WING AND FIXED WING DAILY AIR REPORT

DATE: 23 AUGUST 1996 AMENDMENT # 1 COMPLETE **CDRL TR-04**
TO: CARL MORRIS R&CS 2-4-2
FROM: LARRY LECOUR

SUBJECT: AIR REPORT FOR: **08 AUGUST 1996**

ROTARY WING FLIGHT DATA
PART 1 (MISSION DATA)

FROM	TO	ACFT IDENT	MISSION NO.	ACFT TYPE	NO. OF PAXS	CARGO IN LBS	FLT. HRS
LSS-C	PIN-DA	CGHVH	USC115	B212	5	300	1.6
PIN-DA	LSS-C	CGHVH	USC115	B212	0	2200	1.1
LSS-C	PIN-EB	CGHVH	USC115	B212	2	276	0.8
PIN-EB	PIN-DA	CGHVH	USC115	B212	0	0	0.9
PIN-DA	LSS-C	CGHVH	USC115	B212	0	2150	1.0
DYE-U	BAF-3	CFIBN	UQS130	S61N	4	400	2.1
BAF-3	LSS-Q	CFIBN	UQS130	S61N	1	50	1.2
LSS-Q	BAF-3	CFIBN	UQS130	S61N	0	250	1.9
BAF-3	LSS-Q	CFIBN	UQS130	S61N	0	7	1.2

FIXED WING FLIGHT DATA
PART 1 (MISSION DATA)

FROM	TO	ACFT IDENT	MISSION NO.	ACFT TYPE	NO. OF PAXS	CARGO IN LBS	FLT. HRS
LSS-Q	FOX-3	CFNDN	USQ131	DHC-6	0	2400	2.3
FOX-3	LSS-Q	CFNDN	USQ131	DHC-6	0	50	1.9

PAGE 1

Figure J.1 Example of a Daily Air Report, Page 1

PART 2 (PASSENGER INFORMATION)					
NAME	FROM	TO	COMPANY		
PLEASE SEE ATTACHMENT 1 FOR DETAILS					
PART 3 (CARGO INFORMATION)					
DESCRIPTION	WEIGHT	DEW MANIFEST NUMBER	FROM		TO
PLEASE SEE ATTACHMENT 2 FOR DETAILS					
PART 4 (REMARKS)					
NO ROTARY WING MOVEMENT AT LSS-I.					
FLIGHT USC115 WAS A PMI FLIGHT AND A FLIGHT TO SUPPORT TPS 96086. AIRCRAFT RETURNED TO BASE UPON COMPLETION OF MISSION.					
NO ROTARY WING MOVEMENT AT LSS-F.					
FLIGHT USQ130 WAS TO SUPPORT TPS 96087 AND 96099. AIRCRAFT WAS DISPATCHED FROM RON AT DYE-U AND RETURNED TO BASE UPON COMPLETION OF MISSION.					
NO ROTARY WING MOVEMENT AT LSS-G.					
NO FIXED WING MOVEMENT AT LSS-I, LSS-C, LSS-F OR LSS-G.					
FLIGHT USQ131 WAS A RESUPPLY FLIGHT. AIRCRAFT RETURNED TO BASE UPON COMPLETION OF MISSION.					

PAGE 2

Figure J.2 Example of a Daily Air Report, Page 2

ZONE ONE BELL-212 OPERATIONS BY LEG

FROM	TO	CONCATENATE	Flt Hrs	Count	Min	Mean	Mode	Max	TRIANG 95%	C	TRIANG 5%
BAR-1	BAR-2	BAR-1BAR-2	1.00								
BAR-1	BAR-2	BAR-1BAR-2	1.00								
BAR-1	BAR-2	BAR-1BAR-2	0.80								
BAR-1	BAR-2	BAR-1BAR-2	0.70								
BAR-1	BAR-2	BAR-1BAR-2	0.70								
BAR-1	BAR-2	BAR-1BAR-2	0.60								
BAR-1	BAR-2	BAR-1BAR-2	0.70								
BAR-1	BAR-2	BAR-1BAR-2	0.80								
BAR-1	BAR-2	BAR-1BAR-2	0.80								
BAR-1	BAR-2	BAR-1BAR-2	0.90								
BAR-1	BAR-2	BAR-1BAR-2	0.80								
		BAR-1BAR-2 StdDev	**0.13**	**11**	**0.60**	**0.80**	**0.80**	**1.00**	**0.94**	**0.50**	**0.66**
BAR-1	BAR-B	BAR-1BAR-B	0.40								
BAR-1	BAR-B	BAR-1BAR-B	0.40								
BAR-1	BAR-B	BAR-1BAR-B	0.40								
BAR-1	BAR-B	BAR-1BAR-B	0.40								
BAR-1	BAR-B	BAR-1BAR-B	0.40								
BAR-1	BAR-B	BAR-1BAR-B	0.50								
BAR-1	BAR-B	BAR-1BAR-B	0.40								
		BAR-1BAR-B StdDev	**0.04**	**7**	**0.40**	**0.41**	**0.40**	**0.50**	**0.48**	**0.00**	**0.40**
BAR-2	BAR-2	BAR-2BAR-2	0.80								
		BAR-2BAR-2 StdDev	**#DIV/0!**	**1**	**0.80**	**0.80**	**0.80**	**0.80**	**n/a**	**n/a**	**n/a**
BAR-2	BAR-3	BAR-2BAR-3	1.00								
BAR-2	BAR-3	BAR-2BAR-3	1.00								
		BAR-2BAR-3 StdDev	**0.00**	**2**	**1.00**	**1.00**	**1.00**	**1.00**	**n/a**	**n/a**	**n/a**
BAR-2	BAR-BA3	BAR-2BAR-BA3	0.70								
BAR-2	BAR-BA3	BAR-2BAR-BA3	0.70								
		BAR-2BAR-BA3 StdDev	**0.00**	**2**	**0.70**	**0.70**	**0.70**	**0.70**	**n/a**	**n/a**	**n/a**
BAR-3	BAR-4	BAR-3BAR-4	0.80								
		BAR-3BAR-4 StdDev	**#DIV/0!**	**1**	**0.80**	**0.80**	**0.80**	**0.80**	**n/a**	**n/a**	**n/a**
BAR-4	BAR-4	BAR-4BAR-4	0.10								
		BAR-4BAR-4 StdDev	**#DIV/0!**	**1**	**0.10**	**0.10**	**0.10**	**0.10**	**n/a**	**n/a**	**n/a**
BAR-4	BAR-E	BAR-4BAR-E	0.40								
BAR-4	BAR-E	BAR-4BAR-E	0.70								
BAR-4	BAR-E	BAR-4BAR-E	0.50								
BAR-4	BAR-E	BAR-4BAR-E	0.40								
BAR-4	BAR-E	BAR-4BAR-E	0.50								
BAR-4	BAR-E	BAR-4BAR-E	0.60								
BAR-4	BAR-E	BAR-4BAR-E	0.60								
BAR-4	BAR-E	BAR-4BAR-E	0.50								
BAR-4	BAR-E	BAR-4BAR-E	0.60								
BAR-4	BAR-E	BAR-4BAR-E	0.60								
BAR-4	BAR-E	BAR-4BAR-E	0.70								
		BAR-4BAR-E StdDev	**0.10**	**11**	**0.40**	**0.55**	**0.60**	**0.70**	**0.66**	**0.67**	**0.45**

Figure J.3 Sample Page from Travel Time Analysis

ZONE ONE BELL-212 HELICOPTER OPERATIONS FY 96

Julain date	FROM	TO	ACFT IDENT	MISSION NO.	ACFT TYPE	NO. OF PAXS	CARGO IN LBS	FLT. HRS	MISSION DESCRIPTION
291	LSS-I	BAR-1	CGAHD	USI005	B212	5	933	1.5	PMI
291	BAR-1	BAR-2	CGAHD	USI005	B212	0	0	1.0	PMI
291	BAR-2	BAR-B	CGAHD	USI005	B212	0	879	0.4	PMI
291	BAR-B	BAR-1	CGAHD	USI005	B212	0	879	0.5	PMI
291	BAR-1	BAR-2	CGAHD	USI005	B212	5	300	1.0	PMI
292	BAR-2	BAR-B	CGAHD	USI005	B212	5	300	0.4	PMI
292	BAR-B	BAR-2	CGAHD	USI005	B212	5	700	0.5	PMI
292	BAR-2	LSS-I	CGAHD	USI005	B212	5	1100	1.1	PMI
298	LSS-I	BAR-2	CGAHD	USI009	B212	1	50	0.8	PMI
298	BAR-2	BAR-1	CGAHD	USI009	B212	0	400	0.8	PMI
298	BAR-1	BAR-2	CGAHD	USI009	B212	0	0	0.8	PMI
298	BAR-2	BAR-B	CGAHD	USI009	B212	0	400	0.5	PMI
298	BAR-B	BAR-2	CGAHD	USI009	B212	0	0	0.4	PMI
298	BAR-2	LSS-I	CGAHD	USI009	B212	0	400	1.0	PMI
305	LSS-I	PIN-M	CGAHD	USI012	B212	1	367	2.1	PMI
306	PIN-M	PIN-1BG	CGAHD	USI012	B212	3	500	1.4	PMI
306	PIN-1BG	PIN-M	CGAHD	USI012	B212	3	500	1.3	PMI
307	PIN-M	PIN-1BD	CGAHD	USI012	B212	3	500	0.8	TPS X2
307	PIN-1BD	PIN-M	CGAHD	USI012	B212	3	500	0.8	TPS X2
308	PIN-M	BAR-E	CGAHD	USI012	B212	3	500	1.1	PMI
308	BAR-E	PIN-M	CGAHD	USI012	B212	3	300	1.0	PMI
310	PIN-M	LSS-I	CGAHD	USI012	B212	3	400	2.8	PMI
311	LSS-I	BAR-BA3	CGAHD	USI016	B212	4	1084	0.4	PMI
311	BAR-BA3	LSS-I	CGAHD	USI016	B212	4	1084	0.4	PMI
312	LSS-I	BAR-BA3	CGAHD	USI017	B212	4	465	0.4	PMI
312	BAR-BA3	LSS-I	CGAHD	USI017	B212	4	465	0.4	PMI
314	LSS-I	BAR-DA1	CGAHD	USI018	B212	4	886	1.1	PMI
314	BAR-DA1	LSS-I	CGAHD	USI018	B212	4	723	1.0	PMI
315	LSS-I	BAR-DA1	CGAHD	USI019	B212	4	430	1.0	PMI
315	BAR-DA1	LSS-I	CGAHD	USI019	B212	4	430	1.1	PMI
319	LSS-I	BAR-2.	CGAHD	USI020	B212	3	506	0.9	TPS
321	BAR-2	LSS-I	CGAHD	USI020	B212	3	506	1.1	TPS
322	LSS-I	CAPE PARRY	CGAHD	USI020	B212	3	506	2.3	TPS
324	CAPE PARRY	LSS-I	CGAHD	USI020	B212	0	400	2.1	TPS
326	LSS-I	BAR-4	CGAHD	USI022	B212	4	1037	1.5	PMI
326	BAR-4	PIN-M	CGAHD	USI022	B212	4	793	1.2	PMI
328	PIN-M	BAR-4	CGAHD	USI022	B212	3	600	0.9	PMI
328	BAR-4	PIN-M	CGAHD	USI022	B212	3	520	1.1	PMI
328	PIN-M	LSS-I	CGAHD	USI022	B212	3	500	2.1	PMI

Figure J.4 Sample Page from Mission Composition Analysis

Table J.5 Summary of Analysis on Travel Leg Times, Page 1 of 6

FROM		TO	A/C	Count	Min	Mean	Mode	Max	STD DEV	C	TRIANG 5%	TRIANG 95%
BAR-1		BAR-2	B212	11	0.60	0.80	0.80	1.00	0.13	0.50	0.66	0.94
BAR-1		BAR-B	B212	7	0.40	0.41	0.40	0.50	0.04	0.00	0.40	0.48
BAR-2		BAR-2	B212	1	0.80	0.80	0.80	0.80	#DIV/0!	n/a	n/a	n/a
BAR-2		BAR-3	B212	2	1.00	1.00	1.00	1.00	0.00	n/a	n/a	n/a
BAR-2		BAR-BA3	B212	2	0.70	0.70	0.70	0.70	0.00	n/a	n/a	n/a
BAR-3		BAR-4	B212	1	0.80	0.80	0.80	0.80	#DIV/0!	n/a	n/a	n/a
BAR-4		BAR-4	B212	1	0.10	0.10	0.10	0.10	#DIV/0!	n/a	n/a	n/a
BAR-4		BAR-E	B212	11	0.40	0.55	0.60	0.70	0.10	0.67	0.45	0.66
BAR-4		PIN-1BD	B212	3	1.80	2.27	n/a	2.80	0.50	0.47	1.95	2.64
BAR-4		PIN-M	B212	10	0.80	1.06	1.10	1.60	0.23	0.38	0.91	1.46
BAR-B		BAR-2	B212	24	0.40	0.47	0.40	0.70	0.08	0.00	0.41	0.63
BAR-B		BAR-3	B212	1	1.30	1.30	1.30	1.30	#DIV/0!	n/a	n/a	n/a
BAR-BA3		BAR-3	B212	1	0.40	0.40	0.40	0.40	#DIV/0!	n/a	n/a	n/a
BAR-BA3		BAR-DA1	B212	4	0.60	0.73	0.80	0.80	0.10	1.00	0.64	0.79
BAR-DA1		BAR-4	B212	3	0.40	0.50	n/a	0.60	0.10	0.50	0.43	0.57
BAR-DA1		BAR-DA1	B212	3	0.10	0.13	0.10	0.20	0.06	0.00	0.10	0.18
BAR-E		PIN-1BD	B212	3	1.10	1.23	n/a	1.40	0.15	0.44	1.14	1.35
BAR-E		PIN-1BG	B212	1	1.80	1.80	1.80	1.80	#DIV/0!	n/a	n/a	n/a
BAR-E		PIN-M	B212	21	0.40	0.65	0.50	1.10	0.23	0.14	0.46	0.96
LSS-I		BAR-1	B212	5	1.40	1.50	1.40	1.70	0.12	0.00	1.41	1.63
LSS-I		BAR-2	B212	60	0.60	0.94	1.00	1.20	0.12	0.67	0.71	1.12
LSS-I		BAR-3	B212	27	0.60	0.79	0.70	1.20	0.15	0.17	0.65	1.08
LSS-I		BAR-4	B212	28	1.10	1.38	1.30	1.80	0.16	0.29	1.18	1.67
LSS-I		BAR-B	B212	14	1.10	1.26	1.30	1.40	0.08	0.67	1.15	1.36
LSS-I		BAR-BA3	B212	47	0.30	0.43	0.40	0.60	0.07	0.33	0.34	0.55
LSS-I		BAR-DA1	B212	23	0.80	0.97	1.00	1.20	0.10	0.50	0.86	1.14
LSS-I		CAPE PARRY	B212	2	2.10	2.20	n/a	2.30	0.14	0.50	2.13	2.27
LSS-I		PIN-1BD	B212	2	2.30	2.35	n/a	2.40	0.07	0.50	2.32	2.38
LSS-I		PIN-M	B212	15	1.70	2.15	2.10	2.80	0.26	0.36	1.85	2.60
PIN-1BD		PIN-1BD	B212	4	0.10	0.28	0.10	0.80	0.35	0.00	0.12	0.64
PIN-1BD		PIN-1BG	B212	8	0.50	0.63	0.60	0.90	0.12	0.25	0.54	0.82
PIN-M		PIN-1BD	B212	23	0.50	0.84	0.80	1.40	0.25	0.33	0.62	1.24
PIN-M		PIN-1BG	B212	15	1.10	1.40	1.10	1.90	0.23	0.00	1.12	1.72
PIN-M		PIN-M	B212	1	0.50	0.50	0.50	0.50	#DIV/0!	n/a	n/a	n/a
LSS-I		BAR-2	TO	40	0.70	0.84	0.80	1.00	0.08	0.33	0.74	0.95
LSS-I		PAULATUK	TO	1	1.50	1.50	1.50	1.50	#DIV/0!	n/a	n/a	n/a
LSS-I		PIN-M	TO	66	1.30	1.62	1.60	2.00	0.12	0.43	1.40	1.88
PIN-M		COPPERMINE	TO	1	2.10	2.10	2.10	2.10	#DIV/0!	n/a	n/a	n/a
PIN-3		COPPERMINE	TO	1	0.60	0.60	0.60	0.60	#DIV/0!	n/a	n/a	n/a
PIN-M		PAULATUK	TO	3	0.50	0.57	0.60	0.60	0.06	1.00	0.52	0.60
PIN-M		PIN-3	TO	5	1.60	2.16	1.90	2.80	0.51	0.25	1.73	2.57
CAM-1A		CAM-1A	B212	1	0.40	0.40	0.40	0.40	#DIV/0!	n/a	n/a	n/a
CAM-1A		CAM-1A (BEACH)	B212	2	0.10	0.15	n/a	0.20	0.07	0.50	0.12	0.18
CAM-1A		CAM-2	B212	3	0.80	0.90	1.00	1.00	0.12	1.00	0.84	0.99
CAM-1A		CAM-B	B212	3	0.40	0.43	0.40	0.50	0.06	0.00	0.40	0.48
CAM-1A		CAM-CB	B212	1	1.20	1.20	1.20	1.20	#DIV/0!	n/a	n/a	n/a
CAM-1A		GJOA HAVEN	B212	1	1.30	1.30	1.30	1.30	#DIV/0!	n/a	n/a	n/a
CAM-2		CAM-2	B212	1	1.20	1.20	1.20	1.20	#DIV/0!	n/a	n/a	n/a
CAM-2		CAM-3	B212	3	1.00	1.00	1.00	1.00	0.00	n/a	n/a	n/a

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FROM	TO	A/C	Count	Min	Mean	Mode	Max	STD DEV	C	TRIANG 5%	TRIANG 95%
CAM-2	CAM-CB	B212	14	0.40	0.49	0.50	0.70	0.09	0.33	0.44	0.65
CAM-2	GJOA HAVEN	B212	1	0.60	0.60	0.60	0.60	#DIV/0!	n/a	n/a	n/a
CAM-A3A	CAM-1A	B212	4	0.40	0.45	0.50	0.50	0.06	1.00	0.42	0.50
CAM-A3A	CAM-B	B212	2	0.90	0.90	0.90	0.90	0.00	n/a	n/a	n/a
CAM-B	CAM-2	B212	1	0.50	0.50	0.50	0.50	#DIV/0!	n/a	n/a	n/a
CAM-B	CAM-B (REFUEL)	B212	1	0.10	0.10	0.10	0.10	#DIV/0!	n/a	n/a	n/a
CAM-B	CAM-CB	B212	3	1.10	1.13	n/a	1.30	0.15	0.17	1.12	1.26
CAM-CB	GJOA HAVEN	B212	2	0.10	0.10	0.10	0.10	0.00	n/a	n/a	n/a
LSS-C	CAM-1A	B212	31	0.60	0.79	0.80	1.00	0.09	0.50	0.66	0.94
LSS-C	CAM-2	B212	17	1.30	1.67	1.60	2.10	0.20	0.38	1.41	1.96
LSS-C	CAM-3	B212	3	2.40	2.50	n/a	2.60	0.10	0.50	2.43	2.57
LSS-C	CAM-A3A	B212	28	0.30	0.34	0.30	0.50	0.06	0.00	0.31	0.46
LSS-C	CAM-B	B212	17	1.00	1.25	1.10	1.50	0.18	0.20	1.05	1.40
LSS-C	CAM-CB	B212	2	1.90	2.00	n/a	2.10	0.14	0.50	1.93	2.07
LSS-C	CAM-CB/CAM-1A	B212	1	2.20	2.20	2.20	2.20	#DIV/0!	n/a	n/a	n/a
LSS-C	LSS-C	B212	10	0.10	1.20	0.10	2.70	0.86	0.00	0.17	2.12
LSS-C	PIN-3	B212	48	1.40	1.84	1.80	2.30	0.16	0.44	1.53	2.15
LSS-C	PIN-DA	B212	19	1.00	1.33	1.30	1.60	0.17	0.50	1.09	1.51
LSS-C	PIN-EB	B212	38	0.50	0.65	0.60	0.80	0.10	0.33	0.54	0.75
LSS-C	CAM-1A	B212	1	0.70	0.70	0.70	0.70	#DIV/0!	n/a	n/a	n/a
PIN-2A	PIN-3	B212	22	0.70	0.91	0.90	1.10	0.10	0.50	0.76	1.04
PIN-2A	PIN-CB	B212	6	0.50	0.50	0.50	0.50	0.00	n/a	n/a	n/a
PIN-2A	PIN-EB	B212	1	1.10	1.10	1.10	1.10	#DIV/0!	n/a	n/a	n/a
PIN-2A	PIN-CB	B212	1	0.40	0.40	0.40	0.40	#DIV/0!	n/a	n/a	n/a
PIN-3	COPPERMINE	B212	2	0.60	0.60	0.60	0.60	0.00	n/a	n/a	n/a
PIN-3	LOCAL	B212	2	0.10	0.10	0.10	0.10	0.00	n/a	n/a	n/a
PIN-3	PIN-3	B212	2	0.70	0.70	0.70	0.70	0.00	n/a	n/a	n/a
PIN-3	PIN-DA	B212	16	0.50	0.60	0.60	0.70	0.05	0.50	0.53	0.67
PIN-3	PIN-EB	B212	7	1.20	1.37	1.40	1.70	0.17	0.40	1.27	1.61
PIN-CB	PIN-3	B212	31	0.40	0.46	0.50	0.60	0.06	0.50	0.43	0.57
PIN-CB	PIN-CB	B212	1	0.10	0.10	0.10	0.10	#DIV/0!	n/a	n/a	n/a
PIN-DA	PIN-EB	B212	3	0.70	0.83	0.90	0.90	0.12	1.00	0.74	0.89
CAM-1A	GJOA HAVEN	TO	1	1.10	1.10	1.10	1.10	#DIV/0!	n/a	n/a	n/a
CAM-2	GJOA HAVEN	TO	2	0.4	0.4	0.4	0.4	0.00	n/a	n/a	n/a
CAM-3	GJOA HAVEN	TO	1	0.50	0.50	0.50	0.50	#DIV/0!	n/a	n/a	n/a
CAM-3	SPENCE BAY	TO	3	0.40	0.40	0.40	0.40	0.00	n/a	n/a	n/a
LSS-C	CAM-1A	TO	1	0.60	0.60	0.60	0.60	#DIV/0!	n/a	n/a	n/a
LSS-C	CAM-2	TO	2	1.10	1.20	n/a	1.30	0.14	0.50	1.13	1.27
LSS-C	CAM-3	TO	2	1.70	1.85	n/a	1.90	0.14	0.75	1.74	1.88
LSS-C	CAM-A3A	TO	8	0.30	0.35	0.30	0.40	0.05	0.00	0.30	0.38
LSS-C	CAM-B	TO	2	0.90	0.95	n/a	1.00	0.07	0.50	0.92	0.98
LSS-C	GJOA HAVEN	TO	5	1.40	1.48	1.50	1.50	0.04	1.00	1.42	1.50
LSS-C	PIN-3	TO	22	1.10	1.38	1.20	1.80	0.20	0.14	1.16	1.66
LSS-C	PIN-M	TO	1	2.5	2.5	2.5	2.5	#DIV/0!	n/a	n/a	n/a
LSS-C	SPENCE BAY	TO	2	1.70	1.70	1.70	1.70	0.00	n/a	n/a	n/a
PIN-M	PIN-3	TO	2	1.90	1.95	n/a	2.00	0.07	0.50	1.92	1.98
CAM-3	CAM-3	B212	1	0.60	0.60	0.60	0.60	#DIV/0!	n/a	n/a	n/a
CAM-3	CAM-4	B212	20	0.20	0.90	0.90	1.20	0.20	0.70	0.39	1.08
CAM-3	CAM-5A	B212	5	1.60	1.78	1.90	1.90	0.13	1.00	1.67	1.89

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FROM	TO	A/C	Count	Min	Mean	Mode	Max	STD DEV	C	TRIANG 5%	TRIANG 95%
CAM-3	CAM-D	B212	37	0.40	0.52	0.50	1.10	0.13	0.14	0.46	0.96
CAM-3	GJOA HAVEN	B212	2	0.40	0.55	n/a	0.70	0.21	0.50	0.45	0.65
CAM-3	PELLY BAY	B212	28	0.70	0.98	1.00	1.40	0.13	0.43	0.80	1.28
CAM-4	CAM-5A	B212	2	1.10	1.10	1.10	1.10	0.00	n/a	n/a	n/a
CAM-4	PELLY BAY	B212	22	0.10	0.17	0.10	0.30	0.08	0.00	0.11	0.26
CAM-5A	CAM-FA	B212	5	0.50	0.78	0.60	1.70	0.52	0.08	0.58	1.44
CAM-5A	PELLY BAY	B212	3	1.00	1.10	n/a	1.20	0.10	0.50	1.03	1.17
CAM-CB	CAM-3	B212	5	0.60	0.80	0.60	1.30	0.29	0.00	0.62	1.14
CAM-D	CAM-4	B212	9	0.50	0.64	0.60	0.90	0.11	0.25	0.54	0.82
CAM-D	CAM-5A	B212	1	1.50	1.50	1.50	1.50	#DIV/0!	n/a	n/a	n/a
CAM-D	CAM-D	B212	1	0.10	0.10	0.10	0.10	#DIV/0!	n/a	n/a	n/a
CAM-D	PELLY BAY	B212	22	0.50	0.64	0.50	0.90	0.13	0.00	0.51	0.81
CAM-FA	LOCAL	B212	1	0.10	0.10	0.10	0.10	#DIV/0!	n/a	n/a	n/a
CAM-FA	PELLY BAY	B212	2	1.50	1.65	n/a	1.80	0.21	0.50	1.55	1.75
FOX-1	FOX-1	B212	1	0.10	0.10	0.10	0.10	#DIV/0!	n/a	n/a	n/a
FOX-1	FOX-2	B212	2	0.90	1.05	#	1.20	0.21	0.50	0.95	1.15
FOX-1	FOX-A	B212	3	0.40	0.57	#	0.80	0.21	0.42	0.46	0.73
FOX-2	BEACH	B212	2	0.20	0.20	0.20	0.20	0.00	n/a	n/a	n/a
FOX-2	BEACH TANKS	B212	2	0.10	0.10	0.10	0.10	0.00	n/a	n/a	n/a
FOX-2	FOX-2	B212	13	0.10	0.12	0.10	0.20	0.04	0.00	0.10	0.18
FOX-2	FOX-3	B212	4	0.90	1.00	1.00	1.10	0.08	0.50	0.93	1.07
FOX-2	FOX-B	B212	6	0.60	0.87	0.60	1.60	0.38	0.00	0.63	1.38
FOX-3	FOX-3	B212	1	1.00	1.00	1.00	1.00	#DIV/0!	n/a	n/a	n/a
FOX-2	FOX-2	B212	1	0.10	0.10	0.10	0.10	#DIV/0!	n/a	n/a	n/a
FOX-3	FOX-3	B212	1	0.10	0.10	0.10	0.10	#DIV/0!	n/a	n/a	n/a
FOX-A	FOX-1	B212	3	0.40	0.50	n/a	0.60	0.10	0.50	0.43	0.57
FOX-A	FOX-2	B212	4	0.50	0.58	0.50	0.70	0.10	0.00	0.51	0.66
FOX-A	FOX-3	B212	1	1.50	1.50	1.50	1.50	#DIV/0!	n/a	n/a	n/a
FOX-A	FOX-B	B212	6	1.00	1.10	1.00	1.30	0.13	0.00	1.01	1.23
FOX-B	FOX-3	B212	7	0.50	0.60	0.50	0.80	0.12	0.00	0.51	0.73
FOX-B	FOX-B	B212	1	0.60	0.60	0.60	0.60	#DIV/0!	n/a	n/a	n/a
LSS-F	BEACH	B212	2	1.50	1.50	1.50	1.50	0.00	n/a	n/a	n/a
LSS-F	CAM-3	B212	5	2.40	2.42	2.40	2.50	0.04	0.00	2.40	2.48
LSS-F	CAM-4	B212	15	1.00	1.91	1.80	2.60	0.41	0.50	1.25	2.35
LSS-F	CAM-5A	B212	45	0.90	1.17	1.20	1.50	0.15	0.50	0.99	1.41
LSS-F	CAM-5A/LSS-F	B212	1	2.50	2.50	2.50	2.50	#DIV/0!	n/a	n/a	n/a
LSS-F	CAM-FA	B212	36	0.50	0.69	0.70	1.10	0.14	0.33	0.58	0.99
LSS-F	CAM-FA/CAM-5A	B212	1	1.40	1.40	1.40	1.40	#DIV/0!	n/a	n/a	n/a
LSS-F	CAM-FA/LSS-F	B212	2	0.60	0.95	n/a	1.30	0.49	0.50	0.71	1.19
LSS-F	FOX-1	B212	42	0.50	0.68	0.60	1.00	0.11	0.20	0.55	0.90
LSS-F	FOX-2	B212	18	1.20	1.47	1.40	1.80	0.18	0.33	1.28	1.69
LSS-F	FOX-3	B212	1	2.00	2.00	2.00	2.00	#DIV/0!	n/a	n/a	n/a
LSS-F	FOX-A	B212	27	0.70	1.07	1.00	1.50	0.20	0.38	0.81	1.36
LSS-F	FOX-B	B212	1	1.80	1.80	1.80	1.80	#DIV/0!	n/a	n/a	n/a
LSS-F	LSS-F	B212	5	0.40	1.04	n/a	2.10	0.68	0.38	0.63	1.80
LSS-F	PELLY BAY	B212	48	1.50	1.96	1.80	2.30	0.20	0.38	1.61	2.16
PELLY BAY	PELLY BAY	B212	2	0.30	0.35	n/a	0.40	0.07	0.50	0.32	0.38
CAM-3	PELLY BAY	TO	8	0.60	0.66	0.60	0.90	0.11	0.00	0.61	0.83
CAM-3	SIMPSON LAKE	TO	1	0.40	0.40	0.40	0.40	#DIV/0!	n/a	n/a	n/a
LSS-F	CAM-3	TO	13	1.60	1.88	1.70	2.30	0.22	0.14	1.66	2.16
LSS-F	FOX-3	TO	2	1.60	1.70	n/a	1.80	0.14	0.50	1.63	1.77
LSS-F	GJOA HAVEN	TO	1	2.20	2.20	2.20	2.20	#DIV/0!	n/a	n/a	n/a

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FROM	TO	A/C	Count	Min	Mean	Mode	Max	STD DEV	C	TRIANG 5%	TRIANG 95%
LSS-F	LSS-O	TO	5	2.50	2.82	2.70	3.40	0.34	0.22	2.59	3.22
LSS-F	PELLY BAY	TO	8	1.20	1.43	1.30	1.70	0.18	0.20	1.25	1.60
LSS-F	SIMPSON LAKE	TO	1	1.80	1.80	1.80	1.80	#DIV/0!	n/a	n/a	n/a
LSS-F	SPENCE BAY	TO	1	2.00	2.00	2.00	2.00	#DIV/0!	n/a	n/a	n/a
BAF-2	BAF-3	S61N	1	1.00	1.00	1.00	1.00	#DIV/0!	n/a	n/a	n/a
BAF-2	BROUGHTON ISL	S61N	1	2.30	2.30	2.30	2.30	#DIV/0!	n/a	n/a	n/a
BAF-3	BAF-4A	S61N	1	0.50	0.50	0.50	0.50	#DIV/0!	n/a	n/a	n/a
BAF-3	BROUGHTON	S61N	1	2.20	2.20	2.20	2.20	#DIV/0!	n/a	n/a	n/a
BAF-3	LOCAL	S61N	1	0.30	0.30	0.30	0.30	#DIV/0!	n/a	n/a	n/a
BAF-3	PANGNIRTUNG	S61N	1	2.00	2.00	2.00	2.00	#DIV/0!	n/a	n/a	n/a
BAF-3	BAF-4A	S61N	5	0.50	0.58	0.50	0.70	0.08	0.00	0.51	0.66
BAF-3	BAF-4A	S61N	1	0.60	0.60	0.60	0.60	#DIV/0!	n/a	n/a	n/a
BAF-4A	BEACH	S61N	2	0.10	0.10	0.10	0.10	0.00	n/a	n/a	n/a
BAF-5	BAF-5 (BEACH)	S61N	2	0.10	0.10	0.10	0.10	0.00	n/a	n/a	n/a
BAF-5	LAB-2	S61N	1	1.90	1.90	1.90	1.90	#DIV/0!	n/a	n/a	n/a
DYE-M	BAF-2	S61N	13	1.10	1.25	1.10	1.50	0.13	0.00	1.11	1.41
DYE-M	BAF-3	S61N	5	2.00	2.08	2.10	2.10	0.04	1.00	2.02	2.10
DYE-M	BROUGHTON	S61N	14	0.40	0.82	0.80	1.00	0.15	0.67	0.51	0.92
DYE-M	DYE-BEACH	S61N	2	0.20	0.35	n/a	0.50	0.21	0.50	0.25	0.45
DYE-M	DYE-M	S61N	4	0.20	0.40	0.50	0.50	0.14	1.00	0.27	0.49
DYE-M	PANGNIRTUNG	S61N	3	1.40	1.53	n/a	1.70	0.15	0.44	1.44	1.65
DYE-M/LSS-O	BROUGHTON	S61N	1	3.70	3.70	3.70	3.70	#DIV/0!	n/a	n/a	n/a
FOX-3	BAF-2	S61N	2	2.7	2.75	n/a	2.8	0.07	0.50	2.72	2.78
FOX-3	FOX-3	S61N	4	0.10	1.10	n/a	2.20	0.86	0.48	0.42	1.86
FOX-3	FOX-4	S61N	8	0.90	1.06	0.90	1.70	0.27	0.00	0.92	1.52
FOX-3	FOX-CA	S61N	12	0.40	0.59	0.5	1.10	0.19	0.14	0.46	0.96
FOX-3	PANGNIRTUNG	S61N	2	2.00	2.25	n/a	2.50	0.35	0.50	2.08	2.42
FOX-4	BROUGHTON	S61N	3	0.90	1.00	n/a	1.30	0.26	0.25	0.94	1.22
FOX-4	DYE-M	S61N	2	1.60	1.65	n/a	1.70	0.07	0.50	1.62	1.68
FOX-4	PANGNIRTUNG	S61N	2	1.60	1.90	n/a	2.20	0.42	0.50	1.69	2.11
FOX-4/FOX-CA	BROUGHTON	S61N	1	1.50	1.50	1.50	1.50	#DIV/0!	n/a	n/a	n/a
FOX-5	BAF-3	S61N	1	2.70	2.70	2.70	2.70	#DIV/0!	n/a	n/a	n/a
FOX-5	BROUGHTON	S61N	11	0.10	0.15	0.10	0.30	0.07	0.00	0.11	0.26
FOX-5	DYE-M	S61N	2	0.80	0.90	n/a	1.00	0.14	0.50	0.83	0.97
FOX-5	PANGNIRTUNG	S61N	3	1.00	1.03	1.00	1.10	0.06	0.00	1.00	1.08
FOX-B	FOX-3	S61N	16	0.40	0.51	0.50	0.60	0.06	0.50	0.43	0.57
FOX-CA	DYE-M	S61N	1	2.30	2.30	2.30	2.30	#DIV/0!	n/a	n/a	n/a
FOX-CA	FOX-4	S61N	3	0.50	0.53	0.50	0.60	0.06	0.00	0.50	0.58
FOX-CA	FOX-5	S61N	1	1.50	1.50	1.50	1.50	#DIV/0!	n/a	n/a	n/a
FOX-CA	FOX-CA	S61N	1	1.20	1.20	1.20	1.20	#DIV/0!	n/a	n/a	n/a
FOX-CA	PANGNIRTUNG	S61N	1	1.70	1.70	1.70	1.70	#DIV/0!	n/a	n/a	n/a
LSS-O	BAF-2	S61N	23	1.30	1.63	1.50	2.80	0.32	0.13	1.42	2.49
LSS-O	BAF-2/DYE-M	S61N	1	2.80	2.80	2.80	2.80	#DIV/0!	n/a	n/a	n/a
LSS-O	BAF-3	S61N	56	1.10	1.28	1.20	1.90	0.16	0.13	1.16	1.73
LSS-O	BAF-4A	S61N	14	1.20	1.47	1.30	2.10	0.28	0.11	1.27	1.91
LSS-O	BAF-4A/BAF-3	S61N	1	2.10	2.10	2.10	2.10	#DIV/0!	n/a	n/a	n/a
LSS-O	BAF-5	S61N	15	1.40	1.65	1.60	1.90	0.14	0.40	1.47	1.81
LSS-O	DYE-M	S61N	26	2.00	2.42	2.30	3.20	0.28	0.25	2.13	2.97
LSS-O	F0X-CA	S61N	1	3.20	3.20	3.20	3.20	#DIV/0!	n/a	n/a	n/a
LSS-O	FOX-3	S61N	35	2.40	2.93	2.60	3.60	0.30	0.17	2.51	3.36

Table J.5 Summary of Analysis on Travel Leg Times, Page 5 of 6

FROM	TO	A/C	Count	Min	Mean	Mode	Max	STD DEV	C	TRIANG 5%	TRIANG 95%
LSS-O	FOX-4	S61N	3	2.30	2.83	n/a	3.40	0.55	0.48	2.47	3.22
LSS-O	FOX-5	S61N	1	2.50	2.50	2.50	2.50	#DIV/0!	n/a	n/a	n/a
LSS-O	FOX-B	S61N	4	2.50	2.88	n/a	3.10	0.26	0.63	2.61	3.02
LSS-O	LAB-2	S61N	1	3.60	3.60	3.60	3.60	#DIV/0!	n/a	n/a	n/a
LSS-O	LSS-O	S61N	7	0.40	1.41	0.40	3.00	0.95	0.00	0.47	2.42
LSS-O	LSS-O/DYE-M	S61N	1	0.30	0.30	0.30	0.30	#DIV/0!	n/a	n/a	n/a
LSS-O	LSS-O/FOX-3	S61N	1	3.50	3.50	3.50	3.50	#DIV/0!	n/a	n/a	n/a
LSS-O	PANGNIRTUNG	S61N	11	1.50	1.71	1.70	2.00	0.16	0.40	1.57	1.91
LSS-O	BAF-3	S61N	1	1.30	1.30	1.30	1.30	#DIV/0!	n/a	n/a	n/a
PANGNIRTUNG	BROUGHTON	S61N	1	2.70	2.70	2.70	2.70	#DIV/0!	n/a	n/a	n/a
DYE-M	BAF-3	TO	1	1.40	1.40	1.40	1.40	#DIV/0!	n/a	n/a	n/a
FOX-3	BROUGHTON	TO	1	1.40	1.40	1.40	1.40	#DIV/0!	n/a	n/a	n/a
FOX-3	DYE-M	TO	1	1.30	1.30	1.30	1.30	#DIV/0!	n/a	n/a	n/a
FOX-3/LSS-O	BROUGHTON	TO	1	2.00	2.00	2.00	2.00	#DIV/0!	n/a	n/a	n/a
HOPEDALE	KUUJJUAO	TO	1	2.20	2.20	2.20	2.20	#DIV/0!	n/a	n/a	n/a
HOPEDALE	NAIN	TO	1	0.70	0.70	0.70	0.70	#DIV/0!	n/a	n/a	n/a
LSS-O	BAF-3	TO	15	0.70	0.87	0.80	1.10	0.12	0.25	0.74	1.02
LSS-O	BROUGHTON	TO	8	1.60	1.83	1.70	2.10	0.17	0.20	1.65	2.00
LSS-O	DYE-M	TO	28	1.60	1.76	1.80	1.90	0.11	0.67	1.65	1.86
LSS-O	FOX-3	TO	28	1.70	2.13	2.10	2.70	0.25	0.40	1.84	2.53
LSS-O	KUUJJUAO	TO	2	0.25	2.40	n/a	2.50	0.14	0.96	0.74	2.39
LSS-O	LAB-2	TO	2	2.70	2.70	2.70	2.70	0.00	n/a	n/a	n/a
LSS-O	LSS-O	TO	3.0	0.80	1.93	n/a	2.60	0.99	0.63	1.12	2.36
LSS-O	NAIN	TO	1	2.90	2.90	2.90	2.90	#DIV/0!	n/a	n/a	n/a
LSS-O	KUUJJUAO	TO	1	2.10	2.10	2.10	2.10	#DIV/0!	n/a	n/a	n/a
LSS-O	PANGNIRTUNG	TO	2	1.30	1.40	n/a	1.50	0.14	0.50	1.33	1.47
GOOSE BAY	GOOSE BAY	B212	1	0.30	0.30	0.30	0.30	#DIV/0!	n/a	n/a	n/a
GOOSE BAY	NAIN	B212	1	2.00	2.00	2.00	2.00	#DIV/0!	n/a	n/a	n/a
HOPEDALE	HOPEDALE	B212	2	0.20	0.20	0.20	0.20	0.00	n/a	n/a	n/a
HOPEDALE	MAKKOVIK	B212	1	0.50	0.50	0.50	0.50	#DIV/0!	n/a	n/a	n/a
HOPEDALE	NAIN	B212	1	1.00	1.00	1.00	1.00	#DIV/0!	n/a	n/a	n/a
LAB-1	LAB-2	B212	36	0.90	1.17	1.10	1.50	0.14	0.33	0.98	1.39
LAB-1	SAGLEK	B212	1	2.40	2.40	2.40	2.40	#DIV/0!	n/a	n/a	n/a
LAB-1/LAB-2	SAGLEK	B212	1	2.40	2.40	2.40	2.40	#DIV/0!	n/a	n/a	n/a
LAB-2	AIRSTRIP	B212	1	0.20	0.20	0.20	0.20	#DIV/0!	n/a	n/a	n/a
LAB-2	LAB-1	B212	2	1.20	1.25	n/a	1.30	0.07	0.50	1.22	1.28
LAB-2	LAB-2	B212	44	0.10	0.24	0.10	2.10	0.40	0.00	0.15	1.65
LAB-2	LAB-3	B212	31	0.20	0.98	1.00	1.30	0.24	0.73	0.41	1.17
LAB-2	LAB-4	B212	7	1.80	1.97	1.90	2.20	0.17	0.25	1.84	2.12
LAB-2	NAIN	B212	83	0.10	1.37	1.30	2.10	0.21	0.60	0.45	1.82
LAB-2	SAGLEK	B212	8	0.10	0.66	0.10	2.40	0.99	0.00	0.16	1.89
LAB-3	HOPEDALE	B212	1	1.00	1.00	1.00	1.00	#DIV/0!	n/a	n/a	n/a
LAB-3	LAB-3	B212	3	0.10	0.43	#	0.90	0.42	0.42	0.22	0.76
LAB-3	LAB-4	B212	6	0.90	1.10	1.10	1.30	0.13	0.50	0.96	1.24
LAB-3	NAIN	B212	22	0.40	0.63	0.50	1.90	0.39	0.07	0.49	1.58
LAB-4	HOPEDALE	B212	22	0.20	0.34	0.30	0.60	0.09	0.25	0.24	0.52
LAB-4	LAB-3	B212	1	0.90	0.90	0.90	0.90	#DIV/0!	n/a	n/a	n/a
LAB-4	LAB-4	B212	9	0.10	0.27	0.20	0.60	0.17	0.20	0.15	0.50
LAB-4	LAB-5	B212	7	1.00	1.19	1.20	1.40	0.13	0.50	1.06	1.34

Table J.5 Summary of Analysis on Travel Leg Times, Page 6 of 6

FROM	TO	A/C	Count	Min	Mean	Mode	Max	STD DEV	C	TRIANG 5%	TRIANG 95%
LAB-4	LAB-6	B212	2	1.70	1.85	n/a	2.00	0.21	0.50	1.75	1.95
LAB-4	MAKKOVIK	B212	4	0.60	0.85	0.60	1.40	0.38	0.00	0.62	1.22
LAB-4	NAIN	B212	7	0.60	0.79	0.80	0.90	0.11	0.67	0.65	0.86
LAB-5	CARTWRIGHT	B212	2	0.80	0.90	#	1.00	0.14	0.50	0.83	0.97
LAB-5	LAB-5	B212	4	0.20	0.25	0.30	0.30	0.06	1.00	0.22	0.30
LAB-5	LAB-6	B212	1	0.80	0.80	0.80	0.80	#DIV/0!	n/a	n/a	n/a
LAB-5	MAKKOVIK	B212	19	0.40	0.47	0.40	0.80	0.11	0.00	0.41	0.71
LAB-5	NAIN	B212	4	1.70	1.78	1.70	1.90	0.10	0.00	1.71	1.86
LAB-6	CARTWRIGHT	B212	20	0.20	0.22	0.20	0.30	0.04	0.00	0.20	0.28
LAB-6	HOPEDALE	B212	1	1.70	1.70	1.70	1.70	#DIV/0!	n/a	n/a	n/a
LAB-6	LAB-6	B212	2	0.10	0.10	0.10	0.10	0.00	n/a	n/a	n/a
LSS-G	CARTWRIGHT	B212	2	1.50	1.75	n/a	2.00	0.35	0.50	1.58	1.92
LSS-G	LAB-6	B212	1	1.40	1.40	1.40	1.40	#DIV/0!	n/a	n/a	n/a
LSS-G	CARTWRIGHT	B212	5	1.40	1.55	n/a	1.70	0.21	0.50	1.45	1.65
LSS-G	GOOSE BAY	B212	12	0.10	0.19	0.20	0.30	0.05	0.50	0.13	0.27
LSS-G	HOPEDALE	B212	2	1.50	1.50	1.50	1.50	0.00	n/a	n/a	n/a
LSS-G	LAB-3	B212	3	2.40	2.40	2.40	2.40	0.00	n/a	n/a	n/a
LSS-G	LAB-4	B212	26	1.40	1.67	1.60	2.20	0.18	0.25	1.49	2.05
LSS-G	LAB-5	B212	19	0.50	1.28	1.30	1.90	0.29	0.57	0.74	1.70
LSS-G	LAB-6	B212	17	0.20	1.37	1.40	1.80	0.34	0.75	0.51	1.62
LSS-G	MAKKOVIK	B212	2	1.30	1.40	n/a	1.50	0.14	0.50	1.33	1.47
LSS-G	NAIN	B212	20	1.90	2.19	2.10	2.50	0.21	0.33	1.98	2.39
MAKKOVIK	MAKKOVIK	B212	1	0.90	0.90	0.90	0.90	#DIV/0!	n/a	n/a	n/a
NAIN	NAIN	B212	4	0.40	0.83	1.00	1.00	0.29	1.00	0.53	0.98
HOPEDALE	NAIN	TO	1	0.70	0.70	0.70	0.70	#DIV/0!	n/a	n/a	n/a
KUUJJUAQ	NAIN	TO	1	1.90	1.90	1.90	1.90	#DIV/0!	n/a	n/a	n/a
LAB-2	NAIN	TO	9	0.90	0.99	0.90	1.20	0.11	0.00	0.91	1.13
LAB-6	NAIN	TO	2	1.70	1.85	n/a	2.00	0.21	0.50	1.75	1.95
LSS-G	CARTWRIGHT	TO	16	0.90	1.03	1.00	1.20	0.09	0.33	0.94	1.15
LSS-G	HOPEDALE	TO	3	1.00	1.07	1.10	1.10	0.06	1.00	1.02	1.10
LSS-G	KUUJJUAQ	TO	1	2.50	2.50	2.50	2.50	#DIV/0!	n/a	n/a	n/a
LSS-G	LAB-2	TO	7	1.80	2.19	2.10	2.70	0.29	0.33	1.92	2.54
LSS-G	LAB-6	TO	1	1.10	1.10	1.10	1.10	#DIV/0!	n/a	n/a	n/a
LSS-G	MAKKOVIK	TO	6	0.80	0.95	1.00	1.10	0.10	0.67	0.85	1.06
LSS-G	NAIN	TO	28	1.30	1.56	1.60	1.80	0.14	0.60	1.39	1.73

Table J.6 Summary of Data for MILP Models, Page 1 of 3

Sub.	From	To	A/C	Dist. SMi.	Theor. Value	Pop. Min	Pop. Mode	Pop. Max	5% Min	95% Max	Pop. Mean	Pop. StDev	Pop. Size	Test Stat.	p-value	99%	97.5%	95%
ZONE ONE																		
A/01	LSS-I	Bar-1	B212	189	1.83	1.40	1.40	1.70	1.41	1.63	1.50	0.12	5	-6.15	0.0035	R	R	R
A/02	LSS-I	Bar-B	B212	149	1.44	1.10	1.30	1.40	1.15	1.36	1.26	0.08	14	-8.42	0.0000	R	R	R
A/03	LSS-I	Bar-2	B212	104	1.01	0.60	1.00	1.20	0.71	1.12	0.94	0.12	60	-4.52	0.0000	R	R	R
A/04	LSS-I	Bar-BA3	B212	42	0.41	0.30	0.40	0.60	0.34	0.55	0.43	0.07	43	1.87	0.0680	DNR	DNR	DNR
A/05	LSS-I	Bar-3	B212	79	0.77	0.60	0.70	1.20	0.65	1.08	0.79	0.15	27	0.69	0.4946	DNR	DNR	DNR
A/06	LSS-I	Bar-DA1	B212	110	1.07	0.80	1.00	1.20	0.86	1.14	0.97	0.10	23	-4.80	0.0001	R	R	R
A/07	LSS-I	Bar-4	B212	158	1.53	1.10	1.30	1.80	1.18	1.67	1.38	0.16	28	-4.96	0.0000	R	R	R
A/08	LSS-I	Bar-E	B212	199	1.93													
A./09	LSS-I	Pin-M	B212	250	2.42	1.70	2.10	2.80	1.85	2.60	2.15	0.26	15	-4.02	0.0013	R	R	R
A/10	LSS-I	Pin-1BD	B212	307	2.97	2.30	-	2.40	2.32	2.38	2.35	0.07	2	-12.53	0.0507	DNR	DNR	DNR
A/11	LSS-I	Pin-1BG	B212	362	3.51													
A/12	LSS-I	Pin-2A	B212	417	4.04													
A/13	LSS-I	Pin-CB	B212	468	4.53													
A/14	LSS-I	Pin-3	B212	513	4.97													
A/15	LSS-I	Pin-DA	B212	572	5.54													
A/16	LSS-I	Pin-EB	B212	642	6.22													
01/03	Bar-1	Bar-2	B212	85	0.82	0.60	0.80	1.00	0.66	0.94	0.80	0.13	11	-0.51	0.6209	DNR	DNR	DNR
02/03	Bar-B	Bar-2	B212	46	0.45	0.40	0.40	0.70	0.41	0.63	0.47	0.08	24	1.22	0.2331	DNR	DNR	DNR
07/09	Bar-4	Pin-M	B212	101	0.98	0.80	1.10	1.60	0.91	1.46	1.06	0.23	10	1.10	0.2999	DNR	DNR	DNR
08/09	Bar-E	Pin-M	B212	53	0.51	0.40	0.50	1.10	0.46	0.96	0.65	0.23	21	2.79	0.0113	DNR	R	R
09/10	Pin-M	Pin-1BD	B212	80	0.78	0.50	0.80	1.40	0.62	1.24	0.84	0.25	23	1.15	0.2621	DNR	DNR	DNR
09/11	Pin-M	Pin-1BG	B212	146	1.41	1.10	1.40	1.90	1.12	1.72	1.40	0.23	15	-0.17	0.8687	DNR	DNR	DNR
12/14	Pin-2A	Pin-3	B212	Refer to Zone 2 figures														
13/14	Pin-CB	Pin-3	B212	Refer to Zone 2 figures														
14/15	Pin-3	Pin-DA	B212	Refer to Zone 2 figures														
14/Cp	Pin-3	Coppermine	B212	Refer to Zone 2 figures														
A/B	LSS-I	Cam-M	B212	707	6.85													
A/03	LSS-I	Bar-2	TO	104	0.90	0.70	0.80	1.00	0.74	0.95	0.84	0.08	40	-4.74	0.0000	R	R	R
A/09	LSS-I	Pin-M	TO	250	2.17	1.30	1.60	2.00	1.40	1.88	1.62	0.12	66	-37.24	0.0000	R	R	R
A/Cp	LSS-I	Coppermine	TO	477	4.15													
ZONE TWO																		
B/07	LSS-C	Bar-4	B212	575	5.57													
B/08	LSS-C	Bar-E	B212	526	5.10													
B/09	LSS-C	Pin-M	B212	474	4.59													
B/10	LSS-C	Pin-1BD	B212	403	3.91													
B/11	LSS-C	Pin-1BG	B212	358	3.47													
B/12	LSS-C	Pin-2A	B212	295	2.86													
B/13	LSS-C	Pin-CB	B212	244	2.36													
B/14	LSS-C	Pin-3	B212	207	2.01	1.40	1.80	2.30	1.53	2.15	1.84	0.16	48	-7.36	0.0000	R	R	R
B/15	LSS-C	Pin-DA	B212	150	1.45	1.00	1.30	1.60	1.09	1.51	1.33	0.17	19	-3.08	0.0065	R	R	R
B/16	LSS-C	Pin-EB	B212	66	0.64	0.50	0.60	0.80	0.54	0.75	0.65	0.10	38	0.62	0.5414	DNR	DNR	DNR
B/17	LSS-C	Cam-A3A	B212	36	0.35	0.30	0.30	0.50	0.31	0.46	0.34	0.06	28	-0.88	0.3856	DNR	DNR	DNR
B/18	LSS-C	Cam-1A	B212	86	0.83	0.60	0.80	1.00	0.66	0.94	0.79	0.09	31	-2.47	0.0192	DNR	R	R
B/19	LSS-C	Cam-B	B212	138	1.34	1.00	1.10	1.50	1.05	1.40	1.25	0.18	17	-2.06	0.0559	DNR	DNR	DNR
B/20	LSS-C	Cam-2	B212	185	1.79	1.30	1.60	2.10	1.41	1.96	1.67	0.20	17	-2.47	0.0250	DNR	R	R
B/21	LSS-C	Cam-CB	B212	233	2.26	1.90	-	2.10	1.93	2.07	2.00	0.14	2	-2.63	0.2316	DNR	DNR	DNR
B/22	LSS-C	Cam-3	B212	295	2.86	2.40	-	2.60	2.43	2.57	2.50	0.10	3	-6.24	0.0248	DNR	R	R
B/23	LSS-C	Cam-D	B212	329	3.19													
B/24	LSS-C	Cam-4	B212	387	3.75													
B/25	LSS-C	Cam-5A	B212	488	4.73													
B/26	LSS-C	Cam-FA	B212	529	5.13													
07/09	Bar-4	Pin-M	B212	Refer to Zone 1 figures														
08/09	Bar-E	Pin-M	B212	Refer to Zone 1 figures														
09/10	Pin-M	Pin-1BD	B212	Refer to Zone 1 figures														
09/11	Pin-M	Pin-1BG	B212	Refer to Zone 1 figures														
12/14	Pin-2A	Pin-3	B212	98	0.95	0.70	0.90	1.10	0.76	1.04	0.91	0.10	22	-1.88	0.0746	DNR	DNR	DNR
13/14	Pin-CB	Pin-3	B212	47	0.46	0.40	0.50	0.60	0.43	0.57	0.46	0.06	31	0.00	1.0000	DNR	DNR	DNR
14/15	Pin-3	Pin-DA	B212	60	0.58	0.50	0.60	0.70	0.53	0.67	0.60	0.05	16	1.60	0.1304	DNR	DNR	DNR
20/22	Cam-2	Cam-3	B212	110	1.07	1.00	1.00	1.00	-	-	1.00	0.00	3					
21/22	Cam-CB	Cam-3	B212	62	0.60													
22/23	Cam-3	Cam-D	B212	Refer to Zone 3 figures														
22/24	Cam-3	Cam-4	B212	Refer to Zone 3 figures														

Table J.6 Summary of Data for MILP Models, Page 2 of 3

Sub.	From	To	A/C	Dist. SMi.	Theor. Value	Pop. Min	Pop. Mode	Pop. Max	5% Min	95% Max	Pop. Mean	Pop. StDev	Pop. Size	Test Stat.	p-value	99%	97.5%	95%
14/Cp	Pin-3	Coppermine	B212	75	0.73	0.60	0.60	0.60	-	-	0.60	0.00	2					
22/Gj	Cam-3	Gjoa Haven	B212	62	0.60													
B/C	LSS-C	Fox-M	B212	590	5.72													
B/14	LSS-C	Pin-3	TO	207	1.80	1.10	1.20	1.80	1.16	1.66	1.38	0.20	22	-9.85	0.0000	R	R	R
B/Cp	LSS-C	Coppermine	TO	282	2.45													
B/Gj	LSS-C	Gjoa Haven	TO	233	2.03	1.40	1.50	1.50	1.42	1.50	1.48	0.04	5	-30.75	0.0000	R	R	R
B/09	LSS-C	Pin-M	TO	474	4.12	2.50	2.50	2.50	-	-	2.50	0.00	1					
ZONE THREE																		
C/17	LSS-F	Cam-A3A	B212	558	5.41													
C/18	LSS-F	Cam-1A	B212	514	4.98													
C/19	LSS-F	Cam-B	B212	475	4.60													
C/20	LSS-F	Cam-2	B212	414	4.01													
C/21	LSS-F	Cam-CB	B212	367	3.56													
C/22	LSS-F	Cam-3	B212	305	2.96	2.40	2.40	2.50	2.40	2.48	2.42	0.04	5	-30.19	0.0000	R	R	R
C/23	LSS-F	Cam-D	B212	270	2.62													
C/24	LSS-F	Cam-4	B212	215	2.08	1.00	1.80	2.60	1.25	2.35	1.91	0.41	15	-1.61	0.1306	DNR	DNR	DNR
C/25	LSS-F	Cam-5A	B212	109	1.06	0.90	1.20	1.50	0.99	1.41	1.17	0.15	45	4.92	0.0000	R	R	R
C/26	LSS-F	Cam-FA	B212	62	0.60	0.50	0.70	1.10	0.58	0.99	0.69	0.14	36	3.86	0.0005	R	R	R
C/27	LSS-F	Fox-1	B212	58	0.56	0.50	0.60	1.00	0.55	0.90	0.68	0.11	42	7.07	0.0000	R	R	R
C/28	LSS-F	Fox-A	B212	105	1.02	0.70	1.00	1.50	0.81	1.36	1.07	0.20	27	1.30	0.2053	DNR	DNR	DNR
C/29	LSS-F	Fox-2	B212	161	1.56	1.20	1.40	1.80	1.28	1.69	1.47	0.18	18	-2.12	0.0489	DNR	DNR	R
C/30	LSS-F	Fox-B	B212	213	2.06	1.80	1.80	1.80	-	-	1.80	0.00	1					
C/31	LSS-F	Fox-3	B212	250	2.42													
C/32	LSS-F	Fox-CA	B212	304	2.95													
C/33	LSS-F	Fox-4	B212	364	3.53													
C/34	LSS-F	Fox-5	B212	455	4.41													
C/35	LSS-F	Dye-M	B212	538	5.21													
C/36	LSS-F	Baf-2	B212	544	5.27													
20/22	Cam-2	Cam-3	B212	Refer to Zone 2 figures														
21/22	Cam-CB	Cam-3	B212	Refer to Zone 2 figures														
22/23	Cam-3	Cam-D	B212	39	0.38	0.40	0.50	1.10	0.46	0.96	0.52	0.13	37	6.55	0.0000	R	R	R
22/24	Cam-3	Cam-4	B212	54	0.52	0.20	0.90	1.20	0.39	1.08	0.90	0.20	20	8.50	0.0000	R	R	R
29/31	Fox-2	Fox-3	B212	55	0.53	0.90	1.00	1.10	0.93	1.07	1.00	0.08	4	11.75	0.0013	R	R	R
30/31	Fox-B	Fox-3	B212	50	0.48	0.50	0.50	0.80	0.51	0.73	0.60	0.12	7	2.55	0.0437	DNR	DNR	DNR
31/32	Fox-3	Fox-CA	B212	53	0.51													
31/33	Fox-3	Fox-4	B212	113	1.09													
34/35	Fox-5	Dye-M	B212	89	0.86													
22/Pl	Cam-3	Pelly Bay	B212	54	0.49	0.70	1.00	1.40	0.80	1.28	0.98	0.13	28	19.94	0.0000	R	R	R
C/B	LSS-F	Cam-M	B212	590	5.72													
C/Pl	LSS-F	Pelly Bay	TO	215	1.87	1.20	1.30	1.70	1.25	1.60	1.43	0.18	8	-6.91	0.0002	R	R	R
C/Br	LSS-F	Broughton Isl.	TO	450	3.91													
ZONE FOUR																		
D/25	LSS-Q	Cam-5A	S61N	574	5.22													
D/26	LSS-Q	Cam-FA	S61N	553	5.03													
D/27	LSS-Q	Fox-1	S61N	492	4.47													
D/28	LSS-Q	Fox-A	S61N	455	4.14													
D/29	LSS-Q	Fox-2	S61N	399	3.63													
D/30	LSS-Q	Fox-B	S61N	360	3.27	2.50	-	3.10	2.61	3.02	2.88	0.26	4	-3.00	0.0577	DNR	DNR	DNR
D/31	LSS-Q	Fox-3	S61N	346	3.15	2.40	2.60	3.60	2.51	3.36	2.93	0.30	35	-4.34	0.0001	R	R	R
D/32	LSS-Q	Fox-CA	S61N	338	3.07													
D/33	LSS-Q	Fox-4	S61N	330	3.00	2.30	-	3.40	2.47	3.22	2.83	0.55	3	-0.54	0.6460	DNR	DNR	DNR
D/34	LSS-Q	Fox-5	S61N	294	2.67	2.50	2.50	2.50	-	-	2.50	0.00	1					
D/35	LSS-Q	Dye-M	S61N	289	2.63	2.00	2.30	3.20	2.13	2.97	2.42	0.28	26	-3.82	0.0008	R	R	R
D/36	LSS-Q	Baf-2	S61N	170	1.55	1.30	1.50	2.80	1.42	2.49	1.63	0.32	23	1.20	0.2433	DNR	DNR	DNR
D/37	LSS-Q	Baf-3	S61N	138	1.25	1.10	1.20	1.90	1.16	1.73	1.28	0.16	56	1.40	0.1662	DNR	DNR	DNR
D/38	LSS-Q	Baf-4A	S61N	153	1.39	1.20	1.30	2.10	1.27	1.91	1.47	0.28	14	1.07	0.3045	DNR	DNR	DNR
D/39	LSS-Q	Baf-5	S61N	194	1.76	1.40	1.60	1.90	1.47	1.81	1.65	0.14	15	-3.04	0.0088	R	R	R
D/40	LSS-Q	Lab-1	S61N	306	2.78													
D/41	LSS-Q	Lab-2	S61N	414	3.76	3.60	3.60	3.60	-	-	3.60	0.00	1					

Table J.6 Summary of Data for MILP Models, Page 3 of 3

Sub.	From	To	A/C	Dist. SMi.	Theor. Value	Pop. Min	Pop. Mode	Pop. Max	5% Min	95% Max	Pop. Mean	Pop. StDev	Pop. Size	Test Stat.	p-value	99%	97.5%	95%
D/42	LSS-Q	Lab-3	S61N	517	4.70													
29/31	Fox-2	Fox-3	S61N	55	0.50													
30/31	Fox-B	Fox-3	S61N	50	0.45	0.40	0.50	0.60	0.43	0.57	0.51	0.06	16	4.00	0.0012	R	R	R
31/32	Fox-3	Fox-CA	S61N	53	0.48	0.40	0.50	1.10	0.46	0.96	0.59	0.19	12	2.01	0.0701	DNR	DNR	DNR
31/33	Fox-3	Fox-4	S61N	113	1.03	0.90	0.90	1.70	0.92	1.52	1.06	0.27	8	0.31	0.7625	DNR	DNR	DNR
34/35	Fox-5	Dye-M	S61N	89	0.81	0.80	-	1.00	-	-	0.90	0.14	2	0.91	0.5303	DNR	DNR	DNR
40/41	Lab-1	Lab-2	S61N	118	1.07													
41/42	Lab-2	Lab-3	S61N	103	0.94													
34/Br	Fox-5	Broughton Isl.	S61N	10	0.09	0.10	0.10	0.30	0.11	0.26	0.15	0.07	11	2.84	0.0175	DNR	R	R
41/Na	Lab-2	Nain	S61N	138	1.25													
D/C	LSS-Q	Fox-M	S61N	492	4.47													
D/31	LSS-Q	Fox-3	TO	346	3.01	1.70	2.10	2.70	1.84	2.53	2.13	0.25	28	-18.63	0.0000	R	R	R
D/Br	LSS-Q	Broughton Isl.	TO	294	2.56	1.60	1.70	2.10	1.65	2.00	1.83	0.17	8	-12.15	0.0000	R	R	R
D/Na	LSS-Q	Nain	TO	550	4.78	2.90	2.90	2.90	-	-	2.90	0.00	1					
ZONE FIVE																		
E/39	LSS-G	Baf-5	B212	594	5.76													
E/40	LSS-G	Lab-1	B212	482	4.67													
E/41	LSS-G	Lab-2	B212	367	3.56													
E/42	LSS-G	Lab-3	B212	266	2.58	2.40	2.40	2.40	-	-	2.40	0.00	3					
E/43	LSS-G	Lab-4	B212	167	1.62	1.40	1.60	2.20	1.49	2.05	1.67	0.18	26	1.42	0.1690	DNR	DNR	DNR
E/44	LSS-G	Lab-5	B212	128	1.24	0.50	1.30	1.90	0.74	1.70	1.28	0.29	19	0.60	0.5552	DNR	DNR	DNR
E/45	LSS-G	Lab-6	B212	149	1.44	0.20	1.40	1.80	0.51	1.62	1.37	0.34	17	-0.85	0.4085	DNR	DNR	DNR
39/40	Baf-5	Lab-1	B212	112	1.09													
40/41	Lab-1	Lab-2	B212	118	1.14	0.90	1.10	1.50	0.98	1.39	1.17	0.14	36	1.29	0.2070	DNR	DNR	DNR
41/42	Lab-2	Lab-3	B212	103	1.00	0.20	1.00	1.30	0.41	1.17	0.98	0.24	31	-0.46	0.6460	DNR	DNR	DNR
41/Na	Lab-2	Nain	B212	138	1.34	0.10	1.30	2.10	0.45	1.82	1.37	0.21	83	1.30	0.1967	DNR	DNR	DNR
43/Ho	Lab-4	Hopedale	B212	22	0.21	0.20	0.30	0.60	0.24	0.52	0.85	0.38	4	3.37	0.0435	DNR	DNR	R
44/Ma	Lab-5	Makkovik	B212	44	0.43	0.40	0.40	0.80	0.41	0.71	0.47	0.11	19	1.59	0.1304	DNR	DNR	DNR
45/Ca	Lab-6	Cartwright	B212	15	0.15	0.20	0.20	0.30	0.20	0.28	0.22	0.04	20	7.83	0.0000	R	R	R
E/Na	LSS-G	Nain	TO	229	1.99	1.30	1.60	1.80	1.39	1.73	1.56	0.14	28	-16.25	0.0000	R	R	R
E/Ho	LSS-G	Hopedale	TO	147	1.28	1.00	1.10	1.10	1.02	1.10	1.07	0.06	3	-6.06	0.0261	DNR	DNR	R
E/Ma	LSS-G	Makkovik	TO	131	1.14	0.80	1.00	1.10	0.85	1.06	0.95	0.10	6	-4.65	0.0056	R	R	R
E/Ca	LSS-G	Cartwright	TO	155	1.35	0.90	1.00	1.20	0.94	1.15	1.03	0.09	16	-14.22	0.0000	R	R	R

Appendix K

This appendix presents information corresponding to discussions in Chapter IV.

Table K.1 Number of Visits per Site, FY96

Index	Name	PMI	CM	Emergency	TPS+	TOTAL
01	Bar-1	4	0	0	3	7
02	Bar-B	4	0	1	6	11
03	Bar-2	4	1	2	12	19
04	Bar-BA3	4	0	0	7	11
05	Bar-3	4	0	2	7	13
06	Bar-DA1	4	0	0	7	11
07	Bar-4	4	0	1	6	11
08	Bar-E	4	0	0	3	7
09	Pin-M	4	1	0	7	12
10	Pin-1BD	4	0	1	5	10
11	Pin-1BG	4	0	0	4	8
12	Pin-2A	4	0	1	0	5
13	Pin-CB	4	0	1	1	6
14	Pin-3	4	1	3	9	17
15	Pin-DA	4	0	0	6	10
16	Pin-EB	4	0	1	5	10
17	Cam-A3A	4	0	0	4	8
18	Cam-1A	4	0	0	7	11
19	Cam-B	4	0	0	4	8
20	Cam-2	4	0	2	4	10
21	Cam-CB	4	0	1	3	8
22	Cam-3	4	2	5	10	21
23	Cam-D	4	1	1	6	12
24	Cam-4	4	3	0	5	12
25	Cam-5A	4	2	5	9	20
26	Cam-FA	4	0	1	9	14
27	Fox-1	4	0	0	8	12
28	Fox-A	4	0	2	4	10
29	Fox-2	4	0	0	7	11
30	Fox-B	4	0	0	3	8
31	Fox-3	4	0	0	9	13
32	Fox-CA	4	0	0	3	8
33	Fox-4	4	0	0	3	8
34	Fox-5	4	0	0	2	7
35	Dye-M	4	0	0	8	12
36	Baf-2	4	0	0	4	9
37	Baf-3	4	1	2	11	18
38	Baf-4A	4	0	0	4	9
39	Baf-5	4	0	0	4	9
40	Lab-1	4	1	0	3	8
41	Lab-2	4	1	5	9	19
42	Lab-3	4	0	0	5	9
43	Lab-4	4	0	5	8	17
44	Lab-5	4	0	2	5	11
45	Lab-6	4	0	2	5	11

Table K.2 Estimated Annual Hours Associated with Travel Time Variations of the Validation Model

	Helicopter Hours					Twin Otter Hours				
	I	II	III	IV	V	I	II	III	IV	V
Low	344.6	351.8	426.3	535.3	401.1	135.0	71.9	50.0	170.8	113.0
Medium	395.7	385.4	489.7	554.8	488.7	152.0	73.6	52.0	160.9	120.0
High	492.8	440.5	606.6	757.2	559.8	169.6	80.1	45.7	182.2	118.9

Table K.3 Estimated Annual Hours Associated with the Reduction of the Annual PMI Requirement Based Upon the Medium Travel Leg Values

	Helicopter Hours					Twin Otter Hours				
	I	II	III	IV	V	I	II	III	IV	V
4 PMIs	395.7	385.4	489.7	554.8	488.7	152.0	73.6	52.0	160.9	120.0
3 PMIs	352.9	345.6	437.2	489.8	431.0	120.0	47.5	52.0	125.6	107.9
2 PMIs	310.1	305.8	390.4	424.8	378.4	88.0	21.4	44.6	90.2	87.6

Table K.4 Hourly Usage Comparison of Guarantee Options for the Different PMI Requirement Scenarios

	Helicopter Hours					Twin Otter Hours				
	I	II	III	IV	V	I	II	III	IV	V
4 PMIs, Option One	395.7	385.4	489.7	554.8	488.7	152.0	73.6	52.0	160.9	120.0
4 PMIs, Option Two	400.5	404.6	489.7	554.8	488.7	144.0	47.5	52.0	160.9	120.0
3 PMIs, Option One	352.9	345.6	437.2	489.8	431.0	120.0	47.5	52.0	125.6	107.9
3 PMIs, Option Two	400.3	400.0	437.2	489.8	431.0	56.0	0.0	52.0	125.6	107.9
2 PMIs, Option One	310.1	305.8	390.4	424.8	378.4	88.0	21.4	44.6	90.2	87.6
2 PMIs, Option Two	409.7	400.0	402.4	476.0	419.4	0.0	0.0	44.6	31.6	59.6

Table K.5 Estimated Annual Hours Associated with Travel Time Variations of the Expanded Model

	Helicopter Hours					Twin Otter Hours				
	I	II	III	IV	V	I	II	III	IV	V
Low	977.9	0.0	1629.1	189.8	405.2	222.0	0.0	73.3	0.0	113.0
Medium	1053.9	0.0	1685.9	199.2	483.5	222.0	0.0	74.4	0.0	128.3
High	1164.8	0.0	1786.6	189.8	547.5	227.9	0.0	72.1	0.0	126.9

Table K.6 Estimated Annual Hours Associated with the Zone II LSS Suspended and the Zone III LSS Suspended Expanded Model Solutions

	Helicopter Hours					Twin Otter Hours				
	I	II	III	IV	V	I	II	III	IV	V
Zone II LSS Suspended	1053.9	0.0	1685.9	199.2	483.5	222.0	0.0	74.4	0.0	128.3
Zone III LSS Suspended	395.7	1247.3	0.0	883.9	483.5	152.0	170.0	0.0	126.5	128.3

Table K.7 Run-time Execution Results

SUN SPARCstation 20 CPLEX Linear Optimizer 3.0							
Model	Values	# PMIs	Restricted?	Pre-Solve (seconds)	Solve Time (seconds)	Iterations	Nodes
B	H	4	no	0.07	0.62	179	64
B	M	4	no	0.07	0.28	123	12
B	M	4	yes	0.07	3.60	1581	373
B	L	4	no	0.07	0.27	123	13
B	L	4	yes	0.08	9.58	3659	966
B	M	3	no	0.07	0.32	139	17
B	M	3	yes	0.08	10.75	4421	1211
B	M	2	no	0.07	0.23	92	5
B	M	2	yes	0.08	216.55	48325	20000
E	H	4	no	0.22	2.97	6	22
E	M	4	no	0.20	3.50	714	37
E	L	4	no	0.18	2.10	511	4

(B)ase Model
(E)xpanded Model
(L)ow Values
(M)edium Values
(H)igh Values

Table K.8 Estimated Annual Hourly Usage Associated with the Base Model and the Unrestricted and Restricted Five Zone Variations of the Expanded Model

	Zone I	Zone II	Zone III	Zone IV	Zone V
Helicopter/Base Model	395.7	385.4	489.7	554.8	488.7
Helicopter/Unrestricted Hours	395.7	639.0	717.6	199.2	488.7
Helicopter/Restricted Hours	400.5	639.0	448.9	475.0	488.7
Twin Otter/Base Model	152.0	73.6	52.0	160.9	120.0
Twin Otter/Unrestricted Hours	152.0	96.4	44.7	0.0	120.0
Twin Otter/Restricted Hours	144.0	96.4	0.0	31.6	120.0

Appendix L

This appendix discusses the break even points for the two different pricing options for the helicopter contracts.

Pricing Options

Two helicopter pricing options are evaluated in this section. The first option involves an annual basing charge for the dedicated helicopter plus an additional hourly usage charge. The second option has only an hourly usage charge but requires the compensation of a contractually agreed upon number of hours. The second option is currently in use by NWS.

The evaluation of these two pricing options is separated by zone. Zone II and III have the same charges associated with them and are presented together. The analysis on each zone provides the costs figures and contractual minimum hour requirement, a graph showing the pricing differences for the execution of up to 1200 hours, and a zoom view of the critical area of that graph in which the two pricing options intersect. Points of interest are given which indicate where the two options are practically equal.

Conclusions

For each of the four comparisons (Zone I, Zone II or III, Zone IV, and Zone V), the two pricing options result in similar costs around the area of the contractual minimum hours. This result is not surprising because the contractor agency has their own costs which must be met in order to make a reasonable profit. The only exception is Zone IV, in which the annual basing option is always lower than the contractual minimum hour requirement. For all zones, though, once the number of hours begins to exceed the contractual minimum hours, the difference between the two options becomes dramatic. We can assume that the operation of the helicopters under the annual basing cost option yielded a reasonable amount of profit for the contractor. Therefore, from the contractor's perspective, the extra paid out through the contractual minimum requirement option is pure profit.

It is recommended that a hybrid of these two options be negotiated in which the operating hours executed up to the contractual minimum be compensated for at the higher hourly rate with the minimum hourly guarantee. Above the minimum, though, negotiation should be made for the lower hourly rate previously associated with an annual basing charge. This agreement will yield the contracting agency its profit without over-compensating for services above the minimum.

Comparison for Zone One

The pricing option costs and minimums for Zone One are as follows:

Annual Basing Option:
Basing Cost: $ 780,000
Hourly Cost: $ 825

Hourly Minimum Option:
Hourly Cost: $2,660
Contractual Minimum: 400 hours

Points of Interest:

344 hours -- Annual Basing $1,063,800
Hourly Minimum $1,064,000

425 hours -- Annual Basing $1,130,625
Hourly Minimum $1,130,500

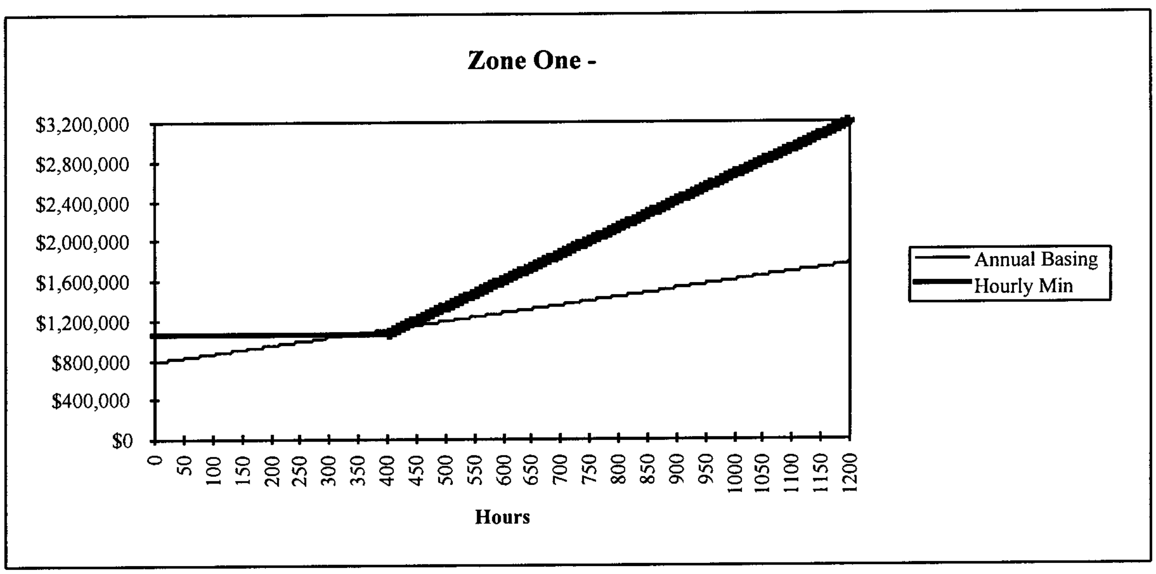

Figure L.1 Comparison of Helicopter Pricing Options -- Zone One

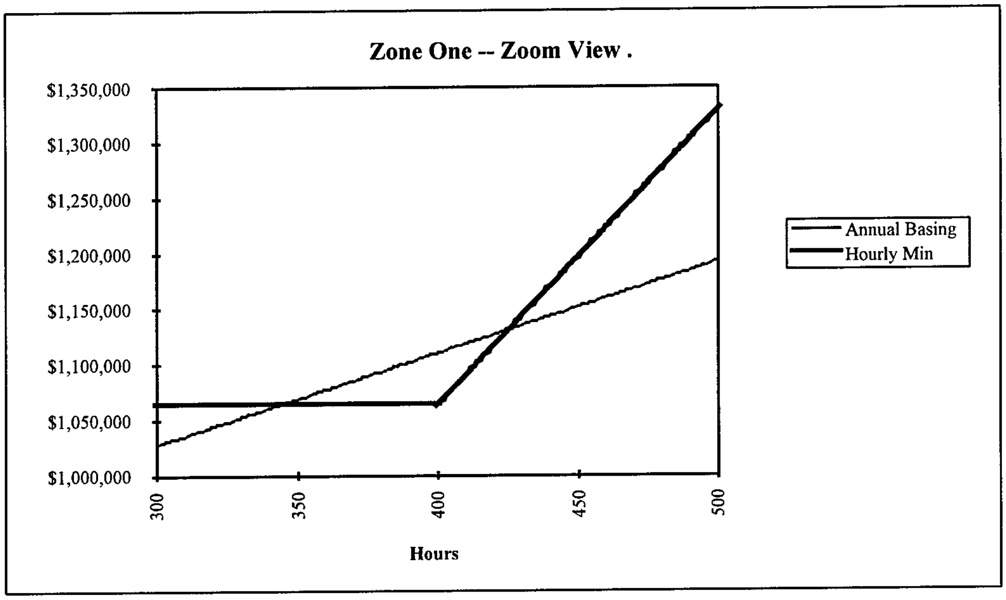

Figure L.2 Comparison of Helicopter Pricing Options -- Zone One (Zoom View)

Comparison for Zone Two or Three

The pricing option costs and minimums for Zone Two or Three are as follows:

Annual Basing Option:
Basing Cost: $ 780,000
Hourly Cost: $ 825

Hourly Minimum Option:
Hourly Cost: $2,740
Contractual Minimum: 400 hours

Points of Interest:

383 hours -- Annual Basing $1,095,975
Hourly Minimum $1,096,000

407 hours -- Annual Basing $1,115,775
Hourly Minimum $1,115,180

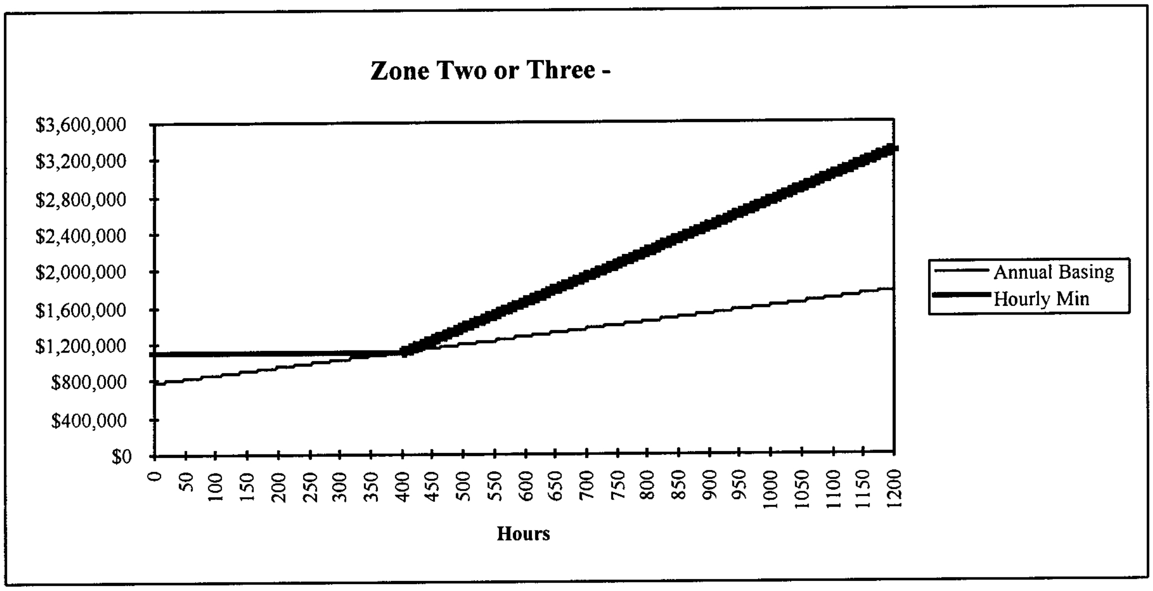

Figure L.4 Comparison of Helicopter Pricing Options -- Zone Two or Three

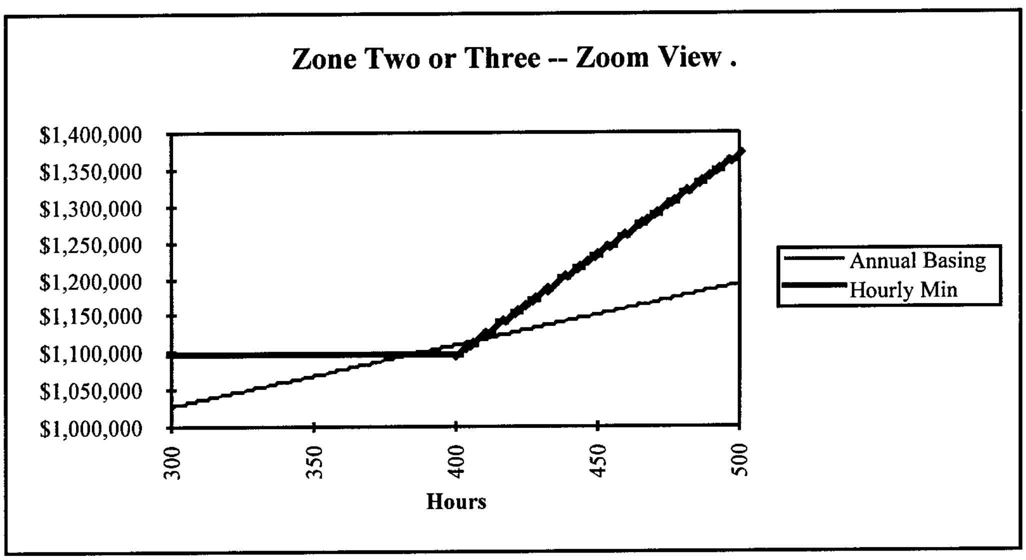

Figure L.4 Comparison of Helicopter Pricing Options -- Zone Two or Three (Zoom View)

Comparison for Zone Four

The pricing option costs and minimums for Zone Four are as follows:

Annual Basing Option:
Basing Cost: $ 1,444,000
Hourly Cost: $ 1400

Hourly Minimum Option:
Hourly Cost: $4,542
Contractual Minimum: 475 hours

Points of Interest:

This point represents the smallest difference between the two options, but still yields a $48,450 difference in favor of the annual basing option.

475 hours -- Annual Basing $2,109,000
Hourly Minimum $2,157,450

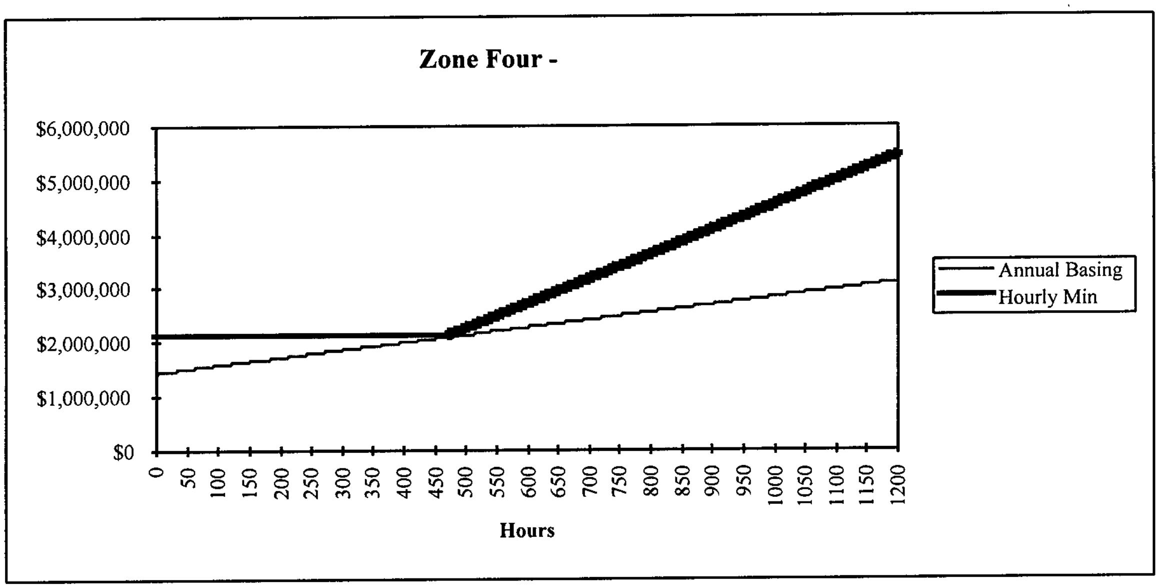

Figure L.5 Comparison of Helicopter Pricing Options -- Zone Four

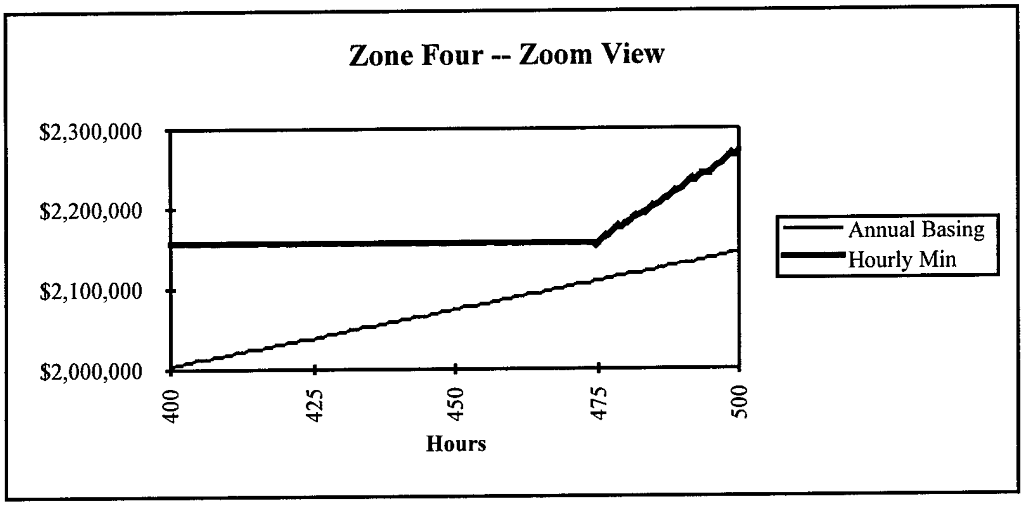

Figure L.6 Comparison of Helicopter Pricing Options -- Zone Four (Zoom View)

<u>Comparison for Zone Five</u>

The pricing option costs and minimums for Zone Five are as follows:

Annual Basing Option:
- Basing Cost: $ 780,000
- Hourly Cost: $ 825

Hourly Minimum Option:
- Hourly Cost: $2,480
- Contractual Minimum: 417 hours

Points of Interest:

257 hours -- Annual Basing $ 992,025
Hourly Minimum $ 992,000

471 hours -- Annual Basing $1,168,575
Hourly Minimum $1,168,080

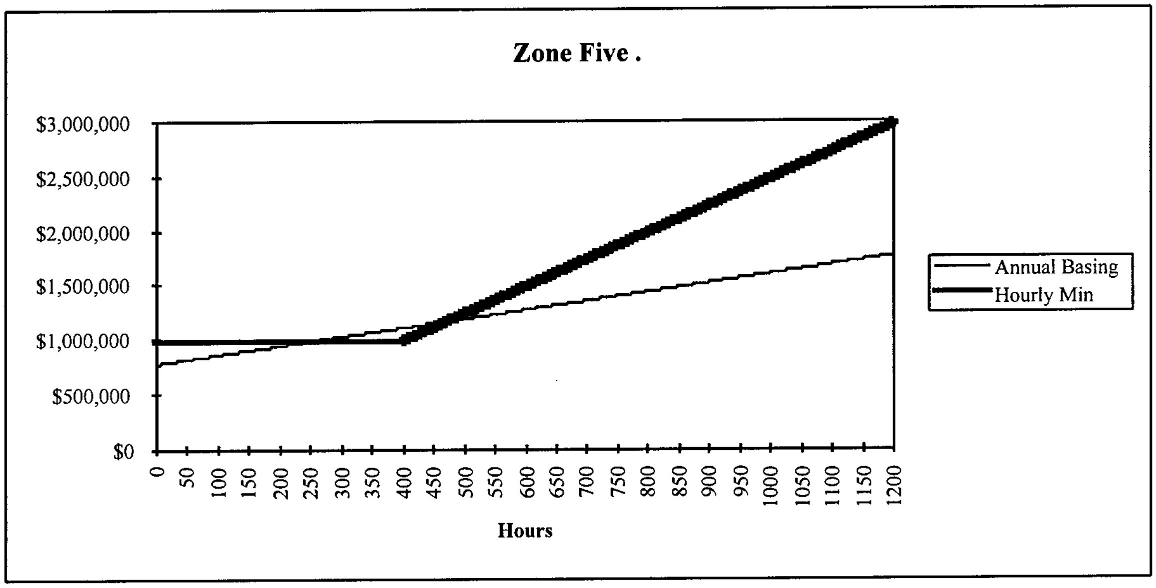

Figure L.7 Comparison of Helicopter Pricing Options -- Zone Five

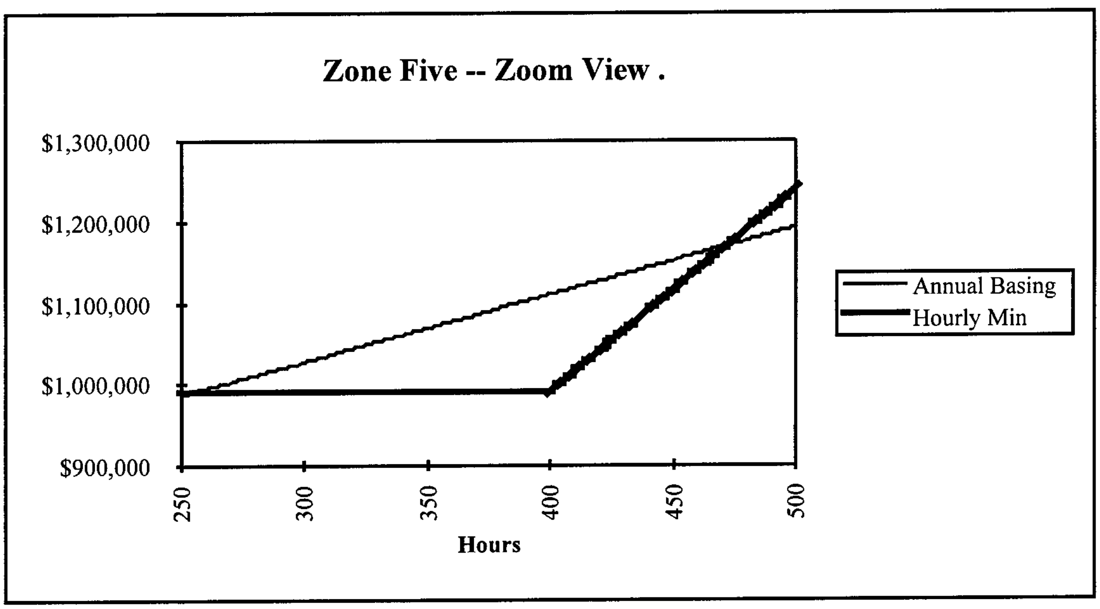

Figure L.8 Comparison of Helicopter Pricing Options -- Zone Five (Zoom View)

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Vita

Captain Sonia E. Leach was born on 13 August 1969 in Lowell, Massachusetts. She graduated from Chelmsford High School, Chelmsford, Massachusetts in 1987 and entered undergraduate studies at The Pennsylvania State University in University Park, Pennsylvania. She graduated with a Bachelor of Science degree in Mathematics in May 1991. She received her commission on 17 May 1991 upon her graduation from college and her completion of training with the Air Force Reserve Officer Training Corps.

Her first assignment was at Wright-Patterson AFB, Ohio as a software acquisition program manager for the EF-111A System Improvement Program System Program Office. During her first assignment, she also served as the Executive Officer. In August 1995, she entered the Graduate School of Engineering, Air Force Institute of Technology.

Permanent Address: 379 Amherst Street, Suite 222

Nashua, NH 03063

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13. ABSTRACT *(Maximum 200 words)*

The North Warning System (NWS), a joint program of the United States Air Force (USAF) and the Royal Canadian Air Force (RCAF), is responsible for the maintenance of 47 remote radar sites across northern Canada. NWS's current airlift operations, which support the radar maintenance activities, consist of both helicopters and fixed wing aircraft positioned at five support depots. This thesis considers whether a reconfiguration of these support depots and the assignment of radar sites to them can result in either an airlift or total cost savings for NWS. Mixed integer linear programming models were formulated to address the questions surrounding a reconfiguration of the NWS which might gain airlift cost savings. Several operational scenarios were considered. The analysis identifies that cost savings may be realized through a number of possible actions.

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