# A ROBUST OPTIMIZATION APPROACH TO SOLID WASTE COLLECTION PLANNING: LOCATION- ALLOCATION, AND SERVICE FREQUENCY

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By

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# A ROBUST OPTIMIZATION APPROACH TO SOLID WASTE COLLECTION PLANNING: LOCATION- ALLOCATION, AND SERVICE FREQUENCY

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# ABSTRACT

Due to population expansion and economic development, municipal solid waste management has become a critical issue. Organizations spend large sums each year for their waste disposal. The University of Missouri has its solid waste serviced by the City of Columbia. In this thesis, we develop a robust optimization approach to support solid waste collection planning at University of Missouri. The aim of this study is minimizing the cost of the university`s annual solid waste disposal contract. In this research we try to choose the best locations for waste collection, assign waste generators to the potential collection centers, and determine the desired service frequency at collection sites. We solve the problem with two methods. First a deterministic model is proposed that considers a single point estimate for all input data. Then since the frequency of service at certain receptacle types was observed to vary in historical data, a robust optimization model is considered to find preferred solutions. GAMS/ CPLEX software is used to solve the model under different scenarios and identify potential waste collection network designs.

# Chapter 1

## Introduction

Solid waste management (SWM) is a very important problem in operations research. Due to population expansion and industrialization, the waste generation rate has increased dramatically within the recent years in all over the world. This fact along with public and environmental health concerns decreases in waste disposal capacities, and political conditions make the importance of SWM more significant [1]. We can categorize solid waste in three groups: Industrial, municipal, and agricultural.

In this study we focus on Municipal Solid Waste management (MSWM), which refers to the management of the waste that is generated as a result of residential, institutional, and commercial activities [2]. In MSWM the trucks move around the city to collect wastes for disposal. The processes involved in MSW management are collection, waste handling and separation, transfer and transport, and disposal. It is important that all of these processes be handled in accordance with legal regulation to prevent health and environmental issues.

A review on current MSWM model indicates that most current MSWM models can be considered in three groups. The first group deals with MSWM based on the cost benefit analysis. In cost benefit analysis, the decision maker looks for ways to measures all the positive and negative effects of decision-making process in a scenario relative to a common measurement, such as dollars. The biggest benefit of this method is having a common measurement tool for investigating different scenarios and choosing the best one

based on a sensible comparison [3].

The second group encompasses the MSWM models based on life cycle analysis. Life cycle analysis (LCA) models consider the potential environmental impact of a product from early stage of its life (raw material extraction) through production, usage, and disposal [4]. It should be mentioned that LCA is one tool among others in "environmental management toolbox", so it should not be considered as the only factor in the process of MSWM.

In the last group, the MSWM models are categorized based on the multi criteria decision analysis (MCDA). In reality waste managers are deciding between the confliction of different criteria like costs and environmental impacts in their decision-making process. For example in cost benefit analysis models, waste managers are mostly concerned about minimizing their cost, however, in life cycle analysis models they care more about public health and as a result may increase the costs. A robust decision usually can be expected when they solve the problem in a multidimensional way. It means that instead of solving the problem with a single objective function; they will propose it with combination of more than one objective function [3]. This fact leads us to the new concept in MSWM, which is Integrated MSWM. In integrated MSWM, communities are looking for ways to decrease their waste generation rates by implementing several alternative waste management techniques like recycling, source reduction, reuse, composting, landfilling and etc. [5; 6; 7; 8; 9].

MSWM includes strategic and operational techniques that have been studied for more than 40 years. Such studies have considered impact factors like selection of solid waste collection technologies, collection sites and landfills locations, vehicle routing,

waste flow allocation, the collection districts, and collection days scheduling [10]. From a modeling perspective, the literature on MSWM problems can be categorized based on 2 different concepts: deterministic and stochastic models. Whenever uncertainty is included in a model, the problem becomes more complicated. Usually researchers approach uncertainty by minimizing expected MSWM costs through interval mathematical analysis, chance-constrained, fuzzy mathematical programming (FMZ), and stochastic approaches [10].

This research was motivated by a project with University of Missouri's Sustainability Office on solving a waste management issue on our campus. Currently, the university is paying City of Columbia approximately $400,000 annually for collecting solid waste disposals around campus. According to [11] the biggest part of the solid waste management costs (about %75), is dedicated to the waste collection process. University of Missouri (MU) and the Sustainability Office do not follow any waste management techniques that focus on reducing waste collection costs while meeting all the necessary demands. As a result, MU is potentially losing thousands of dollars each year from its waste disposal contracts. In this study we looked at finding new ways the university can achieve significant cost savings in its annual solid waste disposal contract. This problem is investigated under the name of cost benefit analysis group since the only concern of the university is the cost associated with their contract.

Our study assessed various locations where trash receptacles could be placed in order to find a better assignment of buildings around campus to each receptacle. There are 111 buildings around campus that currently host receptacles provided by the City of Columbia for collecting trash. There are three primary types of receptacles in use on

campus: dumpsters, roll off containers, and compactors. Given a set of potential collection centers (dumpster and compactor locations) and waste generators (campus buildings) an optimization approach is proposed to determine which potential collection centers should be utilized. This model also identifies which buildings should have their trash assigned to the each of the opened collection centers, and the number of times per week that the City of Columbia should service each opened collection center in order to minimize the total waste disposal cost. We formulate the problem as a mixed- integer program as it is mentioned above; the objective function aims to minimize the total collection costs paid by university to the city. We approach the problem by considering two optimization standpoints: deterministic and robust. First we develop the deterministic model and find the optimal solution. Since we observed uncertainty in the frequency of service for historical data, we also developed robust optimization (RO) approach, as our second problem-solving method. Robust Optimization is a new notion in optimization and few studies have addressed RO models in solid waste management. Instead of dealing with probabilities to address uncertainty in stochastic optimization, the decision maker constructs a feasible solution for any realization of uncertainty in a given set [12]. After writing the mathematical model, we code the problem in GAMS software, using CPLEX, to find the optimal solution. Based on 2013-14 historical data, optimal solution is able to reduce the university`s collection and shows us where to put the receptacles around campus, how to assign buildings to these receptacles, and how many times per week the City of Columbia should give service to these receptacles.

The rest of the thesis is organized as follow:

In chapter 2, literature review discusses the solution approaches to the related problems. In chapter 3, we will present the approaches we considered as our problem solving methods, deterministic and robust optimization. We also will address the optimization modeling of the problem in chapter 3. The solutions of deterministic and robust optimization are discussed in chapter 4. Then, the conclusion and future study is addresses in chapter 5.

# Chapter 2

## Literature Review

Solid waste management deals with organized handling of waste material from generation sources through the recovery processes to disposal [13]. Solid waste management is known to be a complicated and costly procedure for urban areas. Municipal solid waste management (MSWM) is a part of solid waste management that deals with the waste generated as a result of residential, commercial, and industrial activities [2].

A review on municipal solid waste management shows most studies have addressed MSWM problems with three different concepts: cost benefit analysis (CBA) [14; 15], life cycle analysis (LCA) [16; 17; 18; 19; 20; 21; 22; 9], and multi-criteria decision analysis [23; 24]. For years, cost benefit analysis has been considered as one of the essential factors in estimating the effectiveness of MSWM systems [25]. Cost benefit analysis can be used to measure the financial along with social and environmental perspectives. The financial perspective of CBA usually focuses on cost reduction and budget limitations; it can be considered as one of the most important issues in MSWM. CBA helps countries and institutions to allocate sufficient budget to waste management process and avoid inaccurate budget plan which can contribute to serious environmental impacts [25]. [10] indicates that among all the processes involved in solid waste management, the waste collection process covers the majority part of cost (about 75%). For the purpose of this research, we will focus on a financial cost function.

At strategic level of solid waste management, several decisions must be taken.

Regional planning decisions like selection of collection site location [26; 27], transfer station location [28; 29; 30; 31; 32; 33], wastes processing facility location [34; 35; 33; 36], and landfill location [28; 37; 30; 35] in problem solving methods has been studied by many researchers. Such analyses typically aim to identify the best locations for sites while minimizing cost. [27] presents a model to minimize the municipal waste management cost with determining the best position for collection site among all the possible locations.[10; 38]. This paper also addressed waste flow allocation in their strategic planning model to consider the impact of optimal assignment of waste generation points to collection sites in MSWM models. Collection patterns is the other issue in MSWM that deals with routing scheduling for trucks to collect waste around cities, accounting for the time needed to collect wastes as well as choice of collection days [10]. [10; 39] mentioned districting as the purpose of their model. The aim of districting is dividing the regions to some zones in a ways that the total waste flow in each zone is less than the capacity of the trucks serving it. [40] presents a storage, collection, and disposal plan for the Asansol Municipal Cooperation (AMC) of waste part of India. They address a GIS optimal routing model to determine the minimum cost/distance efficient collection path for transporting solid waste to landfill. Load balancing within vehicles, managing fuel consumption and generating work schedules for the workers and vehicles can be calculated in this model. Different combination of these factors, lead to several optimization problems. This approach allows decision makers to choose the appropriated factors for the corresponding problem they want to solve.

After goal definition, the next step is writing the mathematical model of the system. Many studies consider mathematical programming methods for solving solid

waste management problems. We considered mathematical programing models into two groups. Those that consider no randomness involved in the system (deterministic), and those that include uncertainty. Since randomness is unavoidable part of many factors in MSWM, for more realistic results, it should be considered in mathematical modeling of the problem. During recent decades many methods concerning uncertainty in solid waste management planning were developed. In the following section a brief summary of them will be mentioned.

### 2.1. Fuzzy Mathematical Programming

Bellman and Zadeh [41] established the idea of Fuzzy set theory in 1965. In fuzzy programming approach a real problem is first modeled using a mathematical programming model with fuzzy parameters. For solving this problem, since it includes uncertain parameters, first the fuzzy model should transfer to the common mathematical model while managing the uncertainty included in the first model. Then, with optimization techniques the result of the transferred model is calculated; however, this result is not always optimum or efficient result for the first fuzzy mathematical programming model. Therefore, the last phase includes checking the optimality or efficiency of the current solution in fuzzy model [42]. [43] presented a fuzzy methodology from the viewpoint of different groups for the purpose of comparing alternative solutions for the solid waste disposal. An inexact fuzzy linear programming method is presented and applied to MSWM by Huang et al.[45]. Reflecting the uncertainty presented in both interval and fuzzy information in the models coefficients improve both inexact linear programming and fuzzy linear programming methods. Other approaches for tracking randomness in optimization problems such as: inexact fuzzy

integer programming, inexact fuzzy dynamic programming, and inexact fuzzy quadratic programming were proposed later by Huang et al. [44] .All these methods try to improve the existing methods for dealing with uncertainty.

## 2.2. Stochastic Mathematical Programming

Beale (1955) developed stochastic mathematical programming [45]. Stochastic mathematical programming deals with uncertainty included in data parameters by means of probability distribution functions. Indeed, in these problems the coefficients in mathematical models are not exactly known, but the probability distribution function of coefficients are used in the model.

### *2.2.1. Two-Stage Stochastic Programming*

When an analysis of policy scenarios is intended result and the related data are mostly uncertain, Two-stage stochastic programming (TSP) is effective. While some uncertainties are assigned deterministic values followed by some post-optimality analyses, others are expressed as probability density functions in practical applications of Two-stage stochastic programming (TSP) [45]. [46] developed an integrated fuzzy-stochastic linear programming model to improve upon the existing optimization methods with advantages in uncertainty reflection. A two-stage interval-stochastic programming (TISP) model for the planning of solid-waste management systems under uncertainty is presented by [47]. The model comes with the concept of two-stage stochastic programming within an interval-parameter optimization framework.

### *2.2.2. Chance-Constrained Programming*

Cfaames et al. [45] was the first study addressed the CCP model. In CCP models

instead of satisfying all of the constraints, a proportion of them with given probabilities can be satisfied [45]. An inexact two-stage chance-constrained linear programming (ITCLP) method developed for planning waste management systems. The incorporation of the techniques of two-stage and chance-constrained programming within a general interval-optimization framework develops the model. It can approach uncertainties presented as both probability distributions and discrete intervals [45].

### 2.3. Interval Mathematical Programming

The idea if Interval analysis was first presented by Moore (1979)[45] and then extended into inexact mathematical programming (IMP). The emphasis of the IMP approach is on the intrinsic vagueness of its informational characteristics during parameter estimation (Chang et al., 1997)[45]. Uncertain parameters are expressed as intervals with known lower and upper bounds, but unknown distributions [45].

### 2.4. Robust Optimization

Robust Optimization is a new concept of optimization under uncertainty. Instead of considering probabilistic information to protect the solution against uncertainty, RO models construct a solution that is feasible for any realization of the uncertainty in a given set. Most optimization techniques exhibit noticeable sensitivity to perturbations in the data parameters of the problem, therefore they often obtain with results that can be infeasible, suboptimal, or both in the event that parameters vary from their point estimates. To avoid such a result, a concept of traditional optimization theory named robust optimization was developed [12].

Based on the literature, the majority of the existing system optimization models in municipal solid waste management deal with uncertainty with techniques including fuzzy, stochastic, interval mathematical programming, and combinations of the above. However, RO techniques have not been discussed as a problem solving method for MSWM. Therefore, in this research we present an efficient robust optimization model for MSWM. Moreover, studies discussed in this area consider the MSWM from the starting point (waste generation sources) to the final destination (landfills); however, in this research we consider the problem from different point of view. The idea of this thesis is helping the University of Missouri (MU) to achieve savings in its annual MSWM contract with City of Columbia. As a result, we did not consider the whole processes involved in a municipal solid waste management system. We approach the problem from waste collection perspective from the source generations to potential collection centers around the campus.

# Chapter 3

## Methodology

### 3.1. Overview of the Study

The composition of municipal solid waste management is different. Food waste, plastic containers, yard waste, market waste, and product packaging material along with other forms of solid waste contain the mainly composition of waste stream. In 2008, %58.3 of generated waste in Missouri is categorized in the group of municipal solid waste [47], demonstrating the importance of efficient municipal solid waste management planning.

Municipal solid waste management involves several processes. Figure 3-1 shows a graphical view of the processes involved in waste management planning. The first step is the collection process. The waste collection process includes all of the activities needed to collect waste from waste generation points to the collection centers (receptacles). When the trash is gathered in collection centers, trucks move around the city based on their schedule to pick up trash from the collection centers (receptacles). Then, since the waste is typically a combination of several kinds of trash, the waste management company separates and sorts them into groups. The first group is the recyclable items. Material made of metal, plastic, paper, etc. can be recycled and be used many times. The recycling process is really important in waste management planning because it prevents the waste of potential usable material. The second group is the non-recyclable waste items. The non-recyclable material should be transported for disposal to landfills. Reusable material like wood is another kind of waste that can help to prevent waste

production. The last group is organic materials. Organic waste are decomposed and recycled to be use as a fertilizer or soil amendment. All the mentioned processes involved in municipal waste management help to diminish disposal materials, reduce costs, and protect the environment.

In this research we focus on the waste management system of University of Missouri (MU). The goal of this research is to help the university to achieve cost savings in its annual waste disposal contract. While many researchers have studied the entire system of solid waste management, in this research we focus on optimizing the waste collection activities (the first process in figure 3-1). For waste disposal planning, MU has a contract with City of Columbia. Based on that contract, the City is supposed to collect all waste from around campus for disposal. The university pays the City of Columbia for providing trash receptacles and collecting the trash, but it is the responsibility of university to choose the best receptacle types, the best location sites, and best schedule for the collection process. Currently, MU does not utilize any operations research techniques to optimize this process which involves collecting the waste from sources (which are buildings around the campus) assigning the generated waste to receptacles located in potential collection sites, and finding the best collection-planning schedule for each type of receptacle located in each site.

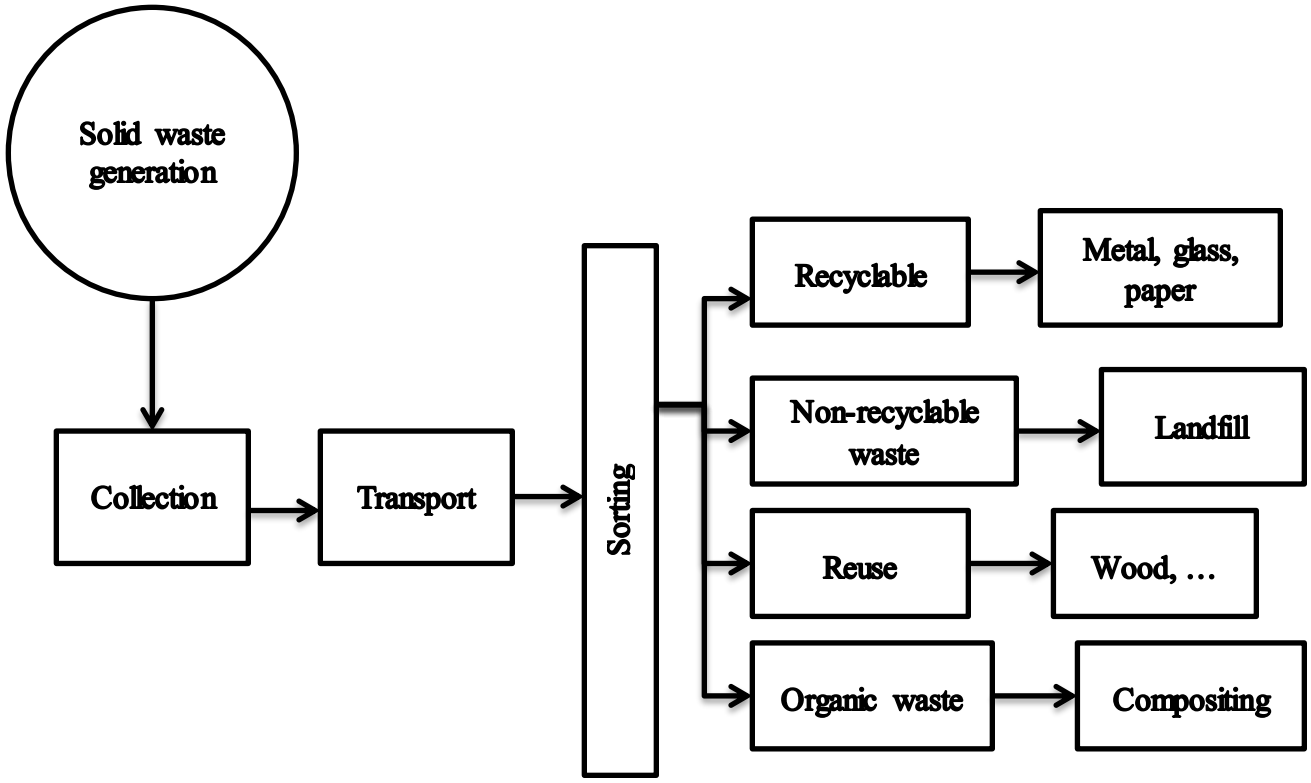


**Figure 3- 1: A graphical view of the processes involved in waste management planning**

## 3.2. Problem Definition

The University of Missouri is the largest educational institution in Missouri. There are several thousand faculty, staff, and students working and studying on the campus daily. Each of these faculty, staff and students generate waste daily in varying amounts. The objective of this research is helping the university to reduce its waste disposal cost by optimizing the MU`s municipal solid waste collection activities. For this reason we investigate the university`s bills and contract to find the procedure that City of Columbia charges the university.

### *3.2.1. Scope of the Contract*

The City offers 4 different containers including: dumpsters, compactors, roll-offs and cardboards containers for collecting trash (Figure 3-2). Based on the scope of the contract, the City provides labor, containers (except side walk containers), trucks and equipment necessary to pick up and dispose of all solid waste and recycling in accordance with the pickup schedule from the university. The city owns, maintains, repairs and replaces all containers, except the university owned containers (sidewalks). An important feature of the contract is that the City of Columbia does not charge the university for recyclable materials. The general pick up schedule is from 3:00 am to 11:00 am Monday through Friday.

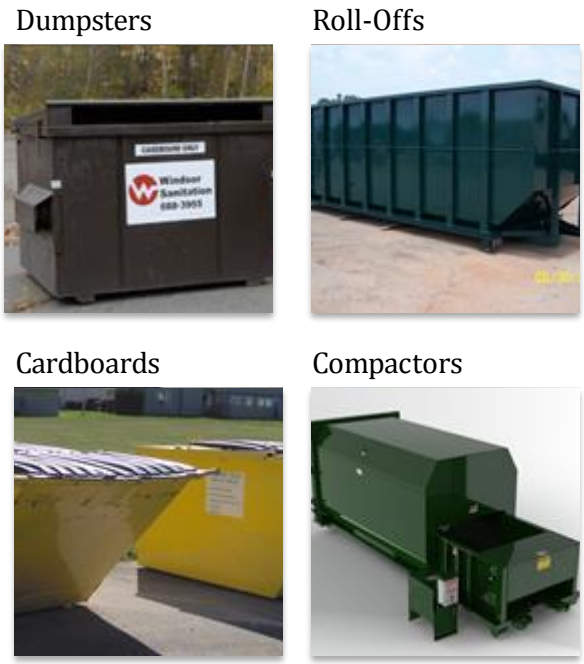


**Figure 3- 2: Receptacle types**

### *3.2.2. Overview of the Study Problem*

There are 111 buildings around campus that currently house receptacles serviced by the city. All 171 receptacles are distributed over these 111 building to collect waste. Figure 3-3 shows the distribution of receptacles over 111 locations. In some location we just have dumpsters, roll-offs, or compactors, while in other we see their different combinations.

As discuss previously, one kind of receptacles used around campus are dumpsters. Estimating the cost associated with dumpsters is straightforward. Indeed, we just need to know the capacity of dumpster and the desired frequency of service to calculate the total cost (Table 3-1); although choosing an appropriate capacity and frequency of service clearly depends upon the volume of trash generated daily at each site. This kind of receptacle may not be efficient because we are not sure whether or not a dumpster is full

when city services it. Currently, the university uses 2-yard dumpsters more frequently than the larger dumpsters. Of the 142 dumpsters distributed around campus, 132 of them are 2-yard dumpsters. In some locations we have 2 or more 2-yard dumpsters allocated in one site. This is counter intuitive, since two 2-yard dumpsters at one site could potentially be replaced with one 4-yard dumpsters, at a cost savings of 2*$129.77- $211.69=$47.85 per month, if serviced five times per week (similar reductions are possible for other dumpster sizes and frequency of service). Unfortunately, university does not have any data for dumpsters regarding their amount of trash per service for recent years, but analyzing the historical data based on the study done in 2003, shows we are not using dumpsters in an inefficient way. Indeed, we observe cases that dumpsters are not full while they got serviced. The second types of receptacles are compactors and roll-offs. The total associated cost in waste collection process for compactors and roll-offs is not straightforward to estimate. Compactors and roll-offs costs depend on the tonnage fee, pulled fee, and depreciation fee:

- Total tonnage removed, at a rate of $34.96 per ton
- Number of times receptacle is serviced ("pulled"):
    - $50.93 per pull for mini (i.e., 14-yard or 15-yard) compactors and roll-offs
    - $71.64 per pull for full-size compactors and roll-offs
- Depreciation fee associated with compactors

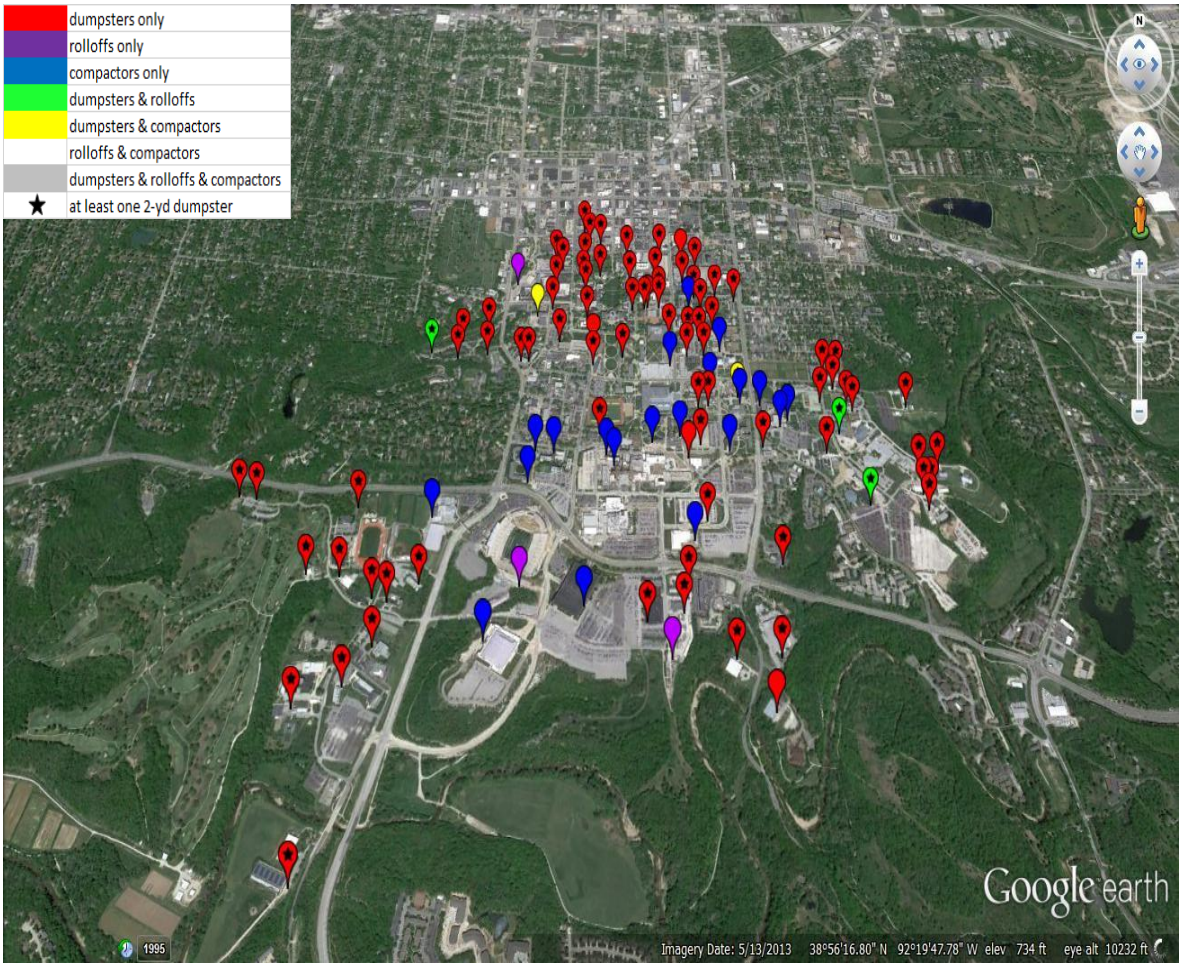


**Figure 3- 3: Distribution of receptacles around campus**

| Services per week | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| 2 Cubic Yard | $ 60.55 | $ 77.85 | $ 95.16 | $ 112.46 | $ 129.77 |
| 4 Cubic Yard | $ 73.25 | $ 107.86 | $ 142.47 | $ 177.08 | $ 211.69 |
| 6 Cubic Yard | $ 88.72 | $ 140.63 | $ 192.55 | $ 244.45 | $ 296.37 |
| 8 Cubic Yard | $ 103.26 | $ 172.48 | $ 241.69 | $ 310.91 | $ 380.00 |

**Table 3- 1: Dumpster service cost based on capacity and frequency of service**

Therefore, based on the volume of trash assigned to compactor and roll-offs, we will have different tonnage fees. The pull fee is a constant fee that does not depend on the volume of trash assigned to these kinds of receptacles. Similar to the charges for dumpsters, when the city services a compactor or roll-off, MU will be charged for pulled fee whether the receptacle is full or not. To the extort that MU can request service for roll-offs and compactors only when they are full, these receptacle types could be more efficient. However, the historical data for compactors-roll offs shows there was many times that city serviced the receptacles while they were almost empty. This suggests that the university is not tracking roll-offs and compactors` service in a proper way.

Optimizing the municipal solid waste management process for University of Missouri is a complicated process. We have three different types of receptacles that can be allocated to different locations. They are charged differently which makes the process of choosing the best ones for the best locations hard. In this study, we look for the best collection sites among the 111 potential options, assign the waste generation points (buildings around campus) to these opened collection sites, and also define the frequency of service the City of Columbia needs to service each dumpster.

### 3.3. Model Formulation

With the overview of study, let us restate the problem: determining the best collection centers between potential locations while allocation their proper receptacle types, assigning the waste generation sources (buildings) to best collection centers, and determining the collection schedule are the decisions to be made for optimizing MU`s

solid waste collection contract. We will utilize operational research techniques to help decision makers solve this problem. In this study, with help of mathematical modeling, we try to reduce the total waste collection cost associated with dumpsters, compactors, and roll-offs.

### *3.3.1. Waste Collection Contract Structure: Deterministic Optimization*

In the scope of cost benefit analysis, consider a waste management system with many potential waste collection centers. Waste can be collected with 3 different types of receptacles. The decision maker should choose which collection center should be opened, and what kind of receptacles should be assigned to the opened centers. This system also has many waste generation points. Each waste generation point should allocate its waste to one of the opened collection centers. It is the responsibility of decision maker (in our case, the university) to optimize assignment of the waste generation points to the opened collection centers, in order to minimize the total cost while ensuring sufficient service (i.e., all generated trash is collected). Furthermore, the manager should decide about the collection schedule (how many times per week a location should be serviced, and which specific days of the week service a particular site). All of these decisions should be taken for optimizing the collection process and reducing costs. For modeling the problem we first will review all of the assumptions we considered:

**Assumptions:**

- City of Columbia offer 3 different receptacles: dumpsters, compactors, and roll-offs
- Each type of receptacles is available in different capacities

- The maximum service frequency that City offers is equal to 5 which means that City can give service to a location at most 5 times a week.
- City services locations 52 weeks of the year, Monday through Fridays
- We assume a constant amount of trash is generated at each building on each day of the week (although there are differences across buildings, and differences across days of the week for a single building).
- Waste collection fees for dumpsters, compactors, and roll offs are known.

To accommodate the planning of such system, we developed an MILP model. This model is presented below:

Minimize

$$\sum_{j}\sum_{u}\sum_{f} 12\, x_{juf}\theta_{uf} + \sum_{j}\sum_{c}\sum_{d} 52\ \Pi_C\ \frac{\boldsymbol{r_{jcd}}}{\beta_c} + \sum_{j}\sum_{c}\sum_{d} 52\, \boldsymbol{r_{jcd}}\frac{\Phi_c}{20} + \sum_{j}\sum_{c} 12\, q_{jc}\ \Omega_C$$

Subject to:

$$\sum_{j} w_{ij} = 1 \qquad \forall\, i \qquad (1)$$

$$\sum_{d_2} \boldsymbol{z_{ijd_1d_2}} + \boldsymbol{v_{ijd_1}} = \alpha_{id_1} w_{ij} \qquad \forall\, i, j, d_1 \in \mathcal{D} \qquad (2)$$

$$\sum_{i} \boldsymbol{v_{ijd_1}} = \sum_{\boldsymbol{c}} \boldsymbol{r_{jcd}} \qquad \forall\, j, d_1 \in \mathcal{D} \qquad (3)$$

$$\sum_{i}\sum_{d_1} \boldsymbol{z_{ijd_1d_2}} = \sum_{\boldsymbol{u}} \boldsymbol{a_{jud_2}} \qquad \forall\, j, d_2 \in \mathcal{D} \qquad (4)$$

$$\boldsymbol{a_{jud_1}} \leq \beta_u \boldsymbol{q_{ju}} \qquad \forall\, j,u, d_1 \in \mathcal{D} \qquad (5)$$

$$\sum_{k} \gamma_k\, \boldsymbol{q_{jk}} \leq \epsilon_j \qquad \forall\, j \qquad (6)$$

$$\sum_{u} \boldsymbol{a_{jud_1}} \leq M y_{jd_1} \qquad \forall\, j, d_1 \in \mathcal{D} \qquad (7)$$

$$\boldsymbol{z_{ijd_1d_1}} \geq \alpha_{id_1} y_{jd_1} - \boldsymbol{v_{ijd_1}} + \boldsymbol{M}(w_{ij} - 1) \qquad \forall\, i, j, d_1 \in \mathcal{D} \qquad (8)$$

$$\boldsymbol{z_{ijd_1d_1}} + \boldsymbol{z_{ijd_1(d_1+1)}} \geq \alpha_{id_1} y_{j(d_1+1)} - \boldsymbol{v_{ijd_1}} + \boldsymbol{M}(w_{ij} - 1) \qquad \forall\, i, j, d_1 \in \mathcal{D} \qquad (9)$$

$$\boldsymbol{z_{ijd_1d_1}} + \boldsymbol{z_{ijd_1(d_1+1)}} + \boldsymbol{z_{ijd_1(d_1+2)}} \geq \alpha_{id_1} y_{j(d_1+2)} - \boldsymbol{v_{ijd_1}} + \boldsymbol{M}\big(w_{ij} - 1\big) \qquad \forall\, i, j, d_1 \in \mathcal{D} \qquad (10)$$

$$\boldsymbol{z_{ijd_1d_1}} + \boldsymbol{z_{ijd_1(d_1+1)}} + \boldsymbol{z_{ijd_1(d_1+2)}} + \boldsymbol{z_{ijd_1(d_1+3)}} \geq \alpha_{id_1} y_{j(d_1+2)} - \boldsymbol{v_{ijd_1}} + \boldsymbol{M}(w_{ij} - 1) \qquad \forall\, i, j, d_1 \in \mathcal{D} \qquad (11)$$

$$\sum_{f} p_{jf} = \sum_{d} y_{jd} \qquad \forall\, j \qquad (12)$$

$$p_{jf_2} \leq p_{jf_1} \qquad \forall\, j \qquad (13)$$

$$p_{jf_3} \leq p_{jf_2} \qquad \forall\, j \qquad (14)$$

$$p_{jf_4} \leq p_{jf_3} \qquad \forall\, j \qquad (15)$$

$$p_{jf_5} \leq p_{jf_4} \qquad \forall\, j \qquad (16)$$

$$x_{juf} \geq q_{ju} + M(p_{jf} - 1) \qquad \forall\, j,u,f \qquad (17)$$

$$v_{ijd} \geq 0;\ r_{jcd} \geq 0;\ z_{ijd_1d_2} \geq 0;\ a_{jud} \geq 0 \qquad \forall\, i; j; d_1, d_2 \in \mathcal{D} \qquad (18)$$

$$q_{jk} \geq 0 \text{ ; Integer} \qquad \forall\, j,k \qquad (19)$$

$$x_{juf} \geq 0 \text{; Integer} \qquad \forall\, j,u,f \qquad (20)$$

$$w_{ij} = 0 \ or\ 1 \qquad \forall\, i; j \qquad (21)$$

$$y_{jd} = 0 \ or\ 1 \qquad \forall\, j,d \qquad (22)$$

$$p_{jf} = 0 \; or \; 1 \qquad \forall \, j, f \qquad (23)$$

Where:

| | |
|---|---|
| $\mathcal{I}$ | Waste generation source locations |
| $\mathcal{J}$ | Potential waste collection sites |
| $\mathcal{K}$ | Receptacle types |
| $\mathcal{C} \subset \mathcal{K}$ | Compactors and roll offs |
| $\mathcal{U} \subset \mathcal{K}$ | Dumpsters |
| $\mathcal{D}$ | Days of week, $\mathcal{D}$ = {Mon, Tue, Wed, Thu, Fri} |
| $\mathcal{F}$ | Frequency of service per week $\mathcal{F}$ = {$f_1$, $f_2$, $f_3$, $f_4$, $f_5$} |

3.6.1.1. Decision Variables

The decision variables in our model are:

$$w_{ij} = \begin{cases} 1 \text{ if waste generated at location } i \text{ is collected at site } j \\ 0 \qquad\qquad otherwise \end{cases}$$

$$y_{jd} = \begin{cases} 1 \text{ if dumpsters at site } j \text{ are serviced on day } d \\ 0 \qquad\qquad otherwise \end{cases}$$

$$p_{jf} = \begin{cases} 1 \text{ if dumpsters at site } j \text{ are serviced at least} \|f\| \text{ times per week} \\ 0 \qquad\qquad otherwise \end{cases}$$

$\boldsymbol{v_{ijd}}$ Volume of trash generated at location $i$ on day $d$ that is assigned to compactors

| | |
|---|---|
| | and roll offs at site $j$ |
| $\boldsymbol{r_{jcd}}$ | Volume of trash generated on day $d$ that is assigned to compactors and roll offs at site $j$ |
| $\boldsymbol{z_{ijd_1d_2}}$ | Volume of waste generated at location $i$ on day $d_1$ that is assigned to a dumpster at site $j$ and serviced on day $d_2$ |
| $\boldsymbol{a_{jud}}$ | Volume of trash assigned to dumpsters of type $u$ at site $j$ that are serviced on day $d$ |
| $\boldsymbol{x_{juf}}$ | Number of dumpsters at site $j$ that are serviced at least $\|\|f\|\|$ times per week |
| $\boldsymbol{q_{jk}}$ | Number of receptacles of type k at site j |

3.6.1.2. Parameters

The input data parameters in our work are:

| | |
|---|---|
| $\theta_{uf}$ | Incremental cost for receiving service $\|\|f\|\|$ times per week (beyond cost for receiving service $\|\|f-1\|\|$times per week) for dumpster of type $u$ |
| $\Pi_C$ | Fixed cost per service for receptacle of type $c$ |
| $\Phi_c$ | Variable cost per ton of trash received from compactor and roll-offs of type $c$ |
| $\alpha_{id}$ | Volume of trash generated at location $i$ on day $d$ |
| $\beta_k$ | Capacity of receptacle type $k$ |
| $\gamma_k$ | Area of space required at location per receptacle of type $k$ |
| $\epsilon_j$ | Area available for trash receptacles at site $j$ |
| $DIST_{ij}$ | Distance between waste generation source $i$ and collection site $j$ |
| $\Omega_C$ | Monthly depreciation fee per receptacle of type $c$ |

3.6.1.3. The description of objective function and constraints

The objective function is minimizing the total cost for collecting waste in system. The first term computes the collection costs for dumpsters. Based on the table (3-1), this cost depends on the dumpster capacity and frequency of service. The three other terms estimate the cost associated with compactors and roll offs. First we have pull fee. For estimating the pull fee, we need to calculate the number of times each compactor and roll off needs to be pulled. This can be calculated by dividing the total allocated waste over their capacity. Second we need to consider the total tonnage fee. Since waste is allocated to receptacles in ton, we need to change its unit to cubic yard which is the receptacle`s capacity unit. We assume that a cubic yard equals to 20 tons. The last term identifies the depreciation fee for compactors and roll offs.

Equation (1) makes sure that all waste generated at location *i* is serviced on one location *j*. Equation (2) implies that if waste generated at location *i* is collected at site *j*, then the total trash generated at location *i* on day $d_1$ equals the total trash assigned to receptacles at location *j*. Equation (3) balances the total quantity of trash allocated to compactors and roll offs at location *j* and amount of waste allocated to each type of these receptacles at that location. Equation (4) similarly balances the total waste assigned and allocated to dumpsters at location *j* with the amount assigned to each dumpster type at location *j*. In equation (5) we ensure that volume of trash assigned to dumpsters at location *j* is less than their total available capacity. Constraint (6) makes certain that we have enough space available for the desired receptacles at location *j*. Equation (7) ensures that dumpster type u is only serviced at site *j* on day $d_1$ if that site received dumpster service on that day. We need to relate the day that dumpster serviced trash is generated to

the first-scheduled service date following generation. This is accomplished through constraints (8) to (11). For dumpsters we need to compute the number of services per week to determine the cost. For this reason, constrains (12) through (16) translate the day of service each week in to the number of weekly services. Constraint (17) then compute the number of dumpsters serviced at least *f* times per week at each location. Equation (18) ensures the non-negativity of decision variables. Some of the decision variables are also integers that are shown in constraints (19) and (20). Meanwhile we have some binary decision variables, as defined in constraints (22) to (23).

Equations (1-7) are found in a typical MILP facility location model. In these constraints we are identifying the best assignment of waste generation points to each collection site. What makes our mathematical modeling different from typical models, are constraints (8) to (17) that track waste allocated to dumpsters and compute the resulting frequency of service at each site.

### *3.3.2. Waste Collection Contract Structure: Robust Optimization*

The University of Missouri provides us historical data related to roll offs and compactors. These historical data show variability in receptacles` weight when they are serviced. Variability can affect costs associated with dumpsters, compactors, and roll offs. Even for a fixed weight, for compactors and roll offs cost variability occurs due to pull fees, since the receptacle weight when it is pulled is not constant. Figure (3-4) shows the variability of amount of trash per pull that was serviced over the interval 20- to 20- for all 30-yard roll offs. As shown by the figure, the amount of trash per service for this receptacle varies from 0.5 to 9.5 tons. It shows around 50 times this receptacle was

serviced when it was allocated just 0.5 ton. To accommodate this uncertainty we utilize Robust Optimization (RO) models.

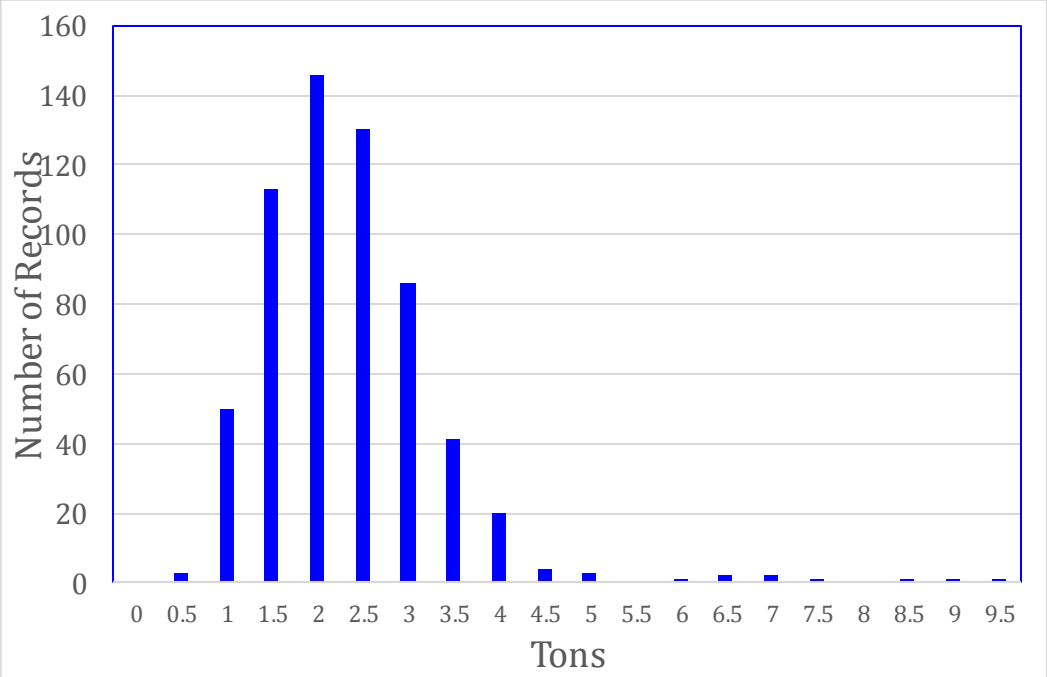


**Figure 3- 4: Variability in weight per pull (30-yard Roll off)**

Since we have uncertainty in amount of trash assigned to receptacles when they are serviced, we need to address this uncertainty in our modeling to get a more reliable result. For this reason we develop a Robust Optimization model.

We developed our robust optimization model based on the approach proposed by Bertsimas and Sim (2003). In this optimization modeling we can control the level of robustness through use of a *protection level* data parameter.

**Minimize**

$$\sum_{j}\sum_{u}\sum_{f} 12\ x_{juf}\theta_{uf} + \sum_{j}\sum_{c}\sum_{d} 52\ \Pi_C\ \frac{\boldsymbol{r_{jcd}}}{\beta_c} + \sum_{j}\sum_{c}\sum_{d} 52\ \boldsymbol{r_{jcd}}\frac{\Phi_c}{20} +$$

$$\sum_{j}\sum_{c} 12\ q_{jc}\ \Omega_C\ + S_0\ \eta_0 + \sum_{j}\sum_{c}\sum_{d} T_0_{jcd}$$

Subject to:

$$\sum_{j} w_{ij} = 1 \qquad \forall\ i \qquad (1)$$

$$\sum_{d_2} \boldsymbol{z_{ijd_1d_2}} + \boldsymbol{v_{ijd_1}} = \alpha_{id_1} w_{ij} \qquad \forall\ i,j,d_1 \in \mathcal{D} \qquad (2)$$

$$\sum_{i} \boldsymbol{v_{ijd_1}} = \sum_{\boldsymbol{c}} \boldsymbol{r_{jcd}} \qquad \forall\ j,d_1 \in \mathcal{D} \qquad (3)$$

$$\sum_{i}\sum_{d_1} \boldsymbol{z_{ijd_1d_2}} = \sum_{\boldsymbol{u}} \boldsymbol{a_{jud_2}} \qquad \forall\ j,d_2 \in \mathcal{D} \qquad (4)$$

$$\boldsymbol{a_{jud_1}} \leq \beta_u \boldsymbol{q_{ju}} \qquad \forall\ j,u,d_1 \in \mathcal{D} \qquad (5)$$

$$\sum_{k} \gamma_k\ \boldsymbol{q_{jk}} \leq \epsilon_j \qquad \forall\ j \qquad (6)$$

$$\sum_{u} \boldsymbol{a_{jud_1}} \leq M y_{jd_1} \qquad \forall\ j,d_1 \in \mathcal{D} \qquad (7)$$

$$\boldsymbol{z_{ijd_1d_1}} \geq \alpha_{id_1} y_{jd_1} - \boldsymbol{v_{ijd_1}} + \boldsymbol{M}(w_{ij} - 1) \qquad \forall\ i,j,d_1 \in \mathcal{D} \qquad (8)$$

$$\boldsymbol{z_{ijd_1d_1}} + \boldsymbol{z_{ijd_1(d_1+1)}} \geq \alpha_{id_1} y_{j(d_1+1)} - \boldsymbol{v_{ijd_1}} + \boldsymbol{M}(w_{ij} - 1) \qquad \forall\ i,j,d_1 \in \mathcal{D} \qquad (9)$$

$$\boldsymbol{z_{ijd_1d_1}} + \boldsymbol{z_{ijd_1(d_1+1)}} + \boldsymbol{z_{ijd_1(d_1+2)}} \geq \alpha_{id_1} y_{j(d_1+2)} - \boldsymbol{v_{ijd_1}} + \boldsymbol{M}\big(w_{ij} - 1\big) \qquad \forall\ i,j,\ d_1 \in \mathcal{D} \qquad (10)$$

$$\boldsymbol{z_{ijd_1d_1}} + \boldsymbol{z_{ijd_1(d_1+1)}} + \boldsymbol{z_{ijd_1(d_1+2)}} + \boldsymbol{z_{ijd_1(d_1+3)}} \geq \alpha_{id_1} y_{j(d_1+2)} - \boldsymbol{v_{ijd_1}} + \boldsymbol{M}(w_{ij} - 1) \qquad \forall\ i,j,\ d_1 \in \mathcal{D} \qquad (11)$$

$$\sum_{f} p_{jf} = \sum_{d} y_{jd} \qquad \forall\, j \qquad (12)$$

$$p_{jf_2} \leq p_{jf_1} \qquad \forall\, j \qquad (13)$$

$$p_{jf_3} \leq p_{jf_2} \qquad \forall\, j \qquad (14)$$

$$p_{jf_4} \leq p_{jf_3} \qquad \forall\, j \qquad (15)$$

$$p_{jf_5} \leq p_{jf_4} \qquad \forall\, j \qquad (16)$$

$$x_{juf} \geq q_{ju} + M(p_{jf} - 1) \qquad \forall\, j,u,f \qquad (17)$$

$$S_0 + T_0_{jcd_1} \geq d_{j,c}\, Yr_{jcd} \qquad \forall\, j,c,d_1 \in \mathcal{D} \qquad (18)$$

$$-Yr_{jcd_1} \leq r_{jcd_1} \leq Yr_{jcd_1} \qquad \forall\, j,c,d_1 \in \mathcal{D} \qquad (19)$$

$$v_{ijd} \geq 0;\ r_{jcd} \geq 0;\ z_{ijd_1d_2} \geq 0;\ a_{jud} \geq 0 \qquad \forall\, i;j;d_1,d_2 \in \mathcal{D} \qquad (20)$$

$$q_{jk} \geq 0 \text{ ; Integer} \qquad \forall\, j,k \qquad (21)$$

$$x_{juf} \geq 0 \text{; Integer} \qquad \forall\, j,u,f \qquad (22)$$

$$w_{ij} = 0\ or\ 1 \qquad \forall\, i;j \qquad (23)$$

$$y_{jd} = 0\ or\ 1 \qquad \forall\, j,d \qquad (24)$$

$$p_{jf} = 0\ or\ 1 \qquad \forall\, j,f \qquad (25)$$

Where:

| | |
|---|---|
| $\mathcal{I}$ | Waste generation source locations |
| $\mathcal{J}$ | Potential waste collection sites |
| $\mathcal{K}$ | Receptacle types |
| $\mathcal{C} \subset \mathcal{K}$ | Compactors and roll offs |
| $\mathcal{U} \subset \mathcal{K}$ | Dumpsters |

| | |
|---|---|
| $\mathcal{D}$ | Days of week, $\mathcal{D}$ = {Mon, Tue, Wed, Thu, Fri} |
| $\mathcal{F}$ | Frequency of service per week $\mathcal{F}$ = {$f_1$, $f_2$, $f_3$, $f_4$, $f_5$} |

3.6.2.1. Decision Variables

There are several decision variables included in RO model:

$$w_{ij}=\begin{cases}1 \text{ if waste generated at location } i \text{ is collected at site } j\\ 0 \qquad\qquad otherwise\end{cases}$$

$$y_{jd}=\begin{cases}1 \text{ if dumpsters at site } j \text{ are serviced on day } d\\ 0 \qquad\qquad otherwise\end{cases}$$

$$p_{jf}=\begin{cases}1 \text{ if dumpster at site } j \text{ are serviced at least} \|f\| \text{ times per week}\\ 0 \qquad\qquad otherwise\end{cases}$$

| | |
|---|---|
| $v_{ijd}$ | Volume of trash generated at location $i$ on day $d$ that is assigned to compactors and roll offs at site $j$ |
| $r_{jcd}$ | Volume of trash generated on day $d$ that is assigned to compactors and roll offs at site $j$ |
| $z_{ijd_1d_2}$ | Volume of waste generated at location $i$ on day $d_1$ that is assigned to a dumpster at site $j$ and serviced on day $d_2$ |
| $a_{jud}$ | Volume of trash assigned to dumpsters of type $u$ at site $j$ that are serviced on day $d$ |
| $x_{juf}$ | Number of dumpsters at site $j$ that are serviced at least $\|\|f\|\|$ times per week |
| $q_{jk}$ | Number of receptacles of type k at site j |
| $S_0$ | Robust variable_1 |
| $T_0_{jcd}$ | Robust variable_3 |
| $Yr_{jcd}$ | Robust variable_5 |

3.6.2.2. Parameters

To calculate the decision variables, we also introduce these parameters:

| | |
|---|---|
| $\theta_{uf}$ | Incremental cost for receiving service $\|\|f\|\|$ times per week (beyond cost for receiving service $\|\|f-1\|\|$times per week) for dumpster of type $u$ |
| $\Pi_c$ | Fixed cost per service for receptacle of type $c$ |
| $\Phi_c$ | Variable cost per ton of trash received from compactor and roll-offs of type $c$ |
| $\alpha_{id}$ | Volume of trash generated at location $i$ on day $d$ |
| $\beta_k$ | Capacity of receptacle type $k$ |
| $\gamma_k$ | Area of space required at location per receptacle of type $k$ |
| $\epsilon_j$ | Area available for trash receptacles at site $j$ |
| $DIST_{ij}$ | Distance between waste generation source $i$ and collection site $j$ |
| $\Omega_c$ | Monthly depreciation fee per receptacle of type $c$ |
| $\eta_0$ | Protection level of robustness in the objective function |
| $d_{j,c}$ | Maximum allowable deviation in objective function coefficient terms (cost) for receptacle type c |

3.6.2.3. The description of objective function and constraints

The RO model is very similar to the deterministic optimization model; however, it has two new data parameters and three new variables. In RO model we have all the constraints and terms in objective function for nonrobust model plus two other new constraints along with two new terms in objective function. As we discussed before,

$r_{jcd}$ is volume of trash generated on day d that is assigned to compactors of type c at site j. Equation (19) computes $Yr_{jcd}$ as the absolute value of $r_{jcd}$. As a result, $d_{jc}\ Yr_{jcd}$ in equation (18) represents the maximum allowable deviation in cost as a result of variations in $r_{jcd}$. $S_0$, relates deviations in cost to the level of $\eta_0$. For instance, if we consider level of robustness ($\eta_0$) equals to 2, $S_0$ represent the second largest deviation in cost. Therefore $T_0_{jcd}$ is the maximum of zero and the difference between any individual deviations and the second largest value ($S_0$). Indeed, these two constraints help us to track $S_0$ and $T_0_{jcd}$, and add worst-case cost increase at protection level $\eta_0$ two other terms in the objective function.

Note that we are not assuming uncertainty in the amount of trash generated at each site on each day. Instead, we are assuming uncertainty in the volume at which each roll off and compactor will be serviced.

GAMS/ CPLEX software was used to solve the model under different scenarios and identify potential waste collection network designs. In the next chapter we will run the two represented models for different scenarios and will discuss how they differ and how much savings we can achieve while optimizing this process.

# Chapter 4

## Computational Result

We now present the result of applying our optimization models to the problem faced by the University of Missouri.

In these models, we identify which collection centers to open, assign waste generation points to opened collection center, and define the best collection schedule. First we will implement the deterministic optimization model to optimize the solid waste management process of the university. Then, since uncertainty exists in the amount of trash assigned to compactors and roll offs per service, we will approach the problem with robust optimization method. At the end we will discuss how their result differ and how much savings can MU potentially achieve.

### 4.1. Application in University of Missouri

#### *4.1.1. System Overview*

Students, faculty, and staff are the main waste generators in campus. Currently, the City of Columbia collects trash from 111 buildings around campus. For our analysis, we will consider these 111 buildings as trash generators. Each of these 111 buildings is also considered as a potential trash collection center. Collection centers are equipped with 3 different receptacles in different capacities:

Dumpsters: 2yard, 4yard, 6yard, 8yard

Compactors: 14yard, 15yard, 25yard, 28yard, 35yard, 28yard-dual compactor, 35yard-dual compactor (dual compactors collect both trash and recyclables, in separate compartments)

Roll offs: 14yard, 20yard, 30yard, 35yard, and 40yard

MU has a contract with City of Columbia to collect waste around campus. Based on the contract, City services the locations at most 5 times a week, Monday to Friday.

### *4.1.2. Current Cost associated with receptacles around campus*

The campus facility total bill for solid waste disposal contract from May 2013 to April 2014 is $463,486. This includes dumpsters, compactors, roll-offs, and sidewalk containers. In discussions with the university, they stated that sidewalk containers were not viewed a critical component of the total bill, since sidewalk containers were only responsible for $41,735 of the total bill. Thus, we do not consider the sidewalk containers in our optimization procedure. Therefore, the total bill excluding sidewalk container charges is equal to $421, 752. There are 258 permanent receptacles around campus. 79 of them are recycling receptacles. As mentioned above, MU is not charged for service to recycling receptacles. Thus, we do not consider cardboards and recyclable containers in our optimization process. This leaves dumpsters, compactors, and roll-offs as the receptacle types we consider in this research. This $421,752 is cost associated with 179 receptacles over campus. We further limited our analysis (again, based on the recommendations of our research sponsors in the university) to consider only receptacles in the main campus area. Because 8 of these 179 receptacles are not located in the main

campus area, we exclude them in our analysis. Thus, our research will optimize the collection process and reduce the associated cost for 171 receptacles included in the main campus area. To obtain a baseline for analysis, we need to estimate these associated with the 171 receptacles in the main campus area (since this cost must be less than the $421,752 associated with all 179 receptacles). In the following section, we look how we estimate the total bill for 171 receptacles included in our analysis.

### *4.1.3. Computing Current Cost associated with 171 receptacles included in our analysis*

It is straightforward to compute the cost associated with dumpsters (table 4-1). Dumpsters are charged based on their capacity and frequency of service. For instance if we consider a 4 cubic yard dumpster with 3 times service in a week, the university pays $142.47 per month.

| Services per week | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| 2 Cubic Yard | $ 60.55 | $ 77.85 | $ 95.16 | $ 112.46 | $ 129.77 |
| 4 Cubic Yard | $ 73.25 | $ 107.86 | $ 142.47 | $ 177.08 | $ 211.69 |
| 6 Cubic Yard | $ 88.72 | $ 140.63 | $ 192.55 | $ 244.45 | $ 296.37 |
| 8 Cubic Yard | $ 103.26 | $ 172.48 | $ 241.69 | $ 310.91 | $ 380.00 |

**Table 4- 1: Dumpsters service cost based on capacity and frequency of service**

The bill received from the City shows MU is charged for 142 dumpsters, 140 of which are included in our analysis (the ones that are located in the main campus area). Table 4-2 shows the number of each size of dumpster in the university`s current contract in the main campus area.

| Dumpsters | 2 yard | 4 yard | 6 yard | 8 yard |
|---|---|---|---|---|
| | 132 | 1 | 3 | 4 |

**Table 4- 2: Distribution of dumpsters around campus**

The total annualized bill associated from May 2013 to April 2014 with this subset of 140 dumpsters is equal to $189,120 (including the two dumpsters that are not in campus area, the total dumpster charge is equal to $192,533). Given total dumpster charge, we can now identify the cost associated with all compactors and roll-offs on the MU contract from May 2013 to April 2014 as: $421,752 – $192,533 = **$229,219**.

Compactors and roll offs are charged in a very different way than are dumpsters. Compactors and roll-offs are billed based on (a) tonnage fee at a rate of $34.96 per ton, (b) number of times the receptacle is serviced ("pulled"), and (c) depreciation fee. The pull fee is different based on the receptacle`s size. For 14 and 15-yard ("mini") compactors and roll-offs the university is charged $50.93 per pull, and for other sizes the charge is $71.64 per pull. While the total depreciation charge appears on the university bill, it is unclear for university how the depreciation fee is calculated for each type of receptacle. Across the total contract, from May 2013 to April 2014, MU was billed for:

- 3,587 compactor and roll-off tons, at a total cost of $125,418
- 277 mini compactor and roll-off pulls, at a total cost of $14,108
- 1,057 full-size compactor and roll-off pulls, at a total cost of $75,723
- Depreciation fee on compactors, at a total cost of $13,970

This total corresponds to the previously mentioned total cost across 37 compactors and roll-offs on contract of **$229,219.**

Across the entire contract, the university is charged for 26 compactors and 11 roll-offs; however, 22 compactors and 9 roll-offs are considered in the main campus area. Table (4-3) and (4-4) shows the different types of compactors and roll-offs in the university`s current contract on the main campus area.

| | Mini | Full | Dual |
|---|---|---|---|
| Compactors | 4 | 14 | 4 |

**Table 4- 3: Distribution of compactors around campus**

| | Mini | Full |
|---|---|---|
| Roll-offs | 1 | 8 |

**Table 4- 4: Distribution of roll offs around campus**

Thus it is considerably more difficult to estimate current cost associated with set of compactors and roll-offs Included in our analysis. To compute their costs, we need to know the tonnage and number of pulls for these 31 receptacles. Unfortunately, we do not have these data for time period May 2013 to April 2014. MU provided us with a spreadsheet containing the date and pull weight for each compactor and roll-off pull, over the period January 2007 through June 2013. In our analysis we used data from January 2012 through June 2013 to estimate the volume of trash generated at each compactor and roll-off.

We estimated annual costs for 31 compactors and roll-offs included in the university`s current contract on the main campus area.

- 3,899 compactor and roll-off tons, at a total cost of $136,326

- 127 mini compactor and roll-off pulls, at a total cost of $6,486
- 948 full-size compactor and roll-off pulls, at a total cost of $67,929
- Depreciation fee on compactors, at a total cost of $10,246 (It is unclear to MU how the city calculates the depreciation fee assessed to compactors. MU simply observes a line item of its monthly bill for depreciation.)

So, the estimated total cost across the 31 compactors and roll-offs located in the main campus is equal to **$220,986.**

This estimation is 9% greater than total trash pull weight recorded on contract from May 2013 to April 2014, despite fact that our analysis includes only 31 of 37 total compactors and roll-offs on contract, and 17% less than total trash pull cost recorded on contract from May 2013 to April 2014, roughly consistent with fact that our analysis includes 31 of 37 total compactors and roll-offs on contract. It should be mentioned that we assumed that pulls would occur when compactor or roll-off was at capacity. However, historical data generally shows pulls occurring at weights less than these capacities based values. Thus, total estimate of current annual costs for receptacles included in our analysis provides baseline for our analysis is: $220,986+ $189,120 = **$410,106.** Recall that total bill from May 2013 to April 2014, excluding sidewalk containers is $421,752. In next parts we discuss how deterministic and robust optimization models could potentially improve the MU`s municipal solid waste contract.

### 4.2. Application in University of Missouri: Deterministic Optimization

As discusses in chapter 3, we developed a deterministic optimization model is developed to minimize the total cost for MU`s municipal solid waste management

contract. Model (a) finds the best collection centers among all potential locations, and (b) allocates the waste generation points, which are buildings in this problem to the selected collection centers, and (c) defines the schedule for City to collect waste around campus. We next discuss modeling assumptions that were made.

**Assumptions:**

1. Each kind of receptacle has specific capacity. For example a 2-yard dumpster can be assigned at most 2 cubic yards waste. For dumpsters and roll-offs the available capacity is considered equal to their nominal capacities. For compactors we assume a 4-to-1 compacting ratio (i.e., 4 cubic yards of trash is received from the trash generation points can be compacted into a volume of one cubic yard.)
2. For choosing the best collection centers and assigning the waste generation points to them, the model needs to know the available space at each location. Indeed, since each of the mentioned receptacles needs a specific area, we have to know the available space at each potential collection point. For this reason, we assume no additional space is available for locating receptacles at any university building. Table (4-5) shows the area each type of receptacle needs. For example, in current situation, location $j_{98}$ (Veterinary Medicine – East Building) has two 2-yard dumpster, we assume the available area for this location equals to the space of two 2-yard dumpster which is 2 * 3024= 6048. Furthermore, we did not account for differences in why different buildings currently have different kinds of

receptacles (e.g., we don't consider if there's any special reason why a location currently prefers roll-offs to compactors).

| Receptacle | Capacity | Area (square inches) |
|---|---|---|
| Dumpster | 2YARD | 3024 |
| | 4YARD | 3888 |
| | 6YARD | 4752 |
| | 8YARD | 4752 |
| Roll Off | 14YARD | 14580 |
| | 20YARD | 25344 |
| | 30YARD | 23760 |
| | 35YARD | 22596 |
| | 40YARD | 22176 |
| Compactor | 14YARD | 21835 |
| | 15YARD | 23736 |
| | 25YARD | 23736 |
| | 28YARD | 23736 |
| | 35YARD | 23736 |
| | 28YARD-DUAL | 23736 |
| | 35YARD-DUAL | 23736 |

**Table 4- 5: Space required by each type of receptacle**

3. For choosing the best facility locations to open and assigning buildings to them, we need to know the daily-generated waste. University of Missouri does not have any current data shows how much waste is generated each day at each building. As a result we look for ways to estimate this parameter. The university performed a study on dumpster utilization in 2003. In this study, students had observed all dumpsters around campus to estimate what percentage of their capacity had been used each day. Using this data we estimated how much waste per day is generated at each building around campus. These buildings in the 2003 study were categorized into 10 groups: academic building, administrative buildings, apartments, residence halls, dining halls, medical buildings, parking garages,

recreation and athletic buildings, research buildings, and support buildings. Since number of dumpsters at each location has changed since 2003 has changed, we need to generalize our estimation to correspond to the current-day dumpster sites. For this reason first we computed the average dumpster percent utilization for each building category for each day of the week. For instance, the 2003 report shows, we have 50 academic buildings on campus with dumpsters. We computed the average percentage utilization of each dumpster on Mondays for all academic buildings. For our analysis, we estimated that the volume of waste generated in academic buildings on Mondays, would be equal to the average utilization computed above multiplied by the total dumpster capacity at each location. We perform these estimations for each day of the week, and for each building type.

We also need to estimate, how much waste on each day of the week is assigned to compactors and roll-offs. The sustainability office provided a spreadsheet which contains the date of service and the weight of receptacle for each compactor and roll off pull. These data provide the total trash generated at each site with a compactor or roll off, but they do not present details on differences associated with generation on different days of the week. We took the average trash generated per day (from the university spreadsheet) and modified it such that the day-of –the-week variation observed in dumpsters (for each building type) also applied to compactors and roll offs (maintaining, however, the average trash per day at each site observed in the spreadsheet.)

Now we can estimate the volume of trash generated in all buildings around campus per specific day. For instance if location *i* is equipped with a dumpster

and a compactor, we should estimate the volume of trash assigned to its dumpster on day d, and also calculate the allocated waste to its compactor on day Then sum these two numbers to find the total volume of trash this building generates on day d (figure 4-1).

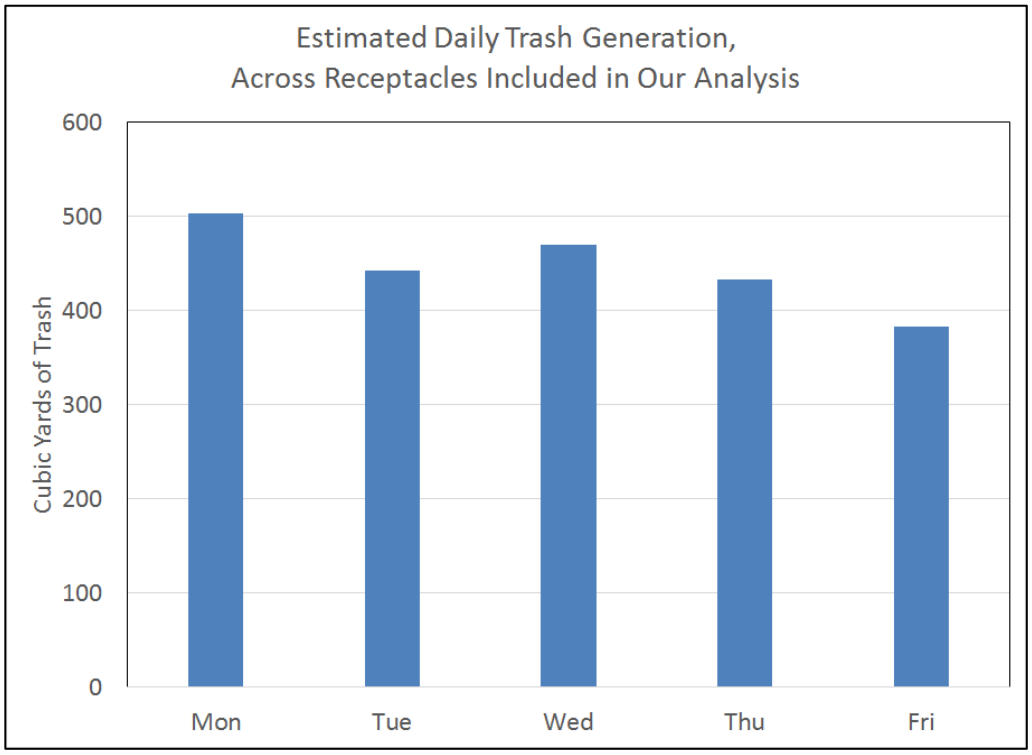


**Figure 4- 1: Trash per day of the week**

4. As we mentioned before, how city charges the university for depreciation cost is not clear. MU pays $10,245.84 per year for compactors. In this analysis we assume depreciation fee is equally divided between all compactor types, generating an average cost of $38.81 per month per compactor.

Now, we have all the required input parameters. GAMS/ CPLEX software is used to run the model. We ran the deterministic model considering two different scenarios. We know that distance is important in assigning buildings to collection centers. As a result, we calculate the distance between all 111 locations, and found that the maximum distance

between trash generation points is 1.757 miles. We recognized that assigning trash from generation point *i* to a different collection point *j* introduces a transportation requirement for university custodial staff. In discussions with university management, they viewed the current custodial staff manpower as being sufficient to handle this new transportation workload. University management also viewed existing vehicles as sufficient to handle the likely transportation requirements. However, probably the 1.757 miles is a long distance for transferring waste. Therefore, we decided to ran the model for two scenarios: in first scenario, no distance restriction exists, while in the second one, a trash generation point can only assign its trash to collection points located within a 0.25 mile radius.

Table (4-6) shows the result of the deterministic model for the MU`s solid waste management contract for these two scenarios.

| **Maximum allowable distance (mile)** | **Total Cost ($)** |
|---|---|
| 0.25 | 283,455.24 |
| 1.757 | 276,037.72 |

**Table 4- 6: Deterministic Optimization results**

Based on the April 2013 to May 2014 bill, MU pays **$410,106** per year for its waste disposal contract. These optimization results suggest the university can achieve considerable savings. For the first scenario, when we have no distance restriction, the total cost reduce 32.7% and when the maximum allowable distance is considered as 0.25 miles, we observe 30.8% decreases in cost. It is interesting that distance does not greatly affect the optimization result remarkably. The deterministic optimization result with maximum allowable distance of 1.757 miles reduces the 111 collection centers to 15

locations around campus (figure4-2). For maximum allowable distance of 0.25 miles, only 28 collection centers are required (figure4-3). These locations are equipped with dumpsters, compactors, roll offs, or their different combinations as shown in the figures.

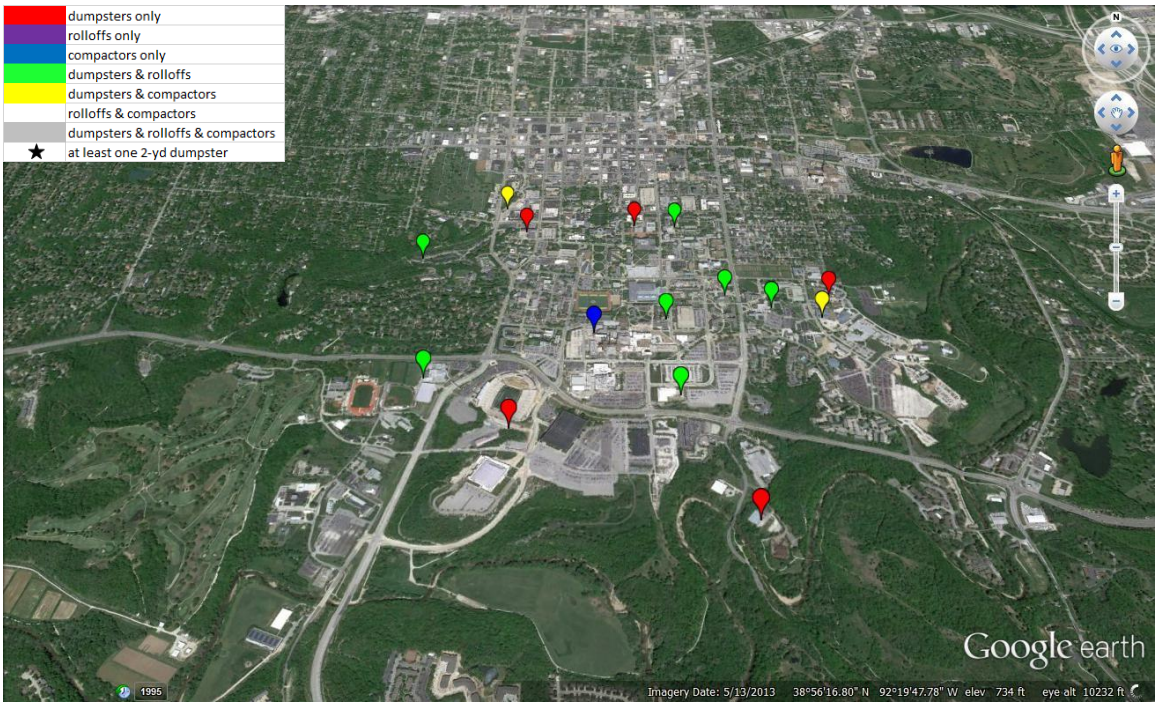


**Figure 4- 2: Distribution of Receptacles around campus-Nonrobust optimization result (Max distance: 1.757)**

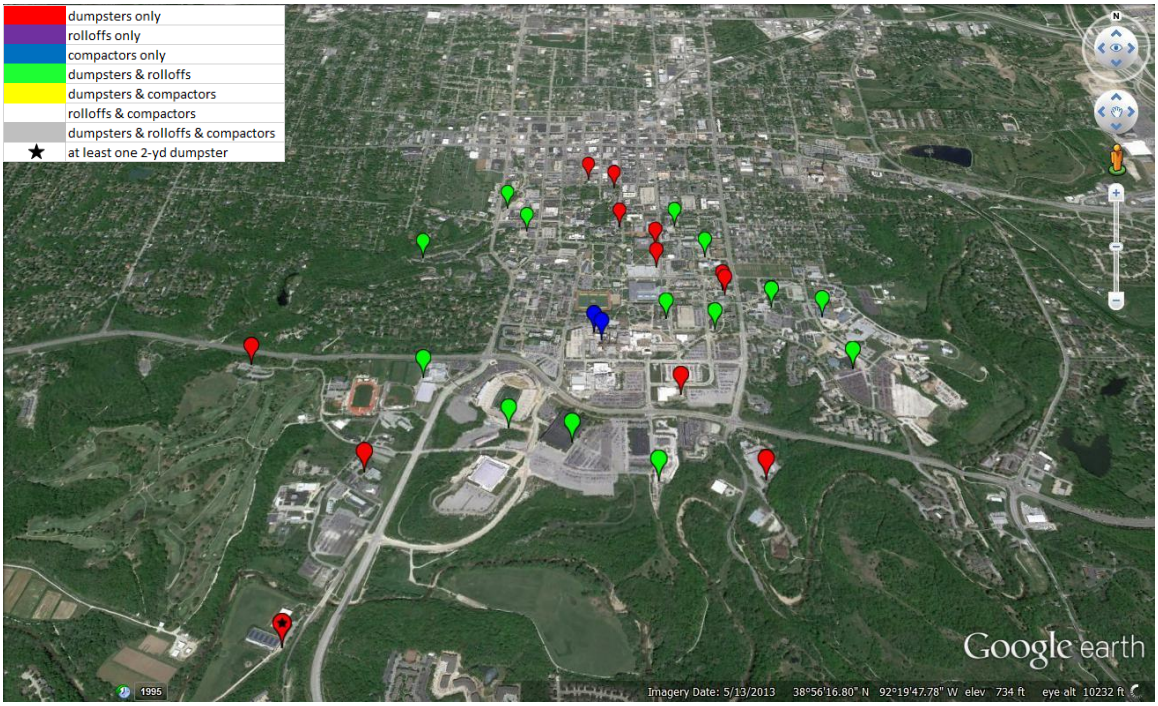


**Figure 4- 3: Distribution of Receptacles around campus-Nonrobust optimization result (Max distance:0. 25)**

Table 4-7 shows when distance restriction is not considered, how many trash generating locations are assigned to a collection location that is between 0 and 0.25 miles away, between 0.25 and 0.5 miles away, between 0.5 and 0.75 miles away, etc. In addition to computing how many locations are in each "distance bucket", also we compute how many tons per week are generated within each distance bucket. Of course, we know that for the solution with maximum distance equal to 0.25 miles, all generating locations are in the first bucket.

| Distance | Number of Generating Locations with Collection Location This Far Away | Weekly Amount of Trash transferred |
|---|---|---|
| 0_0.25 | 35 | 885.9 |
| 0.25_0.5 | 26 | 344.7 |
| 0.5_0.75 | 17 | 431.6 |
| 0.75_1 | 22 | 495 |
| 1_1.25 | 6 | 32.1 |
| 1.25_1.5 | 3 | 23.8 |
| > 1.5 | 2 | 13.5 |

**Table 4-7: Number of locations and amount of waste generated within each distance bucket per week**

As we mentioned in chapter 3, the amount of trash per service for compactors and roll-offs is uncertain (figure 4-4). As a result, the university could be exposed to increased costs, if compactors and roll offs are puled at less-full weights.

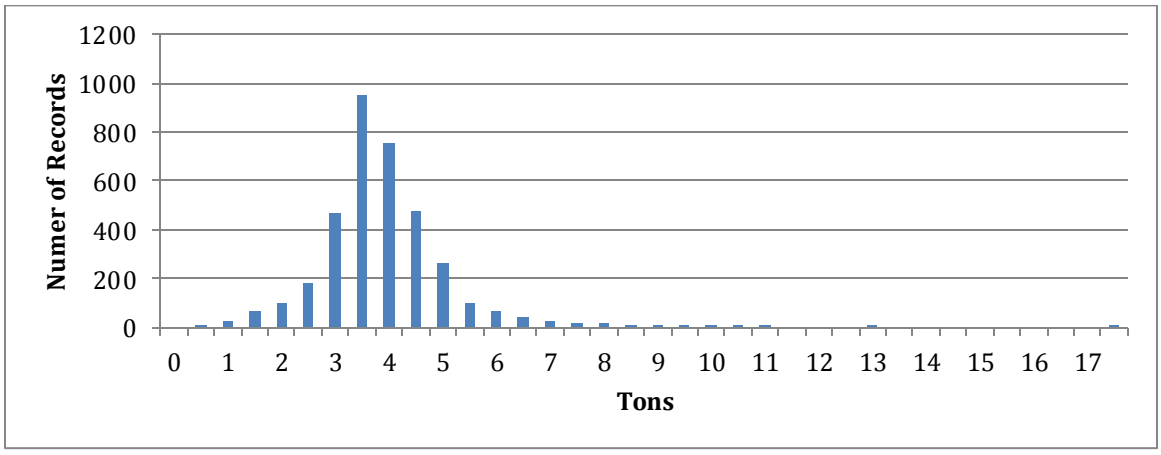


**Figure 4- 4: Variability in volume of trash per service for compactors and roll offs**

To control the uncertainty, we introduce a new data parameter ($d_{jc}$), which is the maximum allowable deviation in cost for compactors and roll offs. In order to calculate $d_{jc}$, we need to calculate the base line value $c_j$. $C_j$ should be calculated based on 52*Pi(KA)/Beta(KA). For example, for 30-yard roll off:

- The baseline value $c_j$ would be 52*71.64/(2.5*20) = 74.5056 (note that we do not need to create a parameter corresponding to $c_j$ in the input file.)
- The $d_j$ value corresponding to our worst-case scenario would be 52*71.64/(0.5*20) – $c_j$ = 372.528-74.5056 = 298.0224. Thus, we need to create a new entry in the input file showing d(30YARD-ROLLOFF) = 298.0224

Accordingly, we calculate the worst-case cost performance of the two solutions from table 4-6:

| Maximum allowable distance (mile) | Worst case cost ($) |
|---|---|
| 1.757 | 511,425.86 |
| 0.25 | 504,954.20 |

**Table 4- 8: Deterministic optimization solutions in worst-case scenarios**

Observe that these, deterministic optimization solutions do not perform well in worst-case scenarios with cost increase 24.7% and 23.1% greater than the current baseline. To avoid the extra charges and achieve savings in worst-case scenarios, we next utilized a Robust Optimization approach.

### 4.3. Application in University of Missouri: Robust Optimization

To reduce MU`s municipal solid waste management cost, we developed a robust optimization method. The uncertainty includes in volume of trash assigned to compactors and roll-offs per service is addressed in this model. To run the model and find a more reliable result we need first discuss about some assumptions.

**Assumptions:**

1. Assumptions 1, 2, 3, and 4 in deterministic optimization model imply here.
2. RO model introduces the other new data parameter ($d_{jc}$), with is maximum allowable deviation in objective function coefficient terms (cost) for receptacle

type c. In order to calculate $d_{jc}$, we need to calculate the base line value $c_j$. $C_j$ should be calculated based on 52*Pi(KA)/Beta(KA).

For 35-yard compactor, figure 4-4 shows that weight when the receptacle was serviced (pulled) typically average between 0.5 and 8.5 tons. We assumed a baseline pull weight of 4.5 tons (the midpoint of this range). This would correspond to a waste annual pull cost of $c_j$ = 52*71.64/(4.5*20)=41.39 per cubic yard of trash serviced per week at 35-yard compactor. To account for worst-case performance, we identify the minimum assumed weight per pull (0.5 tons), and compute the annual cost increase $d_j$=52*71.64/(0.5*20)- $c_j$=331.14.

We ran the RO model using GAMS/ CPLEX software to minimize the total municipal solid waste contract cost. We again considered the same two scenarios related to distance between generation points and collection sites. RO solutions are calculated to avoid worst-case costs in table (4_8).

First scenario (Max distance = 1.757 miles):

The robust solution (obtained by solving with eta_0=100) had a minimum (best-case) total cost of $282,235.87; in the event of uncertainty, the worst-case cost for this solution was $284,818.46.

Second scenario (Max distance = 0.25 miles):

The robust solution (obtained by solving with eta_0=100) for second scenario had a minimum (best-case) total cost of $291,464.94; in the event of uncertainty, the worst-case cost for this solution was $427,242.78.

Figure (4-5) and (4-6) shows distribution of receptacles around campus for two different scenarios in robust optimization.

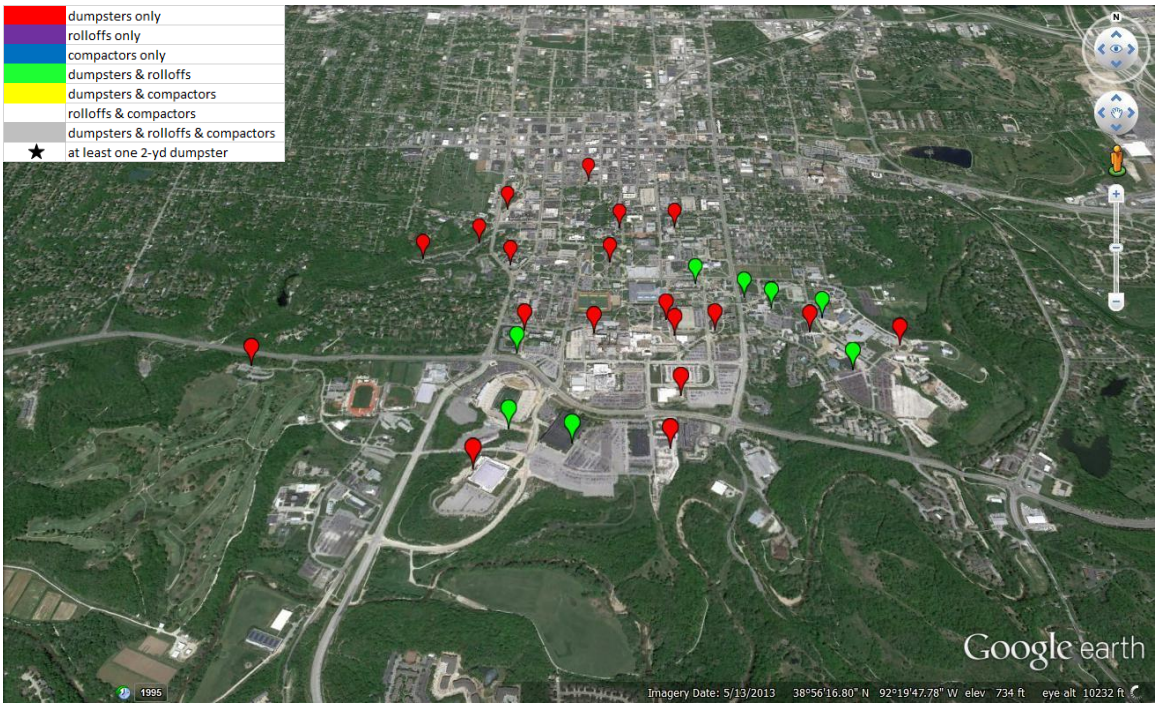


**Figure 4- 5 : Distribution of Receptacles around campus-Robust optimization result (Max distance: 1.757)**

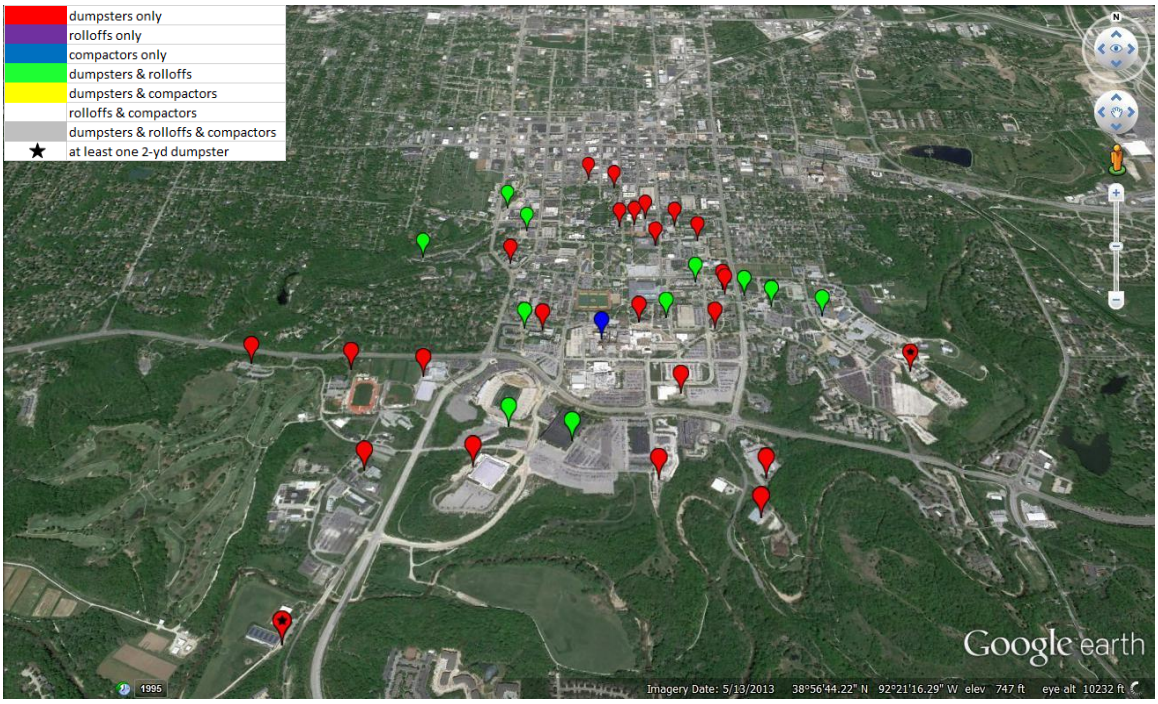


**Figure 4- 6: Distribution of Receptacles around campus-Robust optimization result (Max distance: 0. 25)**

Figure (4-5) shows that 27 collection centers should be opened for the maximum allowable distance 1.757 miles. The same analysis has been done for the maximum allowable distance 0.25 and from 111 locations in current situation we moved to 37 opened locations in RO solution (figure 4-6). Also we observe more distribution of dumpsters around campus in both scenarios. Indeed, since no uncertainty includes in dumpsters, RO solutions approach implementing more dumpsters around campus. It is interesting that when we reduce the maximum allowable distance, the number of selected collection center increases. This also was expected because we do not allow waste to transfer wherever is possible.

How many trash-generating locations are assigned to a collection location in each "distance bucket", and how many tons waste per week are generated within each distance bucket for maximum allowable distance equals to 1.757 is shown in table 4-9.

| Distance | Number of Generating Locations with Collection Location This Far Away | Weekly Amount of Trash transferred |
|---|---|---|
| 0_0.25 | 37 | 830.8 |
| 0.25_0.5 | 25 | 250.9 |
| 0.5_0.75 | 24 | 633.7 |
| 0.75_1 | 18 | 431.9 |
| 1_1.25 | 5 | 75.3 |
| 1.25_1.5 | 1 | 4.2 |
| > 1.5 | 1 | 4.5 |

**Table 4-9: Number of locations and amount of waste generated within each distance bucket per week**

### 4.4. Result Analysis

We can compare the result obtained by the deterministic and RO models over the full range of potential uncertainties.

- First Scenario (Max distance=1.757)

Figure (4-7) shows current, robust, and nonrobust optimization results for the maximum allowable distance of 1.757. The red line shows the behavior of nonrobust optimization result, and the black line tracks the cost associated with receptacles in robust optimization method. When eta_0 equals zero, all models show the cost associated with best-case scenario when uncertainty does not involved. The nonrobust deterministic cost in best-case scenario shows 33% reduction in cost relative to the total current cost of the system is **$410,106** per year. Then we ran the robust optimization model and compared its result with nonrobust and current municipal solid waste management costs. In best-case scenario, the robust optimization cost is 2% more costly than the nonrobust optimization model, but still it brings 31% reductions in current total cost relative to the current contract. In best-case scenario, both models help university achieve significant savings in its annual waste disposal contract.

The next question is how the two mentioned optimization techniques react in presence of uncertainty? Consider here uncertainty related to the weight at which compactors and roll offs are pulled (serviced), since this uncertainty directly affects the total associated cost for waste collection process in campus. When we approach worst case scenarios and include uncertainty in our modeling, the nonrobust optimization model shows huge deviation in costs such that at a moderate safety parameter value (i.e., eta_0 approaches 10), its total associated cost become more than the current cost.

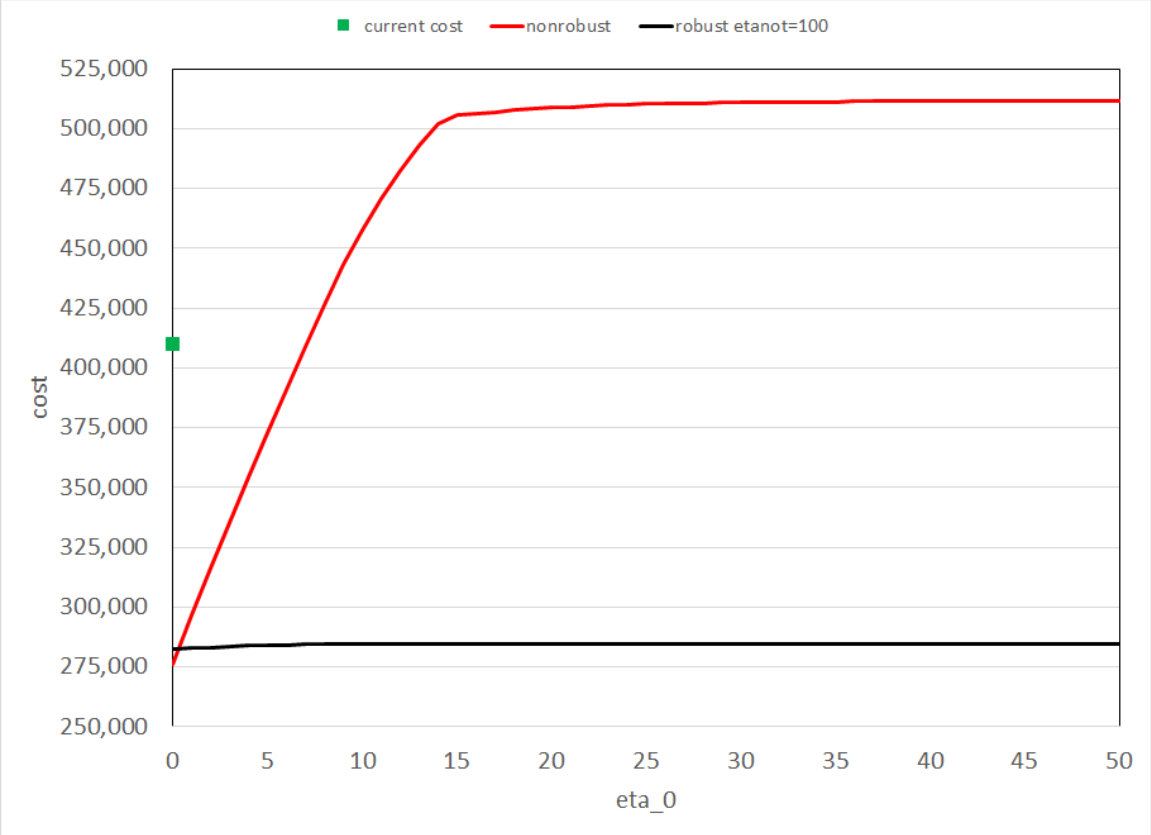


**Figure 4- 7: Comparing the robust and deterministic optimization solutions (Max distance: 1. 757)**

However, for robust optimization modeling, we do not observe huge variation in cost when we increase eta_0. Indeed, in worst-case scenarios the RO solution cost barely

increases from its best-case cost. Although in best-case scenario in robust optimization method we are paying more than deterministic result, this 2% in cost is likely acceptable, since it can assure we will not encounter huge deviation in cost in worst-case scenarios.

- Second scenario (Max distance=0.25 miles)

We repeated the same process for the maximum allowable distance of 0.25.

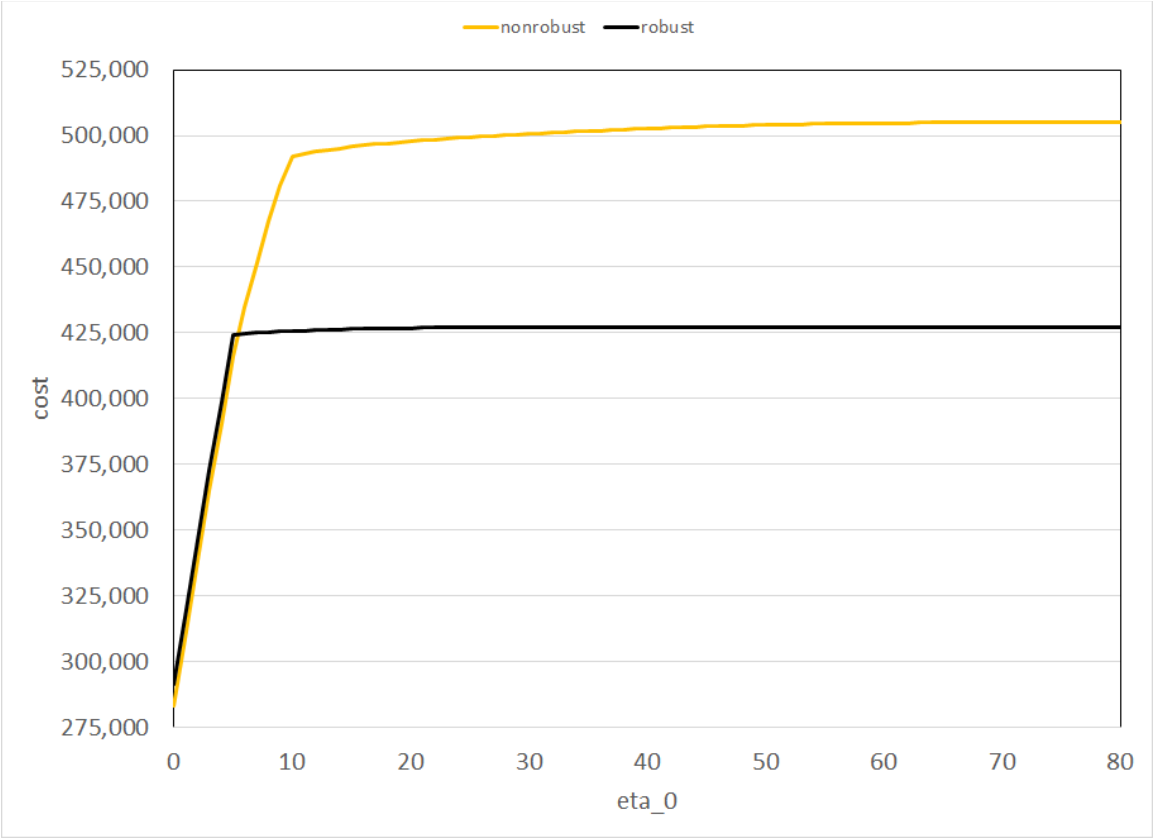


**Figure 4- 8: Comparing the robust and deterministic optimization solution (Max distance: 0. 25)**

We observe the same trend for maximum allowable distance of 0.25 (figure 4-8). In best-case scenario robust optimization result costs slightly more than the nonrobust optimization method (2.7%), while they both cost less than the current waste collection contract. As eta_0 increases, the robust optimization model has a cost much less than the

nonrobust solution. Observe that in worst-case scenario, RO model here has a cost greater than the current solution. This is because, if a 0.25 mile maximum radius is imposed, the highest demand location (University Hospital and Clinics) must be serviced by compactor located on-site, and the worst-case variability associated with this one-site is extremely large (accounting for all of the cost increase between eta_0=0 and eta_0=5 in figure 4-8). Since the current contract has a compactor at this site, it would be equally susceptible to potential worst-case cost increase.

# Chapter 5

## Conclusions and Future Work

### 5.1. Conclusion

In this thesis we considered the problem faced by the University of Missouri as it structures its municipal solid waste management contract. The university pays the city of Columbia to collect trash around campus. The city allows the university to select from among three different receptacle types at each trash collection point. Each type of receptacle is billed differently. As a result, optimizing the collection process is complicated for the university.

For this reason, first we developed a deterministic optimization model to optimize the collection contract. We solved the model for 2 different scenarios. In first scenario, we allow each waste generation point to potentially send its waste to any collection center around campus. In the second scenario, we restricted trash movement to a maximum of 0.25 miles between any waste generation point and collection center. We solved the model with GAMS/CPLEX software. The optimization results suggest university can reduce cost up to 32.7% in first scenario; when we restrict the maximum allowable distance for trash movement to 0.25 mile, we obtain a 30.8% decrease in cost.

Examining historical data, we observed significant variability in the amount of trash contained in compactors and roll offs per pull. We need to address this uncertainty to find a more realistic solution. For this reason, a robust optimization technique is proposed. Similar to the deterministic optimization model, we solved the RO model in

the same two scenarios (no constraint on maximum allowable trash transport distance, and a maximum allowable distance of 0.25 miles) with GAMS/CPLEX software. In both scenarios, RO solution shows slightly (about 2% to 3%, respectively) increased cost above the deterministic optimization result in best-case scenario (note, however, that both RO solutions are significantly less costly than the current contract). However, in worst-case scenarios the deterministic solutions show huge potential increase in cost (greater than 44.3% and 15.3%, respectively) compared to the RO result. Therefore, although in best-case scenario, in RO model we are paying 2% to 3% more than the deterministic solution, the RO solution allows us to ensure that in worst-case scenarios we will not encounter huge deviations in cost.

We also mapped the two-optimization solutions and compared them with the current situation. In both the deterministic optimization and RO solutions, we observed fewer opened collection centers:

First scenario (no maximum allowable distance for trash transport):

In deterministic optimization method: 15 collection centers should be opened.

In Ro method: 27 collection centers should be opened.

Second scenario (0.25 mile maximum allowable distance for trash transport):

In deterministic optimization method: 28 collection centers should be opened.

In Ro method: 37 collection centers should be opened.

Furthermore, in each scenario we observed that the RO solution has more locations assigned with dumpsters, whereas the deterministic optimization solutions make greater use of compactors and roll-offs. This was expected, as in our RO modeling we did not

consider uncertainty in dumpsters. As a result, RO model is willing to more frequently use dumpsters.

### 5.2. Future Work

The findings of this thesis confirm the importance of having an efficient municipal solid waste management contract University of Missouri. As we discussed previously, there are two main future research directions.

First, as we mentioned in chapter 4, the maximum distance between waste generation points on the main campus area is 1.757 miles. The transportation of trash between buildings is a new workload that is not currently being performed by the university, and will require manpower and vehicles. During our meetings with the university management, they stated that they believe that they currently have sufficient resources to handle this transportation; thus, we did not considered these two costs in our modeling. Therefore, one area that can be mentioned as future work is integrating these two terms into the optimization modeling.

Second, we have uncertainty in the volume of trash generated each day. However, as we mentioned in chapter 4, the most recent available data for dumpsters back to 2003. Since we did not have access to this data related to current years, we did not consider this uncertainty in our RO model. As a result, in future work this analysis could be improved by collecting this data and considering this uncertainty, which could lead to an improved solution.

# APPENDIX

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# A. GAMS Code: The deterministic optimization algorithm code used in Chapter 4.

## A.1. Data Parameters:

- **Data_Trash.inc file:**

```
SETS
I     Waste generation sources   /i1*i111/
J     Potential sites to collect waste  / j1*j111/
K                 different bin types available for allocation to collection sites
/2YARD,4YARD,6YARD,8YARD,14YARD-ROLLOFF,20YARD-
ROLLOFF,30YARD-ROLLOFF,35YARD-ROLLOFF,40YARD-ROLLOFF,14YARD-
COMP,15YARD-COMP,25YARD-COMP,28YARD-COMP,35YARD-
COMP,28YARD-DUAL-COMP,35YARD-DUAL-COMP/
KA(K)     bin types compactor and Roll Off /14YARD-ROLLOFF,20YARD-
ROLLOFF,30YARD-ROLLOFF,35YARD-ROLLOFF,40YARD-ROLLOFF,14YARD-
COMP,15YARD-COMP,25YARD-COMP,28YARD-COMP,35YARD-
COMP,28YARD-DUAL-COMP,35YARD-DUAL-COMP/
KB(K)  Other bin types /2YARD,4YARD,6YARD,8YARD/
F      frequency  of times  a bin will  be serviced  /f1*f5/
D1     Days /Mon, Tue, Wed, Thur, Fri/;
Alias  (D1, D2);

Parameters
Beta(K) Capacity of bin type k
/
2YARD                2
4YARD                4
6YARD                6
8YARD                8
14YARD-ROLLOFF       14
20YARD-ROLLOFF       20
30YARD-ROLLOFF       30
35YARD-ROLLOFF       35
40YARD-ROLLOFF       40
14YARD-COMP          56
15YARD-COMP          60
25YARD-COMP          100
28YARD-COMP          112
35YARD-COMP          140
28YARD-DUAL-COMP     56
35YARD-DUAL-COMP     70
/
```

Gama(K) area of space required per receptacle of type k
/
2YARD 3024
4YARD 3888
6YARD 4752
8YARD 4752
14YARD-ROLLOFF 14580
20YARD-ROLLOFF 25344
30YARD-ROLLOFF 23760
35YARD-ROLLOFF 22596
40YARD-ROLLOFF 22176
14YARD-COMP 21835
15YARD-COMP 23736
25YARD-COMP 23736
28YARD-COMP 23736
35YARD-COMP 23736
28YARD-DUAL-COMP 23736
35YARD-DUAL-COMP 23736
/
Epsilon(J) area available for trash receptacles at site j
/J7 3024
J105 3024
J98 6048
J1 3024
J54 9072
J2 3024
J63 9072
J57 3024
J80 19008
J111 3024
J76 23736
J30 3024
J103 22176
J37 6048
J102 59616
J69 21835
J16 3024
J58 3024
J10 3024
J86 6048
J11 3024
J12 6048
J79 9072
J42 23736
J92 23736
J41 23736

| | |
|---|---|
| J24 | 9072 |
| J14 | 6048 |
| J55 | 6048 |
| J17 | 6048 |
| J72 | 3024 |
| J94 | 3024 |
| J70 | 12096 |
| J18 | 3024 |
| J96 | 3024 |
| J22 | 6048 |
| J61 | 3024 |
| J43 | 21835 |
| J81 | 23736 |
| J53 | 3024 |
| J85 | 3024 |
| J60 | 9072 |
| J87 | 3024 |
| J75 | 12096 |
| J84 | 22176 |
| J44 | 23736 |
| J4 | 3024 |
| J15 | 12096 |
| J34 | 6048 |
| J23 | 3024 |
| J36 | 3024 |
| J56 | 23736 |
| J90 | 3024 |
| J45 | 3024 |
| J20 | 3024 |
| J95 | 5070 |
| J104 | 26587 |
| J8 | 3024 |
| J6 | 3024 |
| J46 | 9072 |
| J26 | 23736 |
| J47 | 23736 |
| J109 | 23736 |
| J99 | 23736 |
| J97 | 3024 |
| J83 | 23736 |
| J5 | 3024 |
| J25 | 3024 |
| J82 | 6048 |
| J88 | 23736 |
| J73 | 3024 |
| J28 | 3024 |

J91 3024
J48 23736
J9 3024
J21 23736
J74 3024
J62 62100
J29 3024
J32 3024
J19 21835
J100 5070
J35 8094
J51 5070
J93 26760
J33 3024
J31 3024
J89 23736
J27 3024
J3 4752
J52 3024
J13 3024
J50 26784
J78 6048
J101 3024
J110 4752
J59 3024
J77 6048
J107 6048
J64 6048
J108 23736
J65 6048
J66 6048
J67 6048
J68 28644
J106 3024
J71 3024
J38 9072
J39 3024
J49 3024
J40 9072
/
;
TABLE Alpha(I, D1) Volume of trash generated at location i on day d1

| | Mon | Tue | Wed | Thur | Fri |
|---|---|---|---|---|---|
| I7 | 1.1556 | 0.7722 | 1.0167 | 0.8611 | 0.7833 |
| I105 | 1.1556 | 0.7722 | 1.0167 | 0.8611 | 0.7833 |
| I98 | 1.6556 | 1.3556 | 1.7333 | 2.2833 | 1.4389 |

| | | | | | |
|---|---|---|---|---|---|
| I1 | 1.0333 | 0.9808 | 0.8975 | 1.0000 | 0.8483 |
| I54 | 3.9600 | 3.0600 | 3.7140 | 3.0540 | 3.3120 |
| I2 | 1.0333 | 0.9808 | 0.8975 | 1.0000 | 0.8483 |
| I63 | 3.9600 | 3.0600 | 3.7140 | 3.0540 | 3.3120 |
| I57 | 1.0333 | 0.9808 | 0.8975 | 1.0000 | 0.8483 |
| I80 | 7.2333 | 6.8658 | 6.2825 | 7.0000 | 5.9383 |
| I111 | 0.4571 | 0.4571 | 0.5214 | 0.5214 | 0.4571 |
| I76 | 10.0075 | 10.7773 | 10.0075 | 5.7735 | 5.0037 |
| I30 | 1.0333 | 0.9808 | 0.8975 | 1.0000 | 0.8483 |
| I103 | 6.8570 | 6.8570 | 7.8212 | 7.8212 | 6.8570 |
| I37 | 2.3111 | 1.5444 | 2.0333 | 1.7222 | 1.5667 |
| I102 | 20.2355 | 19.2074 | 17.5755 | 19.5828 | 16.6127 |
| I69 | 3.8770 | 2.0821 | 2.8001 | 2.4591 | 1.9924 |
| I16 | 1.1556 | 0.7722 | 1.0167 | 0.8611 | 0.7833 |
| I58 | 1.1333 | 0.7133 | 0.7400 | 0.5000 | 0.4733 |
| I10 | 1.0333 | 0.9808 | 0.8975 | 1.0000 | 0.8483 |
| I86 | 2.6400 | 2.0400 | 2.4760 | 2.0360 | 2.2080 |
| I11 | 1.3200 | 1.0200 | 1.2380 | 1.0180 | 1.1040 |
| I12 | 2.0667 | 1.9617 | 1.7950 | 2.0000 | 1.6967 |
| I79 | 3.1000 | 2.9425 | 2.6925 | 3.0000 | 2.5450 |
| I42 | 24.3142 | 26.1845 | 24.3142 | 14.0274 | 12.1571 |
| I92 | 8.6467 | 4.6436 | 6.2448 | 5.4843 | 4.4434 |
| I41 | 8.6539 | 7.0857 | 9.0605 | 11.9354 | 7.5213 |
| I24 | 3.9600 | 3.0600 | 3.7140 | 3.0540 | 3.3120 |
| I14 | 2.6400 | 2.0400 | 2.4760 | 2.0360 | 2.2080 |
| I55 | 2.6400 | 2.0400 | 2.4760 | 2.0360 | 2.2080 |
| I17 | 2.6400 | 2.0400 | 2.4760 | 2.0360 | 2.2080 |
| I72 | 1.3200 | 1.0200 | 1.2380 | 1.0180 | 1.1040 |
| I94 | 0.4571 | 0.4571 | 0.5214 | 0.5214 | 0.4571 |
| I70 | 1.8286 | 1.8286 | 2.0857 | 2.0857 | 1.8286 |
| I18 | 1.3200 | 1.0200 | 1.2380 | 1.0180 | 1.1040 |
| I96 | 0.8278 | 0.6778 | 0.8667 | 1.1417 | 0.7194 |
| I22 | 2.0667 | 1.9617 | 1.7950 | 2.0000 | 1.6967 |
| I61 | 0.8278 | 0.6778 | 0.8667 | 1.1417 | 0.7194 |
| I43 | 4.3892 | 2.3572 | 3.1700 | 2.7839 | 2.2556 |
| I81 | 4.2346 | 3.4672 | 4.4335 | 5.8403 | 3.6804 |
| I53 | 1.1556 | 0.7722 | 1.0167 | 0.8611 | 0.7833 |
| I85 | 1.1333 | 0.7133 | 0.7400 | 0.5000 | 0.4733 |
| I60 | 3.9600 | 3.0600 | 3.7140 | 3.0540 | 3.3120 |
| I87 | 1.0333 | 0.9808 | 0.8975 | 1.0000 | 0.8483 |
| I75 | 4.6222 | 3.0889 | 4.0667 | 3.4444 | 3.1333 |
| I84 | 3.8314 | 3.8314 | 4.3702 | 4.3702 | 3.8314 |
| I44 | 10.3680 | 5.5680 | 7.4880 | 6.5760 | 5.3280 |
| I4 | 1.0333 | 0.9808 | 0.8975 | 1.0000 | 0.8483 |
| I15 | 5.2800 | 4.0800 | 4.9520 | 4.0720 | 4.4160 |
| I34 | 2.3111 | 1.5444 | 2.0333 | 1.7222 | 1.5667 |

| | | | | | |
|---|---|---|---|---|---|
| I23 | 1.0333 | 0.9808 | 0.8975 | 1.0000 | 0.8483 |
| I36 | 1.1556 | 0.7722 | 1.0167 | 0.8611 | 0.7833 |
| I56 | 7.7212 | 7.3290 | 6.7063 | 7.4722 | 6.3389 |
| I90 | 1.3200 | 1.0200 | 1.2380 | 1.0180 | 1.1040 |
| I45 | 1.3200 | 1.0200 | 1.2380 | 1.0180 | 1.1040 |
| I20 | 1.1556 | 0.7722 | 1.0167 | 0.8611 | 0.7833 |
| I95 | 3.6522 | 1.2522 | 1.2522 | 1.3174 | 1.3174 |
| I104 | 8.4235 | 9.0715 | 8.4235 | 4.8597 | 4.2118 |
| I8 | 1.3200 | 1.0200 | 1.2380 | 1.0180 | 1.1040 |
| I6 | 1.3200 | 1.0200 | 1.2380 | 1.0180 | 1.1040 |
| I46 | 5.4000 | 2.9000 | 3.9000 | 3.4250 | 2.7750 |
| I26 | 10.9878 | 10.9878 | 11.3948 | 12.2087 | 11.3948 |
| I47 | 4.5025 | 4.5025 | 5.1357 | 5.1357 | 4.5025 |
| I109 | 11.1586 | 11.1586 | 11.5719 | 12.3985 | 11.5719 |
| I99 | 8.4325 | 6.9045 | 8.8287 | 11.6301 | 7.3289 |
| I97 | 1.0333 | 0.9808 | 0.8975 | 1.0000 | 0.8483 |
| I83 | 12.9077 | 12.9077 | 14.7228 | 14.7228 | 12.9077 |
| I5 | 0.4571 | 0.4571 | 0.5214 | 0.5214 | 0.4571 |
| I25 | 1.0333 | 0.9808 | 0.8975 | 1.0000 | 0.8483 |
| I82 | 2.6400 | 2.0400 | 2.4760 | 2.0360 | 2.2080 |
| I88 | 7.2524 | 3.8948 | 5.2378 | 4.5999 | 3.7269 |
| I73 | 1.0333 | 0.9808 | 0.8975 | 1.0000 | 0.8483 |
| I28 | 1.3200 | 1.0200 | 1.2380 | 1.0180 | 1.1040 |
| I91 | 1.1333 | 0.7133 | 0.7400 | 0.5000 | 0.4733 |
| I48 | 4.5232 | 4.8712 | 4.5232 | 2.6096 | 2.2616 |
| I9 | 1.3200 | 1.0200 | 1.2380 | 1.0180 | 1.1040 |
| I21 | 13.9489 | 15.0218 | 13.9489 | 8.0474 | 6.9744 |
| I74 | 1.0333 | 0.9808 | 0.8975 | 1.0000 | 0.8483 |
| I62 | 10.4085 | 10.4085 | 11.8722 | 11.8722 | 10.4085 |
| I29 | 1.3200 | 1.0200 | 1.2380 | 1.0180 | 1.1040 |
| I32 | 1.0333 | 0.9808 | 0.8975 | 1.0000 | 0.8483 |
| I19 | 6.7214 | 3.6097 | 4.8544 | 4.2631 | 3.4541 |
| I100 | 1.8286 | 1.8286 | 2.0857 | 2.0857 | 1.8286 |
| I35 | 5.7778 | 3.8611 | 5.0833 | 4.3056 | 3.9167 |
| I51 | 3.4667 | 2.3167 | 3.0500 | 2.5833 | 2.3500 |
| I93 | 36.0883 | 38.8643 | 36.0883 | 20.8202 | 18.0441 |
| I33 | 0.4571 | 0.4571 | 0.5214 | 0.5214 | 0.4571 |
| I31 | 1.0333 | 0.9808 | 0.8975 | 1.0000 | 0.8483 |
| I89 | 3.4268 | 1.8403 | 2.4749 | 2.1735 | 1.7610 |
| I27 | 1.0333 | 0.9808 | 0.8975 | 1.0000 | 0.8483 |
| I3 | 1.8286 | 1.8286 | 2.0857 | 2.0857 | 1.8286 |
| I52 | 0.4571 | 0.4571 | 0.5214 | 0.5214 | 0.4571 |
| I13 | 1.3200 | 1.0200 | 1.2380 | 1.0180 | 1.1040 |
| I50 | 5.4437 | 5.1671 | 4.7281 | 5.2681 | 4.4691 |
| I78 | 2.0667 | 1.9617 | 1.7950 | 2.0000 | 1.6967 |
| I101 | 1.1333 | 0.7133 | 0.7400 | 0.5000 | 0.4733 |

```
I110    5.4000  5.4000  5.6000  6.0000  5.6000
I59     1.1333  0.7133  0.7400  0.5000  0.4733
I77     2.2667  1.4267  1.4800  1.0000  0.9467
I107    2.3111  1.5444  2.0333  1.7222  1.5667
I64     2.4348  0.8348  0.8348  0.8783  0.8783
I108    77.3348 77.3348 80.1990 85.9275 80.1990
I65     2.4348  0.8348  0.8348  0.8783  0.8783
I66     2.4348  0.8348  0.8348  0.8783  0.8783
I67     2.4348  0.8348  0.8348  0.8783  0.8783
I68     5.7433  1.9691  1.9691  2.0717  2.0717
I106    1.0333  0.9808  0.8975  1.0000  0.8483
I71     1.0333  0.9808  0.8975  1.0000  0.8483
I38     3.9600  3.0600  3.7140  3.0540  3.3120
I39     1.0333  0.9808  0.8975  1.0000  0.8483
I49     1.1333  0.7133  0.7400  0.5000  0.4733
I40     3.1000  2.9425  2.6925  3.0000  2.5450
;
parameter
Pi (KA) fixed  cost per service  for compactor  of type  KA
/
14YARD-ROLLOFF     50.93
20YARD-ROLLOFF     71.64
30YARD-ROLLOFF     71.64
35YARD-ROLLOFF     71.64
40YARD-ROLLOFF     71.64
14YARD-COMP        50.93
15YARD-COMP        50.93
25YARD-COMP        71.64
28YARD-COMP        71.64
35YARD-COMP        71.64
28YARD-DUAL-COMP   71.64
35YARD-DUAL-COMP   71.64
/
Phi(KA)   Variable  cost per ton  of trash serviced  for compactor  and roll-offs  of type KA
/
14YARD-ROLLOFF     34.96
20YARD-ROLLOFF     34.96
30YARD-ROLLOFF     34.96
35YARD-ROLLOFF     34.96
40YARD-ROLLOFF     34.96
14YARD-COMP        34.96
15YARD-COMP        34.96
25YARD-COMP        34.96
28YARD-COMP        34.96
35YARD-COMP        34.96
28YARD-DUAL-COMP   34.96
```

35YARD-DUAL-COMP 34.96
/
;

Table DIST(I, J) distance between waste generation I and collection center J

| | J1 | J2 | J3 | J4 | J5 | J6 | J7 | J8 | J9 | J10 | J11 | J12 | J13 | J14 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| J15 | J16 | J17 | J18 | J19 | J20 | J21 | J22 | J23 | J24 | J25 | J26 | J27 | J28 | |
| J29 | J30 | J31 | J32 | J33 | J34 | J35 | J36 | J37 | J38 | J39 | J40 | J41 | J42 | |
| J43 | J44 | J45 | J46 | J47 | J48 | J49 | J50 | J51 | J52 | J53 | J54 | J55 | J56 | |
| J57 | J58 | J59 | J60 | J61 | J62 | J63 | J64 | J65 | J66 | J67 | J68 | J69 | J70 | |
| J71 | J72 | J73 | J74 | J75 | J76 | J77 | J78 | J79 | J80 | J81 | J82 | J83 | J84 | |
| J85 | J86 | J87 | J88 | J89 | J90 | J91 | J92 | J93 | J94 | J95 | J96 | J97 | J98 | |
| J99 | J100 | J101 | J102 | J103 | J104 | J105 | J106 | J107 | J108 | J109 | J110 | | | |
| J111 | | | | | | | | | | | | | | |
| I1 | 0.001 | 0.396 | 0.551 | 1.268 | 0.725 | 0.790 | 1.546 | 1.240 | 0.639 | 0.052 | 0.636 | | | |
| 0.360 | 0.696 | 0.823 | 0.745 | 0.584 | 0.532 | 0.726 | 0.343 | 0.556 | 0.251 | 0.185 | 0.414 | | | |
| 0.459 | 0.317 | 0.633 | 0.417 | 0.759 | 0.407 | 1.327 | 0.367 | 1.161 | 0.377 | 0.793 | 0.641 | | | |
| 0.823 | 0.843 | 0.053 | 0.050 | 0.444 | 1.088 | 0.761 | 0.161 | 0.327 | 0.869 | 0.836 | 0.448 | | | |
| 0.438 | 0.397 | 0.305 | 0.792 | 0.265 | 0.823 | 0.055 | 0.514 | 0.317 | 0.336 | 0.802 | 0.524 | | | |
| 0.567 | 1.399 | 0.932 | 0.350 | 0.939 | 0.955 | 1.018 | 1.020 | 1.095 | 0.208 | 0.761 | 0.073 | | | |
| 0.522 | 0.655 | 0.346 | 0.586 | 0.188 | 0.714 | 0.378 | 1.301 | 0.215 | 0.860 | 0.702 | 0.436 | | | |
| 0.954 | 0.630 | 0.646 | 1.388 | 0.807 | 0.843 | 0.864 | 0.506 | 0.511 | 0.259 | 0.340 | 0.573 | | | |
| 1.631 | 1.499 | 1.504 | 1.084 | 0.651 | 0.750 | 0.111 | 0.811 | 0.830 | 0.495 | 0.194 | 1.259 | | | |
| 0.624 | 0.564 | 0.442 | 0.366 | | | | | | | | | | | |
| I2 | 0.396 | 0.001 | 0.188 | 0.996 | 0.758 | 0.430 | 1.202 | 0.974 | 0.291 | 0.367 | 0.332 | | | |
| 0.113 | 0.303 | 0.438 | 0.358 | 0.270 | 0.196 | 0.363 | 0.293 | 0.189 | 0.199 | 0.440 | 0.212 | | | |
| 0.078 | 0.691 | 0.363 | 0.151 | 0.384 | 0.051 | 1.035 | 0.227 | 0.899 | 0.714 | 0.459 | 0.723 | | | |
| 0.435 | 0.456 | 0.436 | 0.402 | 0.194 | 0.788 | 0.455 | 0.316 | 0.109 | 0.499 | 0.462 | 0.152 | | | |
| 0.241 | 0.264 | 0.590 | 0.869 | 0.323 | 0.483 | 0.371 | 0.242 | 0.089 | 0.682 | 0.408 | 0.295 | | | |
| 0.176 | 1.099 | 0.542 | 0.047 | 0.550 | 0.561 | 0.625 | 0.632 | 0.705 | 0.237 | 0.690 | 0.453 | | | |
| 0.171 | 0.609 | 0.697 | 0.210 | 0.310 | 0.672 | 0.061 | 1.053 | 0.581 | 0.711 | 0.379 | 0.057 | | | |
| 0.741 | 0.351 | 0.259 | 1.147 | 0.490 | 0.553 | 0.529 | 0.458 | 0.277 | 0.173 | 0.160 | 0.326 | | | |
| 1.446 | 1.252 | 1.163 | 0.885 | 0.257 | 0.355 | 0.458 | 0.772 | 0.434 | 0.592 | 0.589 | 0.935 | | | |
| 0.374 | 0.506 | 0.296 | 0.156 | | | | | | | | | | | |
| I3 | 0.551 | 0.188 | 0.000 | 1.033 | 0.929 | 0.245 | 1.170 | 1.017 | 0.103 | 0.512 | 0.410 | | | |
| 0.193 | 0.175 | 0.276 | 0.204 | 0.104 | 0.047 | 0.178 | 0.478 | 0.010 | 0.386 | 0.623 | 0.197 | | | |
| 0.111 | 0.860 | 0.460 | 0.150 | 0.208 | 0.153 | 1.056 | 0.247 | 0.947 | 0.893 | 0.271 | 0.903 | | | |
| 0.372 | 0.390 | 0.598 | 0.545 | 0.152 | 0.814 | 0.507 | 0.498 | 0.298 | 0.320 | 0.285 | 0.116 | | | |
| 0.403 | 0.438 | 0.774 | 1.045 | 0.512 | 0.294 | 0.537 | 0.134 | 0.239 | 0.859 | 0.271 | 0.196 | | | |
| 0.180 | 1.112 | 0.388 | 0.218 | 0.470 | 0.454 | 0.528 | 0.550 | 0.616 | 0.421 | 0.838 | 0.616 | | | |
| 0.032 | 0.769 | 0.874 | 0.044 | 0.495 | 0.829 | 0.176 | 1.104 | 0.751 | 0.830 | 0.195 | 0.196 | | | |
| 0.828 | 0.193 | 0.238 | 1.200 | 0.527 | 0.606 | 0.340 | 0.628 | 0.414 | 0.360 | 0.345 | 0.198 | | | |
| 1.523 | 1.298 | 1.135 | 0.971 | 0.199 | 0.271 | 0.629 | 0.926 | 0.314 | 0.777 | 0.738 | 0.933 | | | |
| 0.482 | 0.670 | 0.462 | 0.336 | | | | | | | | | | | |
| I4 | 1.268 | 0.996 | 1.033 | 0.000 | 0.848 | 1.072 | 0.437 | 0.037 | 1.075 | 1.271 | 0.665 | | | |
| 1.108 | 0.905 | 0.960 | 0.941 | 1.128 | 1.078 | 1.050 | 0.929 | 1.023 | 1.027 | 1.162 | 1.191 | | | |

1.003 1.416 0.647 1.126 1.009 1.033 0.094 1.219 0.109 1.357 1.155 0.939
0.707 0.697 1.276 1.303 1.156 0.221 0.541 1.110 0.985 1.047 1.026 1.107
0.835 0.871 1.222 0.941 1.014 1.148 1.217 1.165 1.074 1.356 0.886 1.228
0.862 0.168 0.930 1.033 0.680 0.758 0.706 0.651 0.659 1.064 0.660 1.282
1.053 0.737 1.374 0.999 1.084 0.721 1.055 0.103 1.332 0.494 1.152 0.940
0.342 1.207 0.795 0.186 0.510 0.443 1.180 0.811 0.764 1.030 0.946 1.229
0.544 0.268 0.397 0.284 0.837 0.800 1.251 0.703 0.837 0.966 1.430 0.221
0.649 0.769 0.826 0.923
I5 0.725 0.758 0.929 0.848 0.002 1.135 1.258 0.811 1.028 0.761 0.610
0.840 0.946 1.086 1.013 1.024 0.950 1.074 0.476 0.925 0.613 0.545 0.947
0.826 0.696 0.553 0.900 1.071 0.808 0.936 0.934 0.747 0.600 1.188 0.116
0.900 0.912 0.697 0.775 0.943 0.783 0.638 0.590 0.661 1.175 1.138 0.908
0.526 0.495 0.506 0.127 0.497 1.204 0.673 1.000 0.770 0.618 1.019 1.048
0.787 1.014 1.147 0.755 0.985 1.053 1.068 1.033 1.098 0.612 0.196 0.690
0.922 0.179 0.633 0.930 0.569 0.146 0.805 0.824 0.657 0.360 1.123 0.734
0.520 1.109 0.802 0.879 0.675 0.630 1.251 0.301 0.528 0.637 0.603 1.083
1.008 0.985 1.214 0.572 0.848 0.908 0.643 0.150 1.005 0.232 0.795 0.964
0.519 0.262 0.467 0.603
I6 0.790 0.430 0.245 1.072 1.135 0.001 1.114 1.064 0.151 0.748 0.554
0.431 0.197 0.118 0.139 0.216 0.258 0.067 0.709 0.242 0.629 0.868 0.397
0.353 1.103 0.612 0.375 0.069 0.397 1.074 0.451 1.004 1.138 0.084 1.121
0.366 0.375 0.839 0.780 0.356 0.852 0.609 0.743 0.538 0.086 0.068 0.343
0.616 0.660 1.019 1.256 0.751 0.079 0.780 0.296 0.483 1.104 0.186 0.323
0.348 1.115 0.209 0.463 0.410 0.353 0.430 0.472 0.517 0.666 1.019 0.858
0.270 0.965 1.118 0.221 0.739 1.020 0.421 1.158 0.994 0.978 0.127 0.425
0.939 0.223 0.347 1.252 0.610 0.696 0.121 0.839 0.606 0.603 0.579 0.284
1.597 1.338 1.084 1.074 0.296 0.282 0.872 1.110 0.237 1.004 0.973 0.926
0.642 0.872 0.675 0.566
I7 1.546 1.202 1.170 0.437 1.258 1.114 0.001 0.471 1.175 1.537 0.910
1.302 1.005 0.996 1.014 1.243 1.216 1.118 1.231 1.160 1.295 1.478 1.359
1.181 1.749 0.919 1.298 1.067 1.225 0.344 1.400 0.518 1.708 1.194 1.338
0.799 0.781 1.566 1.572 1.316 0.489 0.786 1.400 1.228 1.058 1.052 1.271
1.114 1.162 1.567 1.361 1.319 1.176 1.501 1.302 1.290 1.699 0.942 1.360
1.035 0.281 0.920 1.247 0.713 0.761 0.685 0.643 0.600 1.339 1.063 1.576
1.198 1.123 1.718 1.128 1.377 1.121 1.253 0.511 1.653 0.898 1.225 1.147
0.738 1.304 0.953 0.533 0.740 0.716 1.193 1.160 1.040 1.290 1.207 1.345
0.827 0.517 0.044 0.716 0.977 0.901 1.554 1.120 0.889 1.340 1.727 0.302
0.935 1.130 1.125 1.180
I8 1.240 0.974 1.017 0.037 0.811 1.064 0.471 0.000 1.062 1.244 0.642
1.086 0.893 0.953 0.932 1.113 1.062 1.040 0.899 1.007 1.000 1.131 1.171
0.984 1.383 0.621 1.106 1.000 1.012 0.130 1.198 0.078 1.323 1.147 0.902
0.698 0.690 1.246 1.275 1.137 0.212 0.520 1.081 0.960 1.042 1.020 1.088
0.808 0.843 1.189 0.905 0.984 1.140 1.188 1.148 1.051 1.322 0.879 1.211
0.844 0.204 0.928 1.010 0.678 0.757 0.708 0.653 0.665 1.036 0.623 1.252
1.036 0.701 1.340 0.984 1.055 0.685 1.034 0.096 1.300 0.458 1.141 0.918
0.308 1.194 0.779 0.189 0.492 0.421 1.174 0.778 0.737 1.004 0.920 1.214

0.542 0.281 0.432 0.247 0.823 0.789 1.220 0.666 0.830 0.931 1.399 0.242
0.623 0.735 0.797 0.897
I9 0.639 0.291 0.103 1.075 1.028 0.151 1.175 1.062 0.001 0.597 0.486
0.280 0.174 0.215 0.165 0.075 0.107 0.090 0.580 0.104 0.487 0.722 0.249
0.214 0.953 0.539 0.224 0.136 0.253 1.090 0.304 0.996 0.990 0.168 1.004
0.383 0.398 0.688 0.628 0.207 0.854 0.568 0.597 0.400 0.234 0.204 0.191
0.502 0.539 0.874 1.145 0.614 0.192 0.630 0.153 0.335 0.955 0.239 0.195
0.257 1.141 0.328 0.318 0.463 0.429 0.507 0.538 0.597 0.522 0.930 0.707
0.123 0.865 0.969 0.099 0.596 0.924 0.273 1.153 0.844 0.911 0.096 0.297
0.896 0.133 0.292 1.249 0.581 0.664 0.238 0.727 0.507 0.461 0.448 0.171
1.580 1.342 1.142 1.037 0.243 0.281 0.723 1.019 0.290 0.879 0.822 0.956
0.564 0.767 0.561 0.438
I10 0.052 0.367 0.512 1.271 0.761 0.748 1.537 1.244 0.597 0.001 0.628
0.319 0.663 0.786 0.709 0.540 0.490 0.684 0.354 0.518 0.246 0.229 0.366
0.425 0.365 0.630 0.373 0.719 0.372 1.327 0.318 1.166 0.429 0.748 0.680
0.799 0.820 0.105 0.036 0.398 1.086 0.755 0.180 0.310 0.828 0.796 0.405
0.437 0.402 0.356 0.833 0.285 0.778 0.089 0.467 0.283 0.387 0.768 0.474
0.541 1.398 0.896 0.320 0.915 0.927 0.991 0.996 1.070 0.207 0.787 0.125
0.482 0.682 0.397 0.549 0.206 0.741 0.343 1.308 0.266 0.877 0.656 0.411
0.964 0.582 0.622 1.396 0.799 0.841 0.818 0.529 0.509 0.248 0.331 0.524
1.648 1.507 1.495 1.097 0.623 0.722 0.163 0.841 0.798 0.534 0.227 1.253
0.623 0.587 0.449 0.357
I11 0.636 0.332 0.410 0.665 0.610 0.554 0.910 0.642 0.486 0.628 0.000
0.445 0.357 0.485 0.421 0.514 0.449 0.503 0.334 0.403 0.385 0.582 0.536
0.351 0.858 0.060 0.471 0.486 0.373 0.709 0.558 0.567 0.836 0.622 0.625
0.293 0.307 0.656 0.663 0.506 0.463 0.128 0.492 0.326 0.579 0.544 0.457
0.208 0.262 0.694 0.737 0.421 0.631 0.591 0.529 0.409 0.819 0.413 0.592
0.231 0.776 0.537 0.368 0.392 0.449 0.478 0.455 0.529 0.428 0.470 0.667
0.421 0.432 0.837 0.390 0.470 0.481 0.393 0.720 0.755 0.427 0.580 0.277
0.419 0.602 0.207 0.815 0.171 0.222 0.675 0.348 0.139 0.381 0.297 0.605
1.121 0.920 0.868 0.563 0.258 0.300 0.649 0.562 0.396 0.546 0.818 0.625
0.092 0.359 0.235 0.271
I12 0.360 0.113 0.193 1.108 0.840 0.431 1.302 1.086 0.280 0.319 0.445
0.002 0.353 0.468 0.393 0.231 0.173 0.366 0.365 0.199 0.238 0.451 0.108
0.123 0.673 0.476 0.066 0.400 0.078 1.145 0.114 1.012 0.714 0.439 0.794
0.519 0.539 0.408 0.352 0.108 0.899 0.566 0.329 0.180 0.510 0.477 0.091
0.342 0.352 0.604 0.945 0.369 0.467 0.350 0.174 0.072 0.678 0.456 0.211
0.267 1.208 0.580 0.089 0.629 0.628 0.698 0.711 0.782 0.261 0.788 0.427
0.163 0.702 0.691 0.231 0.332 0.765 0.053 1.166 0.565 0.819 0.349 0.168
0.853 0.294 0.350 1.260 0.600 0.665 0.510 0.545 0.385 0.212 0.239 0.252
1.559 1.365 1.264 0.997 0.335 0.428 0.444 0.867 0.492 0.656 0.546 1.041
0.486 0.597 0.391 0.246
I13 0.696 0.303 0.175 0.905 0.946 0.197 1.005 0.893 0.174 0.663 0.357
0.353 0.000 0.145 0.069 0.238 0.217 0.152 0.546 0.165 0.492 0.737 0.372
0.238 0.993 0.416 0.322 0.129 0.291 0.918 0.421 0.829 1.012 0.270 0.940
0.210 0.226 0.738 0.698 0.327 0.684 0.415 0.615 0.398 0.229 0.192 0.289

0.439 0.488 0.882 1.069 0.602 0.275 0.674 0.299 0.380 0.982 0.106 0.355
0.166 0.967 0.240 0.346 0.297 0.279 0.353 0.376 0.442 0.535 0.823 0.756
0.206 0.774 0.998 0.130 0.606 0.828 0.320 0.985 0.883 0.781 0.247 0.276
0.746 0.306 0.150 1.081 0.421 0.507 0.318 0.655 0.419 0.470 0.426 0.340
1.418 1.173 0.971 0.884 0.100 0.108 0.761 0.916 0.140 0.831 0.889 0.783
0.446 0.685 0.496 0.408
I14 0.823 0.438 0.276 0.960 1.086 0.118 0.996 0.953 0.215 0.786 0.485
0.468 0.145 0.001 0.084 0.290 0.306 0.133 0.691 0.269 0.632 0.877 0.460
0.366 1.128 0.545 0.424 0.081 0.417 0.959 0.514 0.896 1.151 0.201 1.083
0.258 0.264 0.868 0.820 0.416 0.741 0.520 0.754 0.538 0.096 0.067 0.390
0.583 0.633 1.024 1.210 0.746 0.189 0.805 0.368 0.507 1.120 0.078 0.409
0.312 0.999 0.114 0.478 0.292 0.235 0.312 0.354 0.401 0.674 0.955 0.886
0.307 0.911 1.135 0.237 0.746 0.963 0.445 1.048 1.018 0.898 0.233 0.418
0.846 0.324 0.284 1.142 0.515 0.601 0.221 0.798 0.560 0.609 0.570 0.378
1.489 1.226 0.966 0.977 0.239 0.190 0.895 1.047 0.123 0.976 1.013 0.809
0.576 0.825 0.640 0.552
I15 0.745 0.358 0.204 0.941 1.013 0.139 1.014 0.932 0.165 0.709 0.421
0.393 0.069 0.084 0.017 0.238 0.239 0.110 0.610 0.196 0.551 0.795 0.395
0.287 1.047 0.480 0.354 0.071 0.339 0.948 0.448 0.870 1.070 0.218 1.007
0.235 0.247 0.789 0.743 0.350 0.721 0.470 0.672 0.457 0.163 0.127 0.320
0.505 0.554 0.942 1.136 0.664 0.218 0.726 0.310 0.429 1.039 0.075 0.359
0.233 0.994 0.188 0.399 0.301 0.265 0.342 0.374 0.432 0.593 0.888 0.807
0.236 0.840 1.054 0.163 0.665 0.894 0.367 1.025 0.937 0.842 0.215 0.336
0.800 0.291 0.215 1.120 0.472 0.558 0.259 0.722 0.486 0.528 0.488 0.336
1.462 1.209 0.982 0.936 0.166 0.144 0.815 0.981 0.127 0.898 0.936 0.806
0.510 0.752 0.563 0.471
I16 0.584 0.270 0.104 1.128 1.024 0.216 1.243 1.113 0.075 0.540 0.514
0.231 0.238 0.290 0.238 0.000 0.075 0.161 0.563 0.112 0.457 0.682 0.181
0.198 0.901 0.564 0.169 0.210 0.224 1.147 0.235 1.045 0.945 0.209 0.993
0.447 0.463 0.635 0.570 0.142 0.908 0.608 0.558 0.377 0.301 0.275 0.140
0.500 0.530 0.834 1.138 0.587 0.238 0.580 0.080 0.295 0.908 0.313 0.121
0.284 1.200 0.402 0.287 0.533 0.502 0.580 0.609 0.670 0.487 0.940 0.655
0.103 0.868 0.921 0.129 0.560 0.929 0.238 1.202 0.794 0.935 0.118 0.290
0.931 0.089 0.335 1.298 0.626 0.706 0.279 0.723 0.515 0.430 0.430 0.103
1.624 1.394 1.209 1.074 0.291 0.344 0.674 1.027 0.363 0.862 0.763 1.018
0.586 0.767 0.558 0.425
I17 0.532 0.196 0.047 1.078 0.950 0.258 1.216 1.062 0.107 0.490 0.449
0.173 0.217 0.306 0.239 0.075 0.005 0.194 0.490 0.057 0.387 0.617 0.157
0.124 0.846 0.497 0.119 0.232 0.152 1.102 0.209 0.992 0.884 0.270 0.918
0.417 0.436 0.581 0.523 0.111 0.860 0.550 0.493 0.304 0.338 0.307 0.086
0.425 0.456 0.769 1.063 0.516 0.296 0.523 0.088 0.229 0.849 0.310 0.150
0.222 1.158 0.420 0.217 0.514 0.495 0.570 0.594 0.659 0.419 0.867 0.600
0.030 0.794 0.862 0.088 0.492 0.855 0.169 1.148 0.737 0.865 0.185 0.216
0.868 0.161 0.283 1.244 0.571 0.649 0.341 0.648 0.443 0.360 0.356 0.156
1.565 1.343 1.181 1.012 0.246 0.316 0.616 0.953 0.354 0.789 0.716 0.979
0.517 0.693 0.483 0.350

I18 0.726 0.363 0.178 1.050 1.074 0.067 1.118 1.040 0.090 0.684 0.503
0.366 0.152 0.133 0.110 0.161 0.194 0.000 0.643 0.175 0.562 0.801 0.339
0.286 1.038 0.560 0.313 0.053 0.331 1.058 0.394 0.978 1.072 0.119 1.058
0.345 0.357 0.774 0.717 0.297 0.829 0.567 0.676 0.471 0.144 0.114 0.280
0.553 0.595 0.952 1.194 0.685 0.131 0.714 0.241 0.417 1.038 0.177 0.277
0.288 1.103 0.243 0.396 0.407 0.362 0.440 0.477 0.529 0.599 0.963 0.793
0.204 0.906 1.052 0.154 0.672 0.963 0.354 1.132 0.929 0.929 0.107 0.359
0.898 0.191 0.298 1.228 0.573 0.659 0.177 0.776 0.547 0.536 0.513 0.245
1.568 1.317 1.087 1.036 0.246 0.251 0.807 1.054 0.231 0.939 0.910 0.916
0.588 0.812 0.612 0.500
I19 0.343 0.293 0.478 0.929 0.476 0.709 1.231 0.899 0.580 0.354 0.334
0.365 0.546 0.691 0.610 0.563 0.490 0.643 0.004 0.477 0.141 0.249 0.471
0.368 0.524 0.313 0.426 0.654 0.340 0.991 0.459 0.821 0.504 0.748 0.431
0.590 0.609 0.347 0.382 0.469 0.758 0.447 0.182 0.188 0.767 0.729 0.437
0.129 0.072 0.363 0.581 0.089 0.769 0.289 0.529 0.294 0.485 0.640 0.575
0.380 1.065 0.779 0.283 0.703 0.743 0.788 0.775 0.850 0.156 0.449 0.353
0.464 0.351 0.503 0.490 0.156 0.414 0.333 0.959 0.424 0.524 0.672 0.285
0.611 0.643 0.432 1.045 0.495 0.516 0.816 0.191 0.196 0.163 0.134 0.612
1.294 1.156 1.188 0.743 0.462 0.551 0.326 0.518 0.647 0.299 0.503 0.935
0.295 0.248 0.106 0.143
I20 0.556 0.189 0.010 1.023 0.925 0.242 1.160 1.007 0.104 0.518 0.403
0.199 0.165 0.269 0.196 0.112 0.057 0.175 0.477 0.000 0.387 0.626 0.207
0.111 0.865 0.452 0.159 0.203 0.156 1.046 0.256 0.938 0.897 0.271 0.900
0.361 0.380 0.603 0.551 0.162 0.804 0.498 0.501 0.298 0.315 0.280 0.125
0.400 0.435 0.777 1.042 0.512 0.294 0.542 0.144 0.243 0.863 0.263 0.206
0.172 1.102 0.381 0.221 0.459 0.444 0.518 0.540 0.606 0.424 0.833 0.621
0.041 0.765 0.878 0.035 0.497 0.825 0.180 1.095 0.756 0.823 0.198 0.194
0.820 0.200 0.228 1.191 0.518 0.597 0.340 0.625 0.408 0.361 0.344 0.207
1.514 1.289 1.124 0.963 0.189 0.260 0.633 0.921 0.304 0.775 0.745 0.922
0.475 0.666 0.459 0.334
I21 0.251 0.199 0.386 1.027 0.613 0.629 1.295 1.000 0.487 0.246 0.385
0.238 0.492 0.632 0.551 0.457 0.387 0.562 0.141 0.387 0.004 0.245 0.340
0.276 0.508 0.385 0.303 0.582 0.235 1.082 0.322 0.922 0.520 0.655 0.559
0.586 0.606 0.276 0.279 0.345 0.841 0.511 0.125 0.095 0.697 0.660 0.321
0.192 0.165 0.392 0.712 0.131 0.679 0.208 0.410 0.167 0.491 0.595 0.449
0.340 1.153 0.732 0.170 0.703 0.728 0.784 0.781 0.857 0.047 0.589 0.289
0.365 0.492 0.507 0.409 0.114 0.556 0.219 1.067 0.399 0.654 0.571 0.216
0.726 0.529 0.412 1.156 0.555 0.595 0.725 0.332 0.264 0.027 0.089 0.490
1.421 1.266 1.253 0.864 0.427 0.524 0.280 0.659 0.614 0.418 0.438 1.008
0.378 0.389 0.212 0.115
I22 0.185 0.440 0.623 1.162 0.545 0.868 1.478 1.131 0.722 0.229 0.582
0.451 0.737 0.877 0.795 0.682 0.617 0.801 0.249 0.626 0.245 0.001 0.534
0.516 0.276 0.562 0.516 0.824 0.470 1.229 0.498 1.053 0.275 0.887 0.457
0.820 0.840 0.152 0.235 0.553 1.002 0.696 0.125 0.339 0.939 0.902 0.542
0.374 0.320 0.153 0.608 0.161 0.913 0.141 0.623 0.388 0.248 0.840 0.648
0.583 1.305 0.977 0.405 0.935 0.967 1.019 1.011 1.087 0.203 0.602 0.146

0.599 0.495 0.264 0.649 0.131 0.549 0.449 1.183 0.177 0.719 0.799 0.461
0.832 0.744 0.650 1.264 0.744 0.763 0.958 0.362 0.444 0.268 0.319 0.695
1.484 1.376 1.435 0.952 0.670 0.766 0.101 0.642 0.857 0.314 0.274 1.182
0.543 0.415 0.354 0.343
I23 0.414 0.212 0.197 1.191 0.947 0.397 1.359 1.171 0.249 0.366 0.536
0.108 0.372 0.460 0.395 0.181 0.157 0.339 0.471 0.207 0.340 0.534 0.000
0.188 0.731 0.572 0.065 0.383 0.165 1.223 0.055 1.098 0.784 0.385 0.899
0.563 0.582 0.466 0.394 0.046 0.977 0.651 0.417 0.288 0.481 0.453 0.088
0.448 0.460 0.685 1.051 0.470 0.416 0.417 0.103 0.177 0.746 0.466 0.114
0.333 1.283 0.574 0.197 0.665 0.651 0.725 0.746 0.813 0.357 0.896 0.486
0.166 0.810 0.757 0.241 0.425 0.873 0.153 1.254 0.627 0.923 0.292 0.262
0.950 0.216 0.410 1.349 0.681 0.752 0.454 0.653 0.489 0.314 0.347 0.161
1.655 1.452 1.322 1.094 0.382 0.464 0.511 0.975 0.510 0.759 0.585 1.110
0.585 0.705 0.499 0.354
I24 0.459 0.078 0.111 1.003 0.826 0.353 1.181 0.984 0.214 0.425 0.351
0.123 0.238 0.366 0.287 0.198 0.124 0.286 0.368 0.111 0.276 0.516 0.188
0.003 0.762 0.391 0.123 0.308 0.053 1.036 0.221 0.911 0.789 0.382 0.795
0.396 0.416 0.503 0.460 0.156 0.790 0.464 0.392 0.187 0.422 0.387 0.106
0.302 0.332 0.666 0.940 0.401 0.405 0.439 0.185 0.142 0.756 0.343 0.245
0.148 1.096 0.473 0.113 0.506 0.507 0.576 0.588 0.660 0.314 0.746 0.521
0.097 0.671 0.771 0.133 0.387 0.733 0.083 1.066 0.652 0.753 0.303 0.093
0.769 0.283 0.229 1.162 0.493 0.564 0.451 0.525 0.324 0.251 0.235 0.267
1.471 1.264 1.143 0.913 0.212 0.306 0.529 0.832 0.375 0.667 0.651 0.925
0.408 0.569 0.360 0.227
I25 0.317 0.691 0.860 1.416 0.696 1.103 1.749 1.383 0.953 0.365 0.858
0.673 0.993 1.128 1.047 0.901 0.846 1.038 0.524 0.865 0.508 0.276 0.731
0.762 0.000 0.836 0.732 1.068 0.711 1.488 0.683 1.307 0.115 1.109 0.590
1.092 1.112 0.266 0.341 0.761 1.268 0.970 0.384 0.601 1.180 1.145 0.763
0.650 0.596 0.199 0.712 0.437 1.138 0.323 0.831 0.622 0.080 1.098 0.840
0.848 1.565 1.233 0.649 1.208 1.236 1.291 1.285 1.361 0.462 0.809 0.246
0.833 0.706 0.071 0.893 0.399 0.748 0.685 1.428 0.112 0.949 1.018 0.721
1.078 0.947 0.920 1.503 1.018 1.033 1.180 0.605 0.719 0.527 0.590 0.890
1.691 1.615 1.706 1.187 0.935 1.032 0.233 0.824 1.120 0.482 0.185 1.451
0.816 0.650 0.627 0.615
I26 0.633 0.363 0.460 0.647 0.553 0.612 0.919 0.621 0.539 0.630 0.060
0.476 0.416 0.545 0.480 0.564 0.497 0.560 0.313 0.452 0.385 0.562 0.572
0.391 0.836 0.002 0.508 0.544 0.407 0.697 0.590 0.544 0.807 0.679 0.571
0.349 0.362 0.649 0.664 0.545 0.456 0.134 0.482 0.338 0.639 0.603 0.497
0.196 0.244 0.665 0.679 0.401 0.689 0.585 0.574 0.432 0.793 0.473 0.635
0.283 0.768 0.596 0.394 0.442 0.503 0.528 0.501 0.573 0.425 0.410 0.658
0.468 0.374 0.811 0.443 0.459 0.421 0.424 0.695 0.737 0.372 0.634 0.310
0.378 0.652 0.265 0.788 0.182 0.210 0.733 0.299 0.122 0.385 0.301 0.652
1.083 0.895 0.876 0.523 0.316 0.360 0.636 0.503 0.455 0.499 0.809 0.627
0.034 0.305 0.208 0.277
I27 0.417 0.151 0.150 1.126 0.900 0.375 1.298 1.106 0.224 0.373 0.471
0.066 0.322 0.424 0.354 0.169 0.119 0.313 0.426 0.159 0.303 0.516 0.065

0.123 0.732 0.508 0.000 0.351 0.102 1.159 0.102 1.033 0.777 0.377 0.856
0.505 0.525 0.467 0.405 0.048 0.913 0.586 0.394 0.238 0.457 0.426 0.034
0.391 0.408 0.668 1.006 0.434 0.406 0.411 0.108 0.136 0.740 0.421 0.149
0.269 1.219 0.537 0.144 0.610 0.601 0.674 0.692 0.760 0.327 0.840 0.486
0.118 0.757 0.753 0.193 0.398 0.820 0.095 1.188 0.625 0.861 0.287 0.198
0.886 0.229 0.347 1.284 0.616 0.686 0.448 0.602 0.428 0.276 0.297 0.187
1.590 1.386 1.261 1.030 0.323 0.409 0.505 0.921 0.462 0.719 0.598 1.047
0.522 0.652 0.444 0.300
I28 0.759 0.384 0.208 1.009 1.071 0.069 1.067 1.000 0.136 0.719 0.486
0.400 0.129 0.081 0.071 0.210 0.232 0.053 0.654 0.203 0.582 0.824 0.383
0.308 1.068 0.544 0.351 0.001 0.357 1.014 0.438 0.939 1.097 0.148 1.060
0.302 0.313 0.805 0.753 0.340 0.789 0.540 0.700 0.489 0.115 0.078 0.318
0.555 0.601 0.974 1.193 0.701 0.148 0.744 0.288 0.445 1.064 0.127 0.328
0.284 1.058 0.192 0.421 0.357 0.310 0.388 0.425 0.477 0.621 0.951 0.824
0.238 0.900 1.079 0.175 0.694 0.955 0.383 1.093 0.958 0.909 0.157 0.372
0.870 0.244 0.279 1.188 0.542 0.628 0.190 0.776 0.542 0.557 0.527 0.297
1.531 1.276 1.037 1.006 0.228 0.214 0.836 1.043 0.181 0.946 0.946 0.869
0.574 0.809 0.614 0.512
I29 0.407 0.051 0.153 1.033 0.808 0.397 1.225 1.012 0.253 0.372 0.373
0.078 0.291 0.417 0.339 0.224 0.152 0.331 0.340 0.156 0.235 0.470 0.165
0.053 0.711 0.407 0.102 0.357 0.000 1.069 0.186 0.938 0.741 0.420 0.771
0.445 0.465 0.451 0.407 0.144 0.822 0.491 0.345 0.153 0.470 0.435 0.101
0.292 0.314 0.622 0.918 0.364 0.445 0.388 0.192 0.090 0.708 0.396 0.245
0.191 1.132 0.526 0.066 0.557 0.560 0.628 0.639 0.711 0.269 0.741 0.469
0.130 0.660 0.722 0.182 0.343 0.722 0.030 1.092 0.601 0.759 0.337 0.097
0.785 0.303 0.274 1.187 0.524 0.591 0.490 0.508 0.326 0.209 0.207 0.275
1.490 1.291 1.186 0.930 0.262 0.357 0.479 0.823 0.427 0.639 0.598 0.964
0.420 0.556 0.347 0.206
I30 1.327 1.035 1.056 0.094 0.936 1.074 0.344 0.130 1.090 1.327 0.709
1.145 0.918 0.959 0.948 1.147 1.102 1.058 0.991 1.046 1.082 1.229 1.223
1.036 1.488 0.697 1.159 1.014 1.069 0.000 1.254 0.190 1.433 1.158 1.025
0.713 0.701 1.337 1.360 1.186 0.247 0.582 1.171 1.033 1.042 1.024 1.138
0.890 0.930 1.297 1.032 1.078 1.148 1.277 1.190 1.116 1.430 0.888 1.252
0.891 0.078 0.918 1.074 0.671 0.745 0.686 0.632 0.629 1.121 0.746 1.344
1.078 0.819 1.448 1.020 1.145 0.807 1.093 0.176 1.401 0.580 1.162 0.979
0.424 1.223 0.819 0.231 0.546 0.488 1.177 0.884 0.818 1.083 0.998 1.250
0.582 0.278 0.305 0.377 0.858 0.811 1.316 0.793 0.837 1.047 1.494 0.168
0.704 0.845 0.887 0.974
I31 0.367 0.227 0.247 1.219 0.934 0.451 1.400 1.198 0.304 0.318 0.558
0.114 0.421 0.514 0.448 0.235 0.209 0.394 0.459 0.256 0.322 0.498 0.055
0.221 0.683 0.590 0.102 0.438 0.186 1.254 0.001 1.124 0.741 0.438 0.881
0.607 0.627 0.420 0.344 0.098 1.008 0.678 0.385 0.284 0.536 0.508 0.132
0.451 0.456 0.646 1.034 0.447 0.469 0.375 0.157 0.171 0.701 0.518 0.157
0.368 1.316 0.628 0.201 0.712 0.700 0.774 0.793 0.861 0.332 0.894 0.440
0.215 0.804 0.712 0.291 0.395 0.868 0.166 1.278 0.581 0.931 0.345 0.281
0.967 0.266 0.448 1.373 0.710 0.777 0.506 0.645 0.498 0.297 0.343 0.206

1.672 1.477 1.363 1.111 0.425 0.510 0.468 0.970 0.560 0.738 0.533 1.146
0.600 0.699 0.498 0.353
I32 1.161 0.899 0.947 0.109 0.747 1.004 0.518 0.078 0.996 1.166 0.567
1.012 0.829 0.896 0.870 1.045 0.992 0.978 0.821 0.938 0.922 1.053 1.098
0.911 1.307 0.544 1.033 0.939 0.938 0.190 1.124 0.002 1.248 1.087 0.836
0.639 0.632 1.168 1.197 1.064 0.161 0.447 1.003 0.883 0.987 0.963 1.016
0.730 0.764 1.113 0.846 0.906 1.082 1.110 1.078 0.975 1.247 0.821 1.141
0.772 0.268 0.878 0.934 0.629 0.710 0.667 0.612 0.632 0.958 0.557 1.174
0.965 0.630 1.265 0.916 0.977 0.618 0.959 0.157 1.223 0.390 1.077 0.843
0.235 1.127 0.710 0.253 0.421 0.347 1.117 0.702 0.660 0.926 0.843 1.145
0.593 0.354 0.476 0.202 0.755 0.727 1.143 0.605 0.774 0.859 1.321 0.253
0.545 0.660 0.719 0.819
I33 0.377 0.714 0.893 1.357 0.600 1.138 1.708 1.323 0.990 0.429 0.836
0.714 1.012 1.151 1.070 0.945 0.884 1.072 0.504 0.897 0.520 0.275 0.784
0.789 0.115 0.807 0.777 1.097 0.741 1.433 0.741 1.248 0.007 1.152 0.493
1.090 1.109 0.323 0.412 0.809 1.222 0.941 0.398 0.614 1.211 1.175 0.805
0.633 0.576 0.144 0.606 0.424 1.180 0.367 0.880 0.656 0.044 1.115 0.896
0.858 1.510 1.252 0.677 1.204 1.239 1.289 1.278 1.354 0.477 0.729 0.304
0.868 0.631 0.045 0.922 0.406 0.666 0.718 1.361 0.167 0.878 1.063 0.736
1.015 1.000 0.923 1.433 0.989 0.995 1.223 0.550 0.698 0.542 0.593 0.945
1.604 1.544 1.664 1.115 0.944 1.039 0.274 0.735 1.131 0.400 0.288 1.407
0.784 0.588 0.601 0.615
I34 0.793 0.459 0.271 1.155 1.188 0.084 1.194 1.147 0.168 0.748 0.622
0.439 0.270 0.201 0.218 0.209 0.270 0.119 0.748 0.271 0.655 0.887 0.385
0.382 1.109 0.679 0.377 0.148 0.420 1.158 0.438 1.087 1.152 0.001 1.169
0.449 0.458 0.844 0.778 0.350 0.935 0.685 0.762 0.568 0.144 0.143 0.348
0.665 0.704 1.039 1.307 0.782 0.032 0.788 0.282 0.499 1.116 0.269 0.293
0.405 1.199 0.281 0.485 0.493 0.434 0.510 0.554 0.596 0.688 1.081 0.863
0.289 1.022 1.129 0.259 0.762 1.080 0.439 1.240 1.003 1.048 0.092 0.464
1.015 0.182 0.417 1.335 0.689 0.774 0.071 0.889 0.663 0.628 0.615 0.247
1.679 1.422 1.166 1.152 0.365 0.362 0.882 1.172 0.321 1.046 0.969 1.010
0.708 0.927 0.724 0.605
I35 0.641 0.723 0.903 0.939 0.116 1.121 1.338 0.902 1.004 0.680 0.625
0.794 0.940 1.083 1.007 0.993 0.918 1.058 0.431 0.900 0.559 0.457 0.899
0.795 0.590 0.571 0.856 1.060 0.771 1.025 0.881 0.836 0.493 1.169 0.046
0.918 0.932 0.609 0.691 0.900 0.856 0.673 0.518 0.620 1.169 1.131 0.869
0.505 0.465 0.403 0.155 0.434 1.187 0.591 0.960 0.723 0.512 1.020 1.005
0.776 1.103 1.153 0.714 1.012 1.074 1.097 1.067 1.135 0.551 0.282 0.600
0.892 0.223 0.526 0.909 0.499 0.221 0.765 0.921 0.556 0.446 1.097 0.707
0.603 1.074 0.802 0.981 0.715 0.681 1.234 0.286 0.523 0.585 0.564 1.043
1.118 1.088 1.294 0.670 0.845 0.914 0.552 0.257 1.013 0.148 0.697 1.040
0.538 0.267 0.447 0.568
I36 0.823 0.435 0.372 0.707 0.900 0.366 0.799 0.698 0.383 0.799 0.293
0.519 0.210 0.258 0.235 0.447 0.417 0.345 0.590 0.361 0.586 0.820 0.563
0.396 1.092 0.349 0.505 0.302 0.445 0.713 0.607 0.639 1.090 0.449 0.918
0.000 0.021 0.857 0.835 0.519 0.487 0.282 0.710 0.498 0.351 0.325 0.476

0.463 0.520 0.951 1.027 0.666 0.443 0.789 0.503 0.523 1.067 0.181 0.562
0.259 0.760 0.265 0.483 0.117 0.157 0.199 0.197 0.272 0.633 0.745 0.872
0.400 0.721 1.084 0.329 0.694 0.765 0.475 0.792 0.984 0.664 0.449 0.388
0.595 0.516 0.177 0.887 0.267 0.350 0.478 0.640 0.412 0.571 0.502 0.550
1.232 0.974 0.764 0.722 0.184 0.103 0.866 0.838 0.137 0.836 1.016 0.574
0.382 0.652 0.508 0.478
I37 0.843 0.456 0.390 0.697 0.912 0.375 0.781 0.690 0.398 0.820 0.307
0.539 0.226 0.264 0.247 0.463 0.436 0.357 0.609 0.380 0.606 0.840 0.582
0.416 1.112 0.362 0.525 0.313 0.465 0.701 0.627 0.632 1.109 0.458 0.932
0.021 0.001 0.877 0.856 0.539 0.478 0.289 0.730 0.518 0.356 0.331 0.495
0.481 0.538 0.970 1.039 0.685 0.451 0.810 0.521 0.544 1.086 0.189 0.579
0.280 0.746 0.262 0.503 0.096 0.142 0.180 0.176 0.251 0.653 0.754 0.892
0.419 0.733 1.103 0.347 0.713 0.776 0.495 0.784 1.004 0.670 0.462 0.408
0.595 0.531 0.198 0.878 0.270 0.351 0.485 0.655 0.429 0.591 0.522 0.566
1.225 0.964 0.746 0.720 0.204 0.120 0.886 0.847 0.142 0.852 1.037 0.560
0.395 0.666 0.526 0.498
I38 0.053 0.436 0.598 1.276 0.697 0.839 1.566 1.246 0.688 0.105 0.656
0.408 0.738 0.868 0.789 0.635 0.581 0.774 0.347 0.603 0.276 0.152 0.466
0.503 0.266 0.649 0.467 0.805 0.451 1.337 0.420 1.168 0.323 0.844 0.609
0.857 0.877 0.001 0.094 0.495 1.102 0.780 0.167 0.359 0.917 0.883 0.497
0.453 0.408 0.256 0.758 0.263 0.873 0.068 0.565 0.361 0.282 0.844 0.577
0.603 1.411 0.976 0.392 0.973 0.993 1.053 1.053 1.128 0.230 0.747 0.020
0.569 0.640 0.293 0.632 0.192 0.696 0.423 1.305 0.162 0.854 0.752 0.473
0.955 0.683 0.680 1.389 0.826 0.858 0.914 0.497 0.527 0.287 0.364 0.626
1.623 1.501 1.524 1.082 0.689 0.787 0.063 0.792 0.870 0.466 0.162 1.275
0.637 0.554 0.451 0.391
I39 0.050 0.402 0.545 1.303 0.775 0.780 1.572 1.275 0.628 0.036 0.663
0.352 0.698 0.820 0.743 0.570 0.523 0.717 0.382 0.551 0.279 0.235 0.394
0.460 0.341 0.664 0.405 0.753 0.407 1.360 0.344 1.197 0.412 0.778 0.691
0.835 0.856 0.094 0.000 0.428 1.119 0.789 0.203 0.345 0.861 0.829 0.437
0.469 0.433 0.350 0.842 0.309 0.808 0.102 0.496 0.319 0.369 0.803 0.500
0.577 1.431 0.931 0.356 0.951 0.963 1.027 1.032 1.106 0.239 0.808 0.111
0.515 0.703 0.378 0.583 0.230 0.761 0.378 1.339 0.246 0.903 0.685 0.447
0.993 0.610 0.658 1.426 0.834 0.874 0.847 0.552 0.542 0.282 0.366 0.550
1.674 1.537 1.530 1.125 0.659 0.757 0.155 0.860 0.834 0.545 0.194 1.287
0.656 0.610 0.479 0.392
I40 0.444 0.194 0.152 1.156 0.943 0.356 1.316 1.137 0.207 0.398 0.506
0.108 0.327 0.416 0.350 0.142 0.111 0.297 0.469 0.162 0.345 0.553 0.046
0.156 0.761 0.545 0.048 0.340 0.144 1.186 0.098 1.064 0.809 0.350 0.900
0.519 0.539 0.495 0.428 0.020 0.941 0.618 0.432 0.282 0.440 0.411 0.052
0.434 0.451 0.705 1.050 0.476 0.380 0.443 0.072 0.179 0.772 0.421 0.108
0.295 1.245 0.529 0.188 0.621 0.605 0.680 0.701 0.768 0.367 0.882 0.515
0.121 0.800 0.784 0.196 0.438 0.863 0.140 1.220 0.656 0.902 0.258 0.238
0.923 0.192 0.370 1.316 0.646 0.718 0.420 0.646 0.469 0.319 0.341 0.147
1.626 1.418 1.280 1.067 0.340 0.420 0.537 0.964 0.465 0.762 0.620 1.070
0.560 0.696 0.487 0.344

I41 1.088 0.788 0.814 0.221 0.783 0.852 0.489 0.212 0.854 1.086 0.463
0.899 0.684 0.741 0.721 0.908 0.860 0.829 0.758 0.804 0.841 1.002 0.977
0.790 1.268 0.456 0.913 0.789 0.822 0.247 1.008 0.161 1.222 0.935 0.856
0.487 0.478 1.102 1.119 0.941 0.000 0.336 0.935 0.788 0.831 0.808 0.892
0.651 0.694 1.082 0.894 0.846 0.929 1.039 0.947 0.870 1.215 0.667 1.010
0.646 0.313 0.718 0.828 0.469 0.549 0.506 0.451 0.473 0.881 0.587 1.110
0.835 0.638 1.233 0.780 0.910 0.641 0.846 0.307 1.176 0.428 0.931 0.732
0.272 0.987 0.576 0.401 0.299 0.245 0.962 0.672 0.578 0.840 0.756 1.009
0.751 0.489 0.444 0.318 0.617 0.579 1.084 0.655 0.618 0.852 1.260 0.187
0.465 0.641 0.653 0.731
I42 0.761 0.455 0.507 0.541 0.638 0.609 0.786 0.520 0.568 0.755 0.128
0.566 0.415 0.520 0.470 0.608 0.550 0.567 0.447 0.498 0.511 0.696 0.651
0.464 0.970 0.134 0.586 0.540 0.491 0.582 0.678 0.447 0.941 0.685 0.673
0.282 0.289 0.780 0.789 0.618 0.336 0.000 0.614 0.453 0.617 0.585 0.569
0.327 0.377 0.798 0.764 0.535 0.688 0.715 0.634 0.534 0.927 0.443 0.697
0.328 0.649 0.547 0.493 0.350 0.423 0.431 0.396 0.462 0.553 0.469 0.789
0.522 0.461 0.945 0.479 0.591 0.496 0.514 0.603 0.871 0.382 0.656 0.398
0.331 0.693 0.276 0.698 0.048 0.100 0.729 0.419 0.254 0.508 0.424 0.704
1.016 0.800 0.744 0.470 0.326 0.331 0.769 0.561 0.411 0.618 0.941 0.498
0.157 0.413 0.343 0.398
I43 0.161 0.316 0.498 1.110 0.590 0.743 1.400 1.081 0.597 0.180 0.492
0.329 0.615 0.754 0.672 0.558 0.493 0.676 0.182 0.501 0.125 0.125 0.417
0.392 0.384 0.482 0.394 0.700 0.345 1.171 0.385 1.003 0.398 0.762 0.518
0.710 0.730 0.167 0.203 0.432 0.935 0.614 0.000 0.218 0.814 0.778 0.418
0.287 0.241 0.277 0.672 0.105 0.789 0.107 0.502 0.264 0.367 0.719 0.530
0.465 1.244 0.855 0.280 0.826 0.853 0.908 0.904 0.979 0.080 0.607 0.176
0.475 0.503 0.383 0.525 0.027 0.563 0.324 1.141 0.275 0.700 0.676 0.340
0.793 0.623 0.536 1.227 0.660 0.691 0.833 0.349 0.360 0.145 0.208 0.576
1.471 1.338 1.358 0.923 0.552 0.649 0.159 0.663 0.738 0.371 0.327 1.109
0.470 0.407 0.284 0.233
I44 0.327 0.109 0.298 0.985 0.661 0.538 1.228 0.960 0.400 0.310 0.326
0.180 0.398 0.538 0.457 0.377 0.304 0.471 0.188 0.298 0.095 0.339 0.288
0.187 0.601 0.338 0.238 0.489 0.153 1.033 0.284 0.883 0.614 0.568 0.620
0.498 0.518 0.359 0.345 0.282 0.788 0.453 0.218 0.000 0.604 0.567 0.249
0.170 0.172 0.486 0.768 0.214 0.592 0.292 0.341 0.113 0.585 0.501 0.387
0.247 1.102 0.638 0.095 0.614 0.637 0.695 0.694 0.769 0.139 0.610 0.374
0.280 0.522 0.601 0.317 0.208 0.585 0.145 1.032 0.491 0.651 0.488 0.122
0.703 0.455 0.322 1.124 0.495 0.545 0.638 0.365 0.228 0.074 0.059 0.424
1.406 1.232 1.187 0.845 0.334 0.432 0.371 0.688 0.520 0.486 0.519 0.949
0.340 0.417 0.213 0.070
I45 0.869 0.499 0.320 1.047 1.175 0.086 1.058 1.042 0.234 0.828 0.579
0.510 0.229 0.096 0.163 0.301 0.338 0.144 0.767 0.315 0.697 0.939 0.481
0.422 1.180 0.639 0.457 0.115 0.470 1.042 0.536 0.987 1.211 0.144 1.169
0.351 0.356 0.917 0.861 0.440 0.831 0.617 0.814 0.604 0.000 0.038 0.424
0.666 0.713 1.088 1.298 0.816 0.119 0.857 0.381 0.558 1.178 0.174 0.409
0.393 1.079 0.139 0.535 0.371 0.303 0.375 0.423 0.458 0.736 1.048 0.936

0.347 1.002 1.192 0.289 0.809 1.055 0.495 1.137 1.071 0.994 0.210 0.486
0.942 0.308 0.375 1.231 0.611 0.696 0.137 0.884 0.648 0.672 0.641 0.370
1.580 1.312 1.031 1.072 0.327 0.286 0.948 1.141 0.215 1.057 1.055 0.889
0.670 0.914 0.724 0.626
I46 0.836 0.462 0.285 1.026 1.138 0.068 1.052 1.020 0.204 0.796 0.544
0.477 0.192 0.067 0.127 0.275 0.307 0.114 0.729 0.280 0.660 0.902 0.453
0.387 1.145 0.603 0.426 0.078 0.435 1.024 0.508 0.963 1.175 0.143 1.131
0.325 0.331 0.883 0.829 0.411 0.808 0.585 0.778 0.567 0.038 0.001 0.392
0.628 0.675 1.052 1.261 0.778 0.126 0.822 0.354 0.523 1.143 0.144 0.387
0.356 1.063 0.141 0.499 0.355 0.292 0.367 0.412 0.453 0.700 1.012 0.902
0.314 0.965 1.157 0.253 0.773 1.019 0.461 1.115 1.036 0.961 0.194 0.449
0.911 0.290 0.339 1.209 0.581 0.667 0.154 0.847 0.611 0.635 0.604 0.350
1.556 1.292 1.023 1.043 0.291 0.254 0.914 1.105 0.190 1.020 1.022 0.873
0.634 0.877 0.686 0.588
I47 0.448 0.152 0.116 1.107 0.908 0.343 1.271 1.088 0.191 0.405 0.457
0.091 0.289 0.390 0.320 0.140 0.086 0.280 0.437 0.125 0.321 0.542 0.088
0.106 0.763 0.497 0.034 0.318 0.101 1.138 0.132 1.016 0.805 0.348 0.869
0.476 0.495 0.497 0.437 0.052 0.892 0.569 0.418 0.249 0.424 0.392 0.000
0.393 0.414 0.694 1.017 0.452 0.376 0.441 0.092 0.156 0.768 0.388 0.144
0.247 1.197 0.503 0.155 0.580 0.568 0.642 0.661 0.729 0.348 0.841 0.517
0.084 0.761 0.781 0.160 0.420 0.823 0.104 1.172 0.655 0.856 0.258 0.191
0.875 0.208 0.322 1.267 0.597 0.670 0.419 0.609 0.424 0.294 0.306 0.175
1.578 1.369 1.235 1.019 0.295 0.378 0.535 0.924 0.429 0.734 0.631 1.023
0.513 0.657 0.448 0.306
I48 0.438 0.241 0.403 0.835 0.526 0.616 1.114 0.808 0.502 0.437 0.208
0.342 0.439 0.583 0.505 0.500 0.425 0.553 0.129 0.400 0.192 0.374 0.448
0.302 0.650 0.196 0.391 0.555 0.292 0.890 0.451 0.730 0.633 0.665 0.505
0.463 0.481 0.453 0.469 0.434 0.651 0.327 0.287 0.170 0.666 0.628 0.393
0.000 0.057 0.492 0.643 0.213 0.682 0.389 0.482 0.281 0.614 0.527 0.537
0.273 0.962 0.664 0.252 0.575 0.618 0.661 0.646 0.722 0.230 0.449 0.462
0.397 0.369 0.632 0.405 0.263 0.431 0.297 0.875 0.547 0.482 0.597 0.210
0.538 0.586 0.312 0.965 0.374 0.406 0.729 0.225 0.074 0.197 0.117 0.566
1.238 1.075 1.071 0.678 0.348 0.430 0.442 0.531 0.529 0.393 0.614 0.823
0.187 0.267 0.059 0.100
I49 0.397 0.264 0.438 0.871 0.495 0.660 1.162 0.843 0.539 0.402 0.262
0.352 0.488 0.633 0.554 0.530 0.456 0.595 0.072 0.435 0.165 0.320 0.460
0.332 0.596 0.244 0.408 0.601 0.314 0.930 0.456 0.764 0.576 0.704 0.465
0.520 0.538 0.408 0.433 0.451 0.694 0.377 0.241 0.172 0.713 0.675 0.414
0.057 0.001 0.435 0.608 0.159 0.723 0.347 0.505 0.286 0.558 0.579 0.556
0.322 1.003 0.717 0.264 0.632 0.674 0.718 0.704 0.779 0.195 0.438 0.416
0.428 0.350 0.576 0.445 0.216 0.413 0.313 0.906 0.494 0.491 0.633 0.242
0.563 0.614 0.367 0.994 0.425 0.450 0.770 0.195 0.124 0.177 0.113 0.589
1.256 1.105 1.120 0.699 0.400 0.485 0.392 0.515 0.583 0.345 0.567 0.869
0.229 0.245 0.047 0.108
I50 0.305 0.590 0.774 1.222 0.506 1.019 1.567 1.189 0.874 0.356 0.694
0.604 0.882 1.024 0.942 0.834 0.769 0.952 0.363 0.777 0.392 0.153 0.685

0.666 0.199 0.665 0.668 0.974 0.622 1.297 0.646 1.113 0.144 1.039 0.403
0.951 0.970 0.256 0.350 0.705 1.082 0.798 0.277 0.486 1.088 1.052 0.694
0.492 0.435 0.015 0.538 0.286 1.065 0.276 0.775 0.540 0.134 0.984 0.799
0.724 1.374 1.122 0.556 1.065 1.102 1.150 1.138 1.213 0.353 0.610 0.240
0.751 0.508 0.153 0.800 0.280 0.550 0.601 1.231 0.159 0.751 0.952 0.607
0.883 0.896 0.787 1.306 0.846 0.853 1.110 0.413 0.555 0.417 0.459 0.846
1.493 1.417 1.523 0.989 0.810 0.904 0.196 0.629 0.998 0.285 0.299 1.266
0.641 0.454 0.459 0.480
I51 0.792 0.869 1.045 0.941 0.127 1.256 1.361 0.905 1.145 0.833 0.737
0.945 1.069 1.210 1.136 1.138 1.063 1.194 0.581 1.042 0.712 0.608 1.051
0.940 0.712 0.679 1.006 1.193 0.918 1.032 1.034 0.846 0.606 1.307 0.155
1.027 1.039 0.758 0.842 1.050 0.894 0.764 0.672 0.768 1.298 1.261 1.017
0.643 0.608 0.538 0.000 0.588 1.324 0.744 1.109 0.874 0.632 1.144 1.155
0.908 1.109 1.273 0.863 1.112 1.180 1.195 1.160 1.224 0.705 0.312 0.748
1.036 0.306 0.644 1.048 0.653 0.269 0.913 0.907 0.692 0.467 1.239 0.849
0.626 1.221 0.926 0.953 0.801 0.753 1.371 0.418 0.651 0.737 0.711 1.192
1.042 1.055 1.318 0.660 0.972 1.034 0.700 0.242 1.131 0.302 0.836 1.072
0.646 0.385 0.584 0.714
I52 0.265 0.323 0.512 1.014 0.497 0.751 1.319 0.984 0.614 0.285 0.421
0.369 0.602 0.746 0.664 0.587 0.516 0.685 0.089 0.512 0.131 0.161 0.470
0.401 0.437 0.401 0.434 0.701 0.364 1.078 0.447 0.906 0.424 0.782 0.434
0.666 0.685 0.263 0.309 0.476 0.846 0.535 0.105 0.214 0.816 0.778 0.452
0.213 0.159 0.286 0.588 0.001 0.806 0.210 0.542 0.298 0.402 0.701 0.580
0.441 1.152 0.840 0.300 0.780 0.816 0.865 0.855 0.930 0.116 0.503 0.268
0.493 0.399 0.420 0.531 0.079 0.460 0.350 1.042 0.336 0.595 0.701 0.329
0.692 0.660 0.501 1.126 0.583 0.605 0.852 0.244 0.283 0.158 0.176 0.621
1.366 1.238 1.276 0.820 0.526 0.619 0.238 0.561 0.713 0.290 0.416 1.024
0.384 0.302 0.195 0.195
I53 0.823 0.483 0.294 1.148 1.204 0.079 1.176 1.140 0.192 0.778 0.631
0.467 0.275 0.189 0.218 0.238 0.296 0.131 0.769 0.294 0.679 0.913 0.416
0.405 1.138 0.689 0.406 0.148 0.445 1.148 0.469 1.082 1.180 0.032 1.187
0.443 0.451 0.873 0.808 0.380 0.929 0.688 0.789 0.592 0.119 0.126 0.376
0.682 0.723 1.065 1.324 0.806 0.001 0.817 0.313 0.526 1.144 0.262 0.325
0.419 1.188 0.258 0.510 0.480 0.418 0.492 0.537 0.576 0.714 1.093 0.892
0.315 1.036 1.158 0.279 0.788 1.093 0.465 1.235 1.031 1.055 0.124 0.484
1.018 0.214 0.424 1.329 0.689 0.775 0.047 0.906 0.677 0.653 0.637 0.280
1.675 1.414 1.148 1.153 0.373 0.360 0.911 1.184 0.311 1.066 1.000 0.998
0.717 0.942 0.741 0.626
I54 0.055 0.371 0.537 1.217 0.673 0.780 1.501 1.188 0.630 0.089 0.591
0.350 0.674 0.805 0.726 0.580 0.523 0.714 0.289 0.542 0.208 0.141 0.417
0.439 0.323 0.585 0.411 0.744 0.388 1.277 0.375 1.110 0.367 0.788 0.591
0.789 0.810 0.068 0.102 0.443 1.039 0.715 0.107 0.292 0.857 0.822 0.441
0.389 0.347 0.276 0.744 0.210 0.817 0.001 0.514 0.299 0.329 0.779 0.530
0.536 1.349 0.912 0.328 0.906 0.926 0.986 0.986 1.061 0.163 0.707 0.083
0.510 0.601 0.341 0.570 0.134 0.659 0.362 1.248 0.215 0.805 0.698 0.407
0.901 0.633 0.613 1.334 0.761 0.795 0.859 0.452 0.463 0.220 0.297 0.579

1.576 1.446 1.459 1.030 0.622 0.721 0.096 0.757 0.804 0.445 0.229 1.211
0.574 0.509 0.391 0.324
I55 0.514 0.242 0.134 1.165 1.000 0.296 1.302 1.148 0.153 0.467 0.529
0.174 0.299 0.368 0.310 0.080 0.088 0.241 0.529 0.144 0.410 0.623 0.103
0.185 0.831 0.574 0.108 0.288 0.192 1.190 0.157 1.078 0.880 0.282 0.960
0.503 0.521 0.565 0.496 0.072 0.947 0.634 0.502 0.341 0.381 0.354 0.092
0.482 0.505 0.775 1.109 0.542 0.313 0.514 0.001 0.244 0.842 0.384 0.063
0.306 1.246 0.481 0.247 0.597 0.573 0.649 0.675 0.738 0.435 0.930 0.585
0.112 0.851 0.855 0.174 0.506 0.913 0.196 1.234 0.726 0.938 0.189 0.277
0.949 0.121 0.371 1.330 0.657 0.734 0.351 0.700 0.509 0.383 0.398 0.084
1.648 1.429 1.267 1.093 0.333 0.401 0.608 1.014 0.432 0.825 0.688 1.067
0.592 0.748 0.538 0.397
I56 0.317 0.089 0.239 1.074 0.770 0.483 1.290 1.051 0.335 0.283 0.409
0.072 0.380 0.507 0.429 0.295 0.229 0.417 0.294 0.243 0.167 0.388 0.177
0.142 0.622 0.432 0.136 0.445 0.090 1.116 0.171 0.975 0.656 0.499 0.723
0.523 0.544 0.361 0.319 0.179 0.870 0.534 0.264 0.113 0.558 0.523 0.156
0.281 0.286 0.540 0.874 0.298 0.526 0.299 0.244 0.003 0.621 0.485 0.283
0.265 1.182 0.615 0.043 0.637 0.645 0.711 0.719 0.792 0.192 0.723 0.380
0.213 0.635 0.635 0.271 0.265 0.698 0.063 1.127 0.513 0.762 0.412 0.143
0.806 0.363 0.348 1.220 0.571 0.631 0.570 0.477 0.332 0.140 0.172 0.323
1.510 1.327 1.250 0.948 0.343 0.441 0.391 0.801 0.515 0.584 0.509 1.020
0.439 0.529 0.327 0.182
I57 0.336 0.682 0.859 1.356 0.618 1.104 1.699 1.322 0.955 0.387 0.819
0.678 0.982 1.120 1.039 0.908 0.849 1.038 0.485 0.863 0.491 0.248 0.746
0.756 0.080 0.793 0.740 1.064 0.708 1.430 0.701 1.247 0.044 1.116 0.512
1.067 1.086 0.282 0.369 0.772 1.215 0.927 0.367 0.585 1.178 1.143 0.768
0.614 0.558 0.134 0.632 0.402 1.144 0.329 0.842 0.621 0.000 1.086 0.857
0.830 1.508 1.222 0.644 1.182 1.214 1.266 1.257 1.332 0.447 0.738 0.262
0.834 0.637 0.018 0.889 0.378 0.676 0.683 1.364 0.124 0.882 1.026 0.707
1.016 0.961 0.898 1.437 0.975 0.984 1.187 0.546 0.680 0.512 0.567 0.906
1.617 1.549 1.656 1.120 0.917 1.013 0.236 0.749 1.104 0.409 0.245 1.399
0.771 0.588 0.585 0.590
I58 0.802 0.408 0.271 0.886 1.019 0.186 0.942 0.879 0.239 0.768 0.413
0.456 0.106 0.078 0.075 0.313 0.310 0.177 0.640 0.263 0.595 0.840 0.466
0.343 1.098 0.473 0.421 0.127 0.396 0.888 0.518 0.821 1.115 0.269 1.020
0.181 0.189 0.844 0.803 0.421 0.667 0.443 0.719 0.501 0.174 0.144 0.388
0.527 0.579 0.984 1.144 0.701 0.262 0.779 0.384 0.485 1.086 0.000 0.433
0.261 0.931 0.139 0.452 0.230 0.190 0.268 0.301 0.358 0.639 0.882 0.861
0.304 0.842 1.102 0.228 0.709 0.893 0.426 0.973 0.988 0.822 0.283 0.379
0.768 0.363 0.219 1.068 0.437 0.523 0.296 0.736 0.498 0.574 0.526 0.410
1.414 1.153 0.911 0.899 0.179 0.114 0.866 0.975 0.055 0.919 0.994 0.742
0.505 0.760 0.582 0.506
I59 0.524 0.295 0.196 1.228 1.048 0.323 1.360 1.211 0.195 0.474 0.592
0.211 0.355 0.409 0.359 0.121 0.150 0.277 0.575 0.206 0.449 0.648 0.114
0.245 0.840 0.635 0.149 0.328 0.245 1.252 0.157 1.141 0.896 0.293 1.005
0.562 0.579 0.577 0.500 0.108 1.010 0.697 0.530 0.387 0.409 0.387 0.144

0.537 0.556 0.799 1.155 0.580 0.325 0.530 0.063 0.283 0.857 0.433 0.002
0.369 1.307 0.520 0.293 0.652 0.623 0.701 0.729 0.790 0.469 0.985 0.597
0.175 0.904 0.868 0.234 0.537 0.967 0.243 1.297 0.738 0.998 0.204 0.334
1.011 0.113 0.433 1.393 0.720 0.797 0.358 0.751 0.567 0.422 0.446 0.050
1.711 1.492 1.325 1.155 0.395 0.459 0.623 1.068 0.483 0.867 0.688 1.128
0.653 0.800 0.591 0.448
I60 0.567 0.176 0.180 0.862 0.787 0.348 1.035 0.844 0.257 0.541 0.231
0.267 0.166 0.312 0.233 0.284 0.222 0.288 0.380 0.172 0.340 0.583 0.333
0.148 0.848 0.283 0.269 0.284 0.191 0.891 0.368 0.772 0.858 0.405 0.776
0.259 0.280 0.603 0.577 0.295 0.646 0.328 0.465 0.247 0.393 0.356 0.247
0.273 0.322 0.724 0.908 0.441 0.419 0.536 0.306 0.265 0.830 0.261 0.369
0.004 0.950 0.400 0.224 0.374 0.390 0.451 0.456 0.530 0.386 0.676 0.619
0.194 0.618 0.847 0.160 0.453 0.675 0.219 0.929 0.738 0.655 0.352 0.130
0.648 0.371 0.084 1.025 0.352 0.428 0.465 0.492 0.259 0.321 0.266 0.377
1.343 1.125 0.996 0.791 0.087 0.185 0.618 0.767 0.274 0.665 0.760 0.778
0.308 0.525 0.330 0.245
I61 1.399 1.099 1.112 0.168 1.014 1.115 0.281 0.204 1.141 1.398 0.776
1.208 0.967 0.999 0.994 1.200 1.158 1.103 1.065 1.102 1.153 1.305 1.283
1.096 1.565 0.768 1.219 1.058 1.132 0.078 1.316 0.268 1.510 1.199 1.103
0.760 0.746 1.411 1.431 1.245 0.313 0.649 1.244 1.102 1.079 1.063 1.197
0.962 1.003 1.374 1.109 1.152 1.188 1.349 1.246 1.182 1.508 0.931 1.307
0.950 0.000 0.951 1.140 0.708 0.778 0.714 0.661 0.650 1.193 0.824 1.418
1.135 0.898 1.526 1.074 1.219 0.885 1.156 0.231 1.477 0.658 1.208 1.043
0.503 1.274 0.876 0.259 0.610 0.558 1.215 0.961 0.889 1.153 1.068 1.303
0.590 0.275 0.246 0.451 0.913 0.860 1.390 0.870 0.879 1.125 1.568 0.190
0.776 0.923 0.960 1.044
I62 0.932 0.542 0.388 0.930 1.147 0.209 0.920 0.928 0.328 0.896 0.537
0.580 0.240 0.114 0.188 0.402 0.420 0.243 0.779 0.381 0.732 0.977 0.574
0.473 1.233 0.596 0.537 0.192 0.526 0.918 0.628 0.878 1.252 0.281 1.153
0.265 0.262 0.976 0.931 0.529 0.718 0.547 0.855 0.638 0.139 0.141 0.503
0.664 0.717 1.122 1.273 0.840 0.258 0.912 0.481 0.615 1.222 0.139 0.520
0.400 0.951 0.001 0.584 0.250 0.173 0.240 0.290 0.320 0.775 1.003 0.994
0.420 0.969 1.238 0.348 0.846 1.018 0.554 1.024 1.123 0.929 0.334 0.516
0.858 0.429 0.353 1.115 0.532 0.614 0.273 0.869 0.632 0.710 0.664 0.486
1.469 1.192 0.894 0.980 0.317 0.239 1.000 1.096 0.142 1.055 1.123 0.761
0.629 0.891 0.718 0.645
I63 0.350 0.047 0.218 1.033 0.755 0.463 1.247 1.010 0.318 0.320 0.368
0.089 0.346 0.478 0.399 0.287 0.217 0.396 0.283 0.221 0.170 0.405 0.197
0.113 0.649 0.394 0.144 0.421 0.066 1.074 0.201 0.934 0.677 0.485 0.714
0.483 0.503 0.392 0.356 0.188 0.828 0.493 0.280 0.095 0.535 0.499 0.155
0.252 0.264 0.556 0.863 0.300 0.510 0.328 0.247 0.043 0.644 0.452 0.293
0.224 1.140 0.584 0.001 0.597 0.607 0.672 0.679 0.753 0.204 0.699 0.410
0.196 0.614 0.658 0.245 0.277 0.677 0.051 1.087 0.539 0.730 0.401 0.100
0.769 0.363 0.306 1.181 0.529 0.590 0.556 0.458 0.298 0.143 0.153 0.329
1.474 1.287 1.207 0.912 0.304 0.402 0.417 0.779 0.479 0.579 0.544 0.978
0.402 0.509 0.302 0.157

I64 0.939 0.550 0.470 0.680 0.985 0.410 0.713 0.678 0.463 0.915 0.392
0.629 0.297 0.292 0.301 0.533 0.514 0.407 0.703 0.459 0.703 0.935 0.665
0.506 1.208 0.442 0.610 0.357 0.557 0.671 0.712 0.629 1.204 0.493 1.012
0.117 0.096 0.973 0.951 0.621 0.469 0.350 0.826 0.614 0.371 0.355 0.580
0.575 0.632 1.065 1.112 0.780 0.480 0.906 0.597 0.637 1.182 0.230 0.652
0.374 0.708 0.250 0.597 0.001 0.083 0.087 0.082 0.156 0.749 0.819 0.988
0.500 0.807 1.199 0.426 0.810 0.846 0.587 0.774 1.100 0.720 0.513 0.504
0.628 0.592 0.294 0.865 0.321 0.393 0.507 0.740 0.520 0.687 0.618 0.634
1.219 0.943 0.681 0.741 0.295 0.202 0.983 0.910 0.177 0.938 1.133 0.518
0.475 0.747 0.617 0.594
I65 0.955 0.561 0.454 0.758 1.053 0.353 0.761 0.757 0.429 0.927 0.449
0.628 0.279 0.235 0.265 0.502 0.495 0.362 0.743 0.444 0.728 0.967 0.651
0.507 1.236 0.503 0.601 0.310 0.560 0.745 0.700 0.710 1.239 0.434 1.074
0.157 0.142 0.993 0.963 0.605 0.549 0.423 0.853 0.637 0.303 0.292 0.568
0.618 0.674 1.102 1.180 0.816 0.418 0.926 0.573 0.645 1.214 0.190 0.623
0.390 0.778 0.173 0.607 0.083 0.000 0.078 0.120 0.168 0.774 0.892 1.009
0.485 0.874 1.231 0.409 0.839 0.915 0.590 0.853 1.127 0.798 0.467 0.520
0.710 0.552 0.317 0.944 0.397 0.472 0.440 0.797 0.569 0.710 0.648 0.600
1.298 1.019 0.731 0.824 0.305 0.206 1.007 0.983 0.142 0.993 1.149 0.588
0.537 0.808 0.664 0.624
I66 1.018 0.625 0.528 0.706 1.068 0.430 0.685 0.708 0.507 0.991 0.478
0.698 0.353 0.312 0.342 0.580 0.570 0.440 0.788 0.518 0.784 1.019 0.725
0.576 1.291 0.528 0.674 0.388 0.628 0.686 0.774 0.667 1.289 0.510 1.097
0.199 0.180 1.053 1.027 0.680 0.506 0.431 0.908 0.695 0.375 0.367 0.642
0.661 0.718 1.150 1.195 0.865 0.492 0.986 0.649 0.711 1.266 0.268 0.701
0.451 0.714 0.240 0.672 0.087 0.078 0.000 0.055 0.090 0.831 0.899 1.069
0.559 0.890 1.283 0.484 0.893 0.927 0.658 0.804 1.182 0.793 0.544 0.581
0.691 0.630 0.373 0.893 0.398 0.464 0.511 0.826 0.606 0.768 0.701 0.678
1.250 0.962 0.656 0.796 0.368 0.271 1.064 0.989 0.218 1.024 1.211 0.525
0.560 0.832 0.703 0.677
I67 1.020 0.632 0.550 0.651 1.033 0.472 0.643 0.653 0.538 0.996 0.455
0.711 0.376 0.354 0.374 0.609 0.594 0.477 0.775 0.540 0.781 1.011 0.746
0.588 1.285 0.501 0.692 0.425 0.639 0.632 0.793 0.612 1.278 0.554 1.067
0.197 0.176 1.053 1.032 0.701 0.451 0.396 0.904 0.694 0.423 0.412 0.661
0.646 0.704 1.138 1.160 0.855 0.537 0.986 0.675 0.719 1.257 0.301 0.729
0.456 0.661 0.290 0.679 0.082 0.120 0.055 0.001 0.076 0.828 0.860 1.068
0.580 0.857 1.274 0.506 0.887 0.891 0.669 0.749 1.177 0.749 0.582 0.585
0.642 0.664 0.374 0.837 0.359 0.420 0.559 0.801 0.588 0.766 0.696 0.709
1.194 0.908 0.613 0.744 0.377 0.284 1.061 0.949 0.249 1.000 1.213 0.472
0.533 0.803 0.686 0.671
I68 1.095 0.705 0.616 0.659 1.098 0.517 0.600 0.665 0.597 1.070 0.529
0.782 0.442 0.401 0.432 0.670 0.659 0.529 0.850 0.606 0.857 1.087 0.813
0.660 1.361 0.573 0.760 0.477 0.711 0.629 0.861 0.632 1.354 0.596 1.135
0.272 0.251 1.128 1.106 0.768 0.473 0.462 0.979 0.769 0.458 0.453 0.729
0.722 0.779 1.213 1.224 0.930 0.576 1.061 0.738 0.792 1.332 0.358 0.790
0.530 0.650 0.320 0.753 0.156 0.168 0.090 0.076 0.001 0.903 0.921 1.143

0.647 0.922 1.350 0.572 0.963 0.955 0.741 0.760 1.253 0.803 0.633 0.659
0.686 0.719 0.449 0.844 0.423 0.477 0.593 0.872 0.662 0.842 0.772 0.767
1.202 0.907 0.574 0.779 0.450 0.354 1.137 1.009 0.308 1.072 1.288 0.463
0.604 0.872 0.760 0.747
I69 0.208 0.237 0.421 1.064 0.612 0.666 1.339 1.036 0.522 0.207 0.428
0.261 0.535 0.674 0.593 0.487 0.419 0.599 0.156 0.424 0.047 0.203 0.357
0.314 0.462 0.425 0.327 0.621 0.269 1.121 0.332 0.958 0.477 0.688 0.551
0.633 0.653 0.230 0.239 0.367 0.881 0.553 0.080 0.139 0.736 0.700 0.348
0.230 0.195 0.353 0.705 0.116 0.714 0.163 0.435 0.192 0.447 0.639 0.469
0.386 1.193 0.775 0.204 0.749 0.774 0.831 0.828 0.903 0.001 0.603 0.242
0.399 0.503 0.463 0.447 0.074 0.565 0.250 1.101 0.353 0.678 0.603 0.260
0.758 0.555 0.458 1.189 0.599 0.636 0.759 0.343 0.303 0.065 0.135 0.512
1.448 1.300 1.297 0.893 0.473 0.570 0.234 0.668 0.658 0.407 0.392 1.051
0.417 0.401 0.242 0.161
I70 0.761 0.690 0.838 0.660 0.196 1.019 1.063 0.623 0.930 0.787 0.470
0.788 0.823 0.955 0.888 0.940 0.867 0.963 0.449 0.833 0.589 0.602 0.896
0.746 0.809 0.410 0.840 0.951 0.741 0.746 0.894 0.557 0.729 1.081 0.282
0.745 0.754 0.747 0.808 0.882 0.587 0.469 0.607 0.610 1.048 1.012 0.841
0.449 0.438 0.610 0.312 0.503 1.093 0.707 0.930 0.723 0.738 0.882 0.985
0.676 0.824 1.003 0.699 0.819 0.892 0.899 0.860 0.921 0.603 0.022 0.745
0.838 0.107 0.754 0.831 0.582 0.065 0.745 0.645 0.747 0.167 1.026 0.654
0.326 1.028 0.674 0.709 0.501 0.446 1.139 0.260 0.425 0.608 0.551 1.013
0.885 0.819 1.020 0.394 0.723 0.769 0.702 0.095 0.862 0.329 0.873 0.769
0.379 0.202 0.397 0.542
I71 0.073 0.453 0.616 1.282 0.690 0.858 1.576 1.252 0.707 0.125 0.667
0.427 0.756 0.886 0.807 0.655 0.600 0.793 0.353 0.621 0.289 0.146 0.486
0.521 0.246 0.658 0.486 0.824 0.469 1.344 0.440 1.174 0.304 0.863 0.600
0.872 0.892 0.020 0.111 0.515 1.110 0.789 0.176 0.374 0.936 0.902 0.517
0.462 0.416 0.240 0.748 0.268 0.892 0.083 0.585 0.380 0.262 0.861 0.597
0.619 1.418 0.994 0.410 0.988 1.009 1.069 1.068 1.143 0.242 0.745 0.002
0.588 0.638 0.273 0.650 0.200 0.693 0.442 1.309 0.142 0.855 0.772 0.489
0.959 0.703 0.696 1.393 0.836 0.866 0.934 0.498 0.536 0.302 0.377 0.646
1.623 1.505 1.533 1.085 0.705 0.803 0.050 0.787 0.887 0.458 0.151 1.284
0.645 0.553 0.458 0.403
I72 0.522 0.171 0.032 1.053 0.922 0.270 1.198 1.036 0.123 0.482 0.421
0.163 0.206 0.307 0.236 0.103 0.030 0.204 0.464 0.041 0.365 0.599 0.166
0.097 0.833 0.468 0.118 0.238 0.130 1.078 0.215 0.965 0.868 0.289 0.892
0.400 0.419 0.569 0.515 0.121 0.835 0.522 0.475 0.280 0.347 0.314 0.084
0.397 0.428 0.751 1.036 0.493 0.315 0.510 0.112 0.213 0.834 0.304 0.175
0.194 1.135 0.420 0.196 0.500 0.485 0.559 0.580 0.647 0.399 0.838 0.588
0.000 0.765 0.848 0.076 0.473 0.826 0.151 1.122 0.724 0.836 0.208 0.188
0.840 0.190 0.259 1.218 0.545 0.622 0.360 0.621 0.413 0.339 0.330 0.184
1.537 1.317 1.162 0.984 0.224 0.300 0.602 0.924 0.345 0.763 0.709 0.957
0.488 0.664 0.455 0.324
I73 0.655 0.609 0.769 0.737 0.179 0.965 1.123 0.701 0.865 0.682 0.432
0.702 0.774 0.911 0.840 0.868 0.794 0.906 0.351 0.765 0.492 0.495 0.810

0.671 0.706 0.374 0.757 0.900 0.660 0.819 0.804 0.630 0.631 1.022 0.223
0.721 0.733 0.640 0.703 0.800 0.638 0.461 0.503 0.522 1.002 0.965 0.761
0.369 0.350 0.508 0.306 0.399 1.036 0.601 0.851 0.635 0.637 0.842 0.904
0.618 0.898 0.969 0.614 0.807 0.874 0.890 0.857 0.922 0.503 0.107 0.638
0.765 0.000 0.655 0.767 0.477 0.064 0.662 0.732 0.642 0.247 0.961 0.578
0.395 0.955 0.627 0.802 0.500 0.461 1.083 0.161 0.360 0.513 0.463 0.935
0.991 0.913 1.079 0.484 0.674 0.731 0.595 0.167 0.828 0.232 0.766 0.824
0.341 0.105 0.313 0.457
I74 0.346 0.697 0.874 1.374 0.633 1.118 1.718 1.340 0.969 0.397 0.837
0.691 0.998 1.135 1.054 0.921 0.862 1.052 0.503 0.878 0.507 0.264 0.757
0.771 0.071 0.811 0.753 1.079 0.722 1.448 0.712 1.265 0.045 1.129 0.526
1.084 1.103 0.293 0.378 0.784 1.233 0.945 0.383 0.601 1.192 1.157 0.781
0.632 0.576 0.153 0.644 0.420 1.158 0.341 0.855 0.635 0.018 1.102 0.868
0.847 1.526 1.238 0.658 1.199 1.231 1.283 1.274 1.350 0.463 0.754 0.273
0.848 0.655 0.000 0.904 0.394 0.693 0.698 1.381 0.132 0.900 1.039 0.723
1.034 0.973 0.914 1.455 0.993 1.003 1.200 0.564 0.698 0.528 0.583 0.918
1.633 1.566 1.674 1.138 0.933 1.030 0.248 0.765 1.120 0.426 0.245 1.418
0.789 0.606 0.603 0.607
I75 0.586 0.210 0.044 0.999 0.930 0.221 1.128 0.984 0.099 0.549 0.390
0.231 0.130 0.237 0.163 0.129 0.088 0.154 0.490 0.035 0.409 0.649 0.241
0.133 0.893 0.443 0.193 0.175 0.182 1.020 0.291 0.916 0.922 0.259 0.909
0.329 0.347 0.632 0.583 0.196 0.780 0.479 0.525 0.317 0.289 0.253 0.160
0.405 0.445 0.800 1.048 0.531 0.279 0.570 0.174 0.271 0.889 0.228 0.234
0.160 1.074 0.348 0.245 0.426 0.409 0.484 0.506 0.572 0.447 0.831 0.650
0.076 0.767 0.904 0.001 0.520 0.826 0.209 1.073 0.783 0.815 0.195 0.206
0.805 0.214 0.206 1.169 0.497 0.578 0.326 0.631 0.408 0.383 0.359 0.230
1.495 1.265 1.093 0.947 0.163 0.228 0.661 0.920 0.269 0.787 0.776 0.894
0.467 0.669 0.465 0.347
I76 0.188 0.310 0.495 1.084 0.569 0.739 1.377 1.055 0.596 0.206 0.470
0.332 0.606 0.746 0.665 0.560 0.492 0.672 0.156 0.497 0.114 0.131 0.425
0.387 0.399 0.459 0.398 0.694 0.343 1.145 0.395 0.977 0.406 0.762 0.499
0.694 0.713 0.192 0.230 0.438 0.910 0.591 0.027 0.208 0.809 0.773 0.420
0.263 0.216 0.280 0.653 0.079 0.788 0.134 0.506 0.265 0.378 0.709 0.537
0.453 1.219 0.846 0.277 0.810 0.839 0.893 0.887 0.963 0.074 0.582 0.200
0.473 0.477 0.394 0.520 0.000 0.538 0.323 1.115 0.291 0.673 0.676 0.330
0.767 0.627 0.522 1.200 0.638 0.667 0.833 0.323 0.337 0.137 0.191 0.582
1.444 1.312 1.335 0.897 0.539 0.636 0.179 0.639 0.726 0.352 0.351 1.085
0.445 0.381 0.259 0.216
I77 0.714 0.672 0.829 0.721 0.146 1.020 1.121 0.685 0.924 0.741 0.481
0.765 0.828 0.963 0.894 0.929 0.855 0.963 0.414 0.825 0.556 0.549 0.873
0.733 0.748 0.421 0.820 0.955 0.722 0.807 0.868 0.618 0.666 1.080 0.221
0.765 0.776 0.696 0.761 0.863 0.641 0.496 0.563 0.585 1.055 1.019 0.823
0.431 0.413 0.550 0.269 0.460 1.093 0.659 0.913 0.698 0.676 0.893 0.967
0.675 0.885 1.018 0.677 0.846 0.915 0.927 0.891 0.955 0.565 0.065 0.693
0.826 0.064 0.693 0.826 0.538 0.002 0.724 0.708 0.689 0.228 1.020 0.640
0.385 1.016 0.680 0.772 0.532 0.484 1.139 0.224 0.418 0.576 0.526 0.997

0.944 0.882 1.077 0.457 0.728 0.781 0.649 0.103 0.876 0.267 0.817 0.824
0.388 0.169 0.376 0.520
I78 0.378 0.061 0.176 1.055 0.805 0.421 1.253 1.034 0.273 0.343 0.393
0.053 0.320 0.445 0.367 0.238 0.169 0.354 0.333 0.180 0.219 0.449 0.153
0.083 0.685 0.424 0.095 0.383 0.030 1.093 0.166 0.959 0.718 0.439 0.765
0.475 0.495 0.423 0.378 0.140 0.846 0.514 0.324 0.145 0.495 0.461 0.104
0.297 0.313 0.601 0.913 0.350 0.465 0.362 0.196 0.063 0.683 0.426 0.243
0.219 1.156 0.554 0.051 0.587 0.590 0.658 0.669 0.741 0.250 0.745 0.442
0.151 0.662 0.698 0.209 0.323 0.724 0.001 1.113 0.575 0.770 0.353 0.116
0.802 0.312 0.303 1.207 0.547 0.612 0.510 0.507 0.336 0.192 0.203 0.278
1.507 1.312 1.214 0.946 0.292 0.387 0.453 0.826 0.457 0.630 0.569 0.990
0.435 0.557 0.349 0.205
I79 1.301 1.053 1.104 0.103 0.824 1.158 0.511 0.096 1.153 1.308 0.720
1.166 0.985 1.048 1.025 1.202 1.148 1.132 0.959 1.095 1.067 1.183 1.254
1.066 1.428 0.695 1.188 1.093 1.092 0.176 1.278 0.157 1.361 1.240 0.921
0.792 0.784 1.305 1.339 1.220 0.307 0.603 1.141 1.032 1.137 1.115 1.172
0.875 0.906 1.231 0.907 1.042 1.235 1.248 1.234 1.127 1.364 0.973 1.297
0.929 0.231 1.024 1.087 0.774 0.853 0.804 0.749 0.760 1.101 0.645 1.309
1.122 0.732 1.381 1.073 1.115 0.708 1.113 0.002 1.349 0.485 1.232 0.997
0.351 1.283 0.867 0.096 0.577 0.502 1.268 0.824 0.807 1.072 0.990 1.301
0.446 0.200 0.475 0.252 0.912 0.882 1.275 0.675 0.925 0.964 1.454 0.324
0.693 0.777 0.860 0.967
I80 0.215 0.581 0.751 1.332 0.657 0.994 1.653 1.300 0.844 0.266 0.755
0.565 0.883 1.018 0.937 0.794 0.737 0.929 0.424 0.756 0.399 0.177 0.627
0.652 0.112 0.737 0.625 0.958 0.601 1.401 0.581 1.223 0.167 1.003 0.556
0.984 1.004 0.162 0.246 0.656 1.176 0.871 0.275 0.491 1.071 1.036 0.655
0.547 0.494 0.159 0.692 0.336 1.031 0.215 0.726 0.513 0.124 0.988 0.738
0.738 1.477 1.123 0.539 1.100 1.127 1.182 1.177 1.253 0.353 0.747 0.142
0.724 0.642 0.132 0.783 0.291 0.689 0.575 1.349 0.043 0.877 0.912 0.611
0.998 0.844 0.810 1.428 0.918 0.938 1.073 0.526 0.618 0.417 0.482 0.787
1.632 1.540 1.610 1.113 0.825 0.923 0.124 0.774 1.010 0.431 0.150 1.356
0.718 0.575 0.529 0.507
I81 0.860 0.711 0.830 0.494 0.360 0.978 0.898 0.458 0.911 0.877 0.427
0.819 0.781 0.898 0.842 0.935 0.865 0.929 0.524 0.823 0.654 0.719 0.923
0.753 0.949 0.372 0.861 0.909 0.759 0.580 0.931 0.390 0.878 1.048 0.446
0.664 0.670 0.854 0.903 0.902 0.428 0.382 0.700 0.651 0.994 0.961 0.856
0.482 0.491 0.751 0.467 0.595 1.055 0.805 0.938 0.762 0.882 0.822 0.998
0.655 0.658 0.929 0.730 0.720 0.798 0.793 0.749 0.803 0.678 0.167 0.855
0.836 0.247 0.900 0.815 0.673 0.228 0.770 0.485 0.877 0.000 1.006 0.665
0.160 1.023 0.632 0.555 0.401 0.329 1.099 0.358 0.434 0.668 0.597 1.019
0.771 0.667 0.855 0.238 0.683 0.709 0.816 0.227 0.793 0.480 0.993 0.606
0.349 0.304 0.444 0.581
I82 0.702 0.379 0.195 1.152 1.123 0.127 1.225 1.141 0.096 0.656 0.580
0.349 0.247 0.233 0.215 0.118 0.185 0.107 0.672 0.198 0.571 0.799 0.292
0.303 1.018 0.634 0.287 0.157 0.337 1.162 0.345 1.077 1.063 0.092 1.097
0.449 0.462 0.752 0.685 0.258 0.931 0.656 0.676 0.488 0.210 0.194 0.258

0.597 0.633 0.952 1.239 0.701 0.124 0.698 0.189 0.412 1.026 0.283 0.204
0.352 1.208 0.334 0.401 0.513 0.467 0.544 0.582 0.633 0.603 1.026 0.772
0.208 0.961 1.039 0.195 0.676 1.020 0.353 1.232 0.912 1.006 0.001 0.391
0.986 0.097 0.381 1.328 0.666 0.751 0.162 0.822 0.603 0.545 0.538 0.160
1.664 1.419 1.194 1.126 0.331 0.352 0.792 1.116 0.337 0.971 0.877 1.021
0.660 0.863 0.656 0.530
I83 0.436 0.057 0.196 0.940 0.734 0.425 1.147 0.918 0.297 0.411 0.277
0.168 0.276 0.418 0.336 0.290 0.216 0.359 0.285 0.194 0.216 0.461 0.262
0.093 0.721 0.310 0.198 0.372 0.097 0.979 0.281 0.843 0.736 0.464 0.707
0.388 0.408 0.473 0.447 0.238 0.732 0.398 0.340 0.122 0.486 0.449 0.191
0.210 0.242 0.607 0.849 0.329 0.484 0.407 0.277 0.143 0.707 0.379 0.334
0.130 1.043 0.516 0.100 0.504 0.520 0.581 0.585 0.659 0.260 0.654 0.489
0.188 0.578 0.723 0.206 0.330 0.640 0.116 0.997 0.611 0.665 0.391 0.001
0.689 0.376 0.210 1.092 0.433 0.497 0.531 0.433 0.233 0.195 0.155 0.359
1.393 1.197 1.107 0.833 0.215 0.314 0.490 0.739 0.399 0.582 0.630 0.879
0.324 0.477 0.268 0.142
I84 0.954 0.741 0.828 0.342 0.520 0.939 0.738 0.308 0.896 0.964 0.419
0.853 0.746 0.846 0.800 0.931 0.868 0.898 0.611 0.820 0.726 0.832 0.950
0.769 1.078 0.378 0.886 0.870 0.785 0.424 0.967 0.235 1.015 1.015 0.603
0.595 0.595 0.955 0.993 0.923 0.272 0.331 0.793 0.703 0.942 0.911 0.875
0.538 0.563 0.883 0.626 0.692 1.018 0.901 0.949 0.806 1.016 0.768 1.011
0.648 0.503 0.858 0.769 0.628 0.710 0.691 0.642 0.686 0.758 0.326 0.959
0.840 0.395 1.034 0.805 0.767 0.385 0.802 0.351 0.998 0.160 0.986 0.689
0.000 1.018 0.605 0.434 0.330 0.245 1.058 0.474 0.475 0.735 0.655 1.024
0.705 0.546 0.694 0.144 0.656 0.659 0.925 0.385 0.730 0.624 1.104 0.446
0.367 0.428 0.516 0.635
I85 0.630 0.351 0.193 1.207 1.109 0.223 1.304 1.194 0.133 0.582 0.602
0.294 0.306 0.324 0.291 0.089 0.161 0.191 0.643 0.200 0.529 0.744 0.216
0.283 0.947 0.652 0.229 0.244 0.303 1.223 0.266 1.127 1.000 0.182 1.074
0.516 0.531 0.683 0.610 0.192 0.987 0.693 0.623 0.455 0.308 0.290 0.208
0.586 0.614 0.896 1.221 0.660 0.214 0.633 0.121 0.363 0.961 0.363 0.113
0.371 1.274 0.429 0.363 0.592 0.552 0.630 0.664 0.719 0.555 1.028 0.703
0.190 0.955 0.973 0.214 0.627 1.016 0.312 1.283 0.844 1.023 0.097 0.376
1.018 0.001 0.418 1.379 0.709 0.791 0.246 0.808 0.603 0.502 0.510 0.065
1.708 1.474 1.272 1.161 0.372 0.414 0.727 1.114 0.416 0.941 0.799 1.089
0.675 0.853 0.643 0.507
I86 0.646 0.259 0.238 0.795 0.802 0.347 0.953 0.779 0.292 0.622 0.207
0.350 0.150 0.284 0.215 0.335 0.283 0.298 0.432 0.228 0.412 0.650 0.410
0.229 0.920 0.265 0.347 0.279 0.274 0.819 0.448 0.710 0.923 0.417 0.802
0.177 0.198 0.680 0.658 0.370 0.576 0.276 0.536 0.322 0.375 0.339 0.322
0.312 0.367 0.787 0.926 0.501 0.424 0.613 0.371 0.348 0.898 0.219 0.433
0.084 0.876 0.353 0.306 0.294 0.317 0.373 0.374 0.449 0.458 0.674 0.696
0.259 0.627 0.914 0.206 0.522 0.680 0.303 0.867 0.810 0.632 0.381 0.210
0.605 0.418 0.002 0.963 0.291 0.373 0.469 0.517 0.279 0.395 0.331 0.434
1.290 1.060 0.915 0.746 0.052 0.119 0.691 0.766 0.217 0.702 0.839 0.701
0.296 0.542 0.365 0.308

I87 1.388 1.147 1.200 0.186 0.879 1.252 0.533 0.189 1.249 1.396 0.815
1.260 1.081 1.142 1.120 1.298 1.244 1.228 1.045 1.191 1.156 1.264 1.349
1.162 1.503 0.788 1.284 1.188 1.187 0.231 1.373 0.253 1.433 1.335 0.981
0.887 0.878 1.389 1.426 1.316 0.401 0.698 1.227 1.124 1.231 1.209 1.267
0.965 0.994 1.306 0.953 1.126 1.329 1.334 1.330 1.220 1.437 1.068 1.393
1.025 0.259 1.115 1.181 0.865 0.944 0.893 0.837 0.844 1.189 0.709 1.393
1.218 0.802 1.455 1.169 1.200 0.772 1.207 0.096 1.428 0.555 1.328 1.092
0.434 1.379 0.963 0.000 0.673 0.598 1.362 0.904 0.898 1.162 1.081 1.398
0.358 0.112 0.502 0.317 1.008 0.977 1.358 0.729 1.019 1.034 1.537 0.394
0.785 0.854 0.948 1.059
I88 0.807 0.490 0.527 0.510 0.675 0.610 0.740 0.492 0.581 0.799 0.171
0.600 0.421 0.515 0.472 0.626 0.571 0.573 0.495 0.518 0.555 0.744 0.681
0.493 1.018 0.182 0.616 0.542 0.524 0.546 0.710 0.421 0.989 0.689 0.715
0.267 0.270 0.826 0.834 0.646 0.299 0.048 0.660 0.495 0.611 0.581 0.597
0.374 0.425 0.846 0.801 0.583 0.689 0.761 0.657 0.571 0.975 0.437 0.720
0.352 0.610 0.532 0.529 0.321 0.397 0.398 0.359 0.423 0.599 0.501 0.836
0.545 0.500 0.993 0.497 0.638 0.532 0.547 0.577 0.918 0.401 0.666 0.433
0.330 0.709 0.291 0.673 0.000 0.086 0.729 0.465 0.301 0.552 0.468 0.725
0.999 0.773 0.698 0.464 0.338 0.329 0.816 0.591 0.401 0.664 0.987 0.454
0.205 0.457 0.391 0.442
I89 0.843 0.553 0.606 0.443 0.630 0.696 0.716 0.421 0.664 0.841 0.222
0.665 0.507 0.601 0.558 0.706 0.649 0.659 0.516 0.597 0.595 0.763 0.752
0.564 1.033 0.210 0.686 0.628 0.591 0.488 0.777 0.347 0.995 0.774 0.681
0.350 0.351 0.858 0.874 0.718 0.245 0.100 0.691 0.545 0.696 0.667 0.670
0.406 0.450 0.853 0.753 0.605 0.775 0.795 0.734 0.631 0.984 0.523 0.797
0.428 0.558 0.614 0.590 0.393 0.472 0.464 0.420 0.477 0.636 0.446 0.866
0.622 0.461 1.003 0.578 0.667 0.484 0.612 0.502 0.938 0.329 0.751 0.497
0.245 0.791 0.373 0.598 0.086 0.000 0.815 0.454 0.332 0.595 0.511 0.804
0.917 0.700 0.673 0.378 0.421 0.415 0.842 0.532 0.485 0.646 1.017 0.419
0.221 0.435 0.411 0.486
I90 0.864 0.529 0.340 1.180 1.251 0.121 1.193 1.174 0.238 0.818 0.675
0.510 0.318 0.221 0.259 0.279 0.341 0.177 0.816 0.340 0.725 0.958 0.454
0.451 1.180 0.733 0.448 0.190 0.490 1.177 0.506 1.117 1.223 0.071 1.234
0.478 0.485 0.914 0.847 0.420 0.962 0.729 0.833 0.638 0.137 0.154 0.419
0.729 0.770 1.110 1.371 0.852 0.047 0.859 0.351 0.570 1.187 0.296 0.358
0.465 1.215 0.273 0.556 0.507 0.440 0.511 0.559 0.593 0.759 1.139 0.934
0.360 1.083 1.200 0.326 0.833 1.139 0.510 1.268 1.073 1.099 0.162 0.531
1.058 0.246 0.469 1.362 0.729 0.815 0.000 0.953 0.724 0.699 0.684 0.310
1.710 1.446 1.167 1.192 0.417 0.400 0.953 1.230 0.344 1.113 1.039 1.025
0.763 0.989 0.788 0.673
I91 0.506 0.458 0.628 0.811 0.301 0.839 1.160 0.778 0.727 0.529 0.348
0.545 0.655 0.798 0.722 0.723 0.648 0.776 0.191 0.625 0.332 0.362 0.653
0.525 0.605 0.299 0.602 0.776 0.508 0.884 0.645 0.702 0.550 0.889 0.286
0.640 0.655 0.497 0.552 0.646 0.672 0.419 0.349 0.365 0.884 0.847 0.609
0.225 0.195 0.413 0.418 0.244 0.906 0.452 0.700 0.477 0.546 0.736 0.751
0.492 0.961 0.869 0.458 0.740 0.797 0.826 0.801 0.872 0.343 0.260 0.498

0.621 0.161 0.564 0.631 0.323 0.224 0.507 0.824 0.526 0.358 0.822 0.433
0.474 0.808 0.517 0.904 0.465 0.454 0.953 0.000 0.238 0.352 0.306 0.784
1.126 1.016 1.116 0.590 0.560 0.630 0.459 0.327 0.729 0.200 0.636 0.858
0.268 0.059 0.166 0.303
I92 0.511 0.277 0.414 0.764 0.528 0.606 1.040 0.737 0.507 0.509 0.139
0.385 0.419 0.560 0.486 0.515 0.443 0.547 0.196 0.408 0.264 0.444 0.489
0.324 0.719 0.122 0.428 0.542 0.326 0.818 0.498 0.660 0.698 0.663 0.523
0.412 0.429 0.527 0.542 0.469 0.578 0.254 0.360 0.228 0.648 0.611 0.424
0.074 0.124 0.555 0.651 0.283 0.677 0.463 0.509 0.332 0.680 0.498 0.567
0.259 0.889 0.632 0.298 0.520 0.569 0.606 0.588 0.662 0.303 0.425 0.536
0.413 0.360 0.698 0.408 0.337 0.418 0.336 0.807 0.618 0.434 0.603 0.233
0.475 0.603 0.279 0.898 0.301 0.332 0.724 0.238 0.001 0.266 0.183 0.591
1.179 1.007 0.998 0.617 0.322 0.393 0.514 0.513 0.492 0.426 0.687 0.749
0.115 0.266 0.098 0.161
I93 0.259 0.173 0.360 1.030 0.637 0.603 1.290 1.004 0.461 0.248 0.381
0.212 0.470 0.609 0.528 0.430 0.360 0.536 0.163 0.361 0.027 0.268 0.314
0.251 0.527 0.385 0.276 0.557 0.209 1.083 0.297 0.926 0.542 0.628 0.585
0.571 0.591 0.287 0.282 0.319 0.840 0.508 0.145 0.074 0.672 0.635 0.294
0.197 0.177 0.417 0.737 0.158 0.653 0.220 0.383 0.140 0.512 0.574 0.422
0.321 1.153 0.710 0.143 0.687 0.710 0.768 0.766 0.842 0.065 0.608 0.302
0.339 0.513 0.528 0.383 0.137 0.576 0.192 1.072 0.417 0.668 0.545 0.195
0.735 0.502 0.395 1.162 0.552 0.595 0.699 0.352 0.266 0.006 0.085 0.463
1.432 1.272 1.248 0.873 0.408 0.506 0.297 0.679 0.593 0.445 0.449 1.006
0.381 0.408 0.224 0.110
I94 0.340 0.160 0.345 0.946 0.603 0.579 1.207 0.920 0.448 0.331 0.297
0.239 0.426 0.570 0.488 0.430 0.356 0.513 0.134 0.344 0.089 0.319 0.347
0.235 0.590 0.301 0.297 0.527 0.207 0.998 0.343 0.843 0.593 0.615 0.564
0.502 0.522 0.364 0.366 0.341 0.756 0.424 0.208 0.059 0.641 0.604 0.306
0.117 0.113 0.459 0.711 0.176 0.637 0.297 0.398 0.172 0.567 0.526 0.446
0.266 1.068 0.664 0.153 0.618 0.648 0.701 0.696 0.772 0.135 0.551 0.377
0.330 0.463 0.583 0.359 0.191 0.526 0.203 0.990 0.482 0.597 0.538 0.155
0.655 0.510 0.331 1.081 0.468 0.511 0.684 0.306 0.183 0.085 0.000 0.481
1.355 1.190 1.165 0.795 0.352 0.447 0.366 0.628 0.539 0.433 0.526 0.921
0.298 0.358 0.156 0.026
I95 0.573 0.326 0.198 1.229 1.083 0.284 1.345 1.214 0.171 0.524 0.605
0.252 0.340 0.378 0.336 0.103 0.156 0.245 0.612 0.207 0.490 0.695 0.161
0.267 0.890 0.652 0.187 0.297 0.275 1.250 0.206 1.145 0.945 0.247 1.043
0.550 0.566 0.626 0.550 0.147 1.009 0.704 0.576 0.424 0.370 0.350 0.175
0.566 0.589 0.846 1.192 0.621 0.280 0.579 0.084 0.323 0.906 0.410 0.050
0.377 1.303 0.486 0.329 0.634 0.600 0.678 0.709 0.767 0.512 1.013 0.646
0.184 0.935 0.918 0.230 0.582 0.997 0.278 1.301 0.787 1.019 0.160 0.359
1.024 0.065 0.434 1.398 0.725 0.804 0.310 0.784 0.591 0.463 0.481 0.000
1.720 1.495 1.311 1.168 0.392 0.447 0.672 1.097 0.461 0.906 0.737 1.121
0.671 0.831 0.622 0.481
I96 1.631 1.446 1.523 0.544 1.008 1.597 0.827 0.542 1.580 1.648 1.121
1.559 1.418 1.489 1.462 1.624 1.565 1.568 1.294 1.514 1.421 1.484 1.655

1.471 1.691 1.083 1.590 1.531 1.490 0.582 1.672 0.593 1.604 1.679 1.118
1.232 1.225 1.623 1.674 1.626 0.751 1.016 1.471 1.406 1.580 1.556 1.578
1.238 1.256 1.493 1.042 1.366 1.675 1.576 1.648 1.510 1.617 1.414 1.711
1.343 0.590 1.469 1.474 1.219 1.298 1.250 1.194 1.202 1.448 0.885 1.623
1.537 0.991 1.633 1.495 1.444 0.944 1.507 0.446 1.632 0.771 1.664 1.393
0.705 1.708 1.290 0.358 0.999 0.917 1.710 1.126 1.179 1.432 1.355 1.720
0.000 0.316 0.807 0.562 1.338 1.318 1.583 0.868 1.367 1.209 1.756 0.749
1.072 1.070 1.209 1.337
I97 1.499 1.252 1.298 0.268 0.985 1.338 0.517 0.281 1.342 1.507 0.920
1.365 1.173 1.226 1.209 1.394 1.343 1.317 1.156 1.289 1.266 1.376 1.452
1.264 1.615 0.895 1.386 1.276 1.291 0.278 1.477 0.354 1.544 1.422 1.088
0.974 0.964 1.501 1.537 1.418 0.489 0.800 1.338 1.232 1.312 1.292 1.369
1.075 1.105 1.417 1.055 1.238 1.414 1.446 1.429 1.327 1.549 1.153 1.492
1.125 0.275 1.192 1.287 0.943 1.019 0.962 0.908 0.907 1.300 0.819 1.505
1.317 0.913 1.566 1.265 1.312 0.882 1.312 0.200 1.540 0.667 1.419 1.197
0.546 1.474 1.060 0.112 0.773 0.700 1.446 1.016 1.007 1.272 1.190 1.495
0.316 0.002 0.494 0.429 1.103 1.067 1.470 0.836 1.103 1.145 1.649 0.445
0.893 0.966 1.058 1.167
I98 1.504 1.163 1.135 0.397 1.214 1.084 0.044 0.432 1.142 1.495 0.868
1.264 0.971 0.966 0.982 1.209 1.181 1.087 1.188 1.124 1.253 1.435 1.322
1.143 1.706 0.876 1.261 1.037 1.186 0.305 1.363 0.476 1.664 1.166 1.294
0.764 0.746 1.524 1.530 1.280 0.444 0.744 1.358 1.187 1.031 1.023 1.235
1.071 1.120 1.523 1.318 1.276 1.148 1.459 1.267 1.250 1.656 0.911 1.325
0.996 0.246 0.894 1.207 0.681 0.731 0.656 0.613 0.574 1.297 1.020 1.533
1.162 1.079 1.674 1.093 1.335 1.077 1.214 0.475 1.610 0.855 1.194 1.107
0.694 1.272 0.915 0.502 0.698 0.673 1.167 1.116 0.998 1.248 1.165 1.311
0.807 0.494 0.001 0.675 0.940 0.866 1.512 1.077 0.857 1.296 1.685 0.258
0.892 1.086 1.082 1.139
I99 1.084 0.885 0.971 0.284 0.572 1.074 0.716 0.247 1.037 1.097 0.563
0.997 0.884 0.977 0.936 1.074 1.012 1.036 0.743 0.963 0.864 0.952 1.094
0.913 1.187 0.523 1.030 1.006 0.930 0.377 1.111 0.202 1.115 1.152 0.670
0.722 0.720 1.082 1.125 1.067 0.318 0.470 0.923 0.845 1.072 1.043 1.019
0.678 0.699 0.989 0.660 0.820 1.153 1.030 1.093 0.948 1.120 0.899 1.155
0.791 0.451 0.980 0.912 0.741 0.824 0.796 0.744 0.779 0.893 0.394 1.085
0.984 0.484 1.138 0.947 0.897 0.457 0.946 0.252 1.113 0.238 1.126 0.833
0.144 1.161 0.746 0.317 0.464 0.378 1.192 0.590 0.617 0.873 0.795 1.168
0.562 0.429 0.675 0.001 0.796 0.792 1.048 0.424 0.858 0.717 1.226 0.453
0.511 0.539 0.652 0.776
I100 0.651 0.257 0.199 0.837 0.848 0.296 0.977 0.823 0.243 0.623 0.258
0.335 0.100 0.239 0.166 0.291 0.246 0.246 0.462 0.189 0.427 0.670 0.382
0.212 0.935 0.316 0.323 0.228 0.262 0.858 0.425 0.755 0.944 0.365 0.845
0.184 0.204 0.689 0.659 0.340 0.617 0.326 0.552 0.334 0.327 0.291 0.295
0.348 0.400 0.810 0.972 0.526 0.373 0.622 0.333 0.343 0.917 0.179 0.395
0.087 0.913 0.317 0.304 0.295 0.305 0.368 0.377 0.450 0.473 0.723 0.705
0.224 0.674 0.933 0.163 0.539 0.728 0.292 0.912 0.825 0.683 0.331 0.215
0.656 0.372 0.052 1.008 0.338 0.421 0.417 0.560 0.322 0.408 0.352 0.392

1.338 1.103 0.940 0.796 0.002 0.099 0.704 0.816 0.188 0.740 0.845 0.734
0.346 0.587 0.403 0.331
I101 0.750 0.355 0.271 0.800 0.908 0.282 0.901 0.789 0.281 0.722 0.300
0.428 0.108 0.190 0.144 0.344 0.316 0.251 0.551 0.260 0.524 0.766 0.464
0.306 1.032 0.360 0.409 0.214 0.357 0.811 0.510 0.727 1.039 0.362 0.914
0.103 0.120 0.787 0.757 0.420 0.579 0.331 0.649 0.432 0.286 0.254 0.378
0.430 0.485 0.904 1.034 0.619 0.360 0.721 0.401 0.441 1.013 0.114 0.459
0.185 0.860 0.239 0.402 0.202 0.206 0.271 0.284 0.354 0.570 0.769 0.803
0.300 0.731 1.030 0.228 0.636 0.781 0.387 0.882 0.923 0.709 0.352 0.314
0.659 0.414 0.119 0.977 0.329 0.415 0.400 0.630 0.393 0.506 0.447 0.447
1.318 1.067 0.866 0.792 0.099 0.000 0.802 0.862 0.099 0.818 0.943 0.675
0.393 0.652 0.483 0.424
I102 0.111 0.458 0.629 1.251 0.643 0.872 1.554 1.220 0.723 0.163 0.649
0.444 0.761 0.895 0.815 0.674 0.616 0.807 0.326 0.633 0.280 0.101 0.511
0.529 0.233 0.636 0.505 0.836 0.479 1.316 0.468 1.143 0.274 0.882 0.552
0.866 0.886 0.063 0.155 0.537 1.084 0.769 0.159 0.371 0.948 0.914 0.535
0.442 0.392 0.196 0.700 0.238 0.911 0.096 0.608 0.391 0.236 0.866 0.623
0.618 1.390 1.000 0.417 0.983 1.007 1.064 1.061 1.137 0.234 0.702 0.050
0.602 0.595 0.248 0.661 0.179 0.649 0.453 1.275 0.124 0.816 0.792 0.490
0.925 0.727 0.691 1.358 0.816 0.842 0.953 0.459 0.514 0.297 0.366 0.672
1.583 1.470 1.512 1.048 0.704 0.802 0.019 0.742 0.888 0.411 0.179 1.261
0.621 0.514 0.431 0.391
I103 0.811 0.772 0.926 0.703 0.150 1.110 1.120 0.666 1.019 0.841 0.562
0.867 0.916 1.047 0.981 1.027 0.953 1.054 0.518 0.921 0.659 0.642 0.975
0.832 0.824 0.503 0.921 1.043 0.823 0.793 0.970 0.605 0.735 1.172 0.257
0.838 0.847 0.792 0.860 0.964 0.655 0.561 0.663 0.688 1.141 1.105 0.924
0.531 0.515 0.629 0.242 0.561 1.184 0.757 1.014 0.801 0.749 0.975 1.068
0.767 0.870 1.096 0.779 0.910 0.983 0.989 0.949 1.009 0.668 0.095 0.787
0.924 0.167 0.765 0.920 0.639 0.103 0.826 0.675 0.774 0.227 1.116 0.739
0.385 1.114 0.766 0.729 0.591 0.532 1.230 0.327 0.513 0.679 0.628 1.097
0.868 0.836 1.077 0.424 0.816 0.862 0.742 0.003 0.955 0.344 0.906 0.831
0.471 0.271 0.477 0.622
I104 0.830 0.434 0.314 0.837 1.005 0.237 0.889 0.830 0.290 0.798 0.396
0.492 0.140 0.123 0.127 0.363 0.354 0.231 0.647 0.304 0.614 0.857 0.510
0.375 1.120 0.455 0.462 0.181 0.427 0.837 0.560 0.774 1.131 0.321 1.013
0.137 0.142 0.870 0.834 0.465 0.618 0.411 0.738 0.520 0.215 0.190 0.429
0.529 0.583 0.998 1.131 0.713 0.311 0.804 0.432 0.515 1.104 0.055 0.483
0.274 0.879 0.142 0.479 0.177 0.142 0.218 0.249 0.308 0.658 0.862 0.887
0.345 0.828 1.120 0.269 0.726 0.876 0.457 0.925 1.010 0.793 0.337 0.399
0.730 0.416 0.217 1.019 0.401 0.485 0.344 0.729 0.492 0.593 0.539 0.461
1.367 1.103 0.857 0.858 0.188 0.099 0.888 0.955 0.013 0.917 1.023 0.690
0.488 0.750 0.581 0.518
I105 0.495 0.592 0.777 0.966 0.232 1.004 1.340 0.931 0.879 0.534 0.546
0.656 0.831 0.976 0.898 0.862 0.789 0.939 0.299 0.775 0.418 0.314 0.759
0.667 0.482 0.499 0.719 0.946 0.639 1.047 0.738 0.859 0.400 1.046 0.148
0.836 0.852 0.466 0.545 0.762 0.852 0.618 0.371 0.486 1.057 1.020 0.734

0.393 0.345 0.285 0.302 0.290 1.066 0.445 0.825 0.584 0.409 0.919 0.867
0.665 1.125 1.055 0.579 0.938 0.993 1.024 1.000 1.072 0.407 0.329 0.458
0.763 0.232 0.426 0.787 0.352 0.267 0.630 0.964 0.431 0.480 0.971 0.582
0.624 0.941 0.702 1.034 0.664 0.646 1.113 0.200 0.426 0.445 0.433 0.906
1.209 1.145 1.296 0.717 0.740 0.818 0.411 0.344 0.917 0.002 0.566 1.038
0.468 0.212 0.337 0.441
I106 0.194 0.589 0.738 1.430 0.795 0.973 1.727 1.399 0.822 0.227 0.818
0.546 0.889 1.013 0.936 0.763 0.716 0.910 0.503 0.745 0.438 0.274 0.585
0.651 0.185 0.809 0.598 0.946 0.598 1.494 0.533 1.321 0.288 0.969 0.697
1.016 1.037 0.162 0.194 0.620 1.260 0.941 0.327 0.519 1.055 1.022 0.631
0.614 0.567 0.299 0.836 0.416 1.000 0.229 0.688 0.509 0.245 0.994 0.688
0.760 1.568 1.123 0.544 1.133 1.149 1.211 1.213 1.288 0.392 0.873 0.151
0.709 0.766 0.245 0.776 0.351 0.817 0.569 1.454 0.150 0.993 0.877 0.630
1.104 0.799 0.839 1.537 0.987 1.017 1.039 0.636 0.687 0.449 0.526 0.737
1.756 1.649 1.685 1.226 0.845 0.943 0.179 0.906 1.023 0.566 0.000 1.436
0.796 0.689 0.608 0.553
I107 1.259 0.935 0.933 0.221 0.964 0.926 0.302 0.242 0.956 1.253 0.625
1.041 0.783 0.809 0.806 1.018 0.979 0.916 0.935 0.922 1.008 1.182 1.110
0.925 1.451 0.627 1.047 0.869 0.964 0.168 1.146 0.253 1.407 1.010 1.040
0.574 0.560 1.275 1.287 1.070 0.187 0.498 1.109 0.949 0.889 0.873 1.023
0.823 0.869 1.266 1.072 1.024 0.998 1.211 1.067 1.020 1.399 0.742 1.128
0.778 0.190 0.761 0.978 0.518 0.588 0.525 0.472 0.463 1.051 0.769 1.284
0.957 0.824 1.418 0.894 1.085 0.824 0.990 0.324 1.356 0.606 1.021 0.879
0.446 1.089 0.701 0.394 0.454 0.419 1.025 0.858 0.749 1.006 0.921 1.121
0.749 0.445 0.258 0.453 0.734 0.675 1.261 0.831 0.690 1.038 1.436 0.002
0.640 0.828 0.830 0.896
I108 0.624 0.374 0.482 0.649 0.519 0.642 0.935 0.623 0.564 0.623 0.092
0.486 0.446 0.576 0.510 0.586 0.517 0.588 0.295 0.475 0.378 0.543 0.585
0.408 0.816 0.034 0.522 0.574 0.420 0.704 0.600 0.545 0.784 0.708 0.538
0.382 0.395 0.637 0.656 0.560 0.465 0.157 0.470 0.340 0.670 0.634 0.513
0.187 0.229 0.641 0.646 0.384 0.717 0.574 0.592 0.439 0.771 0.505 0.653
0.308 0.776 0.629 0.402 0.475 0.537 0.560 0.533 0.604 0.417 0.379 0.645
0.488 0.341 0.789 0.467 0.445 0.388 0.435 0.693 0.718 0.349 0.660 0.324
0.367 0.675 0.296 0.785 0.205 0.221 0.763 0.268 0.115 0.381 0.298 0.671
1.072 0.893 0.892 0.511 0.346 0.393 0.621 0.471 0.488 0.468 0.796 0.640
0.001 0.272 0.190 0.275
I109 0.564 0.506 0.670 0.769 0.262 0.872 1.130 0.735 0.767 0.587 0.359
0.597 0.685 0.825 0.752 0.767 0.693 0.812 0.248 0.666 0.389 0.415 0.705
0.569 0.650 0.305 0.652 0.809 0.556 0.845 0.699 0.660 0.588 0.927 0.267
0.652 0.666 0.554 0.610 0.696 0.641 0.413 0.407 0.417 0.914 0.877 0.657
0.267 0.245 0.454 0.385 0.302 0.942 0.509 0.748 0.529 0.588 0.760 0.800
0.525 0.923 0.891 0.509 0.747 0.808 0.832 0.803 0.872 0.401 0.202 0.553
0.664 0.105 0.606 0.669 0.381 0.169 0.557 0.777 0.575 0.304 0.863 0.477
0.428 0.853 0.542 0.854 0.457 0.435 0.989 0.059 0.266 0.408 0.358 0.831
1.070 0.966 1.086 0.539 0.587 0.652 0.514 0.271 0.750 0.212 0.689 0.828
0.272 0.000 0.210 0.352

I110 0.442 0.296 0.462 0.826 0.467 0.675 1.125 0.797 0.561 0.449 0.235
0.391 0.496 0.640 0.563 0.558 0.483 0.612 0.106 0.459 0.212 0.354 0.499
0.360 0.627 0.208 0.444 0.614 0.347 0.887 0.498 0.719 0.601 0.724 0.447
0.508 0.526 0.451 0.479 0.487 0.653 0.343 0.284 0.213 0.724 0.686 0.448
0.059 0.047 0.459 0.584 0.195 0.741 0.391 0.538 0.327 0.585 0.582 0.591
0.330 0.960 0.718 0.302 0.617 0.664 0.703 0.686 0.760 0.242 0.397 0.458
0.455 0.313 0.603 0.465 0.259 0.376 0.349 0.860 0.529 0.444 0.656 0.268
0.516 0.643 0.365 0.948 0.391 0.411 0.788 0.166 0.098 0.224 0.156 0.622
1.209 1.058 1.082 0.652 0.403 0.483 0.431 0.477 0.581 0.337 0.608 0.830
0.190 0.210 0.001 0.145
I111 0.366 0.156 0.336 0.923 0.603 0.566 1.180 0.897 0.438 0.357 0.271
0.246 0.408 0.552 0.471 0.425 0.350 0.500 0.143 0.334 0.115 0.343 0.354
0.227 0.615 0.277 0.300 0.512 0.206 0.974 0.353 0.819 0.615 0.605 0.568
0.478 0.498 0.391 0.392 0.344 0.731 0.398 0.233 0.070 0.626 0.588 0.306
0.100 0.108 0.480 0.714 0.195 0.626 0.324 0.397 0.182 0.590 0.506 0.448
0.245 1.044 0.645 0.157 0.594 0.624 0.677 0.671 0.747 0.161 0.542 0.403
0.324 0.457 0.607 0.347 0.216 0.520 0.205 0.967 0.507 0.581 0.530 0.142
0.635 0.507 0.308 1.059 0.442 0.486 0.673 0.303 0.161 0.110 0.026 0.481
1.337 1.167 1.139 0.776 0.331 0.424 0.391 0.622 0.518 0.441 0.553 0.896
0.275 0.352 0.145 0.000
;

Table Teta(KB, F) incremental cost for receiving service f times per week(beyond cost for receiving service f-1 times per week) for bin type KB

| | f1 | f2 | f3 | f4 | f5 |
|---|---|---|---|---|---|
| 2YARD | 60.55 | 17.30 | 17.31 | 17.30 | 17.31 |
| 4YARD | 73.25 | 34.61 | 34.61 | 34.61 | 34.61 |
| 6YARD | 88.72 | 51.91 | 51.92 | 51.90 | 51.92 |
| 8YARD | 103.26 | 69.22 | 69.21 | 69.22 | 69.09 |

;

PARAMETER
OMEGA(KA) monthly depreciation fee per receptacle of type KA
/
14YARD-ROLLOFF 0
20YARD-ROLLOFF 0
30YARD-ROLLOFF 0
35YARD-ROLLOFF 0
40YARD-ROLLOFF 0
14YARD-COMP 38.81
15YARD-COMP 38.81
25YARD-COMP 38.81
28YARD-COMP 38.81
35YARD-COMP 38.81
28YARD-DUAL-COMP 38.81
35YARD-DUAL-COMP 38.81
/
;

## A.2. GAMS Code:

```
$INCLUDE DATA_Trash.inc

Positive variables
V(I,J,D1) Volume of trash generated at location i on day d that is assigned to compactors and roll offs at site j
R(J, KA, D1) Volume of trash generated on day d that is assigned to compactors and roll offs at site j
Z(I, J, D1, D2) Volume of waste generated at location i on day d1 that is assigned to a dumpster at site j and serviced on day d2
A(J, KB, D1) Volume of trash assigned to dumpsters of type u at site j that are serviced on day d1
X(J, KB, F) Number of dumpsters at site j that are serviced at least ?f? times per week
;
Binary variables
Y(J, D1) if dumpsters at site j are serviced on day d1
P(J, F) if dumpsters at site j are serviced on day d
W(I,J) if dumpsters at site j are serviced on day d
;
POSITIVE variables
*integer variables
* alternate between POSITIVE and INTEGER variable type for Q, to identify relaxation bounds
Q(J, K) Number of receptacles of type k at site j
;
Free variable
obj Total Cost
;

EQUATIONS
OBJECTIVE objective function

**********constraints**********

Const_1(I) All waste generated is serviced
Const_2(I,J,D1) volume of trash assigned equals to volume of trash generated
Const_3(J,D1) balance the total waste assigned and allocated to compactors and roll offs
Const_4(J,D2) balances the total waste assigned and allocated to dumpsters
Const_5(J,KB,D1) volume of trash assigned less than dumpsters capacity
Const_6(J) space availability
Const_7(J,D1) ensures that dumpster is only serviced on day d1 if that sire received dumpster service on that day
Const_8(I,J,D1) relate trash assigned to dumpsters to day-of-week for pickup
Const_9(I,J,D1) trash tracking 2 based on the day they are going to be serviced
Const_9_1(I,J,D1) trash tracking 2 based on the day they are going to be serviced
```

Const_10(I,J,D1) trash tracking 3 based on the day they are going to be serviced
Const_10_1(I,J,D1) trash tracking 3 based on the day they are going to be serviced
Const_10_FRI(I,J,D1) trash tracking 3 based on the day they are going to be serviced
Const_11(I,J,D1) trash tracking 4 based on the day they are going to be serviced
Const_11_WED(I,J,D1) trash tracking 4 based on the day they are going to be serviced
Const_11_THU(I,J,D1) trash tracking 4 based on the day they are going to be serviced
Const_11_FRI(I,J,D1) trash tracking 4 based on the day they are going to be serviced
Const_12(J) Translate the day of service each week in to the number of weekly services
Const_13(J) Translate the day of service each week in to the number of weekly services_2
Const_14(J) Translate the day of service each week in to the number of weekly services_3
Const_15(J) Translate the day of service each week in to the number of weekly services_4
Const_16(J) Translate the day of service each week in to the number of weekly services_5
Const_17(J,KB,F) compute the number of dumpsters serviced at least f times at each location
;
OBJECTIVE.. obj =E= SUM((J,KB,F),12*X(J,KB,F)*Teta(KB,F))+SUM((J,KA,D1),52*Pi(KA)*r(J,KA,D1)/Beta(KA))+SUM((J,KA,D1),
52*r(J,KA,D1)*Phi(KA)/20)+SUM((J,KA),12*Q(J,KA)*OMEGA(KA));
Const_1(I)..SUM(J, W(I,J))=e=1;
Const_2(I,J,D1)..SUM(D2,Z(I,J,D1,D2))+V(I,J,D1)=e=Alpha(I,D1)*W(I,J);
Const_3(J,D1)..SUM(I,V(I,J,D1))=e=SUM(KA, r(J,KA,D1));
Const_4(J,D2)..SUM((I,D1),Z(I,J,D1,D2))=E=SUM(KB, A(J,KB,D2));
Const_5(J,KB,D1)..A(J,KB,D1)=L=Beta(KB)*Q(J,KB);
Const_6(J)..SUM(K,Gama(k)*Q(J,K))=L=Epsilon(J);
Const_7(J,D1)..SUM(KB, A(J,KB,D1))=L=1000000000*Y(J,D1);
Const_8(I,J,D1)..Z(I,J,D1,D1)=G=Alpha(I,D1)*Y(J,D1)-V(I,J,D1)+100000000*(W(I,J)-1);
Const_9(I,J,D1)$(ORD(D1)<5)..Z(I,J,D1,D1)+Z(I,J,D1,D1+1)=G=Alpha(I,D1)*Y(J,D1+1)-V(I,J,D1)+100000000*(W(I,J)-1);
Const_9_1(I,J,D1)$(ORD(D1)=5)..Z(I,J,D1,D1)+Z(I,J,D1,"Mon")=G=Alpha(I,D1)*Y(J,"Mon")-V(I,J,D1)+100000000*(W(I,J)-1);
Const_10(I,J,D1)$(ORD(D1)<4)..Z(I,J,D1,D1)+Z(I,J,D1,D1+1)+Z(I,J,D1,D1+2)=G=Alpha(I,D1)*Y(J,D1+2)-V(I,J,D1)+100000000*(W(I,J)-1);
Const_10_1(I,J,D1)$(ORD(D1)=4)..Z(I,J,D1,D1)+Z(I,J,D1,D1+1)+Z(I,J,D1,"Mon")=G=Alpha(I,D1)*Y(J,"Mon")-V(I,J,D1)+100000000*(W(I,J)-1);
Const_10_FRI(I,J,D1)$(ORD(D1)=5)..Z(I,J,D1,D1)+Z(I,J,D1,"Mon")+Z(I,J,D1,"Tue")=G=Alpha(I,D1)*Y(J,"Tue")-V(I,J,D1)+100000000*(W(I,J)-1);
Const_11(I,J,D1)$(ORD(D1)<3)..Z(I,J,D1,D1)+Z(I,J,D1,D1+1)+Z(I,J,D1,D1+2)+Z(I,J,D1,D1+3)=G=Alpha(I,D1)*Y(J,D1+3)-V(I,J,D1)+100000000*(W(I,J)-1);
Const_11_WED(I,J,D1)$(ORD(D1)=3)..Z(I,J,D1,D1)+Z(I,J,D1,D1+1)+Z(I,J,D1,D1+2)+Z(I,J,D1,"Mon")=G=Alpha(I,D1)*Y(J,"Mon")-V(I,J,D1)+100000000*(W(I,J)-1);

```
Const_11_THU(I,J,D1)$(ORD(D1)=4)..Z(I,J,D1,D1)+Z(I,J,D1,D1+1)+Z(I,J,D1,"Mon")
+Z(I,J,D1,"Tue")=G=Alpha(I,D1)*Y(J,"Tue")-V(I,J,D1)+100000000*(W(I,J)-1);
Const_11_FRI(I,J,D1)$(ORD(D1)=5)..Z(I,J,D1,D1)+Z(I,J,D1,"Mon")+Z(I,J,D1,"Tue")+
Z(I,J,D1,"Wed")=G=Alpha(I,D1)*Y(J,"Wed")-V(I,J,D1)+100000000*(W(I,J)-1);

Const_12(J)..SUM(F,P(J,F))=E=SUM(D1,  Y(J,D1));
Const_13(J)..P(J,"f2")=L=P(J,"f1");
Const_14(J)..P(J,"f3")=L=P(J,"f2");
Const_15(J)..P(J,"f4")=L=P(J,"f3");
Const_16(J)..P(J,"f5")=L=P(J,"f4");
Const_17(J,KB,F)..X(J,KB,F)=G=Q(J,KB)+100000000*(P(J,F)-1);
* alternate between MAXDIST=0.25 and MAXDIST=1.757
*PARAMETER MAXDIST maximum allowable distance /0.25/;
PARAMETER MAXDIST maximum allowable distance /1.757/;

Z.FX(I,J,D1,D2)$(DIST(I,J)>MAXDIST)=0;
V.FX(I,J,D1)$(DIST(I,J)>MAXDIST)=0;
W.FX(I,J)$(DIST(I,J)>MAXDIST)=0;

MODEL trash /ALL/;
TRASH.OPTFILE  = 1;
OPTION ITERLIM  = 500000000;
OPTION RESLIM= 86400;
OPTION OPTCR=0.00;
OPTION RMIP=CPLEX;
OPTION MIP=CPLEX;
trash.HOLDFIXED=1;

SOLVE trash USING MIP MINIMIZING obj;
EXECUTE_UNLOAD  'output_Qrelaxed.gdx',v,r,z,a,x,y,p,w,q,obj;

file boundfile  /boundfile.inc/;
boundfile.lw  = 0;
boundfile.tw  = 0;
boundfile.pw  = 32767;

put boundfile
put 'OBJ.LO=',obj.l,';';
```

# B. GAMS Code: The robust optimization algorithm code used in Chapter 4.

## B.1. Data Parameters

- **data_ROtrash_6Oct.inc file:**

```
SETS
I     Waste generation sources   /i1*i111/
J     Potential sites to collect waste / j1*j111/
K              different bin types available for allocation to collection sites
/2YARD,4YARD,6YARD,8YARD,14YARD-ROLLOFF,20YARD-
ROLLOFF,30YARD-ROLLOFF,35YARD-ROLLOFF,40YARD-
ROLLOFF,14YARD-COMP,15YARD-COMP,25YARD-COMP,28YARD-
COMP,35YARD-COMP,28YARD-DUAL-COMP,35YARD-DUAL-COMP/
KA(K)   bin types compactor and Roll Off /14YARD-ROLLOFF,20YARD-
ROLLOFF,30YARD-ROLLOFF,35YARD-ROLLOFF,40YARD-
ROLLOFF,14YARD-COMP,15YARD-COMP,25YARD-COMP,28YARD-
COMP,35YARD-COMP,28YARD-DUAL-COMP,35YARD-DUAL-COMP/
KB(K)  Other bin types /2YARD,4YARD,6YARD,8YARD/
F      frequency of times a bin will be serviced /f1*f5/
D1     Days /Mon, Tue, Wed, Thur, Fri/;
Alias (D1, D2);

Parameters
Beta(K) Capacity of bin type k
/
2YARD              2
4YARD              4
6YARD              6
8YARD              8
*Maryam 15Sep in RO model(C_j)=20*midpoint
14YARD-ROLLOFF         50
20YARD-ROLLOFF         50
30YARD-ROLLOFF         50
35YARD-ROLLOFF         50
40YARD-ROLLOFF         70
14YARD-COMP          30
15YARD-COMP          32.14
25YARD-COMP          85
28YARD-COMP          70
35YARD-COMP          90
28YARD-DUAL-COMP       60
35YARD-DUAL-COMP       65
/
Gama(K)  area of space required per receptacle of type k
```

/
2YARD 3024
4YARD 3888
6YARD 4752
8YARD 4752
14YARD-ROLLOFF 14580
20YARD-ROLLOFF 25344
30YARD-ROLLOFF 23760
35YARD-ROLLOFF 22596
40YARD-ROLLOFF 22176
14YARD-COMP 21835
15YARD-COMP 23736
25YARD-COMP 23736
28YARD-COMP 23736
35YARD-COMP 23736
28YARD-DUAL-COMP 23736
35YARD-DUAL-COMP 23736
/
Epsilon(J) area available for trash receptacles at site j
/J7 3024
J105 3024
J98 6048
J1 3024
J54 9072
J2 3024
J63 9072
J57 3024
J80 19008
J111 3024
J76 23736
J30 3024
J103 22176
J37 6048
J102 59616
J69 21835
J16 3024
J58 3024
J10 3024
J86 6048
J11 3024
J12 6048
J79 9072
J42 23736
J92 23736
J41 23736
J24 9072

J14 6048
J55 6048
J17 6048
J72 3024
J94 3024
J70 12096
J18 3024
J96 3024
J22 6048
J61 3024
J43 21835
J81 23736
J53 3024
J85 3024
J60 9072
J87 3024
J75 12096
J84 22176
J44 23736
J4 3024
J15 12096
J34 6048
J23 3024
J36 3024
J56 23736
J90 3024
J45 3024
J20 3024
J95 5070
J104 26587
J8 3024
J6 3024
J46 9072
J26 23736
J47 23736
J109 23736
J99 23736
J97 3024
J83 23736
J5 3024
J25 3024
J82 6048
J88 23736
J73 3024
J28 3024
J91 3024

J48 23736
J9 3024
J21 23736
J74 3024
J62 62100
J29 3024
J32 3024
J19 21835
J100 5070
J35 8094
J51 5070
J93 26760
J33 3024
J31 3024
J89 23736
J27 3024
J3 4752
J52 3024
J13 3024
J50 26784
J78 6048
J101 3024
J110 4752
J59 3024
J77 6048
J107 6048
J64 6048
*J108 22176 SEE ALICIA LAVAUTE EMAIL 11JUNE2014 SHOWING COMPACTOR AT UNIV HOSPITAL
J108 23736
J65 6048
J66 6048
J67 6048
J68 28644
J106 3024
J71 3024
J38 9072
J39 3024
J49 3024
J40 9072
/
;
TABLE Alpha(I, D1) Volume of trash generated at location i on day d1

| | Mon | Tue | Wed | Thur | Fri |
|---|---|---|---|---|---|
| I7 | 1.1556 | 0.7722 | 1.0167 | 0.8611 | 0.7833 |
| I105 | 1.1556 | 0.7722 | 1.0167 | 0.8611 | 0.7833 |

| | | | | | |
|---|---|---|---|---|---|
| I98 | 1.6556 | 1.3556 | 1.7333 | 2.2833 | 1.4389 |
| I1 | 1.0333 | 0.9808 | 0.8975 | 1.0000 | 0.8483 |
| I54 | 3.9600 | 3.0600 | 3.7140 | 3.0540 | 3.3120 |
| I2 | 1.0333 | 0.9808 | 0.8975 | 1.0000 | 0.8483 |
| I63 | 3.9600 | 3.0600 | 3.7140 | 3.0540 | 3.3120 |
| I57 | 1.0333 | 0.9808 | 0.8975 | 1.0000 | 0.8483 |
| I80 | 7.2333 | 6.8658 | 6.2825 | 7.0000 | 5.9383 |
| I111 | 0.4571 | 0.4571 | 0.5214 | 0.5214 | 0.4571 |
| I76 | 10.0075 | 10.7773 | 10.0075 | 5.7735 | 5.0037 |
| I30 | 1.0333 | 0.9808 | 0.8975 | 1.0000 | 0.8483 |
| I103 | 6.8570 | 6.8570 | 7.8212 | 7.8212 | 6.8570 |
| I37 | 2.3111 | 1.5444 | 2.0333 | 1.7222 | 1.5667 |
| I102 | 20.2355 | 19.2074 | 17.5755 | 19.5828 | 16.6127 |
| I69 | 3.8770 | 2.0821 | 2.8001 | 2.4591 | 1.9924 |
| I16 | 1.1556 | 0.7722 | 1.0167 | 0.8611 | 0.7833 |
| I58 | 1.1333 | 0.7133 | 0.7400 | 0.5000 | 0.4733 |
| I10 | 1.0333 | 0.9808 | 0.8975 | 1.0000 | 0.8483 |
| I86 | 2.6400 | 2.0400 | 2.4760 | 2.0360 | 2.2080 |
| I11 | 1.3200 | 1.0200 | 1.2380 | 1.0180 | 1.1040 |
| I12 | 2.0667 | 1.9617 | 1.7950 | 2.0000 | 1.6967 |
| I79 | 3.1000 | 2.9425 | 2.6925 | 3.0000 | 2.5450 |
| I42 | 24.3142 | 26.1845 | 24.3142 | 14.0274 | 12.1571 |
| I92 | 8.6467 | 4.6436 | 6.2448 | 5.4843 | 4.4434 |
| I41 | 8.6539 | 7.0857 | 9.0605 | 11.9354 | 7.5213 |
| I24 | 3.9600 | 3.0600 | 3.7140 | 3.0540 | 3.3120 |
| I14 | 2.6400 | 2.0400 | 2.4760 | 2.0360 | 2.2080 |
| I55 | 2.6400 | 2.0400 | 2.4760 | 2.0360 | 2.2080 |
| I17 | 2.6400 | 2.0400 | 2.4760 | 2.0360 | 2.2080 |
| I72 | 1.3200 | 1.0200 | 1.2380 | 1.0180 | 1.1040 |
| I94 | 0.4571 | 0.4571 | 0.5214 | 0.5214 | 0.4571 |
| I70 | 1.8286 | 1.8286 | 2.0857 | 2.0857 | 1.8286 |
| I18 | 1.3200 | 1.0200 | 1.2380 | 1.0180 | 1.1040 |
| I96 | 0.8278 | 0.6778 | 0.8667 | 1.1417 | 0.7194 |
| I22 | 2.0667 | 1.9617 | 1.7950 | 2.0000 | 1.6967 |
| I61 | 0.8278 | 0.6778 | 0.8667 | 1.1417 | 0.7194 |
| I43 | 4.3892 | 2.3572 | 3.1700 | 2.7839 | 2.2556 |
| I81 | 4.2346 | 3.4672 | 4.4335 | 5.8403 | 3.6804 |
| I53 | 1.1556 | 0.7722 | 1.0167 | 0.8611 | 0.7833 |
| I85 | 1.1333 | 0.7133 | 0.7400 | 0.5000 | 0.4733 |
| I60 | 3.9600 | 3.0600 | 3.7140 | 3.0540 | 3.3120 |
| I87 | 1.0333 | 0.9808 | 0.8975 | 1.0000 | 0.8483 |
| I75 | 4.6222 | 3.0889 | 4.0667 | 3.4444 | 3.1333 |
| I84 | 3.8314 | 3.8314 | 4.3702 | 4.3702 | 3.8314 |
| I44 | 10.3680 | 5.5680 | 7.4880 | 6.5760 | 5.3280 |
| I4 | 1.0333 | 0.9808 | 0.8975 | 1.0000 | 0.8483 |
| I15 | 5.2800 | 4.0800 | 4.9520 | 4.0720 | 4.4160 |

| | | | | | |
|---|---|---|---|---|---|
| I34 | 2.3111 | 1.5444 | 2.0333 | 1.7222 | 1.5667 |
| I23 | 1.0333 | 0.9808 | 0.8975 | 1.0000 | 0.8483 |
| I36 | 1.1556 | 0.7722 | 1.0167 | 0.8611 | 0.7833 |
| I56 | 7.7212 | 7.3290 | 6.7063 | 7.4722 | 6.3389 |
| I90 | 1.3200 | 1.0200 | 1.2380 | 1.0180 | 1.1040 |
| I45 | 1.3200 | 1.0200 | 1.2380 | 1.0180 | 1.1040 |
| I20 | 1.1556 | 0.7722 | 1.0167 | 0.8611 | 0.7833 |
| I95 | 3.6522 | 1.2522 | 1.2522 | 1.3174 | 1.3174 |
| I104 | 8.4235 | 9.0715 | 8.4235 | 4.8597 | 4.2118 |
| I8 | 1.3200 | 1.0200 | 1.2380 | 1.0180 | 1.1040 |
| I6 | 1.3200 | 1.0200 | 1.2380 | 1.0180 | 1.1040 |
| I46 | 5.4000 | 2.9000 | 3.9000 | 3.4250 | 2.7750 |
| I26 | 10.9878 | 10.9878 | 11.3948 | 12.2087 | 11.3948 |
| I47 | 4.5025 | 4.5025 | 5.1357 | 5.1357 | 4.5025 |
| I109 | 11.1586 | 11.1586 | 11.5719 | 12.3985 | 11.5719 |
| I99 | 8.4325 | 6.9045 | 8.8287 | 11.6301 | 7.3289 |
| I97 | 1.0333 | 0.9808 | 0.8975 | 1.0000 | 0.8483 |
| I83 | 12.9077 | 12.9077 | 14.7228 | 14.7228 | 12.9077 |
| I5 | 0.4571 | 0.4571 | 0.5214 | 0.5214 | 0.4571 |
| I25 | 1.0333 | 0.9808 | 0.8975 | 1.0000 | 0.8483 |
| I82 | 2.6400 | 2.0400 | 2.4760 | 2.0360 | 2.2080 |
| I88 | 7.2524 | 3.8948 | 5.2378 | 4.5999 | 3.7269 |
| I73 | 1.0333 | 0.9808 | 0.8975 | 1.0000 | 0.8483 |
| I28 | 1.3200 | 1.0200 | 1.2380 | 1.0180 | 1.1040 |
| I91 | 1.1333 | 0.7133 | 0.7400 | 0.5000 | 0.4733 |
| I48 | 4.5232 | 4.8712 | 4.5232 | 2.6096 | 2.2616 |
| I9 | 1.3200 | 1.0200 | 1.2380 | 1.0180 | 1.1040 |
| I21 | 13.9489 | 15.0218 | 13.9489 | 8.0474 | 6.9744 |
| I74 | 1.0333 | 0.9808 | 0.8975 | 1.0000 | 0.8483 |
| I62 | 10.4085 | 10.4085 | 11.8722 | 11.8722 | 10.4085 |
| I29 | 1.3200 | 1.0200 | 1.2380 | 1.0180 | 1.1040 |
| I32 | 1.0333 | 0.9808 | 0.8975 | 1.0000 | 0.8483 |
| I19 | 6.7214 | 3.6097 | 4.8544 | 4.2631 | 3.4541 |
| I100 | 1.8286 | 1.8286 | 2.0857 | 2.0857 | 1.8286 |
| I35 | 5.7778 | 3.8611 | 5.0833 | 4.3056 | 3.9167 |
| I51 | 3.4667 | 2.3167 | 3.0500 | 2.5833 | 2.3500 |
| I93 | 36.0883 | 38.8643 | 36.0883 | 20.8202 | 18.0441 |
| I33 | 0.4571 | 0.4571 | 0.5214 | 0.5214 | 0.4571 |
| I31 | 1.0333 | 0.9808 | 0.8975 | 1.0000 | 0.8483 |
| I89 | 3.4268 | 1.8403 | 2.4749 | 2.1735 | 1.7610 |
| I27 | 1.0333 | 0.9808 | 0.8975 | 1.0000 | 0.8483 |
| I3 | 1.8286 | 1.8286 | 2.0857 | 2.0857 | 1.8286 |
| I52 | 0.4571 | 0.4571 | 0.5214 | 0.5214 | 0.4571 |
| I13 | 1.3200 | 1.0200 | 1.2380 | 1.0180 | 1.1040 |
| I50 | 5.4437 | 5.1671 | 4.7281 | 5.2681 | 4.4691 |
| I78 | 2.0667 | 1.9617 | 1.7950 | 2.0000 | 1.6967 |

```
I101    1.1333  0.7133  0.7400  0.5000  0.4733
I110    5.4000  5.4000  5.6000  6.0000  5.6000
I59     1.1333  0.7133  0.7400  0.5000  0.4733
I77     2.2667  1.4267  1.4800  1.0000  0.9467
I107    2.3111  1.5444  2.0333  1.7222  1.5667
I64     2.4348  0.8348  0.8348  0.8783  0.8783
I108    77.3348 77.3348 80.1990 85.9275 80.1990
I65     2.4348  0.8348  0.8348  0.8783  0.8783
I66     2.4348  0.8348  0.8348  0.8783  0.8783
I67     2.4348  0.8348  0.8348  0.8783  0.8783
I68     5.7433  1.9691  1.9691  2.0717  2.0717
I106    1.0333  0.9808  0.8975  1.0000  0.8483
I71     1.0333  0.9808  0.8975  1.0000  0.8483
I38     3.9600  3.0600  3.7140  3.0540  3.3120
I39     1.0333  0.9808  0.8975  1.0000  0.8483
I49     1.1333  0.7133  0.7400  0.5000  0.4733
I40     3.1000  2.9425  2.6925  3.0000  2.5450
;
parameter
Pi (KA) fixed  cost per service  for compactor  of type  KA
/
14YARD-ROLLOFF     50.93
20YARD-ROLLOFF     71.64
30YARD-ROLLOFF     71.64
35YARD-ROLLOFF     71.64
40YARD-ROLLOFF     71.64
14YARD-COMP        50.93
15YARD-COMP        50.93
25YARD-COMP        71.64
28YARD-COMP        71.64
35YARD-COMP        71.64
28YARD-DUAL-COMP   71.64
35YARD-DUAL-COMP   71.64
/
Phi(KA)   Variable cost per tone of trash serviced  for compactor and roll-offs of type
KA
/
14YARD-ROLLOFF     34.96
20YARD-ROLLOFF     34.96
30YARD-ROLLOFF     34.96
35YARD-ROLLOFF     34.96
40YARD-ROLLOFF     34.96
14YARD-COMP        34.96
15YARD-COMP        34.96
25YARD-COMP        34.96
28YARD-COMP        34.96
```

35YARD-COMP 34.96
28YARD-DUAL-COMP 34.96
35YARD-DUAL-COMP 34.96
/
;
Table DIST(I, J) distance between waste generation I and collection center J

| | J1 | J2 | J3 | J4 | J5 | J6 | J7 | J8 | J9 | J10 | J11 | J12 | J13 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| J14 | J15 | J16 | J17 | J18 | J19 | J20 | J21 | J22 | J23 | J24 | J25 | J26 | |
| J27 | J28 | J29 | J30 | J31 | J32 | J33 | J34 | J35 | J36 | J37 | J38 | J39 | |
| J40 | J41 | J42 | J43 | J44 | J45 | J46 | J47 | J48 | J49 | J50 | J51 | J52 | |
| J53 | J54 | J55 | J56 | J57 | J58 | J59 | J60 | J61 | J62 | J63 | J64 | J65 | |
| J66 | J67 | J68 | J69 | J70 | J71 | J72 | J73 | J74 | J75 | J76 | J77 | J78 | |
| J79 | J80 | J81 | J82 | J83 | J84 | J85 | J86 | J87 | J88 | J89 | J90 | J91 | |
| J92 | J93 | J94 | J95 | J96 | J97 | J98 | J99 | J100 | J101 | J102 | J103 | | |
| J104 | J105 | J106 | J107 | J108 | J109 | J110 | J111 | | | | | | |
| I1 | 0.001 | 0.396 | 0.551 | 1.268 | 0.725 | 0.790 | 1.546 | 1.240 | 0.639 | 0.052 | | | |
| 0.636 | 0.360 | 0.696 | 0.823 | 0.745 | 0.584 | 0.532 | 0.726 | 0.343 | 0.556 | 0.251 | | | |
| 0.185 | 0.414 | 0.459 | 0.317 | 0.633 | 0.417 | 0.759 | 0.407 | 1.327 | 0.367 | 1.161 | | | |
| 0.377 | 0.793 | 0.641 | 0.823 | 0.843 | 0.053 | 0.050 | 0.444 | 1.088 | 0.761 | 0.161 | | | |
| 0.327 | 0.869 | 0.836 | 0.448 | 0.438 | 0.397 | 0.305 | 0.792 | 0.265 | 0.823 | 0.055 | | | |
| 0.514 | 0.317 | 0.336 | 0.802 | 0.524 | 0.567 | 1.399 | 0.932 | 0.350 | 0.939 | 0.955 | | | |
| 1.018 | 1.020 | 1.095 | 0.208 | 0.761 | 0.073 | 0.522 | 0.655 | 0.346 | 0.586 | 0.188 | | | |
| 0.714 | 0.378 | 1.301 | 0.215 | 0.860 | 0.702 | 0.436 | 0.954 | 0.630 | 0.646 | 1.388 | | | |
| 0.807 | 0.843 | 0.864 | 0.506 | 0.511 | 0.259 | 0.340 | 0.573 | 1.631 | 1.499 | 1.504 | | | |
| 1.084 | 0.651 | 0.750 | 0.111 | 0.811 | 0.830 | 0.495 | 0.194 | 1.259 | 0.624 | 0.564 | | | |
| 0.442 | 0.366 | | | | | | | | | | | | |
| I2 | 0.396 | 0.001 | 0.188 | 0.996 | 0.758 | 0.430 | 1.202 | 0.974 | 0.291 | 0.367 | | | |
| 0.332 | 0.113 | 0.303 | 0.438 | 0.358 | 0.270 | 0.196 | 0.363 | 0.293 | 0.189 | 0.199 | | | |
| 0.440 | 0.212 | 0.078 | 0.691 | 0.363 | 0.151 | 0.384 | 0.051 | 1.035 | 0.227 | 0.899 | | | |
| 0.714 | 0.459 | 0.723 | 0.435 | 0.456 | 0.436 | 0.402 | 0.194 | 0.788 | 0.455 | 0.316 | | | |
| 0.109 | 0.499 | 0.462 | 0.152 | 0.241 | 0.264 | 0.590 | 0.869 | 0.323 | 0.483 | 0.371 | | | |
| 0.242 | 0.089 | 0.682 | 0.408 | 0.295 | 0.176 | 1.099 | 0.542 | 0.047 | 0.550 | 0.561 | | | |
| 0.625 | 0.632 | 0.705 | 0.237 | 0.690 | 0.453 | 0.171 | 0.609 | 0.697 | 0.210 | 0.310 | | | |
| 0.672 | 0.061 | 1.053 | 0.581 | 0.711 | 0.379 | 0.057 | 0.741 | 0.351 | 0.259 | 1.147 | | | |
| 0.490 | 0.553 | 0.529 | 0.458 | 0.277 | 0.173 | 0.160 | 0.326 | 1.446 | 1.252 | 1.163 | | | |
| 0.885 | 0.257 | 0.355 | 0.458 | 0.772 | 0.434 | 0.592 | 0.589 | 0.935 | 0.374 | 0.506 | | | |
| 0.296 | 0.156 | | | | | | | | | | | | |
| I3 | 0.551 | 0.188 | 0.000 | 1.033 | 0.929 | 0.245 | 1.170 | 1.017 | 0.103 | 0.512 | | | |
| 0.410 | 0.193 | 0.175 | 0.276 | 0.204 | 0.104 | 0.047 | 0.178 | 0.478 | 0.010 | 0.386 | | | |
| 0.623 | 0.197 | 0.111 | 0.860 | 0.460 | 0.150 | 0.208 | 0.153 | 1.056 | 0.247 | 0.947 | | | |
| 0.893 | 0.271 | 0.903 | 0.372 | 0.390 | 0.598 | 0.545 | 0.152 | 0.814 | 0.507 | 0.498 | | | |
| 0.298 | 0.320 | 0.285 | 0.116 | 0.403 | 0.438 | 0.774 | 1.045 | 0.512 | 0.294 | 0.537 | | | |
| 0.134 | 0.239 | 0.859 | 0.271 | 0.196 | 0.180 | 1.112 | 0.388 | 0.218 | 0.470 | 0.454 | | | |
| 0.528 | 0.550 | 0.616 | 0.421 | 0.838 | 0.616 | 0.032 | 0.769 | 0.874 | 0.044 | 0.495 | | | |
| 0.829 | 0.176 | 1.104 | 0.751 | 0.830 | 0.195 | 0.196 | 0.828 | 0.193 | 0.238 | 1.200 | | | |
| 0.527 | 0.606 | 0.340 | 0.628 | 0.414 | 0.360 | 0.345 | 0.198 | 1.523 | 1.298 | 1.135 | | | |

0.971 0.199 0.271 0.629 0.926 0.314 0.777 0.738 0.933 0.482 0.670
0.462 0.336
I4 1.268 0.996 1.033 0.000 0.848 1.072 0.437 0.037 1.075 1.271
0.665 1.108 0.905 0.960 0.941 1.128 1.078 1.050 0.929 1.023 1.027
1.162 1.191 1.003 1.416 0.647 1.126 1.009 1.033 0.094 1.219 0.109
1.357 1.155 0.939 0.707 0.697 1.276 1.303 1.156 0.221 0.541 1.110
0.985 1.047 1.026 1.107 0.835 0.871 1.222 0.941 1.014 1.148 1.217
1.165 1.074 1.356 0.886 1.228 0.862 0.168 0.930 1.033 0.680 0.758
0.706 0.651 0.659 1.064 0.660 1.282 1.053 0.737 1.374 0.999 1.084
0.721 1.055 0.103 1.332 0.494 1.152 0.940 0.342 1.207 0.795 0.186
0.510 0.443 1.180 0.811 0.764 1.030 0.946 1.229 0.544 0.268 0.397
0.284 0.837 0.800 1.251 0.703 0.837 0.966 1.430 0.221 0.649 0.769
0.826 0.923
I5 0.725 0.758 0.929 0.848 0.002 1.135 1.258 0.811 1.028 0.761
0.610 0.840 0.946 1.086 1.013 1.024 0.950 1.074 0.476 0.925 0.613
0.545 0.947 0.826 0.696 0.553 0.900 1.071 0.808 0.936 0.934 0.747
0.600 1.188 0.116 0.900 0.912 0.697 0.775 0.943 0.783 0.638 0.590
0.661 1.175 1.138 0.908 0.526 0.495 0.506 0.127 0.497 1.204 0.673
1.000 0.770 0.618 1.019 1.048 0.787 1.014 1.147 0.755 0.985 1.053
1.068 1.033 1.098 0.612 0.196 0.690 0.922 0.179 0.633 0.930 0.569
0.146 0.805 0.824 0.657 0.360 1.123 0.734 0.520 1.109 0.802 0.879
0.675 0.630 1.251 0.301 0.528 0.637 0.603 1.083 1.008 0.985 1.214
0.572 0.848 0.908 0.643 0.150 1.005 0.232 0.795 0.964 0.519 0.262
0.467 0.603
I6 0.790 0.430 0.245 1.072 1.135 0.001 1.114 1.064 0.151 0.748
0.554 0.431 0.197 0.118 0.139 0.216 0.258 0.067 0.709 0.242 0.629
0.868 0.397 0.353 1.103 0.612 0.375 0.069 0.397 1.074 0.451 1.004
1.138 0.084 1.121 0.366 0.375 0.839 0.780 0.356 0.852 0.609 0.743
0.538 0.086 0.068 0.343 0.616 0.660 1.019 1.256 0.751 0.079 0.780
0.296 0.483 1.104 0.186 0.323 0.348 1.115 0.209 0.463 0.410 0.353
0.430 0.472 0.517 0.666 1.019 0.858 0.270 0.965 1.118 0.221 0.739
1.020 0.421 1.158 0.994 0.978 0.127 0.425 0.939 0.223 0.347 1.252
0.610 0.696 0.121 0.839 0.606 0.603 0.579 0.284 1.597 1.338 1.084
1.074 0.296 0.282 0.872 1.110 0.237 1.004 0.973 0.926 0.642 0.872
0.675 0.566
I7 1.546 1.202 1.170 0.437 1.258 1.114 0.001 0.471 1.175 1.537
0.910 1.302 1.005 0.996 1.014 1.243 1.216 1.118 1.231 1.160 1.295
1.478 1.359 1.181 1.749 0.919 1.298 1.067 1.225 0.344 1.400 0.518
1.708 1.194 1.338 0.799 0.781 1.566 1.572 1.316 0.489 0.786 1.400
1.228 1.058 1.052 1.271 1.114 1.162 1.567 1.361 1.319 1.176 1.501
1.302 1.290 1.699 0.942 1.360 1.035 0.281 0.920 1.247 0.713 0.761
0.685 0.643 0.600 1.339 1.063 1.576 1.198 1.123 1.718 1.128 1.377
1.121 1.253 0.511 1.653 0.898 1.225 1.147 0.738 1.304 0.953 0.533
0.740 0.716 1.193 1.160 1.040 1.290 1.207 1.345 0.827 0.517 0.044
0.716 0.977 0.901 1.554 1.120 0.889 1.340 1.727 0.302 0.935 1.130
1.125 1.180

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| I8 | 1.240 | 0.974 | 1.017 | 0.037 | 0.811 | 1.064 | 0.471 | 0.000 | 1.062 | 1.244 |
| 0.642 | 1.086 | 0.893 | 0.953 | 0.932 | 1.113 | 1.062 | 1.040 | 0.899 | 1.007 | 1.000 |
| 1.131 | 1.171 | 0.984 | 1.383 | 0.621 | 1.106 | 1.000 | 1.012 | 0.130 | 1.198 | 0.078 |
| 1.323 | 1.147 | 0.902 | 0.698 | 0.690 | 1.246 | 1.275 | 1.137 | 0.212 | 0.520 | 1.081 |
| 0.960 | 1.042 | 1.020 | 1.088 | 0.808 | 0.843 | 1.189 | 0.905 | 0.984 | 1.140 | 1.188 |
| 1.148 | 1.051 | 1.322 | 0.879 | 1.211 | 0.844 | 0.204 | 0.928 | 1.010 | 0.678 | 0.757 |
| 0.708 | 0.653 | 0.665 | 1.036 | 0.623 | 1.252 | 1.036 | 0.701 | 1.340 | 0.984 | 1.055 |
| 0.685 | 1.034 | 0.096 | 1.300 | 0.458 | 1.141 | 0.918 | 0.308 | 1.194 | 0.779 | 0.189 |
| 0.492 | 0.421 | 1.174 | 0.778 | 0.737 | 1.004 | 0.920 | 1.214 | 0.542 | 0.281 | 0.432 |
| 0.247 | 0.823 | 0.789 | 1.220 | 0.666 | 0.830 | 0.931 | 1.399 | 0.242 | 0.623 | 0.735 |
| 0.797 | 0.897 | | | | | | | | | |
| I9 | 0.639 | 0.291 | 0.103 | 1.075 | 1.028 | 0.151 | 1.175 | 1.062 | 0.001 | 0.597 |
| 0.486 | 0.280 | 0.174 | 0.215 | 0.165 | 0.075 | 0.107 | 0.090 | 0.580 | 0.104 | 0.487 |
| 0.722 | 0.249 | 0.214 | 0.953 | 0.539 | 0.224 | 0.136 | 0.253 | 1.090 | 0.304 | 0.996 |
| 0.990 | 0.168 | 1.004 | 0.383 | 0.398 | 0.688 | 0.628 | 0.207 | 0.854 | 0.568 | 0.597 |
| 0.400 | 0.234 | 0.204 | 0.191 | 0.502 | 0.539 | 0.874 | 1.145 | 0.614 | 0.192 | 0.630 |
| 0.153 | 0.335 | 0.955 | 0.239 | 0.195 | 0.257 | 1.141 | 0.328 | 0.318 | 0.463 | 0.429 |
| 0.507 | 0.538 | 0.597 | 0.522 | 0.930 | 0.707 | 0.123 | 0.865 | 0.969 | 0.099 | 0.596 |
| 0.924 | 0.273 | 1.153 | 0.844 | 0.911 | 0.096 | 0.297 | 0.896 | 0.133 | 0.292 | 1.249 |
| 0.581 | 0.664 | 0.238 | 0.727 | 0.507 | 0.461 | 0.448 | 0.171 | 1.580 | 1.342 | 1.142 |
| 1.037 | 0.243 | 0.281 | 0.723 | 1.019 | 0.290 | 0.879 | 0.822 | 0.956 | 0.564 | 0.767 |
| 0.561 | 0.438 | | | | | | | | | |
| I10 | 0.052 | 0.367 | 0.512 | 1.271 | 0.761 | 0.748 | 1.537 | 1.244 | 0.597 | 0.001 |
| 0.628 | 0.319 | 0.663 | 0.786 | 0.709 | 0.540 | 0.490 | 0.684 | 0.354 | 0.518 | 0.246 |
| 0.229 | 0.366 | 0.425 | 0.365 | 0.630 | 0.373 | 0.719 | 0.372 | 1.327 | 0.318 | 1.166 |
| 0.429 | 0.748 | 0.680 | 0.799 | 0.820 | 0.105 | 0.036 | 0.398 | 1.086 | 0.755 | 0.180 |
| 0.310 | 0.828 | 0.796 | 0.405 | 0.437 | 0.402 | 0.356 | 0.833 | 0.285 | 0.778 | 0.089 |
| 0.467 | 0.283 | 0.387 | 0.768 | 0.474 | 0.541 | 1.398 | 0.896 | 0.320 | 0.915 | 0.927 |
| 0.991 | 0.996 | 1.070 | 0.207 | 0.787 | 0.125 | 0.482 | 0.682 | 0.397 | 0.549 | 0.206 |
| 0.741 | 0.343 | 1.308 | 0.266 | 0.877 | 0.656 | 0.411 | 0.964 | 0.582 | 0.622 | 1.396 |
| 0.799 | 0.841 | 0.818 | 0.529 | 0.509 | 0.248 | 0.331 | 0.524 | 1.648 | 1.507 | 1.495 |
| 1.097 | 0.623 | 0.722 | 0.163 | 0.841 | 0.798 | 0.534 | 0.227 | 1.253 | 0.623 | 0.587 |
| 0.449 | 0.357 | | | | | | | | | |
| I11 | 0.636 | 0.332 | 0.410 | 0.665 | 0.610 | 0.554 | 0.910 | 0.642 | 0.486 | 0.628 |
| 0.000 | 0.445 | 0.357 | 0.485 | 0.421 | 0.514 | 0.449 | 0.503 | 0.334 | 0.403 | 0.385 |
| 0.582 | 0.536 | 0.351 | 0.858 | 0.060 | 0.471 | 0.486 | 0.373 | 0.709 | 0.558 | 0.567 |
| 0.836 | 0.622 | 0.625 | 0.293 | 0.307 | 0.656 | 0.663 | 0.506 | 0.463 | 0.128 | 0.492 |
| 0.326 | 0.579 | 0.544 | 0.457 | 0.208 | 0.262 | 0.694 | 0.737 | 0.421 | 0.631 | 0.591 |
| 0.529 | 0.409 | 0.819 | 0.413 | 0.592 | 0.231 | 0.776 | 0.537 | 0.368 | 0.392 | 0.449 |
| 0.478 | 0.455 | 0.529 | 0.428 | 0.470 | 0.667 | 0.421 | 0.432 | 0.837 | 0.390 | 0.470 |
| 0.481 | 0.393 | 0.720 | 0.755 | 0.427 | 0.580 | 0.277 | 0.419 | 0.602 | 0.207 | 0.815 |
| 0.171 | 0.222 | 0.675 | 0.348 | 0.139 | 0.381 | 0.297 | 0.605 | 1.121 | 0.920 | 0.868 |
| 0.563 | 0.258 | 0.300 | 0.649 | 0.562 | 0.396 | 0.546 | 0.818 | 0.625 | 0.092 | 0.359 |
| 0.235 | 0.271 | | | | | | | | | |
| I12 | 0.360 | 0.113 | 0.193 | 1.108 | 0.840 | 0.431 | 1.302 | 1.086 | 0.280 | 0.319 |
| 0.445 | 0.002 | 0.353 | 0.468 | 0.393 | 0.231 | 0.173 | 0.366 | 0.365 | 0.199 | 0.238 |

0.451 0.108 0.123 0.673 0.476 0.066 0.400 0.078 1.145 0.114 1.012
0.714 0.439 0.794 0.519 0.539 0.408 0.352 0.108 0.899 0.566 0.329
0.180 0.510 0.477 0.091 0.342 0.352 0.604 0.945 0.369 0.467 0.350
0.174 0.072 0.678 0.456 0.211 0.267 1.208 0.580 0.089 0.629 0.628
0.698 0.711 0.782 0.261 0.788 0.427 0.163 0.702 0.691 0.231 0.332
0.765 0.053 1.166 0.565 0.819 0.349 0.168 0.853 0.294 0.350 1.260
0.600 0.665 0.510 0.545 0.385 0.212 0.239 0.252 1.559 1.365 1.264
0.997 0.335 0.428 0.444 0.867 0.492 0.656 0.546 1.041 0.486 0.597
0.391 0.246
I13 0.696 0.303 0.175 0.905 0.946 0.197 1.005 0.893 0.174 0.663
0.357 0.353 0.000 0.145 0.069 0.238 0.217 0.152 0.546 0.165 0.492
0.737 0.372 0.238 0.993 0.416 0.322 0.129 0.291 0.918 0.421 0.829
1.012 0.270 0.940 0.210 0.226 0.738 0.698 0.327 0.684 0.415 0.615
0.398 0.229 0.192 0.289 0.439 0.488 0.882 1.069 0.602 0.275 0.674
0.299 0.380 0.982 0.106 0.355 0.166 0.967 0.240 0.346 0.297 0.279
0.353 0.376 0.442 0.535 0.823 0.756 0.206 0.774 0.998 0.130 0.606
0.828 0.320 0.985 0.883 0.781 0.247 0.276 0.746 0.306 0.150 1.081
0.421 0.507 0.318 0.655 0.419 0.470 0.426 0.340 1.418 1.173 0.971
0.884 0.100 0.108 0.761 0.916 0.140 0.831 0.889 0.783 0.446 0.685
0.496 0.408
I14 0.823 0.438 0.276 0.960 1.086 0.118 0.996 0.953 0.215 0.786
0.485 0.468 0.145 0.001 0.084 0.290 0.306 0.133 0.691 0.269 0.632
0.877 0.460 0.366 1.128 0.545 0.424 0.081 0.417 0.959 0.514 0.896
1.151 0.201 1.083 0.258 0.264 0.868 0.820 0.416 0.741 0.520 0.754
0.538 0.096 0.067 0.390 0.583 0.633 1.024 1.210 0.746 0.189 0.805
0.368 0.507 1.120 0.078 0.409 0.312 0.999 0.114 0.478 0.292 0.235
0.312 0.354 0.401 0.674 0.955 0.886 0.307 0.911 1.135 0.237 0.746
0.963 0.445 1.048 1.018 0.898 0.233 0.418 0.846 0.324 0.284 1.142
0.515 0.601 0.221 0.798 0.560 0.609 0.570 0.378 1.489 1.226 0.966
0.977 0.239 0.190 0.895 1.047 0.123 0.976 1.013 0.809 0.576 0.825
0.640 0.552
I15 0.745 0.358 0.204 0.941 1.013 0.139 1.014 0.932 0.165 0.709
0.421 0.393 0.069 0.084 0.017 0.238 0.239 0.110 0.610 0.196 0.551
0.795 0.395 0.287 1.047 0.480 0.354 0.071 0.339 0.948 0.448 0.870
1.070 0.218 1.007 0.235 0.247 0.789 0.743 0.350 0.721 0.470 0.672
0.457 0.163 0.127 0.320 0.505 0.554 0.942 1.136 0.664 0.218 0.726
0.310 0.429 1.039 0.075 0.359 0.233 0.994 0.188 0.399 0.301 0.265
0.342 0.374 0.432 0.593 0.888 0.807 0.236 0.840 1.054 0.163 0.665
0.894 0.367 1.025 0.937 0.842 0.215 0.336 0.800 0.291 0.215 1.120
0.472 0.558 0.259 0.722 0.486 0.528 0.488 0.336 1.462 1.209 0.982
0.936 0.166 0.144 0.815 0.981 0.127 0.898 0.936 0.806 0.510 0.752
0.563 0.471
I16 0.584 0.270 0.104 1.128 1.024 0.216 1.243 1.113 0.075 0.540
0.514 0.231 0.238 0.290 0.238 0.000 0.075 0.161 0.563 0.112 0.457
0.682 0.181 0.198 0.901 0.564 0.169 0.210 0.224 1.147 0.235 1.045
0.945 0.209 0.993 0.447 0.463 0.635 0.570 0.142 0.908 0.608 0.558

0.377 0.301 0.275 0.140 0.500 0.530 0.834 1.138 0.587 0.238 0.580
0.080 0.295 0.908 0.313 0.121 0.284 1.200 0.402 0.287 0.533 0.502
0.580 0.609 0.670 0.487 0.940 0.655 0.103 0.868 0.921 0.129 0.560
0.929 0.238 1.202 0.794 0.935 0.118 0.290 0.931 0.089 0.335 1.298
0.626 0.706 0.279 0.723 0.515 0.430 0.430 0.103 1.624 1.394 1.209
1.074 0.291 0.344 0.674 1.027 0.363 0.862 0.763 1.018 0.586 0.767
0.558 0.425
I17 0.532 0.196 0.047 1.078 0.950 0.258 1.216 1.062 0.107 0.490
0.449 0.173 0.217 0.306 0.239 0.075 0.005 0.194 0.490 0.057 0.387
0.617 0.157 0.124 0.846 0.497 0.119 0.232 0.152 1.102 0.209 0.992
0.884 0.270 0.918 0.417 0.436 0.581 0.523 0.111 0.860 0.550 0.493
0.304 0.338 0.307 0.086 0.425 0.456 0.769 1.063 0.516 0.296 0.523
0.088 0.229 0.849 0.310 0.150 0.222 1.158 0.420 0.217 0.514 0.495
0.570 0.594 0.659 0.419 0.867 0.600 0.030 0.794 0.862 0.088 0.492
0.855 0.169 1.148 0.737 0.865 0.185 0.216 0.868 0.161 0.283 1.244
0.571 0.649 0.341 0.648 0.443 0.360 0.356 0.156 1.565 1.343 1.181
1.012 0.246 0.316 0.616 0.953 0.354 0.789 0.716 0.979 0.517 0.693
0.483 0.350
I18 0.726 0.363 0.178 1.050 1.074 0.067 1.118 1.040 0.090 0.684
0.503 0.366 0.152 0.133 0.110 0.161 0.194 0.000 0.643 0.175 0.562
0.801 0.339 0.286 1.038 0.560 0.313 0.053 0.331 1.058 0.394 0.978
1.072 0.119 1.058 0.345 0.357 0.774 0.717 0.297 0.829 0.567 0.676
0.471 0.144 0.114 0.280 0.553 0.595 0.952 1.194 0.685 0.131 0.714
0.241 0.417 1.038 0.177 0.277 0.288 1.103 0.243 0.396 0.407 0.362
0.440 0.477 0.529 0.599 0.963 0.793 0.204 0.906 1.052 0.154 0.672
0.963 0.354 1.132 0.929 0.929 0.107 0.359 0.898 0.191 0.298 1.228
0.573 0.659 0.177 0.776 0.547 0.536 0.513 0.245 1.568 1.317 1.087
1.036 0.246 0.251 0.807 1.054 0.231 0.939 0.910 0.916 0.588 0.812
0.612 0.500
I19 0.343 0.293 0.478 0.929 0.476 0.709 1.231 0.899 0.580 0.354
0.334 0.365 0.546 0.691 0.610 0.563 0.490 0.643 0.004 0.477 0.141
0.249 0.471 0.368 0.524 0.313 0.426 0.654 0.340 0.991 0.459 0.821
0.504 0.748 0.431 0.590 0.609 0.347 0.382 0.469 0.758 0.447 0.182
0.188 0.767 0.729 0.437 0.129 0.072 0.363 0.581 0.089 0.769 0.289
0.529 0.294 0.485 0.640 0.575 0.380 1.065 0.779 0.283 0.703 0.743
0.788 0.775 0.850 0.156 0.449 0.353 0.464 0.351 0.503 0.490 0.156
0.414 0.333 0.959 0.424 0.524 0.672 0.285 0.611 0.643 0.432 1.045
0.495 0.516 0.816 0.191 0.196 0.163 0.134 0.612 1.294 1.156 1.188
0.743 0.462 0.551 0.326 0.518 0.647 0.299 0.503 0.935 0.295 0.248
0.106 0.143
I20 0.556 0.189 0.010 1.023 0.925 0.242 1.160 1.007 0.104 0.518
0.403 0.199 0.165 0.269 0.196 0.112 0.057 0.175 0.477 0.000 0.387
0.626 0.207 0.111 0.865 0.452 0.159 0.203 0.156 1.046 0.256 0.938
0.897 0.271 0.900 0.361 0.380 0.603 0.551 0.162 0.804 0.498 0.501
0.298 0.315 0.280 0.125 0.400 0.435 0.777 1.042 0.512 0.294 0.542
0.144 0.243 0.863 0.263 0.206 0.172 1.102 0.381 0.221 0.459 0.444

0.518 0.540 0.606 0.424 0.833 0.621 0.041 0.765 0.878 0.035 0.497
0.825 0.180 1.095 0.756 0.823 0.198 0.194 0.820 0.200 0.228 1.191
0.518 0.597 0.340 0.625 0.408 0.361 0.344 0.207 1.514 1.289 1.124
0.963 0.189 0.260 0.633 0.921 0.304 0.775 0.745 0.922 0.475 0.666
0.459 0.334
I21 0.251 0.199 0.386 1.027 0.613 0.629 1.295 1.000 0.487 0.246
0.385 0.238 0.492 0.632 0.551 0.457 0.387 0.562 0.141 0.387 0.004
0.245 0.340 0.276 0.508 0.385 0.303 0.582 0.235 1.082 0.322 0.922
0.520 0.655 0.559 0.586 0.606 0.276 0.279 0.345 0.841 0.511 0.125
0.095 0.697 0.660 0.321 0.192 0.165 0.392 0.712 0.131 0.679 0.208
0.410 0.167 0.491 0.595 0.449 0.340 1.153 0.732 0.170 0.703 0.728
0.784 0.781 0.857 0.047 0.589 0.289 0.365 0.492 0.507 0.409 0.114
0.556 0.219 1.067 0.399 0.654 0.571 0.216 0.726 0.529 0.412 1.156
0.555 0.595 0.725 0.332 0.264 0.027 0.089 0.490 1.421 1.266 1.253
0.864 0.427 0.524 0.280 0.659 0.614 0.418 0.438 1.008 0.378 0.389
0.212 0.115
I22 0.185 0.440 0.623 1.162 0.545 0.868 1.478 1.131 0.722 0.229
0.582 0.451 0.737 0.877 0.795 0.682 0.617 0.801 0.249 0.626 0.245
0.001 0.534 0.516 0.276 0.562 0.516 0.824 0.470 1.229 0.498 1.053
0.275 0.887 0.457 0.820 0.840 0.152 0.235 0.553 1.002 0.696 0.125
0.339 0.939 0.902 0.542 0.374 0.320 0.153 0.608 0.161 0.913 0.141
0.623 0.388 0.248 0.840 0.648 0.583 1.305 0.977 0.405 0.935 0.967
1.019 1.011 1.087 0.203 0.602 0.146 0.599 0.495 0.264 0.649 0.131
0.549 0.449 1.183 0.177 0.719 0.799 0.461 0.832 0.744 0.650 1.264
0.744 0.763 0.958 0.362 0.444 0.268 0.319 0.695 1.484 1.376 1.435
0.952 0.670 0.766 0.101 0.642 0.857 0.314 0.274 1.182 0.543 0.415
0.354 0.343
I23 0.414 0.212 0.197 1.191 0.947 0.397 1.359 1.171 0.249 0.366
0.536 0.108 0.372 0.460 0.395 0.181 0.157 0.339 0.471 0.207 0.340
0.534 0.000 0.188 0.731 0.572 0.065 0.383 0.165 1.223 0.055 1.098
0.784 0.385 0.899 0.563 0.582 0.466 0.394 0.046 0.977 0.651 0.417
0.288 0.481 0.453 0.088 0.448 0.460 0.685 1.051 0.470 0.416 0.417
0.103 0.177 0.746 0.466 0.114 0.333 1.283 0.574 0.197 0.665 0.651
0.725 0.746 0.813 0.357 0.896 0.486 0.166 0.810 0.757 0.241 0.425
0.873 0.153 1.254 0.627 0.923 0.292 0.262 0.950 0.216 0.410 1.349
0.681 0.752 0.454 0.653 0.489 0.314 0.347 0.161 1.655 1.452 1.322
1.094 0.382 0.464 0.511 0.975 0.510 0.759 0.585 1.110 0.585 0.705
0.499 0.354
I24 0.459 0.078 0.111 1.003 0.826 0.353 1.181 0.984 0.214 0.425
0.351 0.123 0.238 0.366 0.287 0.198 0.124 0.286 0.368 0.111 0.276
0.516 0.188 0.003 0.762 0.391 0.123 0.308 0.053 1.036 0.221 0.911
0.789 0.382 0.795 0.396 0.416 0.503 0.460 0.156 0.790 0.464 0.392
0.187 0.422 0.387 0.106 0.302 0.332 0.666 0.940 0.401 0.405 0.439
0.185 0.142 0.756 0.343 0.245 0.148 1.096 0.473 0.113 0.506 0.507
0.576 0.588 0.660 0.314 0.746 0.521 0.097 0.671 0.771 0.133 0.387
0.733 0.083 1.066 0.652 0.753 0.303 0.093 0.769 0.283 0.229 1.162

0.493 0.564 0.451 0.525 0.324 0.251 0.235 0.267 1.471 1.264 1.143
0.913 0.212 0.306 0.529 0.832 0.375 0.667 0.651 0.925 0.408 0.569
0.360 0.227
I25 0.317 0.691 0.860 1.416 0.696 1.103 1.749 1.383 0.953 0.365
0.858 0.673 0.993 1.128 1.047 0.901 0.846 1.038 0.524 0.865 0.508
0.276 0.731 0.762 0.000 0.836 0.732 1.068 0.711 1.488 0.683 1.307
0.115 1.109 0.590 1.092 1.112 0.266 0.341 0.761 1.268 0.970 0.384
0.601 1.180 1.145 0.763 0.650 0.596 0.199 0.712 0.437 1.138 0.323
0.831 0.622 0.080 1.098 0.840 0.848 1.565 1.233 0.649 1.208 1.236
1.291 1.285 1.361 0.462 0.809 0.246 0.833 0.706 0.071 0.893 0.399
0.748 0.685 1.428 0.112 0.949 1.018 0.721 1.078 0.947 0.920 1.503
1.018 1.033 1.180 0.605 0.719 0.527 0.590 0.890 1.691 1.615 1.706
1.187 0.935 1.032 0.233 0.824 1.120 0.482 0.185 1.451 0.816 0.650
0.627 0.615
I26 0.633 0.363 0.460 0.647 0.553 0.612 0.919 0.621 0.539 0.630
0.060 0.476 0.416 0.545 0.480 0.564 0.497 0.560 0.313 0.452 0.385
0.562 0.572 0.391 0.836 0.002 0.508 0.544 0.407 0.697 0.590 0.544
0.807 0.679 0.571 0.349 0.362 0.649 0.664 0.545 0.456 0.134 0.482
0.338 0.639 0.603 0.497 0.196 0.244 0.665 0.679 0.401 0.689 0.585
0.574 0.432 0.793 0.473 0.635 0.283 0.768 0.596 0.394 0.442 0.503
0.528 0.501 0.573 0.425 0.410 0.658 0.468 0.374 0.811 0.443 0.459
0.421 0.424 0.695 0.737 0.372 0.634 0.310 0.378 0.652 0.265 0.788
0.182 0.210 0.733 0.299 0.122 0.385 0.301 0.652 1.083 0.895 0.876
0.523 0.316 0.360 0.636 0.503 0.455 0.499 0.809 0.627 0.034 0.305
0.208 0.277
I27 0.417 0.151 0.150 1.126 0.900 0.375 1.298 1.106 0.224 0.373
0.471 0.066 0.322 0.424 0.354 0.169 0.119 0.313 0.426 0.159 0.303
0.516 0.065 0.123 0.732 0.508 0.000 0.351 0.102 1.159 0.102 1.033
0.777 0.377 0.856 0.505 0.525 0.467 0.405 0.048 0.913 0.586 0.394
0.238 0.457 0.426 0.034 0.391 0.408 0.668 1.006 0.434 0.406 0.411
0.108 0.136 0.740 0.421 0.149 0.269 1.219 0.537 0.144 0.610 0.601
0.674 0.692 0.760 0.327 0.840 0.486 0.118 0.757 0.753 0.193 0.398
0.820 0.095 1.188 0.625 0.861 0.287 0.198 0.886 0.229 0.347 1.284
0.616 0.686 0.448 0.602 0.428 0.276 0.297 0.187 1.590 1.386 1.261
1.030 0.323 0.409 0.505 0.921 0.462 0.719 0.598 1.047 0.522 0.652
0.444 0.300
I28 0.759 0.384 0.208 1.009 1.071 0.069 1.067 1.000 0.136 0.719
0.486 0.400 0.129 0.081 0.071 0.210 0.232 0.053 0.654 0.203 0.582
0.824 0.383 0.308 1.068 0.544 0.351 0.001 0.357 1.014 0.438 0.939
1.097 0.148 1.060 0.302 0.313 0.805 0.753 0.340 0.789 0.540 0.700
0.489 0.115 0.078 0.318 0.555 0.601 0.974 1.193 0.701 0.148 0.744
0.288 0.445 1.064 0.127 0.328 0.284 1.058 0.192 0.421 0.357 0.310
0.388 0.425 0.477 0.621 0.951 0.824 0.238 0.900 1.079 0.175 0.694
0.955 0.383 1.093 0.958 0.909 0.157 0.372 0.870 0.244 0.279 1.188
0.542 0.628 0.190 0.776 0.542 0.557 0.527 0.297 1.531 1.276 1.037

1.006 0.228 0.214 0.836 1.043 0.181 0.946 0.946 0.869 0.574 0.809
0.614 0.512
I29 0.407 0.051 0.153 1.033 0.808 0.397 1.225 1.012 0.253 0.372
0.373 0.078 0.291 0.417 0.339 0.224 0.152 0.331 0.340 0.156 0.235
0.470 0.165 0.053 0.711 0.407 0.102 0.357 0.000 1.069 0.186 0.938
0.741 0.420 0.771 0.445 0.465 0.451 0.407 0.144 0.822 0.491 0.345
0.153 0.470 0.435 0.101 0.292 0.314 0.622 0.918 0.364 0.445 0.388
0.192 0.090 0.708 0.396 0.245 0.191 1.132 0.526 0.066 0.557 0.560
0.628 0.639 0.711 0.269 0.741 0.469 0.130 0.660 0.722 0.182 0.343
0.722 0.030 1.092 0.601 0.759 0.337 0.097 0.785 0.303 0.274 1.187
0.524 0.591 0.490 0.508 0.326 0.209 0.207 0.275 1.490 1.291 1.186
0.930 0.262 0.357 0.479 0.823 0.427 0.639 0.598 0.964 0.420 0.556
0.347 0.206
I30 1.327 1.035 1.056 0.094 0.936 1.074 0.344 0.130 1.090 1.327
0.709 1.145 0.918 0.959 0.948 1.147 1.102 1.058 0.991 1.046 1.082
1.229 1.223 1.036 1.488 0.697 1.159 1.014 1.069 0.000 1.254 0.190
1.433 1.158 1.025 0.713 0.701 1.337 1.360 1.186 0.247 0.582 1.171
1.033 1.042 1.024 1.138 0.890 0.930 1.297 1.032 1.078 1.148 1.277
1.190 1.116 1.430 0.888 1.252 0.891 0.078 0.918 1.074 0.671 0.745
0.686 0.632 0.629 1.121 0.746 1.344 1.078 0.819 1.448 1.020 1.145
0.807 1.093 0.176 1.401 0.580 1.162 0.979 0.424 1.223 0.819 0.231
0.546 0.488 1.177 0.884 0.818 1.083 0.998 1.250 0.582 0.278 0.305
0.377 0.858 0.811 1.316 0.793 0.837 1.047 1.494 0.168 0.704 0.845
0.887 0.974
I31 0.367 0.227 0.247 1.219 0.934 0.451 1.400 1.198 0.304 0.318
0.558 0.114 0.421 0.514 0.448 0.235 0.209 0.394 0.459 0.256 0.322
0.498 0.055 0.221 0.683 0.590 0.102 0.438 0.186 1.254 0.001 1.124
0.741 0.438 0.881 0.607 0.627 0.420 0.344 0.098 1.008 0.678 0.385
0.284 0.536 0.508 0.132 0.451 0.456 0.646 1.034 0.447 0.469 0.375
0.157 0.171 0.701 0.518 0.157 0.368 1.316 0.628 0.201 0.712 0.700
0.774 0.793 0.861 0.332 0.894 0.440 0.215 0.804 0.712 0.291 0.395
0.868 0.166 1.278 0.581 0.931 0.345 0.281 0.967 0.266 0.448 1.373
0.710 0.777 0.506 0.645 0.498 0.297 0.343 0.206 1.672 1.477 1.363
1.111 0.425 0.510 0.468 0.970 0.560 0.738 0.533 1.146 0.600 0.699
0.498 0.353
I32 1.161 0.899 0.947 0.109 0.747 1.004 0.518 0.078 0.996 1.166
0.567 1.012 0.829 0.896 0.870 1.045 0.992 0.978 0.821 0.938 0.922
1.053 1.098 0.911 1.307 0.544 1.033 0.939 0.938 0.190 1.124 0.002
1.248 1.087 0.836 0.639 0.632 1.168 1.197 1.064 0.161 0.447 1.003
0.883 0.987 0.963 1.016 0.730 0.764 1.113 0.846 0.906 1.082 1.110
1.078 0.975 1.247 0.821 1.141 0.772 0.268 0.878 0.934 0.629 0.710
0.667 0.612 0.632 0.958 0.557 1.174 0.965 0.630 1.265 0.916 0.977
0.618 0.959 0.157 1.223 0.390 1.077 0.843 0.235 1.127 0.710 0.253
0.421 0.347 1.117 0.702 0.660 0.926 0.843 1.145 0.593 0.354 0.476
0.202 0.755 0.727 1.143 0.605 0.774 0.859 1.321 0.253 0.545 0.660
0.719 0.819

I33 0.377 0.714 0.893 1.357 0.600 1.138 1.708 1.323 0.990 0.429
0.836 0.714 1.012 1.151 1.070 0.945 0.884 1.072 0.504 0.897 0.520
0.275 0.784 0.789 0.115 0.807 0.777 1.097 0.741 1.433 0.741 1.248
0.007 1.152 0.493 1.090 1.109 0.323 0.412 0.809 1.222 0.941 0.398
0.614 1.211 1.175 0.805 0.633 0.576 0.144 0.606 0.424 1.180 0.367
0.880 0.656 0.044 1.115 0.896 0.858 1.510 1.252 0.677 1.204 1.239
1.289 1.278 1.354 0.477 0.729 0.304 0.868 0.631 0.045 0.922 0.406
0.666 0.718 1.361 0.167 0.878 1.063 0.736 1.015 1.000 0.923 1.433
0.989 0.995 1.223 0.550 0.698 0.542 0.593 0.945 1.604 1.544 1.664
1.115 0.944 1.039 0.274 0.735 1.131 0.400 0.288 1.407 0.784 0.588
0.601 0.615
I34 0.793 0.459 0.271 1.155 1.188 0.084 1.194 1.147 0.168 0.748
0.622 0.439 0.270 0.201 0.218 0.209 0.270 0.119 0.748 0.271 0.655
0.887 0.385 0.382 1.109 0.679 0.377 0.148 0.420 1.158 0.438 1.087
1.152 0.001 1.169 0.449 0.458 0.844 0.778 0.350 0.935 0.685 0.762
0.568 0.144 0.143 0.348 0.665 0.704 1.039 1.307 0.782 0.032 0.788
0.282 0.499 1.116 0.269 0.293 0.405 1.199 0.281 0.485 0.493 0.434
0.510 0.554 0.596 0.688 1.081 0.863 0.289 1.022 1.129 0.259 0.762
1.080 0.439 1.240 1.003 1.048 0.092 0.464 1.015 0.182 0.417 1.335
0.689 0.774 0.071 0.889 0.663 0.628 0.615 0.247 1.679 1.422 1.166
1.152 0.365 0.362 0.882 1.172 0.321 1.046 0.969 1.010 0.708 0.927
0.724 0.605
I35 0.641 0.723 0.903 0.939 0.116 1.121 1.338 0.902 1.004 0.680
0.625 0.794 0.940 1.083 1.007 0.993 0.918 1.058 0.431 0.900 0.559
0.457 0.899 0.795 0.590 0.571 0.856 1.060 0.771 1.025 0.881 0.836
0.493 1.169 0.046 0.918 0.932 0.609 0.691 0.900 0.856 0.673 0.518
0.620 1.169 1.131 0.869 0.505 0.465 0.403 0.155 0.434 1.187 0.591
0.960 0.723 0.512 1.020 1.005 0.776 1.103 1.153 0.714 1.012 1.074
1.097 1.067 1.135 0.551 0.282 0.600 0.892 0.223 0.526 0.909 0.499
0.221 0.765 0.921 0.556 0.446 1.097 0.707 0.603 1.074 0.802 0.981
0.715 0.681 1.234 0.286 0.523 0.585 0.564 1.043 1.118 1.088 1.294
0.670 0.845 0.914 0.552 0.257 1.013 0.148 0.697 1.040 0.538 0.267
0.447 0.568
I36 0.823 0.435 0.372 0.707 0.900 0.366 0.799 0.698 0.383 0.799
0.293 0.519 0.210 0.258 0.235 0.447 0.417 0.345 0.590 0.361 0.586
0.820 0.563 0.396 1.092 0.349 0.505 0.302 0.445 0.713 0.607 0.639
1.090 0.449 0.918 0.000 0.021 0.857 0.835 0.519 0.487 0.282 0.710
0.498 0.351 0.325 0.476 0.463 0.520 0.951 1.027 0.666 0.443 0.789
0.503 0.523 1.067 0.181 0.562 0.259 0.760 0.265 0.483 0.117 0.157
0.199 0.197 0.272 0.633 0.745 0.872 0.400 0.721 1.084 0.329 0.694
0.765 0.475 0.792 0.984 0.664 0.449 0.388 0.595 0.516 0.177 0.887
0.267 0.350 0.478 0.640 0.412 0.571 0.502 0.550 1.232 0.974 0.764
0.722 0.184 0.103 0.866 0.838 0.137 0.836 1.016 0.574 0.382 0.652
0.508 0.478
I37 0.843 0.456 0.390 0.697 0.912 0.375 0.781 0.690 0.398 0.820
0.307 0.539 0.226 0.264 0.247 0.463 0.436 0.357 0.609 0.380 0.606

0.840 0.582 0.416 1.112 0.362 0.525 0.313 0.465 0.701 0.627 0.632
1.109 0.458 0.932 0.021 0.001 0.877 0.856 0.539 0.478 0.289 0.730
0.518 0.356 0.331 0.495 0.481 0.538 0.970 1.039 0.685 0.451 0.810
0.521 0.544 1.086 0.189 0.579 0.280 0.746 0.262 0.503 0.096 0.142
0.180 0.176 0.251 0.653 0.754 0.892 0.419 0.733 1.103 0.347 0.713
0.776 0.495 0.784 1.004 0.670 0.462 0.408 0.595 0.531 0.198 0.878
0.270 0.351 0.485 0.655 0.429 0.591 0.522 0.566 1.225 0.964 0.746
0.720 0.204 0.120 0.886 0.847 0.142 0.852 1.037 0.560 0.395 0.666
0.526 0.498
I38 0.053 0.436 0.598 1.276 0.697 0.839 1.566 1.246 0.688 0.105
0.656 0.408 0.738 0.868 0.789 0.635 0.581 0.774 0.347 0.603 0.276
0.152 0.466 0.503 0.266 0.649 0.467 0.805 0.451 1.337 0.420 1.168
0.323 0.844 0.609 0.857 0.877 0.001 0.094 0.495 1.102 0.780 0.167
0.359 0.917 0.883 0.497 0.453 0.408 0.256 0.758 0.263 0.873 0.068
0.565 0.361 0.282 0.844 0.577 0.603 1.411 0.976 0.392 0.973 0.993
1.053 1.053 1.128 0.230 0.747 0.020 0.569 0.640 0.293 0.632 0.192
0.696 0.423 1.305 0.162 0.854 0.752 0.473 0.955 0.683 0.680 1.389
0.826 0.858 0.914 0.497 0.527 0.287 0.364 0.626 1.623 1.501 1.524
1.082 0.689 0.787 0.063 0.792 0.870 0.466 0.162 1.275 0.637 0.554
0.451 0.391
I39 0.050 0.402 0.545 1.303 0.775 0.780 1.572 1.275 0.628 0.036
0.663 0.352 0.698 0.820 0.743 0.570 0.523 0.717 0.382 0.551 0.279
0.235 0.394 0.460 0.341 0.664 0.405 0.753 0.407 1.360 0.344 1.197
0.412 0.778 0.691 0.835 0.856 0.094 0.000 0.428 1.119 0.789 0.203
0.345 0.861 0.829 0.437 0.469 0.433 0.350 0.842 0.309 0.808 0.102
0.496 0.319 0.369 0.803 0.500 0.577 1.431 0.931 0.356 0.951 0.963
1.027 1.032 1.106 0.239 0.808 0.111 0.515 0.703 0.378 0.583 0.230
0.761 0.378 1.339 0.246 0.903 0.685 0.447 0.993 0.610 0.658 1.426
0.834 0.874 0.847 0.552 0.542 0.282 0.366 0.550 1.674 1.537 1.530
1.125 0.659 0.757 0.155 0.860 0.834 0.545 0.194 1.287 0.656 0.610
0.479 0.392
I40 0.444 0.194 0.152 1.156 0.943 0.356 1.316 1.137 0.207 0.398
0.506 0.108 0.327 0.416 0.350 0.142 0.111 0.297 0.469 0.162 0.345
0.553 0.046 0.156 0.761 0.545 0.048 0.340 0.144 1.186 0.098 1.064
0.809 0.350 0.900 0.519 0.539 0.495 0.428 0.020 0.941 0.618 0.432
0.282 0.440 0.411 0.052 0.434 0.451 0.705 1.050 0.476 0.380 0.443
0.072 0.179 0.772 0.421 0.108 0.295 1.245 0.529 0.188 0.621 0.605
0.680 0.701 0.768 0.367 0.882 0.515 0.121 0.800 0.784 0.196 0.438
0.863 0.140 1.220 0.656 0.902 0.258 0.238 0.923 0.192 0.370 1.316
0.646 0.718 0.420 0.646 0.469 0.319 0.341 0.147 1.626 1.418 1.280
1.067 0.340 0.420 0.537 0.964 0.465 0.762 0.620 1.070 0.560 0.696
0.487 0.344
I41 1.088 0.788 0.814 0.221 0.783 0.852 0.489 0.212 0.854 1.086
0.463 0.899 0.684 0.741 0.721 0.908 0.860 0.829 0.758 0.804 0.841
1.002 0.977 0.790 1.268 0.456 0.913 0.789 0.822 0.247 1.008 0.161
1.222 0.935 0.856 0.487 0.478 1.102 1.119 0.941 0.000 0.336 0.935

0.788 0.831 0.808 0.892 0.651 0.694 1.082 0.894 0.846 0.929 1.039
0.947 0.870 1.215 0.667 1.010 0.646 0.313 0.718 0.828 0.469 0.549
0.506 0.451 0.473 0.881 0.587 1.110 0.835 0.638 1.233 0.780 0.910
0.641 0.846 0.307 1.176 0.428 0.931 0.732 0.272 0.987 0.576 0.401
0.299 0.245 0.962 0.672 0.578 0.840 0.756 1.009 0.751 0.489 0.444
0.318 0.617 0.579 1.084 0.655 0.618 0.852 1.260 0.187 0.465 0.641
0.653 0.731
I42 0.761 0.455 0.507 0.541 0.638 0.609 0.786 0.520 0.568 0.755
0.128 0.566 0.415 0.520 0.470 0.608 0.550 0.567 0.447 0.498 0.511
0.696 0.651 0.464 0.970 0.134 0.586 0.540 0.491 0.582 0.678 0.447
0.941 0.685 0.673 0.282 0.289 0.780 0.789 0.618 0.336 0.000 0.614
0.453 0.617 0.585 0.569 0.327 0.377 0.798 0.764 0.535 0.688 0.715
0.634 0.534 0.927 0.443 0.697 0.328 0.649 0.547 0.493 0.350 0.423
0.431 0.396 0.462 0.553 0.469 0.789 0.522 0.461 0.945 0.479 0.591
0.496 0.514 0.603 0.871 0.382 0.656 0.398 0.331 0.693 0.276 0.698
0.048 0.100 0.729 0.419 0.254 0.508 0.424 0.704 1.016 0.800 0.744
0.470 0.326 0.331 0.769 0.561 0.411 0.618 0.941 0.498 0.157 0.413
0.343 0.398
I43 0.161 0.316 0.498 1.110 0.590 0.743 1.400 1.081 0.597 0.180
0.492 0.329 0.615 0.754 0.672 0.558 0.493 0.676 0.182 0.501 0.125
0.125 0.417 0.392 0.384 0.482 0.394 0.700 0.345 1.171 0.385 1.003
0.398 0.762 0.518 0.710 0.730 0.167 0.203 0.432 0.935 0.614 0.000
0.218 0.814 0.778 0.418 0.287 0.241 0.277 0.672 0.105 0.789 0.107
0.502 0.264 0.367 0.719 0.530 0.465 1.244 0.855 0.280 0.826 0.853
0.908 0.904 0.979 0.080 0.607 0.176 0.475 0.503 0.383 0.525 0.027
0.563 0.324 1.141 0.275 0.700 0.676 0.340 0.793 0.623 0.536 1.227
0.660 0.691 0.833 0.349 0.360 0.145 0.208 0.576 1.471 1.338 1.358
0.923 0.552 0.649 0.159 0.663 0.738 0.371 0.327 1.109 0.470 0.407
0.284 0.233
I44 0.327 0.109 0.298 0.985 0.661 0.538 1.228 0.960 0.400 0.310
0.326 0.180 0.398 0.538 0.457 0.377 0.304 0.471 0.188 0.298 0.095
0.339 0.288 0.187 0.601 0.338 0.238 0.489 0.153 1.033 0.284 0.883
0.614 0.568 0.620 0.498 0.518 0.359 0.345 0.282 0.788 0.453 0.218
0.000 0.604 0.567 0.249 0.170 0.172 0.486 0.768 0.214 0.592 0.292
0.341 0.113 0.585 0.501 0.387 0.247 1.102 0.638 0.095 0.614 0.637
0.695 0.694 0.769 0.139 0.610 0.374 0.280 0.522 0.601 0.317 0.208
0.585 0.145 1.032 0.491 0.651 0.488 0.122 0.703 0.455 0.322 1.124
0.495 0.545 0.638 0.365 0.228 0.074 0.059 0.424 1.406 1.232 1.187
0.845 0.334 0.432 0.371 0.688 0.520 0.486 0.519 0.949 0.340 0.417
0.213 0.070
I45 0.869 0.499 0.320 1.047 1.175 0.086 1.058 1.042 0.234 0.828
0.579 0.510 0.229 0.096 0.163 0.301 0.338 0.144 0.767 0.315 0.697
0.939 0.481 0.422 1.180 0.639 0.457 0.115 0.470 1.042 0.536 0.987
1.211 0.144 1.169 0.351 0.356 0.917 0.861 0.440 0.831 0.617 0.814
0.604 0.000 0.038 0.424 0.666 0.713 1.088 1.298 0.816 0.119 0.857
0.381 0.558 1.178 0.174 0.409 0.393 1.079 0.139 0.535 0.371 0.303

0.375 0.423 0.458 0.736 1.048 0.936 0.347 1.002 1.192 0.289 0.809
1.055 0.495 1.137 1.071 0.994 0.210 0.486 0.942 0.308 0.375 1.231
0.611 0.696 0.137 0.884 0.648 0.672 0.641 0.370 1.580 1.312 1.031
1.072 0.327 0.286 0.948 1.141 0.215 1.057 1.055 0.889 0.670 0.914
0.724 0.626
I46 0.836 0.462 0.285 1.026 1.138 0.068 1.052 1.020 0.204 0.796
0.544 0.477 0.192 0.067 0.127 0.275 0.307 0.114 0.729 0.280 0.660
0.902 0.453 0.387 1.145 0.603 0.426 0.078 0.435 1.024 0.508 0.963
1.175 0.143 1.131 0.325 0.331 0.883 0.829 0.411 0.808 0.585 0.778
0.567 0.038 0.001 0.392 0.628 0.675 1.052 1.261 0.778 0.126 0.822
0.354 0.523 1.143 0.144 0.387 0.356 1.063 0.141 0.499 0.355 0.292
0.367 0.412 0.453 0.700 1.012 0.902 0.314 0.965 1.157 0.253 0.773
1.019 0.461 1.115 1.036 0.961 0.194 0.449 0.911 0.290 0.339 1.209
0.581 0.667 0.154 0.847 0.611 0.635 0.604 0.350 1.556 1.292 1.023
1.043 0.291 0.254 0.914 1.105 0.190 1.020 1.022 0.873 0.634 0.877
0.686 0.588
I47 0.448 0.152 0.116 1.107 0.908 0.343 1.271 1.088 0.191 0.405
0.457 0.091 0.289 0.390 0.320 0.140 0.086 0.280 0.437 0.125 0.321
0.542 0.088 0.106 0.763 0.497 0.034 0.318 0.101 1.138 0.132 1.016
0.805 0.348 0.869 0.476 0.495 0.497 0.437 0.052 0.892 0.569 0.418
0.249 0.424 0.392 0.000 0.393 0.414 0.694 1.017 0.452 0.376 0.441
0.092 0.156 0.768 0.388 0.144 0.247 1.197 0.503 0.155 0.580 0.568
0.642 0.661 0.729 0.348 0.841 0.517 0.084 0.761 0.781 0.160 0.420
0.823 0.104 1.172 0.655 0.856 0.258 0.191 0.875 0.208 0.322 1.267
0.597 0.670 0.419 0.609 0.424 0.294 0.306 0.175 1.578 1.369 1.235
1.019 0.295 0.378 0.535 0.924 0.429 0.734 0.631 1.023 0.513 0.657
0.448 0.306
I48 0.438 0.241 0.403 0.835 0.526 0.616 1.114 0.808 0.502 0.437
0.208 0.342 0.439 0.583 0.505 0.500 0.425 0.553 0.129 0.400 0.192
0.374 0.448 0.302 0.650 0.196 0.391 0.555 0.292 0.890 0.451 0.730
0.633 0.665 0.505 0.463 0.481 0.453 0.469 0.434 0.651 0.327 0.287
0.170 0.666 0.628 0.393 0.000 0.057 0.492 0.643 0.213 0.682 0.389
0.482 0.281 0.614 0.527 0.537 0.273 0.962 0.664 0.252 0.575 0.618
0.661 0.646 0.722 0.230 0.449 0.462 0.397 0.369 0.632 0.405 0.263
0.431 0.297 0.875 0.547 0.482 0.597 0.210 0.538 0.586 0.312 0.965
0.374 0.406 0.729 0.225 0.074 0.197 0.117 0.566 1.238 1.075 1.071
0.678 0.348 0.430 0.442 0.531 0.529 0.393 0.614 0.823 0.187 0.267
0.059 0.100
I49 0.397 0.264 0.438 0.871 0.495 0.660 1.162 0.843 0.539 0.402
0.262 0.352 0.488 0.633 0.554 0.530 0.456 0.595 0.072 0.435 0.165
0.320 0.460 0.332 0.596 0.244 0.408 0.601 0.314 0.930 0.456 0.764
0.576 0.704 0.465 0.520 0.538 0.408 0.433 0.451 0.694 0.377 0.241
0.172 0.713 0.675 0.414 0.057 0.001 0.435 0.608 0.159 0.723 0.347
0.505 0.286 0.558 0.579 0.556 0.322 1.003 0.717 0.264 0.632 0.674
0.718 0.704 0.779 0.195 0.438 0.416 0.428 0.350 0.576 0.445 0.216
0.413 0.313 0.906 0.494 0.491 0.633 0.242 0.563 0.614 0.367 0.994

0.425 0.450 0.770 0.195 0.124 0.177 0.113 0.589 1.256 1.105 1.120
0.699 0.400 0.485 0.392 0.515 0.583 0.345 0.567 0.869 0.229 0.245
0.047 0.108
I50 0.305 0.590 0.774 1.222 0.506 1.019 1.567 1.189 0.874 0.356
0.694 0.604 0.882 1.024 0.942 0.834 0.769 0.952 0.363 0.777 0.392
0.153 0.685 0.666 0.199 0.665 0.668 0.974 0.622 1.297 0.646 1.113
0.144 1.039 0.403 0.951 0.970 0.256 0.350 0.705 1.082 0.798 0.277
0.486 1.088 1.052 0.694 0.492 0.435 0.015 0.538 0.286 1.065 0.276
0.775 0.540 0.134 0.984 0.799 0.724 1.374 1.122 0.556 1.065 1.102
1.150 1.138 1.213 0.353 0.610 0.240 0.751 0.508 0.153 0.800 0.280
0.550 0.601 1.231 0.159 0.751 0.952 0.607 0.883 0.896 0.787 1.306
0.846 0.853 1.110 0.413 0.555 0.417 0.459 0.846 1.493 1.417 1.523
0.989 0.810 0.904 0.196 0.629 0.998 0.285 0.299 1.266 0.641 0.454
0.459 0.480
I51 0.792 0.869 1.045 0.941 0.127 1.256 1.361 0.905 1.145 0.833
0.737 0.945 1.069 1.210 1.136 1.138 1.063 1.194 0.581 1.042 0.712
0.608 1.051 0.940 0.712 0.679 1.006 1.193 0.918 1.032 1.034 0.846
0.606 1.307 0.155 1.027 1.039 0.758 0.842 1.050 0.894 0.764 0.672
0.768 1.298 1.261 1.017 0.643 0.608 0.538 0.000 0.588 1.324 0.744
1.109 0.874 0.632 1.144 1.155 0.908 1.109 1.273 0.863 1.112 1.180
1.195 1.160 1.224 0.705 0.312 0.748 1.036 0.306 0.644 1.048 0.653
0.269 0.913 0.907 0.692 0.467 1.239 0.849 0.626 1.221 0.926 0.953
0.801 0.753 1.371 0.418 0.651 0.737 0.711 1.192 1.042 1.055 1.318
0.660 0.972 1.034 0.700 0.242 1.131 0.302 0.836 1.072 0.646 0.385
0.584 0.714
I52 0.265 0.323 0.512 1.014 0.497 0.751 1.319 0.984 0.614 0.285
0.421 0.369 0.602 0.746 0.664 0.587 0.516 0.685 0.089 0.512 0.131
0.161 0.470 0.401 0.437 0.401 0.434 0.701 0.364 1.078 0.447 0.906
0.424 0.782 0.434 0.666 0.685 0.263 0.309 0.476 0.846 0.535 0.105
0.214 0.816 0.778 0.452 0.213 0.159 0.286 0.588 0.001 0.806 0.210
0.542 0.298 0.402 0.701 0.580 0.441 1.152 0.840 0.300 0.780 0.816
0.865 0.855 0.930 0.116 0.503 0.268 0.493 0.399 0.420 0.531 0.079
0.460 0.350 1.042 0.336 0.595 0.701 0.329 0.692 0.660 0.501 1.126
0.583 0.605 0.852 0.244 0.283 0.158 0.176 0.621 1.366 1.238 1.276
0.820 0.526 0.619 0.238 0.561 0.713 0.290 0.416 1.024 0.384 0.302
0.195 0.195
I53 0.823 0.483 0.294 1.148 1.204 0.079 1.176 1.140 0.192 0.778
0.631 0.467 0.275 0.189 0.218 0.238 0.296 0.131 0.769 0.294 0.679
0.913 0.416 0.405 1.138 0.689 0.406 0.148 0.445 1.148 0.469 1.082
1.180 0.032 1.187 0.443 0.451 0.873 0.808 0.380 0.929 0.688 0.789
0.592 0.119 0.126 0.376 0.682 0.723 1.065 1.324 0.806 0.001 0.817
0.313 0.526 1.144 0.262 0.325 0.419 1.188 0.258 0.510 0.480 0.418
0.492 0.537 0.576 0.714 1.093 0.892 0.315 1.036 1.158 0.279 0.788
1.093 0.465 1.235 1.031 1.055 0.124 0.484 1.018 0.214 0.424 1.329
0.689 0.775 0.047 0.906 0.677 0.653 0.637 0.280 1.675 1.414 1.148

1.153 0.373 0.360 0.911 1.184 0.311 1.066 1.000 0.998 0.717 0.942
0.741 0.626
I54 0.055 0.371 0.537 1.217 0.673 0.780 1.501 1.188 0.630 0.089
0.591 0.350 0.674 0.805 0.726 0.580 0.523 0.714 0.289 0.542 0.208
0.141 0.417 0.439 0.323 0.585 0.411 0.744 0.388 1.277 0.375 1.110
0.367 0.788 0.591 0.789 0.810 0.068 0.102 0.443 1.039 0.715 0.107
0.292 0.857 0.822 0.441 0.389 0.347 0.276 0.744 0.210 0.817 0.001
0.514 0.299 0.329 0.779 0.530 0.536 1.349 0.912 0.328 0.906 0.926
0.986 0.986 1.061 0.163 0.707 0.083 0.510 0.601 0.341 0.570 0.134
0.659 0.362 1.248 0.215 0.805 0.698 0.407 0.901 0.633 0.613 1.334
0.761 0.795 0.859 0.452 0.463 0.220 0.297 0.579 1.576 1.446 1.459
1.030 0.622 0.721 0.096 0.757 0.804 0.445 0.229 1.211 0.574 0.509
0.391 0.324
I55 0.514 0.242 0.134 1.165 1.000 0.296 1.302 1.148 0.153 0.467
0.529 0.174 0.299 0.368 0.310 0.080 0.088 0.241 0.529 0.144 0.410
0.623 0.103 0.185 0.831 0.574 0.108 0.288 0.192 1.190 0.157 1.078
0.880 0.282 0.960 0.503 0.521 0.565 0.496 0.072 0.947 0.634 0.502
0.341 0.381 0.354 0.092 0.482 0.505 0.775 1.109 0.542 0.313 0.514
0.001 0.244 0.842 0.384 0.063 0.306 1.246 0.481 0.247 0.597 0.573
0.649 0.675 0.738 0.435 0.930 0.585 0.112 0.851 0.855 0.174 0.506
0.913 0.196 1.234 0.726 0.938 0.189 0.277 0.949 0.121 0.371 1.330
0.657 0.734 0.351 0.700 0.509 0.383 0.398 0.084 1.648 1.429 1.267
1.093 0.333 0.401 0.608 1.014 0.432 0.825 0.688 1.067 0.592 0.748
0.538 0.397
I56 0.317 0.089 0.239 1.074 0.770 0.483 1.290 1.051 0.335 0.283
0.409 0.072 0.380 0.507 0.429 0.295 0.229 0.417 0.294 0.243 0.167
0.388 0.177 0.142 0.622 0.432 0.136 0.445 0.090 1.116 0.171 0.975
0.656 0.499 0.723 0.523 0.544 0.361 0.319 0.179 0.870 0.534 0.264
0.113 0.558 0.523 0.156 0.281 0.286 0.540 0.874 0.298 0.526 0.299
0.244 0.003 0.621 0.485 0.283 0.265 1.182 0.615 0.043 0.637 0.645
0.711 0.719 0.792 0.192 0.723 0.380 0.213 0.635 0.635 0.271 0.265
0.698 0.063 1.127 0.513 0.762 0.412 0.143 0.806 0.363 0.348 1.220
0.571 0.631 0.570 0.477 0.332 0.140 0.172 0.323 1.510 1.327 1.250
0.948 0.343 0.441 0.391 0.801 0.515 0.584 0.509 1.020 0.439 0.529
0.327 0.182
I57 0.336 0.682 0.859 1.356 0.618 1.104 1.699 1.322 0.955 0.387
0.819 0.678 0.982 1.120 1.039 0.908 0.849 1.038 0.485 0.863 0.491
0.248 0.746 0.756 0.080 0.793 0.740 1.064 0.708 1.430 0.701 1.247
0.044 1.116 0.512 1.067 1.086 0.282 0.369 0.772 1.215 0.927 0.367
0.585 1.178 1.143 0.768 0.614 0.558 0.134 0.632 0.402 1.144 0.329
0.842 0.621 0.000 1.086 0.857 0.830 1.508 1.222 0.644 1.182 1.214
1.266 1.257 1.332 0.447 0.738 0.262 0.834 0.637 0.018 0.889 0.378
0.676 0.683 1.364 0.124 0.882 1.026 0.707 1.016 0.961 0.898 1.437
0.975 0.984 1.187 0.546 0.680 0.512 0.567 0.906 1.617 1.549 1.656
1.120 0.917 1.013 0.236 0.749 1.104 0.409 0.245 1.399 0.771 0.588
0.585 0.590

I58 0.802 0.408 0.271 0.886 1.019 0.186 0.942 0.879 0.239 0.768
0.413 0.456 0.106 0.078 0.075 0.313 0.310 0.177 0.640 0.263 0.595
0.840 0.466 0.343 1.098 0.473 0.421 0.127 0.396 0.888 0.518 0.821
1.115 0.269 1.020 0.181 0.189 0.844 0.803 0.421 0.667 0.443 0.719
0.501 0.174 0.144 0.388 0.527 0.579 0.984 1.144 0.701 0.262 0.779
0.384 0.485 1.086 0.000 0.433 0.261 0.931 0.139 0.452 0.230 0.190
0.268 0.301 0.358 0.639 0.882 0.861 0.304 0.842 1.102 0.228 0.709
0.893 0.426 0.973 0.988 0.822 0.283 0.379 0.768 0.363 0.219 1.068
0.437 0.523 0.296 0.736 0.498 0.574 0.526 0.410 1.414 1.153 0.911
0.899 0.179 0.114 0.866 0.975 0.055 0.919 0.994 0.742 0.505 0.760
0.582 0.506
I59 0.524 0.295 0.196 1.228 1.048 0.323 1.360 1.211 0.195 0.474
0.592 0.211 0.355 0.409 0.359 0.121 0.150 0.277 0.575 0.206 0.449
0.648 0.114 0.245 0.840 0.635 0.149 0.328 0.245 1.252 0.157 1.141
0.896 0.293 1.005 0.562 0.579 0.577 0.500 0.108 1.010 0.697 0.530
0.387 0.409 0.387 0.144 0.537 0.556 0.799 1.155 0.580 0.325 0.530
0.063 0.283 0.857 0.433 0.002 0.369 1.307 0.520 0.293 0.652 0.623
0.701 0.729 0.790 0.469 0.985 0.597 0.175 0.904 0.868 0.234 0.537
0.967 0.243 1.297 0.738 0.998 0.204 0.334 1.011 0.113 0.433 1.393
0.720 0.797 0.358 0.751 0.567 0.422 0.446 0.050 1.711 1.492 1.325
1.155 0.395 0.459 0.623 1.068 0.483 0.867 0.688 1.128 0.653 0.800
0.591 0.448
I60 0.567 0.176 0.180 0.862 0.787 0.348 1.035 0.844 0.257 0.541
0.231 0.267 0.166 0.312 0.233 0.284 0.222 0.288 0.380 0.172 0.340
0.583 0.333 0.148 0.848 0.283 0.269 0.284 0.191 0.891 0.368 0.772
0.858 0.405 0.776 0.259 0.280 0.603 0.577 0.295 0.646 0.328 0.465
0.247 0.393 0.356 0.247 0.273 0.322 0.724 0.908 0.441 0.419 0.536
0.306 0.265 0.830 0.261 0.369 0.004 0.950 0.400 0.224 0.374 0.390
0.451 0.456 0.530 0.386 0.676 0.619 0.194 0.618 0.847 0.160 0.453
0.675 0.219 0.929 0.738 0.655 0.352 0.130 0.648 0.371 0.084 1.025
0.352 0.428 0.465 0.492 0.259 0.321 0.266 0.377 1.343 1.125 0.996
0.791 0.087 0.185 0.618 0.767 0.274 0.665 0.760 0.778 0.308 0.525
0.330 0.245
I61 1.399 1.099 1.112 0.168 1.014 1.115 0.281 0.204 1.141 1.398
0.776 1.208 0.967 0.999 0.994 1.200 1.158 1.103 1.065 1.102 1.153
1.305 1.283 1.096 1.565 0.768 1.219 1.058 1.132 0.078 1.316 0.268
1.510 1.199 1.103 0.760 0.746 1.411 1.431 1.245 0.313 0.649 1.244
1.102 1.079 1.063 1.197 0.962 1.003 1.374 1.109 1.152 1.188 1.349
1.246 1.182 1.508 0.931 1.307 0.950 0.000 0.951 1.140 0.708 0.778
0.714 0.661 0.650 1.193 0.824 1.418 1.135 0.898 1.526 1.074 1.219
0.885 1.156 0.231 1.477 0.658 1.208 1.043 0.503 1.274 0.876 0.259
0.610 0.558 1.215 0.961 0.889 1.153 1.068 1.303 0.590 0.275 0.246
0.451 0.913 0.860 1.390 0.870 0.879 1.125 1.568 0.190 0.776 0.923
0.960 1.044
I62 0.932 0.542 0.388 0.930 1.147 0.209 0.920 0.928 0.328 0.896
0.537 0.580 0.240 0.114 0.188 0.402 0.420 0.243 0.779 0.381 0.732

0.977 0.574 0.473 1.233 0.596 0.537 0.192 0.526 0.918 0.628 0.878
1.252 0.281 1.153 0.265 0.262 0.976 0.931 0.529 0.718 0.547 0.855
0.638 0.139 0.141 0.503 0.664 0.717 1.122 1.273 0.840 0.258 0.912
0.481 0.615 1.222 0.139 0.520 0.400 0.951 0.001 0.584 0.250 0.173
0.240 0.290 0.320 0.775 1.003 0.994 0.420 0.969 1.238 0.348 0.846
1.018 0.554 1.024 1.123 0.929 0.334 0.516 0.858 0.429 0.353 1.115
0.532 0.614 0.273 0.869 0.632 0.710 0.664 0.486 1.469 1.192 0.894
0.980 0.317 0.239 1.000 1.096 0.142 1.055 1.123 0.761 0.629 0.891
0.718 0.645
I63 0.350 0.047 0.218 1.033 0.755 0.463 1.247 1.010 0.318 0.320
0.368 0.089 0.346 0.478 0.399 0.287 0.217 0.396 0.283 0.221 0.170
0.405 0.197 0.113 0.649 0.394 0.144 0.421 0.066 1.074 0.201 0.934
0.677 0.485 0.714 0.483 0.503 0.392 0.356 0.188 0.828 0.493 0.280
0.095 0.535 0.499 0.155 0.252 0.264 0.556 0.863 0.300 0.510 0.328
0.247 0.043 0.644 0.452 0.293 0.224 1.140 0.584 0.001 0.597 0.607
0.672 0.679 0.753 0.204 0.699 0.410 0.196 0.614 0.658 0.245 0.277
0.677 0.051 1.087 0.539 0.730 0.401 0.100 0.769 0.363 0.306 1.181
0.529 0.590 0.556 0.458 0.298 0.143 0.153 0.329 1.474 1.287 1.207
0.912 0.304 0.402 0.417 0.779 0.479 0.579 0.544 0.978 0.402 0.509
0.302 0.157
I64 0.939 0.550 0.470 0.680 0.985 0.410 0.713 0.678 0.463 0.915
0.392 0.629 0.297 0.292 0.301 0.533 0.514 0.407 0.703 0.459 0.703
0.935 0.665 0.506 1.208 0.442 0.610 0.357 0.557 0.671 0.712 0.629
1.204 0.493 1.012 0.117 0.096 0.973 0.951 0.621 0.469 0.350 0.826
0.614 0.371 0.355 0.580 0.575 0.632 1.065 1.112 0.780 0.480 0.906
0.597 0.637 1.182 0.230 0.652 0.374 0.708 0.250 0.597 0.001 0.083
0.087 0.082 0.156 0.749 0.819 0.988 0.500 0.807 1.199 0.426 0.810
0.846 0.587 0.774 1.100 0.720 0.513 0.504 0.628 0.592 0.294 0.865
0.321 0.393 0.507 0.740 0.520 0.687 0.618 0.634 1.219 0.943 0.681
0.741 0.295 0.202 0.983 0.910 0.177 0.938 1.133 0.518 0.475 0.747
0.617 0.594
I65 0.955 0.561 0.454 0.758 1.053 0.353 0.761 0.757 0.429 0.927
0.449 0.628 0.279 0.235 0.265 0.502 0.495 0.362 0.743 0.444 0.728
0.967 0.651 0.507 1.236 0.503 0.601 0.310 0.560 0.745 0.700 0.710
1.239 0.434 1.074 0.157 0.142 0.993 0.963 0.605 0.549 0.423 0.853
0.637 0.303 0.292 0.568 0.618 0.674 1.102 1.180 0.816 0.418 0.926
0.573 0.645 1.214 0.190 0.623 0.390 0.778 0.173 0.607 0.083 0.000
0.078 0.120 0.168 0.774 0.892 1.009 0.485 0.874 1.231 0.409 0.839
0.915 0.590 0.853 1.127 0.798 0.467 0.520 0.710 0.552 0.317 0.944
0.397 0.472 0.440 0.797 0.569 0.710 0.648 0.600 1.298 1.019 0.731
0.824 0.305 0.206 1.007 0.983 0.142 0.993 1.149 0.588 0.537 0.808
0.664 0.624
I66 1.018 0.625 0.528 0.706 1.068 0.430 0.685 0.708 0.507 0.991
0.478 0.698 0.353 0.312 0.342 0.580 0.570 0.440 0.788 0.518 0.784
1.019 0.725 0.576 1.291 0.528 0.674 0.388 0.628 0.686 0.774 0.667
1.289 0.510 1.097 0.199 0.180 1.053 1.027 0.680 0.506 0.431 0.908

0.695 0.375 0.367 0.642 0.661 0.718 1.150 1.195 0.865 0.492 0.986
0.649 0.711 1.266 0.268 0.701 0.451 0.714 0.240 0.672 0.087 0.078
0.000 0.055 0.090 0.831 0.899 1.069 0.559 0.890 1.283 0.484 0.893
0.927 0.658 0.804 1.182 0.793 0.544 0.581 0.691 0.630 0.373 0.893
0.398 0.464 0.511 0.826 0.606 0.768 0.701 0.678 1.250 0.962 0.656
0.796 0.368 0.271 1.064 0.989 0.218 1.024 1.211 0.525 0.560 0.832
0.703 0.677
I67 1.020 0.632 0.550 0.651 1.033 0.472 0.643 0.653 0.538 0.996
0.455 0.711 0.376 0.354 0.374 0.609 0.594 0.477 0.775 0.540 0.781
1.011 0.746 0.588 1.285 0.501 0.692 0.425 0.639 0.632 0.793 0.612
1.278 0.554 1.067 0.197 0.176 1.053 1.032 0.701 0.451 0.396 0.904
0.694 0.423 0.412 0.661 0.646 0.704 1.138 1.160 0.855 0.537 0.986
0.675 0.719 1.257 0.301 0.729 0.456 0.661 0.290 0.679 0.082 0.120
0.055 0.001 0.076 0.828 0.860 1.068 0.580 0.857 1.274 0.506 0.887
0.891 0.669 0.749 1.177 0.749 0.582 0.585 0.642 0.664 0.374 0.837
0.359 0.420 0.559 0.801 0.588 0.766 0.696 0.709 1.194 0.908 0.613
0.744 0.377 0.284 1.061 0.949 0.249 1.000 1.213 0.472 0.533 0.803
0.686 0.671
I68 1.095 0.705 0.616 0.659 1.098 0.517 0.600 0.665 0.597 1.070
0.529 0.782 0.442 0.401 0.432 0.670 0.659 0.529 0.850 0.606 0.857
1.087 0.813 0.660 1.361 0.573 0.760 0.477 0.711 0.629 0.861 0.632
1.354 0.596 1.135 0.272 0.251 1.128 1.106 0.768 0.473 0.462 0.979
0.769 0.458 0.453 0.729 0.722 0.779 1.213 1.224 0.930 0.576 1.061
0.738 0.792 1.332 0.358 0.790 0.530 0.650 0.320 0.753 0.156 0.168
0.090 0.076 0.001 0.903 0.921 1.143 0.647 0.922 1.350 0.572 0.963
0.955 0.741 0.760 1.253 0.803 0.633 0.659 0.686 0.719 0.449 0.844
0.423 0.477 0.593 0.872 0.662 0.842 0.772 0.767 1.202 0.907 0.574
0.779 0.450 0.354 1.137 1.009 0.308 1.072 1.288 0.463 0.604 0.872
0.760 0.747
I69 0.208 0.237 0.421 1.064 0.612 0.666 1.339 1.036 0.522 0.207
0.428 0.261 0.535 0.674 0.593 0.487 0.419 0.599 0.156 0.424 0.047
0.203 0.357 0.314 0.462 0.425 0.327 0.621 0.269 1.121 0.332 0.958
0.477 0.688 0.551 0.633 0.653 0.230 0.239 0.367 0.881 0.553 0.080
0.139 0.736 0.700 0.348 0.230 0.195 0.353 0.705 0.116 0.714 0.163
0.435 0.192 0.447 0.639 0.469 0.386 1.193 0.775 0.204 0.749 0.774
0.831 0.828 0.903 0.001 0.603 0.242 0.399 0.503 0.463 0.447 0.074
0.565 0.250 1.101 0.353 0.678 0.603 0.260 0.758 0.555 0.458 1.189
0.599 0.636 0.759 0.343 0.303 0.065 0.135 0.512 1.448 1.300 1.297
0.893 0.473 0.570 0.234 0.668 0.658 0.407 0.392 1.051 0.417 0.401
0.242 0.161
I70 0.761 0.690 0.838 0.660 0.196 1.019 1.063 0.623 0.930 0.787
0.470 0.788 0.823 0.955 0.888 0.940 0.867 0.963 0.449 0.833 0.589
0.602 0.896 0.746 0.809 0.410 0.840 0.951 0.741 0.746 0.894 0.557
0.729 1.081 0.282 0.745 0.754 0.747 0.808 0.882 0.587 0.469 0.607
0.610 1.048 1.012 0.841 0.449 0.438 0.610 0.312 0.503 1.093 0.707
0.930 0.723 0.738 0.882 0.985 0.676 0.824 1.003 0.699 0.819 0.892

0.899 0.860 0.921 0.603 0.022 0.745 0.838 0.107 0.754 0.831 0.582
0.065 0.745 0.645 0.747 0.167 1.026 0.654 0.326 1.028 0.674 0.709
0.501 0.446 1.139 0.260 0.425 0.608 0.551 1.013 0.885 0.819 1.020
0.394 0.723 0.769 0.702 0.095 0.862 0.329 0.873 0.769 0.379 0.202
0.397 0.542
I71 0.073 0.453 0.616 1.282 0.690 0.858 1.576 1.252 0.707 0.125
0.667 0.427 0.756 0.886 0.807 0.655 0.600 0.793 0.353 0.621 0.289
0.146 0.486 0.521 0.246 0.658 0.486 0.824 0.469 1.344 0.440 1.174
0.304 0.863 0.600 0.872 0.892 0.020 0.111 0.515 1.110 0.789 0.176
0.374 0.936 0.902 0.517 0.462 0.416 0.240 0.748 0.268 0.892 0.083
0.585 0.380 0.262 0.861 0.597 0.619 1.418 0.994 0.410 0.988 1.009
1.069 1.068 1.143 0.242 0.745 0.002 0.588 0.638 0.273 0.650 0.200
0.693 0.442 1.309 0.142 0.855 0.772 0.489 0.959 0.703 0.696 1.393
0.836 0.866 0.934 0.498 0.536 0.302 0.377 0.646 1.623 1.505 1.533
1.085 0.705 0.803 0.050 0.787 0.887 0.458 0.151 1.284 0.645 0.553
0.458 0.403
I72 0.522 0.171 0.032 1.053 0.922 0.270 1.198 1.036 0.123 0.482
0.421 0.163 0.206 0.307 0.236 0.103 0.030 0.204 0.464 0.041 0.365
0.599 0.166 0.097 0.833 0.468 0.118 0.238 0.130 1.078 0.215 0.965
0.868 0.289 0.892 0.400 0.419 0.569 0.515 0.121 0.835 0.522 0.475
0.280 0.347 0.314 0.084 0.397 0.428 0.751 1.036 0.493 0.315 0.510
0.112 0.213 0.834 0.304 0.175 0.194 1.135 0.420 0.196 0.500 0.485
0.559 0.580 0.647 0.399 0.838 0.588 0.000 0.765 0.848 0.076 0.473
0.826 0.151 1.122 0.724 0.836 0.208 0.188 0.840 0.190 0.259 1.218
0.545 0.622 0.360 0.621 0.413 0.339 0.330 0.184 1.537 1.317 1.162
0.984 0.224 0.300 0.602 0.924 0.345 0.763 0.709 0.957 0.488 0.664
0.455 0.324
I73 0.655 0.609 0.769 0.737 0.179 0.965 1.123 0.701 0.865 0.682
0.432 0.702 0.774 0.911 0.840 0.868 0.794 0.906 0.351 0.765 0.492
0.495 0.810 0.671 0.706 0.374 0.757 0.900 0.660 0.819 0.804 0.630
0.631 1.022 0.223 0.721 0.733 0.640 0.703 0.800 0.638 0.461 0.503
0.522 1.002 0.965 0.761 0.369 0.350 0.508 0.306 0.399 1.036 0.601
0.851 0.635 0.637 0.842 0.904 0.618 0.898 0.969 0.614 0.807 0.874
0.890 0.857 0.922 0.503 0.107 0.638 0.765 0.000 0.655 0.767 0.477
0.064 0.662 0.732 0.642 0.247 0.961 0.578 0.395 0.955 0.627 0.802
0.500 0.461 1.083 0.161 0.360 0.513 0.463 0.935 0.991 0.913 1.079
0.484 0.674 0.731 0.595 0.167 0.828 0.232 0.766 0.824 0.341 0.105
0.313 0.457
I74 0.346 0.697 0.874 1.374 0.633 1.118 1.718 1.340 0.969 0.397
0.837 0.691 0.998 1.135 1.054 0.921 0.862 1.052 0.503 0.878 0.507
0.264 0.757 0.771 0.071 0.811 0.753 1.079 0.722 1.448 0.712 1.265
0.045 1.129 0.526 1.084 1.103 0.293 0.378 0.784 1.233 0.945 0.383
0.601 1.192 1.157 0.781 0.632 0.576 0.153 0.644 0.420 1.158 0.341
0.855 0.635 0.018 1.102 0.868 0.847 1.526 1.238 0.658 1.199 1.231
1.283 1.274 1.350 0.463 0.754 0.273 0.848 0.655 0.000 0.904 0.394
0.693 0.698 1.381 0.132 0.900 1.039 0.723 1.034 0.973 0.914 1.455

0.993 1.003 1.200 0.564 0.698 0.528 0.583 0.918 1.633 1.566 1.674
1.138 0.933 1.030 0.248 0.765 1.120 0.426 0.245 1.418 0.789 0.606
0.603 0.607
I75 0.586 0.210 0.044 0.999 0.930 0.221 1.128 0.984 0.099 0.549
0.390 0.231 0.130 0.237 0.163 0.129 0.088 0.154 0.490 0.035 0.409
0.649 0.241 0.133 0.893 0.443 0.193 0.175 0.182 1.020 0.291 0.916
0.922 0.259 0.909 0.329 0.347 0.632 0.583 0.196 0.780 0.479 0.525
0.317 0.289 0.253 0.160 0.405 0.445 0.800 1.048 0.531 0.279 0.570
0.174 0.271 0.889 0.228 0.234 0.160 1.074 0.348 0.245 0.426 0.409
0.484 0.506 0.572 0.447 0.831 0.650 0.076 0.767 0.904 0.001 0.520
0.826 0.209 1.073 0.783 0.815 0.195 0.206 0.805 0.214 0.206 1.169
0.497 0.578 0.326 0.631 0.408 0.383 0.359 0.230 1.495 1.265 1.093
0.947 0.163 0.228 0.661 0.920 0.269 0.787 0.776 0.894 0.467 0.669
0.465 0.347
I76 0.188 0.310 0.495 1.084 0.569 0.739 1.377 1.055 0.596 0.206
0.470 0.332 0.606 0.746 0.665 0.560 0.492 0.672 0.156 0.497 0.114
0.131 0.425 0.387 0.399 0.459 0.398 0.694 0.343 1.145 0.395 0.977
0.406 0.762 0.499 0.694 0.713 0.192 0.230 0.438 0.910 0.591 0.027
0.208 0.809 0.773 0.420 0.263 0.216 0.280 0.653 0.079 0.788 0.134
0.506 0.265 0.378 0.709 0.537 0.453 1.219 0.846 0.277 0.810 0.839
0.893 0.887 0.963 0.074 0.582 0.200 0.473 0.477 0.394 0.520 0.000
0.538 0.323 1.115 0.291 0.673 0.676 0.330 0.767 0.627 0.522 1.200
0.638 0.667 0.833 0.323 0.337 0.137 0.191 0.582 1.444 1.312 1.335
0.897 0.539 0.636 0.179 0.639 0.726 0.352 0.351 1.085 0.445 0.381
0.259 0.216
I77 0.714 0.672 0.829 0.721 0.146 1.020 1.121 0.685 0.924 0.741
0.481 0.765 0.828 0.963 0.894 0.929 0.855 0.963 0.414 0.825 0.556
0.549 0.873 0.733 0.748 0.421 0.820 0.955 0.722 0.807 0.868 0.618
0.666 1.080 0.221 0.765 0.776 0.696 0.761 0.863 0.641 0.496 0.563
0.585 1.055 1.019 0.823 0.431 0.413 0.550 0.269 0.460 1.093 0.659
0.913 0.698 0.676 0.893 0.967 0.675 0.885 1.018 0.677 0.846 0.915
0.927 0.891 0.955 0.565 0.065 0.693 0.826 0.064 0.693 0.826 0.538
0.002 0.724 0.708 0.689 0.228 1.020 0.640 0.385 1.016 0.680 0.772
0.532 0.484 1.139 0.224 0.418 0.576 0.526 0.997 0.944 0.882 1.077
0.457 0.728 0.781 0.649 0.103 0.876 0.267 0.817 0.824 0.388 0.169
0.376 0.520
I78 0.378 0.061 0.176 1.055 0.805 0.421 1.253 1.034 0.273 0.343
0.393 0.053 0.320 0.445 0.367 0.238 0.169 0.354 0.333 0.180 0.219
0.449 0.153 0.083 0.685 0.424 0.095 0.383 0.030 1.093 0.166 0.959
0.718 0.439 0.765 0.475 0.495 0.423 0.378 0.140 0.846 0.514 0.324
0.145 0.495 0.461 0.104 0.297 0.313 0.601 0.913 0.350 0.465 0.362
0.196 0.063 0.683 0.426 0.243 0.219 1.156 0.554 0.051 0.587 0.590
0.658 0.669 0.741 0.250 0.745 0.442 0.151 0.662 0.698 0.209 0.323
0.724 0.001 1.113 0.575 0.770 0.353 0.116 0.802 0.312 0.303 1.207
0.547 0.612 0.510 0.507 0.336 0.192 0.203 0.278 1.507 1.312 1.214

0.946 0.292 0.387 0.453 0.826 0.457 0.630 0.569 0.990 0.435 0.557
0.349 0.205
I79 1.301 1.053 1.104 0.103 0.824 1.158 0.511 0.096 1.153 1.308
0.720 1.166 0.985 1.048 1.025 1.202 1.148 1.132 0.959 1.095 1.067
1.183 1.254 1.066 1.428 0.695 1.188 1.093 1.092 0.176 1.278 0.157
1.361 1.240 0.921 0.792 0.784 1.305 1.339 1.220 0.307 0.603 1.141
1.032 1.137 1.115 1.172 0.875 0.906 1.231 0.907 1.042 1.235 1.248
1.234 1.127 1.364 0.973 1.297 0.929 0.231 1.024 1.087 0.774 0.853
0.804 0.749 0.760 1.101 0.645 1.309 1.122 0.732 1.381 1.073 1.115
0.708 1.113 0.002 1.349 0.485 1.232 0.997 0.351 1.283 0.867 0.096
0.577 0.502 1.268 0.824 0.807 1.072 0.990 1.301 0.446 0.200 0.475
0.252 0.912 0.882 1.275 0.675 0.925 0.964 1.454 0.324 0.693 0.777
0.860 0.967
I80 0.215 0.581 0.751 1.332 0.657 0.994 1.653 1.300 0.844 0.266
0.755 0.565 0.883 1.018 0.937 0.794 0.737 0.929 0.424 0.756 0.399
0.177 0.627 0.652 0.112 0.737 0.625 0.958 0.601 1.401 0.581 1.223
0.167 1.003 0.556 0.984 1.004 0.162 0.246 0.656 1.176 0.871 0.275
0.491 1.071 1.036 0.655 0.547 0.494 0.159 0.692 0.336 1.031 0.215
0.726 0.513 0.124 0.988 0.738 0.738 1.477 1.123 0.539 1.100 1.127
1.182 1.177 1.253 0.353 0.747 0.142 0.724 0.642 0.132 0.783 0.291
0.689 0.575 1.349 0.043 0.877 0.912 0.611 0.998 0.844 0.810 1.428
0.918 0.938 1.073 0.526 0.618 0.417 0.482 0.787 1.632 1.540 1.610
1.113 0.825 0.923 0.124 0.774 1.010 0.431 0.150 1.356 0.718 0.575
0.529 0.507
I81 0.860 0.711 0.830 0.494 0.360 0.978 0.898 0.458 0.911 0.877
0.427 0.819 0.781 0.898 0.842 0.935 0.865 0.929 0.524 0.823 0.654
0.719 0.923 0.753 0.949 0.372 0.861 0.909 0.759 0.580 0.931 0.390
0.878 1.048 0.446 0.664 0.670 0.854 0.903 0.902 0.428 0.382 0.700
0.651 0.994 0.961 0.856 0.482 0.491 0.751 0.467 0.595 1.055 0.805
0.938 0.762 0.882 0.822 0.998 0.655 0.658 0.929 0.730 0.720 0.798
0.793 0.749 0.803 0.678 0.167 0.855 0.836 0.247 0.900 0.815 0.673
0.228 0.770 0.485 0.877 0.000 1.006 0.665 0.160 1.023 0.632 0.555
0.401 0.329 1.099 0.358 0.434 0.668 0.597 1.019 0.771 0.667 0.855
0.238 0.683 0.709 0.816 0.227 0.793 0.480 0.993 0.606 0.349 0.304
0.444 0.581
I82 0.702 0.379 0.195 1.152 1.123 0.127 1.225 1.141 0.096 0.656
0.580 0.349 0.247 0.233 0.215 0.118 0.185 0.107 0.672 0.198 0.571
0.799 0.292 0.303 1.018 0.634 0.287 0.157 0.337 1.162 0.345 1.077
1.063 0.092 1.097 0.449 0.462 0.752 0.685 0.258 0.931 0.656 0.676
0.488 0.210 0.194 0.258 0.597 0.633 0.952 1.239 0.701 0.124 0.698
0.189 0.412 1.026 0.283 0.204 0.352 1.208 0.334 0.401 0.513 0.467
0.544 0.582 0.633 0.603 1.026 0.772 0.208 0.961 1.039 0.195 0.676
1.020 0.353 1.232 0.912 1.006 0.001 0.391 0.986 0.097 0.381 1.328
0.666 0.751 0.162 0.822 0.603 0.545 0.538 0.160 1.664 1.419 1.194
1.126 0.331 0.352 0.792 1.116 0.337 0.971 0.877 1.021 0.660 0.863
0.656 0.530

I83 0.436 0.057 0.196 0.940 0.734 0.425 1.147 0.918 0.297 0.411
0.277 0.168 0.276 0.418 0.336 0.290 0.216 0.359 0.285 0.194 0.216
0.461 0.262 0.093 0.721 0.310 0.198 0.372 0.097 0.979 0.281 0.843
0.736 0.464 0.707 0.388 0.408 0.473 0.447 0.238 0.732 0.398 0.340
0.122 0.486 0.449 0.191 0.210 0.242 0.607 0.849 0.329 0.484 0.407
0.277 0.143 0.707 0.379 0.334 0.130 1.043 0.516 0.100 0.504 0.520
0.581 0.585 0.659 0.260 0.654 0.489 0.188 0.578 0.723 0.206 0.330
0.640 0.116 0.997 0.611 0.665 0.391 0.001 0.689 0.376 0.210 1.092
0.433 0.497 0.531 0.433 0.233 0.195 0.155 0.359 1.393 1.197 1.107
0.833 0.215 0.314 0.490 0.739 0.399 0.582 0.630 0.879 0.324 0.477
0.268 0.142
I84 0.954 0.741 0.828 0.342 0.520 0.939 0.738 0.308 0.896 0.964
0.419 0.853 0.746 0.846 0.800 0.931 0.868 0.898 0.611 0.820 0.726
0.832 0.950 0.769 1.078 0.378 0.886 0.870 0.785 0.424 0.967 0.235
1.015 1.015 0.603 0.595 0.595 0.955 0.993 0.923 0.272 0.331 0.793
0.703 0.942 0.911 0.875 0.538 0.563 0.883 0.626 0.692 1.018 0.901
0.949 0.806 1.016 0.768 1.011 0.648 0.503 0.858 0.769 0.628 0.710
0.691 0.642 0.686 0.758 0.326 0.959 0.840 0.395 1.034 0.805 0.767
0.385 0.802 0.351 0.998 0.160 0.986 0.689 0.000 1.018 0.605 0.434
0.330 0.245 1.058 0.474 0.475 0.735 0.655 1.024 0.705 0.546 0.694
0.144 0.656 0.659 0.925 0.385 0.730 0.624 1.104 0.446 0.367 0.428
0.516 0.635
I85 0.630 0.351 0.193 1.207 1.109 0.223 1.304 1.194 0.133 0.582
0.602 0.294 0.306 0.324 0.291 0.089 0.161 0.191 0.643 0.200 0.529
0.744 0.216 0.283 0.947 0.652 0.229 0.244 0.303 1.223 0.266 1.127
1.000 0.182 1.074 0.516 0.531 0.683 0.610 0.192 0.987 0.693 0.623
0.455 0.308 0.290 0.208 0.586 0.614 0.896 1.221 0.660 0.214 0.633
0.121 0.363 0.961 0.363 0.113 0.371 1.274 0.429 0.363 0.592 0.552
0.630 0.664 0.719 0.555 1.028 0.703 0.190 0.955 0.973 0.214 0.627
1.016 0.312 1.283 0.844 1.023 0.097 0.376 1.018 0.001 0.418 1.379
0.709 0.791 0.246 0.808 0.603 0.502 0.510 0.065 1.708 1.474 1.272
1.161 0.372 0.414 0.727 1.114 0.416 0.941 0.799 1.089 0.675 0.853
0.643 0.507
I86 0.646 0.259 0.238 0.795 0.802 0.347 0.953 0.779 0.292 0.622
0.207 0.350 0.150 0.284 0.215 0.335 0.283 0.298 0.432 0.228 0.412
0.650 0.410 0.229 0.920 0.265 0.347 0.279 0.274 0.819 0.448 0.710
0.923 0.417 0.802 0.177 0.198 0.680 0.658 0.370 0.576 0.276 0.536
0.322 0.375 0.339 0.322 0.312 0.367 0.787 0.926 0.501 0.424 0.613
0.371 0.348 0.898 0.219 0.433 0.084 0.876 0.353 0.306 0.294 0.317
0.373 0.374 0.449 0.458 0.674 0.696 0.259 0.627 0.914 0.206 0.522
0.680 0.303 0.867 0.810 0.632 0.381 0.210 0.605 0.418 0.002 0.963
0.291 0.373 0.469 0.517 0.279 0.395 0.331 0.434 1.290 1.060 0.915
0.746 0.052 0.119 0.691 0.766 0.217 0.702 0.839 0.701 0.296 0.542
0.365 0.308
I87 1.388 1.147 1.200 0.186 0.879 1.252 0.533 0.189 1.249 1.396
0.815 1.260 1.081 1.142 1.120 1.298 1.244 1.228 1.045 1.191 1.156

1.264 1.349 1.162 1.503 0.788 1.284 1.188 1.187 0.231 1.373 0.253
1.433 1.335 0.981 0.887 0.878 1.389 1.426 1.316 0.401 0.698 1.227
1.124 1.231 1.209 1.267 0.965 0.994 1.306 0.953 1.126 1.329 1.334
1.330 1.220 1.437 1.068 1.393 1.025 0.259 1.115 1.181 0.865 0.944
0.893 0.837 0.844 1.189 0.709 1.393 1.218 0.802 1.455 1.169 1.200
0.772 1.207 0.096 1.428 0.555 1.328 1.092 0.434 1.379 0.963 0.000
0.673 0.598 1.362 0.904 0.898 1.162 1.081 1.398 0.358 0.112 0.502
0.317 1.008 0.977 1.358 0.729 1.019 1.034 1.537 0.394 0.785 0.854
0.948 1.059
I88 0.807 0.490 0.527 0.510 0.675 0.610 0.740 0.492 0.581 0.799
0.171 0.600 0.421 0.515 0.472 0.626 0.571 0.573 0.495 0.518 0.555
0.744 0.681 0.493 1.018 0.182 0.616 0.542 0.524 0.546 0.710 0.421
0.989 0.689 0.715 0.267 0.270 0.826 0.834 0.646 0.299 0.048 0.660
0.495 0.611 0.581 0.597 0.374 0.425 0.846 0.801 0.583 0.689 0.761
0.657 0.571 0.975 0.437 0.720 0.352 0.610 0.532 0.529 0.321 0.397
0.398 0.359 0.423 0.599 0.501 0.836 0.545 0.500 0.993 0.497 0.638
0.532 0.547 0.577 0.918 0.401 0.666 0.433 0.330 0.709 0.291 0.673
0.000 0.086 0.729 0.465 0.301 0.552 0.468 0.725 0.999 0.773 0.698
0.464 0.338 0.329 0.816 0.591 0.401 0.664 0.987 0.454 0.205 0.457
0.391 0.442
I89 0.843 0.553 0.606 0.443 0.630 0.696 0.716 0.421 0.664 0.841
0.222 0.665 0.507 0.601 0.558 0.706 0.649 0.659 0.516 0.597 0.595
0.763 0.752 0.564 1.033 0.210 0.686 0.628 0.591 0.488 0.777 0.347
0.995 0.774 0.681 0.350 0.351 0.858 0.874 0.718 0.245 0.100 0.691
0.545 0.696 0.667 0.670 0.406 0.450 0.853 0.753 0.605 0.775 0.795
0.734 0.631 0.984 0.523 0.797 0.428 0.558 0.614 0.590 0.393 0.472
0.464 0.420 0.477 0.636 0.446 0.866 0.622 0.461 1.003 0.578 0.667
0.484 0.612 0.502 0.938 0.329 0.751 0.497 0.245 0.791 0.373 0.598
0.086 0.000 0.815 0.454 0.332 0.595 0.511 0.804 0.917 0.700 0.673
0.378 0.421 0.415 0.842 0.532 0.485 0.646 1.017 0.419 0.221 0.435
0.411 0.486
I90 0.864 0.529 0.340 1.180 1.251 0.121 1.193 1.174 0.238 0.818
0.675 0.510 0.318 0.221 0.259 0.279 0.341 0.177 0.816 0.340 0.725
0.958 0.454 0.451 1.180 0.733 0.448 0.190 0.490 1.177 0.506 1.117
1.223 0.071 1.234 0.478 0.485 0.914 0.847 0.420 0.962 0.729 0.833
0.638 0.137 0.154 0.419 0.729 0.770 1.110 1.371 0.852 0.047 0.859
0.351 0.570 1.187 0.296 0.358 0.465 1.215 0.273 0.556 0.507 0.440
0.511 0.559 0.593 0.759 1.139 0.934 0.360 1.083 1.200 0.326 0.833
1.139 0.510 1.268 1.073 1.099 0.162 0.531 1.058 0.246 0.469 1.362
0.729 0.815 0.000 0.953 0.724 0.699 0.684 0.310 1.710 1.446 1.167
1.192 0.417 0.400 0.953 1.230 0.344 1.113 1.039 1.025 0.763 0.989
0.788 0.673
I91 0.506 0.458 0.628 0.811 0.301 0.839 1.160 0.778 0.727 0.529
0.348 0.545 0.655 0.798 0.722 0.723 0.648 0.776 0.191 0.625 0.332
0.362 0.653 0.525 0.605 0.299 0.602 0.776 0.508 0.884 0.645 0.702
0.550 0.889 0.286 0.640 0.655 0.497 0.552 0.646 0.672 0.419 0.349

0.365 0.884 0.847 0.609 0.225 0.195 0.413 0.418 0.244 0.906 0.452
0.700 0.477 0.546 0.736 0.751 0.492 0.961 0.869 0.458 0.740 0.797
0.826 0.801 0.872 0.343 0.260 0.498 0.621 0.161 0.564 0.631 0.323
0.224 0.507 0.824 0.526 0.358 0.822 0.433 0.474 0.808 0.517 0.904
0.465 0.454 0.953 0.000 0.238 0.352 0.306 0.784 1.126 1.016 1.116
0.590 0.560 0.630 0.459 0.327 0.729 0.200 0.636 0.858 0.268 0.059
0.166 0.303
I92 0.511 0.277 0.414 0.764 0.528 0.606 1.040 0.737 0.507 0.509
0.139 0.385 0.419 0.560 0.486 0.515 0.443 0.547 0.196 0.408 0.264
0.444 0.489 0.324 0.719 0.122 0.428 0.542 0.326 0.818 0.498 0.660
0.698 0.663 0.523 0.412 0.429 0.527 0.542 0.469 0.578 0.254 0.360
0.228 0.648 0.611 0.424 0.074 0.124 0.555 0.651 0.283 0.677 0.463
0.509 0.332 0.680 0.498 0.567 0.259 0.889 0.632 0.298 0.520 0.569
0.606 0.588 0.662 0.303 0.425 0.536 0.413 0.360 0.698 0.408 0.337
0.418 0.336 0.807 0.618 0.434 0.603 0.233 0.475 0.603 0.279 0.898
0.301 0.332 0.724 0.238 0.001 0.266 0.183 0.591 1.179 1.007 0.998
0.617 0.322 0.393 0.514 0.513 0.492 0.426 0.687 0.749 0.115 0.266
0.098 0.161
I93 0.259 0.173 0.360 1.030 0.637 0.603 1.290 1.004 0.461 0.248
0.381 0.212 0.470 0.609 0.528 0.430 0.360 0.536 0.163 0.361 0.027
0.268 0.314 0.251 0.527 0.385 0.276 0.557 0.209 1.083 0.297 0.926
0.542 0.628 0.585 0.571 0.591 0.287 0.282 0.319 0.840 0.508 0.145
0.074 0.672 0.635 0.294 0.197 0.177 0.417 0.737 0.158 0.653 0.220
0.383 0.140 0.512 0.574 0.422 0.321 1.153 0.710 0.143 0.687 0.710
0.768 0.766 0.842 0.065 0.608 0.302 0.339 0.513 0.528 0.383 0.137
0.576 0.192 1.072 0.417 0.668 0.545 0.195 0.735 0.502 0.395 1.162
0.552 0.595 0.699 0.352 0.266 0.006 0.085 0.463 1.432 1.272 1.248
0.873 0.408 0.506 0.297 0.679 0.593 0.445 0.449 1.006 0.381 0.408
0.224 0.110
I94 0.340 0.160 0.345 0.946 0.603 0.579 1.207 0.920 0.448 0.331
0.297 0.239 0.426 0.570 0.488 0.430 0.356 0.513 0.134 0.344 0.089
0.319 0.347 0.235 0.590 0.301 0.297 0.527 0.207 0.998 0.343 0.843
0.593 0.615 0.564 0.502 0.522 0.364 0.366 0.341 0.756 0.424 0.208
0.059 0.641 0.604 0.306 0.117 0.113 0.459 0.711 0.176 0.637 0.297
0.398 0.172 0.567 0.526 0.446 0.266 1.068 0.664 0.153 0.618 0.648
0.701 0.696 0.772 0.135 0.551 0.377 0.330 0.463 0.583 0.359 0.191
0.526 0.203 0.990 0.482 0.597 0.538 0.155 0.655 0.510 0.331 1.081
0.468 0.511 0.684 0.306 0.183 0.085 0.000 0.481 1.355 1.190 1.165
0.795 0.352 0.447 0.366 0.628 0.539 0.433 0.526 0.921 0.298 0.358
0.156 0.026
I95 0.573 0.326 0.198 1.229 1.083 0.284 1.345 1.214 0.171 0.524
0.605 0.252 0.340 0.378 0.336 0.103 0.156 0.245 0.612 0.207 0.490
0.695 0.161 0.267 0.890 0.652 0.187 0.297 0.275 1.250 0.206 1.145
0.945 0.247 1.043 0.550 0.566 0.626 0.550 0.147 1.009 0.704 0.576
0.424 0.370 0.350 0.175 0.566 0.589 0.846 1.192 0.621 0.280 0.579
0.084 0.323 0.906 0.410 0.050 0.377 1.303 0.486 0.329 0.634 0.600

0.678 0.709 0.767 0.512 1.013 0.646 0.184 0.935 0.918 0.230 0.582
0.997 0.278 1.301 0.787 1.019 0.160 0.359 1.024 0.065 0.434 1.398
0.725 0.804 0.310 0.784 0.591 0.463 0.481 0.000 1.720 1.495 1.311
1.168 0.392 0.447 0.672 1.097 0.461 0.906 0.737 1.121 0.671 0.831
0.622 0.481
I96 1.631 1.446 1.523 0.544 1.008 1.597 0.827 0.542 1.580 1.648
1.121 1.559 1.418 1.489 1.462 1.624 1.565 1.568 1.294 1.514 1.421
1.484 1.655 1.471 1.691 1.083 1.590 1.531 1.490 0.582 1.672 0.593
1.604 1.679 1.118 1.232 1.225 1.623 1.674 1.626 0.751 1.016 1.471
1.406 1.580 1.556 1.578 1.238 1.256 1.493 1.042 1.366 1.675 1.576
1.648 1.510 1.617 1.414 1.711 1.343 0.590 1.469 1.474 1.219 1.298
1.250 1.194 1.202 1.448 0.885 1.623 1.537 0.991 1.633 1.495 1.444
0.944 1.507 0.446 1.632 0.771 1.664 1.393 0.705 1.708 1.290 0.358
0.999 0.917 1.710 1.126 1.179 1.432 1.355 1.720 0.000 0.316 0.807
0.562 1.338 1.318 1.583 0.868 1.367 1.209 1.756 0.749 1.072 1.070
1.209 1.337
I97 1.499 1.252 1.298 0.268 0.985 1.338 0.517 0.281 1.342 1.507
0.920 1.365 1.173 1.226 1.209 1.394 1.343 1.317 1.156 1.289 1.266
1.376 1.452 1.264 1.615 0.895 1.386 1.276 1.291 0.278 1.477 0.354
1.544 1.422 1.088 0.974 0.964 1.501 1.537 1.418 0.489 0.800 1.338
1.232 1.312 1.292 1.369 1.075 1.105 1.417 1.055 1.238 1.414 1.446
1.429 1.327 1.549 1.153 1.492 1.125 0.275 1.192 1.287 0.943 1.019
0.962 0.908 0.907 1.300 0.819 1.505 1.317 0.913 1.566 1.265 1.312
0.882 1.312 0.200 1.540 0.667 1.419 1.197 0.546 1.474 1.060 0.112
0.773 0.700 1.446 1.016 1.007 1.272 1.190 1.495 0.316 0.002 0.494
0.429 1.103 1.067 1.470 0.836 1.103 1.145 1.649 0.445 0.893 0.966
1.058 1.167
I98 1.504 1.163 1.135 0.397 1.214 1.084 0.044 0.432 1.142 1.495
0.868 1.264 0.971 0.966 0.982 1.209 1.181 1.087 1.188 1.124 1.253
1.435 1.322 1.143 1.706 0.876 1.261 1.037 1.186 0.305 1.363 0.476
1.664 1.166 1.294 0.764 0.746 1.524 1.530 1.280 0.444 0.744 1.358
1.187 1.031 1.023 1.235 1.071 1.120 1.523 1.318 1.276 1.148 1.459
1.267 1.250 1.656 0.911 1.325 0.996 0.246 0.894 1.207 0.681 0.731
0.656 0.613 0.574 1.297 1.020 1.533 1.162 1.079 1.674 1.093 1.335
1.077 1.214 0.475 1.610 0.855 1.194 1.107 0.694 1.272 0.915 0.502
0.698 0.673 1.167 1.116 0.998 1.248 1.165 1.311 0.807 0.494 0.001
0.675 0.940 0.866 1.512 1.077 0.857 1.296 1.685 0.258 0.892 1.086
1.082 1.139
I99 1.084 0.885 0.971 0.284 0.572 1.074 0.716 0.247 1.037 1.097
0.563 0.997 0.884 0.977 0.936 1.074 1.012 1.036 0.743 0.963 0.864
0.952 1.094 0.913 1.187 0.523 1.030 1.006 0.930 0.377 1.111 0.202
1.115 1.152 0.670 0.722 0.720 1.082 1.125 1.067 0.318 0.470 0.923
0.845 1.072 1.043 1.019 0.678 0.699 0.989 0.660 0.820 1.153 1.030
1.093 0.948 1.120 0.899 1.155 0.791 0.451 0.980 0.912 0.741 0.824
0.796 0.744 0.779 0.893 0.394 1.085 0.984 0.484 1.138 0.947 0.897
0.457 0.946 0.252 1.113 0.238 1.126 0.833 0.144 1.161 0.746 0.317

0.464 0.378 1.192 0.590 0.617 0.873 0.795 1.168 0.562 0.429 0.675
0.001 0.796 0.792 1.048 0.424 0.858 0.717 1.226 0.453 0.511 0.539
0.652 0.776
I100 0.651 0.257 0.199 0.837 0.848 0.296 0.977 0.823 0.243 0.623
0.258 0.335 0.100 0.239 0.166 0.291 0.246 0.246 0.462 0.189 0.427
0.670 0.382 0.212 0.935 0.316 0.323 0.228 0.262 0.858 0.425 0.755
0.944 0.365 0.845 0.184 0.204 0.689 0.659 0.340 0.617 0.326 0.552
0.334 0.327 0.291 0.295 0.348 0.400 0.810 0.972 0.526 0.373 0.622
0.333 0.343 0.917 0.179 0.395 0.087 0.913 0.317 0.304 0.295 0.305
0.368 0.377 0.450 0.473 0.723 0.705 0.224 0.674 0.933 0.163 0.539
0.728 0.292 0.912 0.825 0.683 0.331 0.215 0.656 0.372 0.052 1.008
0.338 0.421 0.417 0.560 0.322 0.408 0.352 0.392 1.338 1.103 0.940
0.796 0.002 0.099 0.704 0.816 0.188 0.740 0.845 0.734 0.346 0.587
0.403 0.331
I101 0.750 0.355 0.271 0.800 0.908 0.282 0.901 0.789 0.281 0.722
0.300 0.428 0.108 0.190 0.144 0.344 0.316 0.251 0.551 0.260 0.524
0.766 0.464 0.306 1.032 0.360 0.409 0.214 0.357 0.811 0.510 0.727
1.039 0.362 0.914 0.103 0.120 0.787 0.757 0.420 0.579 0.331 0.649
0.432 0.286 0.254 0.378 0.430 0.485 0.904 1.034 0.619 0.360 0.721
0.401 0.441 1.013 0.114 0.459 0.185 0.860 0.239 0.402 0.202 0.206
0.271 0.284 0.354 0.570 0.769 0.803 0.300 0.731 1.030 0.228 0.636
0.781 0.387 0.882 0.923 0.709 0.352 0.314 0.659 0.414 0.119 0.977
0.329 0.415 0.400 0.630 0.393 0.506 0.447 0.447 1.318 1.067 0.866
0.792 0.099 0.000 0.802 0.862 0.099 0.818 0.943 0.675 0.393 0.652
0.483 0.424
I102 0.111 0.458 0.629 1.251 0.643 0.872 1.554 1.220 0.723 0.163
0.649 0.444 0.761 0.895 0.815 0.674 0.616 0.807 0.326 0.633 0.280
0.101 0.511 0.529 0.233 0.636 0.505 0.836 0.479 1.316 0.468 1.143
0.274 0.882 0.552 0.866 0.886 0.063 0.155 0.537 1.084 0.769 0.159
0.371 0.948 0.914 0.535 0.442 0.392 0.196 0.700 0.238 0.911 0.096
0.608 0.391 0.236 0.866 0.623 0.618 1.390 1.000 0.417 0.983 1.007
1.064 1.061 1.137 0.234 0.702 0.050 0.602 0.595 0.248 0.661 0.179
0.649 0.453 1.275 0.124 0.816 0.792 0.490 0.925 0.727 0.691 1.358
0.816 0.842 0.953 0.459 0.514 0.297 0.366 0.672 1.583 1.470 1.512
1.048 0.704 0.802 0.019 0.742 0.888 0.411 0.179 1.261 0.621 0.514
0.431 0.391
I103 0.811 0.772 0.926 0.703 0.150 1.110 1.120 0.666 1.019 0.841
0.562 0.867 0.916 1.047 0.981 1.027 0.953 1.054 0.518 0.921 0.659
0.642 0.975 0.832 0.824 0.503 0.921 1.043 0.823 0.793 0.970 0.605
0.735 1.172 0.257 0.838 0.847 0.792 0.860 0.964 0.655 0.561 0.663
0.688 1.141 1.105 0.924 0.531 0.515 0.629 0.242 0.561 1.184 0.757
1.014 0.801 0.749 0.975 1.068 0.767 0.870 1.096 0.779 0.910 0.983
0.989 0.949 1.009 0.668 0.095 0.787 0.924 0.167 0.765 0.920 0.639
0.103 0.826 0.675 0.774 0.227 1.116 0.739 0.385 1.114 0.766 0.729
0.591 0.532 1.230 0.327 0.513 0.679 0.628 1.097 0.868 0.836 1.077

0.424 0.816 0.862 0.742 0.003 0.955 0.344 0.906 0.831 0.471 0.271
0.477 0.622
I104 0.830 0.434 0.314 0.837 1.005 0.237 0.889 0.830 0.290 0.798
0.396 0.492 0.140 0.123 0.127 0.363 0.354 0.231 0.647 0.304 0.614
0.857 0.510 0.375 1.120 0.455 0.462 0.181 0.427 0.837 0.560 0.774
1.131 0.321 1.013 0.137 0.142 0.870 0.834 0.465 0.618 0.411 0.738
0.520 0.215 0.190 0.429 0.529 0.583 0.998 1.131 0.713 0.311 0.804
0.432 0.515 1.104 0.055 0.483 0.274 0.879 0.142 0.479 0.177 0.142
0.218 0.249 0.308 0.658 0.862 0.887 0.345 0.828 1.120 0.269 0.726
0.876 0.457 0.925 1.010 0.793 0.337 0.399 0.730 0.416 0.217 1.019
0.401 0.485 0.344 0.729 0.492 0.593 0.539 0.461 1.367 1.103 0.857
0.858 0.188 0.099 0.888 0.955 0.013 0.917 1.023 0.690 0.488 0.750
0.581 0.518
I105 0.495 0.592 0.777 0.966 0.232 1.004 1.340 0.931 0.879 0.534
0.546 0.656 0.831 0.976 0.898 0.862 0.789 0.939 0.299 0.775 0.418
0.314 0.759 0.667 0.482 0.499 0.719 0.946 0.639 1.047 0.738 0.859
0.400 1.046 0.148 0.836 0.852 0.466 0.545 0.762 0.852 0.618 0.371
0.486 1.057 1.020 0.734 0.393 0.345 0.285 0.302 0.290 1.066 0.445
0.825 0.584 0.409 0.919 0.867 0.665 1.125 1.055 0.579 0.938 0.993
1.024 1.000 1.072 0.407 0.329 0.458 0.763 0.232 0.426 0.787 0.352
0.267 0.630 0.964 0.431 0.480 0.971 0.582 0.624 0.941 0.702 1.034
0.664 0.646 1.113 0.200 0.426 0.445 0.433 0.906 1.209 1.145 1.296
0.717 0.740 0.818 0.411 0.344 0.917 0.002 0.566 1.038 0.468 0.212
0.337 0.441
I106 0.194 0.589 0.738 1.430 0.795 0.973 1.727 1.399 0.822 0.227
0.818 0.546 0.889 1.013 0.936 0.763 0.716 0.910 0.503 0.745 0.438
0.274 0.585 0.651 0.185 0.809 0.598 0.946 0.598 1.494 0.533 1.321
0.288 0.969 0.697 1.016 1.037 0.162 0.194 0.620 1.260 0.941 0.327
0.519 1.055 1.022 0.631 0.614 0.567 0.299 0.836 0.416 1.000 0.229
0.688 0.509 0.245 0.994 0.688 0.760 1.568 1.123 0.544 1.133 1.149
1.211 1.213 1.288 0.392 0.873 0.151 0.709 0.766 0.245 0.776 0.351
0.817 0.569 1.454 0.150 0.993 0.877 0.630 1.104 0.799 0.839 1.537
0.987 1.017 1.039 0.636 0.687 0.449 0.526 0.737 1.756 1.649 1.685
1.226 0.845 0.943 0.179 0.906 1.023 0.566 0.000 1.436 0.796 0.689
0.608 0.553
I107 1.259 0.935 0.933 0.221 0.964 0.926 0.302 0.242 0.956 1.253
0.625 1.041 0.783 0.809 0.806 1.018 0.979 0.916 0.935 0.922 1.008
1.182 1.110 0.925 1.451 0.627 1.047 0.869 0.964 0.168 1.146 0.253
1.407 1.010 1.040 0.574 0.560 1.275 1.287 1.070 0.187 0.498 1.109
0.949 0.889 0.873 1.023 0.823 0.869 1.266 1.072 1.024 0.998 1.211
1.067 1.020 1.399 0.742 1.128 0.778 0.190 0.761 0.978 0.518 0.588
0.525 0.472 0.463 1.051 0.769 1.284 0.957 0.824 1.418 0.894 1.085
0.824 0.990 0.324 1.356 0.606 1.021 0.879 0.446 1.089 0.701 0.394
0.454 0.419 1.025 0.858 0.749 1.006 0.921 1.121 0.749 0.445 0.258
0.453 0.734 0.675 1.261 0.831 0.690 1.038 1.436 0.002 0.640 0.828
0.830 0.896

I108 0.624 0.374 0.482 0.649 0.519 0.642 0.935 0.623 0.564 0.623
0.092 0.486 0.446 0.576 0.510 0.586 0.517 0.588 0.295 0.475 0.378
0.543 0.585 0.408 0.816 0.034 0.522 0.574 0.420 0.704 0.600 0.545
0.784 0.708 0.538 0.382 0.395 0.637 0.656 0.560 0.465 0.157 0.470
0.340 0.670 0.634 0.513 0.187 0.229 0.641 0.646 0.384 0.717 0.574
0.592 0.439 0.771 0.505 0.653 0.308 0.776 0.629 0.402 0.475 0.537
0.560 0.533 0.604 0.417 0.379 0.645 0.488 0.341 0.789 0.467 0.445
0.388 0.435 0.693 0.718 0.349 0.660 0.324 0.367 0.675 0.296 0.785
0.205 0.221 0.763 0.268 0.115 0.381 0.298 0.671 1.072 0.893 0.892
0.511 0.346 0.393 0.621 0.471 0.488 0.468 0.796 0.640 0.001 0.272
0.190 0.275
I109 0.564 0.506 0.670 0.769 0.262 0.872 1.130 0.735 0.767 0.587
0.359 0.597 0.685 0.825 0.752 0.767 0.693 0.812 0.248 0.666 0.389
0.415 0.705 0.569 0.650 0.305 0.652 0.809 0.556 0.845 0.699 0.660
0.588 0.927 0.267 0.652 0.666 0.554 0.610 0.696 0.641 0.413 0.407
0.417 0.914 0.877 0.657 0.267 0.245 0.454 0.385 0.302 0.942 0.509
0.748 0.529 0.588 0.760 0.800 0.525 0.923 0.891 0.509 0.747 0.808
0.832 0.803 0.872 0.401 0.202 0.553 0.664 0.105 0.606 0.669 0.381
0.169 0.557 0.777 0.575 0.304 0.863 0.477 0.428 0.853 0.542 0.854
0.457 0.435 0.989 0.059 0.266 0.408 0.358 0.831 1.070 0.966 1.086
0.539 0.587 0.652 0.514 0.271 0.750 0.212 0.689 0.828 0.272 0.000
0.210 0.352
I110 0.442 0.296 0.462 0.826 0.467 0.675 1.125 0.797 0.561 0.449
0.235 0.391 0.496 0.640 0.563 0.558 0.483 0.612 0.106 0.459 0.212
0.354 0.499 0.360 0.627 0.208 0.444 0.614 0.347 0.887 0.498 0.719
0.601 0.724 0.447 0.508 0.526 0.451 0.479 0.487 0.653 0.343 0.284
0.213 0.724 0.686 0.448 0.059 0.047 0.459 0.584 0.195 0.741 0.391
0.538 0.327 0.585 0.582 0.591 0.330 0.960 0.718 0.302 0.617 0.664
0.703 0.686 0.760 0.242 0.397 0.458 0.455 0.313 0.603 0.465 0.259
0.376 0.349 0.860 0.529 0.444 0.656 0.268 0.516 0.643 0.365 0.948
0.391 0.411 0.788 0.166 0.098 0.224 0.156 0.622 1.209 1.058 1.082
0.652 0.403 0.483 0.431 0.477 0.581 0.337 0.608 0.830 0.190 0.210
0.001 0.145
I111 0.366 0.156 0.336 0.923 0.603 0.566 1.180 0.897 0.438 0.357
0.271 0.246 0.408 0.552 0.471 0.425 0.350 0.500 0.143 0.334 0.115
0.343 0.354 0.227 0.615 0.277 0.300 0.512 0.206 0.974 0.353 0.819
0.615 0.605 0.568 0.478 0.498 0.391 0.392 0.344 0.731 0.398 0.233
0.070 0.626 0.588 0.306 0.100 0.108 0.480 0.714 0.195 0.626 0.324
0.397 0.182 0.590 0.506 0.448 0.245 1.044 0.645 0.157 0.594 0.624
0.677 0.671 0.747 0.161 0.542 0.403 0.324 0.457 0.607 0.347 0.216
0.520 0.205 0.967 0.507 0.581 0.530 0.142 0.635 0.507 0.308 1.059
0.442 0.486 0.673 0.303 0.161 0.110 0.026 0.481 1.337 1.167 1.139
0.776 0.331 0.424 0.391 0.622 0.518 0.441 0.553 0.896 0.275 0.352
0.145 0.000
;

Table Teta(KB, F) incremental cost for receiving service f times per week(beyond cost for receiving service f-1 times per week) for bin type KB

| | f1 | f2 | f3 | f4 | f5 |
|---|---|---|---|---|---|
| 2YARD | 60.55 | 17.30 | 17.31 | 17.30 | 17.31 |
| 4YARD | 73.25 | 34.61 | 34.61 | 34.61 | 34.61 |
| 6YARD | 88.72 | 51.91 | 51.92 | 51.90 | 51.92 |
| 8YARD | 103.26 | 69.22 | 69.21 | 69.22 | 69.09 |

;

PARAMETER

OMEGA(KA) monthly depreciation fee per receptacle of type KA

/

14YARD-ROLLOFF 0
20YARD-ROLLOFF 0
30YARD-ROLLOFF 0
35YARD-ROLLOFF 0
40YARD-ROLLOFF 0
14YARD-COMP 38.81
15YARD-COMP 38.81
25YARD-COMP 38.81
28YARD-COMP 38.81
35YARD-COMP 38.81
28YARD-DUAL-COMP 38.81
35YARD-DUAL-COMP 38.81

/

;

PARAMETER

d_PRIME(KA) cost uncertainty second variable

/

14YARD-ROLLOFF 79.4508
20YARD-ROLLOFF 111.7584
30YARD-ROLLOFF 298.0224
35YARD-ROLLOFF 49.6704
40YARD-ROLLOFF 133.0457
14YARD-COMP 176.5573
15YARD-COMP 164.7868
25YARD-COMP 142.4371
28YARD-COMP 70.9577
35YARD-COMP 331.136
28YARD-DUAL-COMP 310.44
35YARD-DUAL-COMP 128.952

/

d(J,KA) COST uncertainty first variable;

LOOP((J,KA),
d(J,KA)= d_PRIME(KA);
);

Parameter

```
Delta(KA) variation from midpoint
/
14YARD-ROLLOFF        30
20YARD-ROLLOFF        30
30YARD-ROLLOFF        40
35YARD-ROLLOFF        20
40YARD-ROLLOFF        50
14YARD-COMP          20
15YARD-COMP          21.43
25YARD-COMP          65
28YARD-COMP          40
35YARD-COMP          80
28YARD-DUAL-COMP      50
35YARD-DUAL-COMP      45
/
a_hat(J,KA,D1) VARIATION FROM MIDPOINT;
LOOP((J,KA,D1),
  a_hat(J,KA,D1)= Delta(KA);
);
```

- **Eta_mult.inc file:**

```
Parameter Eta_0 objective multiplier /15/;
Parameter Eta (J,KA,D1) constraint multiplier;
Eta (J,KA,D1)=0;
```

- **Maxdist.inc file:**

```
PARAMETER MAXDIST maximum allowable distance /0.25/;
```

## B.2. GAMS Code (Q_RELAXED)

```
$INCLUDE data_ROtrash_6Oct.inc
$INCLUDE Eta_mult.inc

Positive variables
V(I,J,D1) Volume of trash generated at location i on day d that is assigned to compactors and roll offs at site j
R(J, KA, D1) Volume of trash generated on day d that is assigned to compactors and roll offs at site j
Z(I, J, D1, D2) Volume of waste generated at location i on day d1 that is assigned to a dumpster at site j and serviced on day d2
```

A(J, KB, D1) Volume of trash assigned to dumpsters of type u at site j that are serviced on day d1
X(J, KB, F) Number of dumpsters at site j that are serviced at least ?f? times per week
S_0 Robust variable_1
T_0(J,KA,D1) Robust variable_2
Yr(J,KA,D1) Robust variable_3
;
Binary variables
Y(J, D1) if dumpsters at site j are serviced on day d1
P(J, F) if dumpsters at site j are serviced at least f times per week
W(I,J) if waste generated at location i is collected at site j
;
integer variables
* alternate between POSITIVE and INTEGER variable type for Q, to identify relaxation bounds
Q(J, K) Number of receptacles of type k at site j
;
Free variable
obj Total Cost
;

EQUATIONS
OBJECTIVE objective function

**********constraints**********

Const_1(I) All waste generated is serviced
Const_2(I,J,D1) volume of trash assigned equals to volume of trash generated
Const_3(J,D1) balance the total waste assigned and allocated to compactors and roll offs
Const_4(J,D2) balances the total waste assigned and allocated to dumpsters
Const_5(J,KB,D1) volume of trash assigned less than dumpsters capacity
Const_6(J) space availability
Const_7(J,D1) ensures that dumpster is only serviced on day d1 if that sire received dumpster service on that day
Const_8(I,J,D1) relate trash assigned to dumpsters to day-of-week for pickup
Const_9(I,J,D1) trash tracking 2 based on the day they are going to be serviced
Const_9_1(I,J,D1) trash tracking 2 based on the day they are going to be serviced
Const_10(I,J,D1) trash tracking 3 based on the day they are going to be serviced
Const_10_1(I,J,D1) trash tracking 3 based on the day they are going to be serviced
Const_10_FRI(I,J,D1) trash tracking 3 based on the day they are going to be serviced
Const_11(I,J,D1) trash tracking 4 based on the day they are going to be serviced
Const_11_WED(I,J,D1) trash tracking 4 based on the day they are going to be serviced
Const_11_THU(I,J,D1) trash tracking 4 based on the day they are going to be serviced
Const_11_FRI(I,J,D1) trash tracking 4 based on the day they are going to be serviced
Const_12(J) Translate the day of service each week in to the number of weekly services

Const_13(J) Translate the day of service each week in to the number of weekly services_2
Const_14(J) Translate the day of service each week in to the number of weekly services_3
Const_15(J) Translate the day of service each week in to the number of weekly services_4
Const_16(J) Translate the day of service each week in to the number of weekly services_5
Const_17(J,KB,F) compute the number of dumpsters serviced at least f times at each location
**********Robust Constraints**********
Const_18(J,KA,D1) First RO Model constraint
Const_19(J,KA,D1) Second RO Model constraint
Const_20(J,KA,D1) Second RO Model contraint_1
;
OBJECTIVE.. obj =E= SUM((J,KB,F),12*X(J,KB,F)*Teta(KB,F))+SUM((J,KA,D1),52*Pi(KA)*r(J,KA,D1)/Beta(KA))+SUM((J,KA,D1),52*r(J,KA,D1)*Phi(KA)/20)+SUM((J,KA),12*Q(J,KA)*OMEGA(KA));
Const_1(I)..SUM(J, W(I,J))=e=1;
Const_2(I,J,D1)..SUM(D2,Z(I,J,D1,D2))+V(I,J,D1)=e=Alpha(I,D1)*W(I,J);
Const_3(J,D1)..SUM(I,V(I,J,D1))=e=SUM(KA, r(J,KA,D1));
Const_4(J,D2)..SUM((I,D1),Z(I,J,D1,D2))=E=SUM(KB, A(J,KB,D2));
Const_5(J,KB,D1)..A(J,KB,D1)=L=Beta(KB)*Q(J,KB);
Const_6(J)..SUM(K,Gama(k)*Q(J,K))=L=Epsilon(J);
Const_7(J,D1)..SUM(KB, A(J,KB,D1))=L=1000000000*Y(J,D1);
Const_8(I,J,D1)..Z(I,J,D1,D1)=G=Alpha(I,D1)*Y(J,D1)-V(I,J,D1)+100000000*(W(I,J)-1);
Const_9(I,J,D1)$(ORD(D1)<5)..Z(I,J,D1,D1)+Z(I,J,D1,D1+1)=G=Alpha(I,D1)*Y(J,D1+1)-V(I,J,D1)+100000000*(W(I,J)-1);
Const_9_1(I,J,D1)$(ORD(D1)=5)..Z(I,J,D1,D1)+Z(I,J,D1,"Mon")=G=Alpha(I,D1)*Y(J,"Mon")-V(I,J,D1)+100000000*(W(I,J)-1);
Const_10(I,J,D1)$(ORD(D1)<4)..Z(I,J,D1,D1)+Z(I,J,D1,D1+1)+Z(I,J,D1,D1+2)=G=Alpha(I,D1)*Y(J,D1+2)-V(I,J,D1)+100000000*(W(I,J)-1);
Const_10_1(I,J,D1)$(ORD(D1)=4)..Z(I,J,D1,D1)+Z(I,J,D1,D1+1)+Z(I,J,D1,"Mon")=G=Alpha(I,D1)*Y(J,"Mon")-V(I,J,D1)+100000000*(W(I,J)-1);
Const_10_FRI(I,J,D1)$(ORD(D1)=5)..Z(I,J,D1,D1)+Z(I,J,D1,"Mon")+Z(I,J,D1,"Tue")=G=Alpha(I,D1)*Y(J,"Tue")-V(I,J,D1)+100000000*(W(I,J)-1);
Const_11(I,J,D1)$(ORD(D1)<3)..Z(I,J,D1,D1)+Z(I,J,D1,D1+1)+Z(I,J,D1,D1+2)+Z(I,J,D1,D1+3)=G=Alpha(I,D1)*Y(J,D1+3)-V(I,J,D1)+100000000*(W(I,J)-1);
Const_11_WED(I,J,D1)$(ORD(D1)=3)..Z(I,J,D1,D1)+Z(I,J,D1,D1+1)+Z(I,J,D1,D1+2)+Z(I,J,D1,"Mon")=G=Alpha(I,D1)*Y(J,"Mon")-V(I,J,D1)+100000000*(W(I,J)-1);
Const_11_THU(I,J,D1)$(ORD(D1)=4)..Z(I,J,D1,D1)+Z(I,J,D1,D1+1)+Z(I,J,D1,"Mon")+Z(I,J,D1,"Tue")=G=Alpha(I,D1)*Y(J,"Tue")-V(I,J,D1)+100000000*(W(I,J)-1);
Const_11_FRI(I,J,D1)$(ORD(D1)=5)..Z(I,J,D1,D1)+Z(I,J,D1,"Mon")+Z(I,J,D1,"Tue")+Z(I,J,D1,"Wed")=G=Alpha(I,D1)*Y(J,"Wed")-V(I,J,D1)+100000000*(W(I,J)-1);

```
Const_12(J)..SUM(F,P(J,F))=E=SUM(D1,  Y(J,D1));
Const_13(J)..P(J,"f2")=L=P(J,"f1");
Const_14(J)..P(J,"f3")=L=P(J,"f2");
Const_15(J)..P(J,"f4")=L=P(J,"f3");
Const_16(J)..P(J,"f5")=L=P(J,"f4");
Const_17(J,KB,F)..X(J,KB,F)=G=Q(J,KB)+100000000*(P(J,F)-1);
Const_18(J,KA,D1)..S_0+T_0(J,KA,D1)=G=d(J,KA)*Yr(J,KA,D1);
Const_19(J,KA,D1)..-Yr(J,KA,D1)=L=r(J,KA,D1);
Const_20(J,KA,D1)..r(J,KA,D1)=L=Yr(J,KA,D1);


$include  maxdist.inc

Z.FX(I,J,D1,D2)$(DIST(I,J)>MAXDIST)=0;
V.FX(I,J,D1)$(DIST(I,J)>MAXDIST)=0;
W.FX(I,J)$(DIST(I,J)>MAXDIST)=0;

MODEL trash /ALL/;
TRASH.OPTFILE  = 1;
OPTION ITERLIM  = 500000000;
OPTION RESLIM=  86400;
OPTION OPTCR=0.00;
OPTION RMIP=CPLEX;
OPTION MIP=CPLEX;
trash.HOLDFIXED=1;

SOLVE trash USING MIP MINIMIZING obj;
EXECUTE_UNLOAD  'output_Qrelax.gdx',v,r,z,a,x,y,p,w,q,obj,s_0,s,t_0,t,yr,yq;

parameters
yval(j,d1)  value  from relaxation
pval(j,f)  value  from relaxation
wval(i,j)  value  from relaxation
objval value  from relaxation;

yval(j,d1)=y.l(j,d1);
pval(j,f)=p.l(j,f);
wval(i,j)=w.l(i,j);
objval=obj.l;

EXECUTE_UNLOAD  'relaxfix.gdx',yval,pval,wval,objval;
```

### B.3. GAMS Code (Q_ Integer)

```
$INCLUDE data_ROtrash_6Oct.inc
```

$INCLUDE Eta_mult.inc

Positive variables
V(I,J,D1) Volume of trash generated at location i on day d that is assigned to compactors and roll offs at site j
R(J, KA, D1) Volume of trash generated on day d that is assigned to compactors and roll offs at site j
Z(I, J, D1, D2) Volume of waste generated at location i on day d1 that is assigned to a dumpster at site j and serviced on day d2
A(J, KB, D1) Volume of trash assigned to dumpsters of type u at site j that are serviced on day d1
X(J, KB, F) Number of dumpsters at site j that are serviced at least ?f? times per week
S_0 Robust variable_1
T_0(J,KA,D1) Robust variable_2
Yr(J,KA,D1) Robust variable_3
;
Binary variables
Y(J, D1) if dumpsters at site j are serviced on day d1
P(J, F) if dumpsters at site j are serviced at least f times per week
W(I,J) if waste generated at location i is collected at site j
;
integer variables
* alternate between POSITIVE and INTEGER variable type for Q, to identify relaxation bounds
Q(J, K) Number of receptacles of type k at site j
;
Free variable
obj Total Cost
;

EQUATIONS
OBJECTIVE objective function

**********constraints**********

Const_1(I) All waste generated is serviced
Const_2(I,J,D1) volume of trash assigned equals to volume of trash generated
Const_3(J,D1) balance the total waste assigned and allocated to compactors and roll offs
Const_4(J,D2) balances the total waste assigned and allocated to dumpsters
Const_5(J,KB,D1) volume of trash assigned less than dumpsters capacity
Const_6(J) space availability
Const_7(J,D1) ensures that dumpster is only serviced on day d1 if that sire received dumpster service on that day
Const_8(I,J,D1) relate trash assigned to dumpsters to day-of-week for pickup
Const_9(I,J,D1) trash tracking 2 based on the day they are going to be serviced
Const_9_1(I,J,D1) trash tracking 2 based on the day they are going to be serviced

Const_10(I,J,D1) trash tracking 3 based on the day they are going to be serviced
Const_10_1(I,J,D1) trash tracking 3 based on the day they are going to be serviced
Const_10_FRI(I,J,D1) trash tracking 3 based on the day they are going to be serviced
Const_11(I,J,D1) trash tracking 4 based on the day they are going to be serviced
Const_11_WED(I,J,D1) trash tracking 4 based on the day they are going to be serviced
Const_11_THU(I,J,D1) trash tracking 4 based on the day they are going to be serviced
Const_11_FRI(I,J,D1) trash tracking 4 based on the day they are going to be serviced
Const_12(J) Translate the day of service each week in to the number of weekly services
Const_13(J) Translate the day of service each week in to the number of weekly services_2
Const_14(J) Translate the day of service each week in to the number of weekly services_3
Const_15(J) Translate the day of service each week in to the number of weekly services_4
Const_16(J) Translate the day of service each week in to the number of weekly services_5
Const_17(J,KB,F) compute the number of dumpsters serviced at least f times at each location
*******Robust Constraints**********
Const_18(J,KA,D1) First RO Model constraint
Const_19(J,KA,D1) Second RO Model constraint
Const_20(J,KA,D1) Second RO Model contraint_1
;
OBJECTIVE.. obj =E= SUM((J,KB,F),12*X(J,KB,F)*Teta(KB,F))+SUM((J,KA,D1),52*Pi(KA)*r(J,KA,D1)/Beta(KA))+SUM((J,KA,D1),
52*r(J,KA,D1)*Phi(KA)/20)+SUM((J,KA),12*Q(J,KA)*OMEGA(KA));
Const_1(I)..SUM(J, W(I,J))=e=1;
Const_2(I,J,D1)..SUM(D2,Z(I,J,D1,D2))+V(I,J,D1)=e=Alpha(I,D1)*W(I,J);
Const_3(J,D1)..SUM(I,V(I,J,D1))=e=SUM(KA, r(J,KA,D1));
Const_4(J,D2)..SUM((I,D1),Z(I,J,D1,D2))=E=SUM(KB, A(J,KB,D2));
Const_5(J,KB,D1)..A(J,KB,D1)=L=Beta(KB)*Q(J,KB);
Const_6(J)..SUM(K,Gama(k)*Q(J,K))=L=Epsilon(J);
Const_7(J,D1)..SUM(KB, A(J,KB,D1))=L=1000000000*Y(J,D1);
Const_8(I,J,D1)..Z(I,J,D1,D1)=G=Alpha(I,D1)*Y(J,D1)-V(I,J,D1)+100000000*(W(I,J)-1);
Const_9(I,J,D1)$(ORD(D1)<5)..Z(I,J,D1,D1)+Z(I,J,D1,D1+1)=G=Alpha(I,D1)*Y(J,D1+1)-V(I,J,D1)+100000000*(W(I,J)-1);
Const_9_1(I,J,D1)$(ORD(D1)=5)..Z(I,J,D1,D1)+Z(I,J,D1,"Mon")=G=Alpha(I,D1)*Y(J,"Mon")-V(I,J,D1)+100000000*(W(I,J)-1);
Const_10(I,J,D1)$(ORD(D1)<4)..Z(I,J,D1,D1)+Z(I,J,D1,D1+1)+Z(I,J,D1,D1+2)=G=Alpha(I,D1)*Y(J,D1+2)-V(I,J,D1)+100000000*(W(I,J)-1);
Const_10_1(I,J,D1)$(ORD(D1)=4)..Z(I,J,D1,D1)+Z(I,J,D1,D1+1)+Z(I,J,D1,"Mon")=G=Alpha(I,D1)*Y(J,"Mon")-V(I,J,D1)+100000000*(W(I,J)-1);
Const_10_FRI(I,J,D1)$(ORD(D1)=5)..Z(I,J,D1,D1)+Z(I,J,D1,"Mon")+Z(I,J,D1,"Tue")=G=Alpha(I,D1)*Y(J,"Tue")-V(I,J,D1)+100000000*(W(I,J)-1);

```
Const_11(I,J,D1)$(ORD(D1)<3)..Z(I,J,D1,D1)+Z(I,J,D1,D1+1)+Z(I,J,D1,D1+2)+Z(I,J,D
1,D1+3)=G=Alpha(I,D1)*Y(J,D1+3)-V(I,J,D1)+100000000*(W(I,J)-1);
Const_11_WED(I,J,D1)$(ORD(D1)=3)..Z(I,J,D1,D1)+Z(I,J,D1,D1+1)+Z(I,J,D1,D1+2)+
Z(I,J,D1,"Mon")=G=Alpha(I,D1)*Y(J,"Mon")-V(I,J,D1)+100000000*(W(I,J)-1);
Const_11_THU(I,J,D1)$(ORD(D1)=4)..Z(I,J,D1,D1)+Z(I,J,D1,D1+1)+Z(I,J,D1,"Mon")
+Z(I,J,D1,"Tue")=G=Alpha(I,D1)*Y(J,"Tue")-V(I,J,D1)+100000000*(W(I,J)-1);
Const_11_FRI(I,J,D1)$(ORD(D1)=5)..Z(I,J,D1,D1)+Z(I,J,D1,"Mon")+Z(I,J,D1,"Tue")+
Z(I,J,D1,"Wed")=G=Alpha(I,D1)*Y(J,"Wed")-V(I,J,D1)+100000000*(W(I,J)-1);

Const_12(J)..SUM(F,P(J,F))=E=SUM(D1,  Y(J,D1));
Const_13(J)..P(J,"f2")=L=P(J,"f1");
Const_14(J)..P(J,"f3")=L=P(J,"f2");
Const_15(J)..P(J,"f4")=L=P(J,"f3");
Const_16(J)..P(J,"f5")=L=P(J,"f4");
Const_17(J,KB,F)..X(J,KB,F)=G=Q(J,KB)+100000000*(P(J,F)-1);
Const_18(J,KA,D1)..S_0+T_0(J,KA,D1)=G=d(J,KA)*Yr(J,KA,D1);
Const_19(J,KA,D1)..-Yr(J,KA,D1)=L=r(J,KA,D1);
Const_20(J,KA,D1)..r(J,KA,D1)=L=Yr(J,KA,D1);

$include  maxdist.inc

Z.FX(I,J,D1,D2)$(DIST(I,J)>MAXDIST)=0;
V.FX(I,J,D1)$(DIST(I,J)>MAXDIST)=0;
W.FX(I,J)$(DIST(I,J)>MAXDIST)=0;


parameters
yval(j,d1)  value  from relaxation
pval(j,f)  value  from relaxation
wval(i,j)  value  from relaxation
objval value  from relaxation
;

$Gdxin  relaxfix
$load yval pval wval objval
$Gdxin

MODEL trash /ALL/;
TRASH.OPTFILE  = 1;
OPTION ITERLIM  = 500000000;
OPTION RESLIM=  86400;
OPTION OPTCR=0.00;
OPTION RMIP=CPLEX;
OPTION MIP=CPLEX;
trash.HOLDFIXED=1;
```

```
SOLVE trash USING MIP MINIMIZING obj;
EXECUTE_UNLOAD  'output_Qinteger.gdx',v,r,z,a,x,y,p,w,q,obj,s_0,s,t_0,t,yr,yq;
```