University of Stellenbosch

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The location of the routine laboratory

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Declaration

I, the undersigned, hereby declare that the work contained in this thesis is my own original work and has not previously in its entirety or in part been submitted at any university for a degree.

Ek, die ondergetekende verklaar hiermee dat die werk gedoen in hierdie tesis my eie oorspronklike werk is wat nog nie voorheen gedeeltelik of volledig by enige universiteit vir 'n graad aangebied is nie.

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Opsomming

Inleiding

In die afgelope 50 jaar het daar wêreldwyd groot, gesentraliseerde fasiliteite tot stand gekom wat kliniese laboratoriumdienste teen 'n relatiewe lae koste per toets aan die gesondheidsorgmark verskaf het. In Suid-Afrika was daar die amalgamasie van drie onafhanklike geïnkorporeerde patologie praktyke (Drs. du Buisson & Vennote, Drs. Bruinette, Kramer & Vennote en Dr. Bouwer & Vennote) wat deur die samesmelting van hulle volumes (omsette) en nasionale netwerke ekonomieë van skaal en omvang wou bewerkstellig. Patologie laboratoriums staar twee teenoorgestelde uitdagings in die gesig. Aan die eenkant van die skaal is daar die verhoogde verwagtings van die kliënte wat gebruik maak van die laboratoriums, en aan die ander kant is daar die befondsers wat die laboratoriumdiens teen 'n laer koste wil hê sonder om kwaliteit nadelig te beïnvloed.

Die voordele wat verkry is deur roetine toetse in perifere laboratoriums te doen, is besig om minder aantreklik te word namate die koste daaraan verbonde om die dienste te verskaf toeneem. Deur die heringenieurswese van die laboratoriumorganisasie, raak dit al hoe meer moontlik om die roetine toetse te sentraliseer en om sodoende die koste te verlaag.

Klassifikasie van die diens

Die rede waarom 'n toets aangevra word bepaal die verlangde omdraaityd vir resultering. Die omdraaityd vorm die basis vir die klassifikasie van die diens, en dit is belangrik om die omdraaityd in gedagte te hou wanneer daar besluit moet word of 'n toets gesentraliseer kan word al dan nie. Toetse wat 'n omdraaityd, tyd vandat die monster gekollekteer is totdat die resultaat beskikbaar is, van minder as 30 minute verlang, word as 'n **spoed** toets geklassifiseer. Toetse wat nie benodig word vir die onmiddellike diagnosering van 'n pasiënt se toestand nie, en wat 'n omdraaityd van langer as 6 ure vereis, word as 'n **roetine** toets geklassifiseer. Toetse met 'n verlangde omdraaityd van tussen 30 minute en 6 ure word as **dringende** toetse geklassifiseer.

Tendense in die diagnostiese bedryf

Teen 'n totale koste van meer as R50 miljoen, vir 'n laboratorium met 'n grootte van tussen 6 000 en 10 000 pasiënte per dag, is totale laboratorium outomatisasie (TLA) onbekostigbaar. Aanpasbare outomatisasie maak dit vir die private patologie laboratorium moontlik om die verwagte koste besparing in die kort-, medium- en lang termyn te behaal.

Aanpasbare outomatisasie behels die **konsolidering** van meer as een analisator in 'n enkele werksel wat ontwerp is om meer werk (volumes en verskeidenheid) teen 'n hoër spoed met minder reagense, verbruikbare items en arbeid te verrig. Hierdie werkselle is hoë deurset analisators wat hoë volumes benodig om die voordele te benut waarvoor hulle ontwerp is. **Moduliriteit** en **skaalbaarheid** sal verseker dat daar aan die ruimte, volume en menu vereistes van individuele laboratoriums (gesentraliseerd en gedesentraliseerd) voldoen sal word. **Pendelbare** resultate verseker dat dieselfde toetse wat op verskillende analisators gedoen is se resultate uniform verstaan en geinterpreteer sal word.

Algemene laboratoriums, soos hulle vandag bestaan, is onder druk van gefokusde lae koste laboratoriums wat selfs internasionaal kan wees. Met die fokus op diens (veral omdraaityd) het laboratoriums in die verlede teen groot koste gedesentraliseer. Daar is vandag 'n hernieude dryfkrag na minder verskaffers wat die voordele van standaardisasie, makliker administrasie, beter kwaliteit, meer aantreklike prysbeleid, ensovoorts sal verskaf.

Desentralisasie versus sentralisasie

Desentralisasie lei tot die duplisering van infrastruktuur, ondersteuningsdienste, toerusting en bestuur. Daar is 'n plek vir desentralisasie in die patologie toetsmatriks, hoofsaaklik as gevolg van operasionele en nie finansiële beperkings nie. Geografiese isolasie, mark vereistes as gevolg van kompeterende kragte en die aard van die toetse verlang, is faktore wat sal lei tot die stigting van 'n gedesentralisaerde laboratorium. Een voordeel van desentralisasie is die moontlike verlaging in omdraaityd. 'n Addisionele voordeel is die strategiese of kompeterende voordeel wat 'n nasionale of internasionale netwerk verskaf.

In teenstelling met die bogenoemde word die volgende voordele geassosieer met die sentralisasie van die roetine laboratorium aktiwiteite:

- Lae veranderlike, inkrementele, en proses beheer koste per toets.
- Laer totale bedryfskoste.
- Laer totale fout tempo in 'n operateur neutrale en geoutomatiseerde omgewing.
- Kwaliteitsverbetering filosofie.
- Operasionele en administratiewe voordeel van gesentraliseerde bestuur.
- Beter en makliker kommunikasie.

Die vier vlak strategie wat voorgestel word in die *Witskrif vir die Transformasie van die Gesondheidsorgstelsel in Suid-Afrika* is niks anders as die gesentraliseerde laboratoriumdiens wat voorgestel word in die literatuur nie, en die belangrikheid hiervan kan gesien word in die wêreldwye tendense van die diagnostiese bedryf. Patologie laboratoriums (openbaar en privaat)

moet ag slaan op die koste druk en kompeterende druk, of hulle moet hulself gereed maak vir die erodering van hulle markaandeel deur ander laboratriums wat reeds die weerstand teen sentralisasie oorkom het. Die enigste risiko wat geassosieer kan word met die sentralisasie van roetine toetse is die verlies in politieke mag van individuele patoloë en laboratorium bestuurders. Die fokus moet nie soseer wees op die koste van sentraliasie nie, maar eerder op die koste verbonde aan nie-voldoening.

Koste struktuur

In Suid-Afrika het die potensiële verlaging in operasionele koste, deur die amalgamasie van groot onafhanklike praktyke, nog nie gerealiseer nie. Eerstens is daar die devaluasie van die Rand teen die ander internasionale geldeenhede. Aangesien die verskaffers van patologiedienste baie afhanklik is van invoere (toerusting, verbruikbare items en reagense) het die devaluasie van die Rand 'n aansienlike impak gehad op die koste beperking strategieë en winsgewindheid. Tweedens, Suid-Afrika het 'n inflasiesyfer van net onder 6% wat veroorsaak dat die salarisrekening van die patologie laboratorium jaarliks beduidend styg. Die effek hiervan is groot as in gedagte gehou word dat die salarisrekening 38% uitmaak van die totale kostes. Derdens, as gevolg van die kompleksiteit van die patologie omgewing en ook as gevolg van historiese redes sal dit baie moeilik wees vir die patologie bedryf om van binne te verander. 'n Paradigma skuif in die manier waarop patologiedienste verskaf word is nodig om die langtermyn winsgewindheid te verseker.

Gelykbreekpunt vir roetine toetse

Dit is duidelik dat die laboratriumbestuur in die algemeen nie weet wat dit kos om sekere roetine toetse uit te voer nie. Die redes hiervoor is veelvoudig van aard en kan soos volg opgesom word:

- In die verlede was die klem op volumes en omset eerder as op die winsgewindheid van die toetse wat gedoen word.
- Die patologie organisasie is dikwels nie gestruktureer in besigheidseenhede nie.
- Die inligting wat nodig is om die winsgewindheid van toetse te bereken is óf nie beskikbaar nie óf dit kan nie verkry word van die LIS in 'n formaat wat verstaanbaar is vir die laboratoriumbestuurder nie.
- Dikwels is die laboratriumbestuurder 'n mediese tegnoloog sonder enige formele opleiding of ondervinding in finansiële bestuur en kosterekening prosedures.

'n Gelykbreek analise van die direkte reagenskoste vir 5 roetine toetse het daarop gewys dat die geselekteerde toetse selde winsgewind gedoen kan word in die perifere laboratoriums.

Implementering

Die voordele van sentralisasie kan bereik word deur een van twee scenarios te volg. Eerstens, elkeen van die drie bestaande stadsregionale laboratoriums (Johannesburg, Pretoria en Durban) kan optree as verwysingslaboratoriums vir die roetine werk van die areas waarin hulle geleë is. Spesialiswerk sal dan van een stadsregionale laboratorium na 'n ander een gestuur word om die volumes te verhoog sodat ekonomieë van skaal bewerkstellig kan word. Tweedens, een sentrale roetine laboratorium sal optree as verwysingslaboratorium vir alle roetine patologie toetse.

Hierdie twee scenarios is geëvalueer aan die hand van die tegnologie, infrastruktuur, hulpbron, logistiek, kommunikasie, politieke en strategiese beperkings wat inherent deel is van die patologie organisasie. Vir die evaluasie van die scenarios is daar aan elkeen van die beperkings 'n gewig toegeken wat 'n aanduiding is van die relatiewe belangrikheid van die beperking. Hierdie scenario's is ook geëvalueer teen die besigheidsrisiko's, finansiële risiko's, versekerbare risiko's en kliniese risiko's wat betrokke is by die dag-tot-dag funksionering van die patologie laboratoriums.

'n Tabel is opgestel wat aangedui het dat die tweede scenario, waar 'n enkele sentrale roetine laboratorium gebruik word, verkies word bo die huidige scenario van drie stadsregionale laboratoriums. Al die tekortkominge van die tweede scenario teenoor die eerste scenario kan oorkom word deur gebruik te maak van toepaslike tegnologie en behoorlike beplanning. Versekeringsprodukte kan die probleme rondom die strategiese risikos, wat geassosieer word met natuurlike rampe, aanspreek.

'n Tweerigting benadering is gevolg om die beste ligging te bepaal vir die roetine patologie laboratorium. Eerstens is 'n eenvoudige netwerk, bestaande uit slegs 4 punte (regionale model), gebruik om die probleem te konseptualiseer. Tweedens is netwerk- en grafiekteorie gebruik om die totale netwerk, wat bestaan uit die 22 laboratorium streke, op te los.

Regionale model

Die twee stadsregionale laboratoriums in Johannesburg en Pretoria, sowel as die laboratorium in Kempton Park, vorm die hoeke van die driehoek wat die netwerk verteenwoordig. Hierdie is die bestaande fasiliteite wat die sentrale roetine laboratorium kan akkommodeer. Midrand vorm die vierde punt en is geleë op die lyn wat Johannesburg en Pretoria met mekaar verbind. Die totale maandelikse pasiënt getalle vir elke punt is gedeel deur 1 000 om 'n gewig toe te ken, wat 'n aanduiding is van die relatiewe belangrikheid van elke punt. Die totale maandelikse pasiënt volumes vir Pretoria, Johannesburg en Kempton Park is 75 116, 37 789 en 73 346 onderskeidelik.

Die koste daaraan verbonde om monsters te kollekteer, van enige punt in die netwerk na 'n sentrale punt, is 'n funksie van die produk van werklike afstand na die punt van waar die monsters gekollekteer word, en die gewig van die punt van waar die monsters gekollekteer word. Die totale koste vir die kollektering van monsters vanaf alle punte in die netwerk na 'n sentrale punt is gelyk aan die som van die bogenoemde produkte vir alle punte in die netwerk. Die totale koste, bereken volgens die metode hierbo, dui daarop dat Kempton Park die beste ligging het vir 'n sentrale roetine laboratorium. Midrand sal die tweede beste ligging hê met 'n totale koste wat 2% hoër is as die van Kempton Park. Die totale kollekteringskoste van Johannesburg (52%) en Pretoria (22%) is baie hoër as die koste by Kempton Park en Midrand.

'n Sensitiwiteitsanalise is gedoen om die invloed van die pasiënte getalle by elke punt, en die effek van die verkeer deur Midrand, te beoordeel. Die sensitiwiteitsanalise het daarop gewys dat 'n vermindering in die pasiënte getalle by Kempton Park die skaal ten gunste van Midrand sal swaai. Die waarskynlikheid dat die volumes by Kempton Park sal verhoog is egter hoër aangesien werk moontlik vanaf Durban en Kaapstad ingevlieg sal word. 'n Relatiewe klein toename in die pasiënte getalle van Pretoria sal ook die skaal ten gunste van Midrand swaai. Die waarskynlikheid hiervan is egter baie klein as gevolg van die toenemende kompetisie in die mark wat reeds versadig is. Slegs indien die pasiënte getalle in Johannesburg drasties verhoog sal die skaal ten gunste van Midrand swaai. Wanneer die verkeersdigthede in berekening gebring word, word die haalbaarheid van Midrand as ligging negatief beïnvloed.

Netwerk- en grafiekteorie

Netwerk- en grafiekteorie het 'n wye toepassing in die oplos van liggingsprobleme. Daar is toe besluit dat dit ook gebruik sal word in die ondersoek na die optimale ligging van die sentrale roetine patologie laboratorium. 'n Uitgebreide studietoer deur Duitsland en die VSA het aangetoon dat gevorderde algoritmes selde, indien ooit, gebruik word in die evaluasie van die ligging van patologie laboratoriums.

Die moontlike liggings van die sentrale laboratorium is aangedui deur hoekpunte ("vertices"). 'n Enkele hoekpunt is gebruik om die moontlike ligging aan te dui in areas waar Ampath deur meer as een laboratorium verteenwoordig word. Die volgende twee redes ondersteun die aanname:

- In die meeste streke is die laboratoriums naby aan mekaar geleë aangesien die ligging van laboratoriums afhanklik is van die ligging van hospitale, klinieke, spreekkamers van dokters en spesialiste, ensovoorts.
- Wanneer roetine laboratoriumtoetse gesentraliseer word sal beide laboratoriums hulle werk na dieselfde sentrale fasiliteit stuur. Aangesien die afstand van die perifere laboratoriums na

die sentrale laboratorium baie groter is as die afstand tussen die perifere laboratoriums, in 'n bepaalde streek, sal die resultaat van die model nie beduidend beïnvloed word nie.

Die 22 laboratoriums wat die hoekpunte van die grafiek vorm is die Brits-, Rustenburg- Pretoria-, Potgietersrus-, Pietersburg-, Tzaneen-, Louis Trichardt-, Midrand-, Krugersdorp- Johannesburg-, Kempton Park-, Boksburg-, Benoni-, Witbank-, Middelburg-, Nelspruit-, Potchefstroom-, Alberton-, Germiston-, Trichardt-, Springs- en Ermelo laboratoriums.

Hierdie hoekpunte is met mekaar verbind deur middel van lyne waarna verwys word as koorde ("edges"). Aangesien ons net belangstel in die eindpunte van die koorde – verkeer kan in beide rigtings beweeg – is die grafiek 'n ongerigte grafiek. Die lengte van die koorde wat gebruik word in die model is gelyk aan die werklike afstand tussen die hoekpunte.

Verskillende grootte populasies word verteenwoordig deur elkeen van die hoekpunte en daarom is dit belangrik dat hulle relatiewe belangrikheid aangedui word deur 'n gewig. Die gemiddelde aantal pasiënte per maand wat by elke hoekpunt 'n oorsprong het, is gebruik as 'n aanduiding van die hoekpunt se relatiewe belangrikheid.

Klassifikasie van die liggingsprobleem

Die **potensiële ligging** van die sentrale fasiliteit kan teoreties op die hoekpunte of op die koorde van die netwerk wees. Die ondersteuningsdienste waarop die roetine laboratorium staat maak sluit die verskaffers, betroubare elektrisiteits- en waterbronne, telefone, store, ensovoorts in. Aangesien hierdie ondersteuningsdienste gewoonlik by die hoekpunte gelee is, is daar besluit dat die sentrale fasiliteit ook hier gelee moet wees. Die **aanvraag** vir gesondheidsdienste (hospitale, kliniekе, spreekkamers, ens.) is gewoonlik ook by die hoekpunt gelee.

Eerstens, as 'n gesondheidsdiens of nooddiens, sal die **doelwitfunksie** wees om die maksimum reiskoste te minimeer. Laasgenoemde is nodig sodat daar aan die perifere laboratorium 'n diens met die beste moontlike omdraaityd gelewer kan word. Tweedens, vir 'n sentrale roetine patologie laboratorium, sal die kostedruk wat uitgeoefen word deur 'n veranderende gesondheidssorg omgewing vereis dat die totale koste geminimeer word. Aangesien beide die ligging en die aanvraag by die hoekpunt voorkom is dit nodig om die senter en die mediaan te bereken.

Berekening van die middelpunt en die mediaan

Die middelpunt is die hoekpunt in die netwerk wat so geleë is dat die hoekpunt wat die verste van hom geleë is, so naby as moontlik is. Die mediaan is die hoekpunt wat so geleë is dat die totale afstand na al die ander hoekpunte in die netwerk, 'n minimum is.

Die kortste-afstand-matriks is bereken deur van Floyd se kortste-afstand algoritme gebruik te maak. Daar is voorsiening gemaak vir die gewigte van elke hoekpunt deur elke kolom in die kortste-afstand-matriks te vermenigvuldig met die gewig van die ooreenstemmende hoekpunt. Die resultaat is 'n geweegde kortste-afstand-matriks wat gebruik kan word in die berekening van die middelpunt en die mediaan.

'n Excel sigblad is gebruik om die middelpunt en mediaan te bereken. Die mediaan het bykans geen verskil – die verskil was slegs 0,1% - getoon tussen die eerste twee hoekpunte, naamlik Midrand en Kempton Park nie. Die berekeninge het aangetoon dat Kempton Park (4% beter as Midrand) by die middelpunt geleë is.

Kwalitatiewe analise

Met die keuse van 'n ligging vir die sentrale roetine laboratorium het die kwalitatiewe analise daarop gewys dat Kempton Park beter geleë is as Midrand. Die volgende redes kan hiervoor aangevoer word:

- Kempton Park voorsien maklike toegang tot die padinfrastruktuur (N1, N3, N12, N17, R21, R24 en R28) wat die hoofslagaar vorm vir die kollekteringsdiens.
- Die laboratorium personeel (tegnoloë en tegnici) is as 'n reël meer mobiel as die nie-tegniese personeel en daarom nie so afhanklik van openbare vervoer nie.
- Kempton Park is minder as 5 kilometer vanaf die Johannesburg Internasionale Lughawe, wat die hoogste frekwensie van inkomende binnelandse vlugte het, geleë. Dit sal verseker dat 'n omdraaityd van minder as 24 uur gewaarborg kan word.
- In Kempton Park kan addisionele vloerspasie aangeskaf word teen minder as 50% van die koste in Midrand.
- Die fasiliteit in Kempton Park (Pomona) is minder as twee jaar oud en is spesifiek ontwerp as 'n laboratorium.
- 'n Groot persentasie van die inkomende logistiek behels die verskaffing van reagense en analisators. Die aflewering hiervan geskied direk vanaf die lughawe en daarom kan goeie leitye verseker word.

Gevolgtrekkings en aanbevelings

Die toekomstige tendense sluit in die totstandkoming van groter gesentraliseerde patologie laboratoriums, wat besit word deur gesondheidssorggroepe, eerder as die huidige opset waar patoloë tradisioneel die enigste aandeelhouers in die laboratoriums is. Nieteenstaande die baie voordele daaraan verbonde om roetine patologietoetse te sentraliseer sal daar altyd plek wees in die patologie toetsmatriks vir gedesentraliseerde toetse.

Die sterk tyd, koste en kwaliteit druk het 'n baie belangrike invloed op laboratoriums gehad. Eerstens beinvloed die finansiële druk die aantal en tipe toetse wat aangevra word. Dit sal toenemend lei tot 'n vermindering in die inkomste van patologie laboratoriums. Tweedens, ten spyte van hierdie kostedruk is pasiënte baie meer ingelig en vereis hulle 'n beter diens, beide in terme van omdraaityd en verhoogde inligtingsvereiste van die verslag.

Hierdie vereistes sal veroorsaak dat die bestuurders van patologie laboratoriums onder druk bly:

- Hulle sal hulle vaste en veranderlike koste moet verlaag. As gevolg van die relatiewe hoë vastekoste tot veranderlike koste verhouding is dit baie moeilik vir gedesentraliseerde laboratoriums om baie van die roetine toetse winsgewind te doen. Ekonomieë van skaal kan behaal word deur hierdie roetine toetse te sentraliseer.
- Hulle sal moet verseker dat hulle omdraaityd binne aanvaarbare grense bly.
- Hulle sal hulle laboratoriums moet akkrediteer om te verseker dat hulle voldoen aan die internasionale standaarde, met betrekking tot patologie laboratoriums, om sodoende nie-analitiese bronne van foute te elemineer.
- Hulle sal stelsels moet installeer wat vinnig aan die veranderende behoeftes van die mark kan voldoen. Sodoende sal hulle hul ratspasbaarheid verseker in 'n vinnig veranderende diagnostiese omgewing.

Aangesien totale laboratorium outomatisasie baie duur is, moet die heringenieurswese van die sentrale roetine laboratorium gefokus wees op aanpasbare outomatisasie, om sodoende die vereiste besparing op die kort, medium en lang termyn teweeg te bring.

Sentralisasie sal aan die roetine patologie laboratorium die volgende voordele verskaf:

- Lae veranderlike, inkrementele, en prosesbeheerkoste per toets.
- Lae totale fout tempo in 'n operateur neutrale en geoutomatiseerde omgewing.
- Kwaliteitsverbeterings filosofie.
- Operasionele en administratiewe voordele van sentrale bestuur.
- Makliker kommunikasie in 'n gesentraliseerde laboratorium omgewing.

Die berekening van die middelpunt en mediaan vanaf die kortste-afstand-matriks, met behulp van Floyd se kortste-afstand algoritme, van die laboratorium netwerk het daarop gewys dat die sentrale roetine patologie laboratorium in Kempton Park gelee moet wees. Hierdie aanbeveling word ondersteun deur 'n aantal faktore wat in berekening gebring is met die kwalitatiewe analise:

- Minder as 25% van Ampath se totale omset kom van buite Gauteng.
- Hierdie perseel is in die nabyheid (minder as 5 kilometer) van die Johannesburg Internasionale Lughawe wat die hoogste frekwensie van inkomende binnelandse vlugte het.
- Hierdie perseel verskaf maklike toegang tot die padinfrastruktuur wat die hoofslagaar vorm van die kollekteringsstelsel.
- Die huidige fasiliteit is 'n goed ontwerpte laboratorium met genoeg spasie om uit te brei met 'n toename in pasiënte getalle. Die uitbreiding kan hier geskied teen 'n relatiewe lae koste in vergelyking met ander persele.
- Die meeste van die hoof verskaffers van diagnostiese produkte se hoofkantore is in Gauteng en dit verseker kort leitye vir toerusting, reagense en verbruikbare items.

Synopsis

Introduction

The past 50 years have seen the world-wide establishment of large and centralised facilities providing clinical laboratory services at a relatively low cost per test to the health care market. In South Africa there has been the amalgamation of three independent pathology groups (Drs. du Buisson & Partners, Drs. Bruinette, Kramer & Partners and Drs. Bouwer & Partners) to utilise their combined volumes and regional networks to achieve economies of scale and scope. These pathology laboratories face the opposing challenges of increased expectations from professionals using the laboratory and the drive from the funders of health care that demand a fast and accurate service at a lower cost.

The advantages of value adding by performing routine testing at the peripheral sites are declining as the cost of providing this service increases. Through the re-engineering of the organisation and the integration of the physical and virtual value chain it is becoming increasingly possible to centralise the routine pathology tests in order to contain the cost of producing these results.

Service classification

The reason why a specific test is requested by the medical professional determines the required TAT (turn-around-time). The TAT forms the basis for the classification of the service and is important in determining whether a test can be centralised. Tests that require a TAT of no more than 30 minutes, from the time the specimen is collected, are called STAT tests. Tests that are not needed for the immediate diagnosis of the patient's condition and that require a TAT of longer than 6 hours are called routine tests. Tests that require a TAT of between 30 minutes and 6 hours are called urgent tests.

Trends in the diagnostic industry

At a cost of more than R50 million, for a laboratory doing between 6 000 and 10 000 patients per day, TLA (Total Laboratory Automation) is too expensive. Flexible automation is providing the private pathology laboratories with the means to achieve the expected cost saving in the short-, medium- and long term.

Flexible automation is the concept of **consolidating** multiple analysers into single workcells that are designed to do more work (volumes and menus) at higher speeds with less reagents, consumables and labour. These workcells are high throughput analysers that require high

volumes to achieve the advantages for which they are designed. **Modularity** and **scalability** will ensure that space, volume and menu requirements of individual laboratories (centralised and decentralised) are met. **Commutable** results will ensure that tests done on different analysers will have results that can be uniformly understood and interpreted.

Generalist laboratories as we know them today are under threat from focused low-cost laboratories, which might or might not be international. With the focus on service the pathology laboratories have in the past decentralised at great cost. There is a renewed drive to fewer suppliers that will provide the advantages of standardisation, easier administration, better quality, more attractive pricing policies, etc.

Decentralisation versus centralisation

Decentralisation leads to the duplication of infrastructure, support services, equipment and management. There is place for decentralisation in the pathology-testing matrix mainly due to operational requirements and not financial constraints. Geographical isolation, market demands due to competitive forces and the nature of the testing required are factors that will lead to the establishment of a decentralised laboratory. Decentralisation does however provide the advantage of a decrease in TAT that can lead to a strategic or competitive advantage through the provision of a national or international network.

In contrast to the above mentioned, centralisation will provide the following advantages:

- Low variable, incremental, and process control cost per test.
- Lower total operating cost.
- Low total error rate in an operator neutral and automated environment.
- Quality improvement philosophy.
- Operational and administrative advantages of centralised management.
- Better and easier communication.

The four level strategy proposed in the *White Paper for the Transformation of the Health System in South Africa* is nothing less than the centralised laboratory service proposed by the literature and the importance of this can be seen in the trends of the diagnostic industry world-wide. Pathology laboratories (public and private) must comply with the cost and competitive pressures or face the erosion of their market share by other laboratories that have overcome the resistance to centralisation. The only risk associated with the centralisation of routine testing is the loss in political power by individual pathologist and laboratory managers. It is not the cost of centralisation that should be the focus of the debate, but rather the cost of not complying to the cost pressures.

Cost structure

In South Africa the potential reduction in operating cost through the amalgamation of large independent practices has not yet materialised. Firstly, there is a continuous devaluation of the Rand against other international currencies with no prospect of any change in this trend. Since the providers of pathology services are heavily dependent on imports (equipment, consumables and reagents) the devaluation of the Rand has had a negative impact on their cost containment strategies and therefore their profitability. Secondly, South Africa experiences an inflation rate of just below 6%, which ensures that the pathology service providers are faced with an ever increasing salary bill (38% of total cost). Thirdly, due to the complexity of the pathology environment and historic reasons it will be very difficult for the pathology practices to change from within. A paradigm shift in the way pathology services are provided is therefore necessary to ensure their long term viability.

Break-even point for routine testing

It is obvious that the laboratory management in general does not know the cost involved in performing certain routine tests. The reasons for this situation are numerous and can be summarised as follow:

- In the past there has been an emphasis on patient volumes and turnover rather than on the profitability of the tests that are performed.
- The pathology organisations are often not structured in business units.
- The information necessary to calculate the profitability of the tests are either not available or cannot be retrieved from the LIS (Laboratory Information System) in a format that can be understood by the laboratory manager.
- Often the laboratory manager is a medical technologist without any formal training or experience in financial management and costing procedures.

A break-even analysis of the direct reagent cost for a sample of 5 routine tests has indicated that the selected tests can seldom be performed profitably at the peripheral laboratories.

Implementation

The advantages of centralisation can be achieved by following one of two scenarios. Firstly, each one of the existing three city regional laboratories (Johannesburg, Pretoria and Durban) could act as a reference laboratory for the routine work in the regions in which they are located. Specialised work would be sent from one city regional laboratory to another to achieve economies of scale by combining their volumes. Secondly, one central routine laboratory in Gauteng could act as reference laboratory for all the routine pathology tests.

These two scenarios were evaluated with reference to the technology, infrastructure, resource, logistics, communication, political and strategic constraints that are inherent to the organisation. For the evaluation of the scenarios each one of the constraints were assigned a weight that is an indication of its relative importance. These scenarios were also evaluated against the business, financial, insurable and clinical risks involved with the day to day functioning of pathology laboratories.

. weighted table has indicated that the second scenario, in which a central routine laboratory will be used, is preferred to the existing scenario of three city regional laboratories. All the problems associated with scenario two as apposed to scenario one can be overcome with the selection of suitable technology and proper planning. Insurance products will address the issue of strategic risk associated with natural disasters.

A two-way approach was used to find the best location for the routine pathology laboratory. Firstly, a simple network consisting of only four points (regional model) was used to conceptualise the problem. Secondly, network and graph theory was used to solve the complete network representing the 22 laboratory regions of the Ampath pathology network.

Regional model

The two city regional laboratories in Johannesburg and Pretoria as well the Pomona laboratory in Kempton Park form the corners of the triangle of this network since they are the existing facilities that are best suited to accommodate a central routine laboratory. Midrand forms the fourth point and is located on the line connecting Johannesburg and Pretoria. The total monthly patient volume for each facility was divided by 1000 to obtain a weight representative of it relative importance. The total monthly patient volumes for Pretoria, Johannesburg and Kempton Park are 75 116, 37 789 and 73 346 respectively.

The cost of collecting specimens from any point in the network to a specific point is a function of the product of the actual distance to that point from which the specimens are collected and the weight of that point from which the specimens are collected. The total cost of collecting specimens from all points in the network to a central point is the sum of the above mentioned products for all points in the network. According to this total cost method the best location for the central facility will be at Kempton Park. Midrand will be second best with a total cost that is 2% higher than that of Kempton Park. The total collection cost at Johannesburg (52%) and Pretoria (22%) will be much higher than that of Kempton Park and Midrand. Since the fairness of the

allocation of patients (weights) to the points could be questioned it was necessary to do a sensitivity analysis.

The sensitivity analysis addressed the varying of the patient volumes and the effect of the traffic through Midrand. The results showed that a reduction in the number of patients at Kempton Park would tip the balance in favour of Midrand. The chances are actually better that the patient volumes at Kempton Park will increase due to the possibility of work being flown in from other major laboratories in Cape Town and Durban. A fairly small increase in the patient volumes at Pretoria will change the result in favour of Midrand. It is however very unlikely that there will be any significant rise in the patient volumes due to fact that Drs. du Buisson & Partners, is percentage wise, the strongest pathology practice in the region with very little scope of increasing its market share. If the patient volume at Johannesburg is increased significantly it will change the decision in favour of Midrand. By bringing the traffic densities into the equation the feasibility of Midrand as location is reduced quite significantly.

Network and graph theory

Since network and graph theory has a wide application in the solution of location problems it was decided that it would also be used for the investigation into the location of the central routine pathology laboratory. An extensive visit to laboratories in Germany and the United States showed that advanced algorithms are seldom, if ever, used in establishing or evaluating the location of pathology laboratories.

The possible locations for the central laboratory were represented by vertices. A single vertice was used to represent the possible location in areas where Ampath was represented by more than one laboratory. This a valid assumption for two reasons:

- In most regions the laboratories are located in close proximity, since the location of pathology laboratories are dependent on the location of hospitals, clinics, physician's offices, specialist's offices, etc.
- In centralised routine laboratory testing both laboratories will send their work to the same central facility. Since the distance from the peripheral laboratories to the central laboratory is much greater than the distance between the peripheral laboratories in the region the model will not be influenced significantly.

The 22 laboratories forming the vertices of the graph are the Brits-, Rustenburg-, Pretoria-, Potgietersrus-, Pietersburg-, Tzaneen-, Louis Trichardt-, Midrand-, Krugersdorp-, Johannesburg-, Kempton Park-, Boksburg-, Benoni-, Witbank-, Middelburg-, Nelspruit-, Potchefstroom-, Alberton-, Germiston-, Trichardt-, Springs- and Ermelo laboratories.

These vertices are connected by lines referred to as edges. Since we are only concerned with the end points of each edge - traffic can move in any direction between the vertices - the resultant graph is an undirected graph. The length of the edges used in the model are equal to the actual travel distance between the points.

Since different size populations are represented by each of these vertices it is important that their relative importance in the network will be indicated by assigning a weight to every vertice. The average number of patients per month originating from each vertice was used as an indication of their relative importance.

Classification of the location problem

The **potential location** of the facility could theoretically be on the vertex or anywhere on the network. The support services that the routine laboratory must rely on include suppliers, reliable power and water supply, telephones, warehousing, etc. As these are usually located at the vertices, it was decided that the facility should also be located at the vertice.

The **location of demand** for the health services (hospitals, clinics, physician's offices, etc.) are more likely to be found on the vertices as it will tend to service higher density populations.

Firstly, as a health service or an emergency service, the **objective function** will be to minimise the maximum travel cost. This is necessary in order to provide the peripheral laboratory with the best possible TAT. Secondly, for a central routine pathology laboratory the cost pressure exercised by a changing health care environment creates the need to minimise the total maximum cost. Since both the location and the demand occur at the vertices in this model it is necessary to calculate the centre and the median for this problem.

Calculation of centre and median

The centre is that vertice in the network that is located in such a way that the vertice in the network that is the furthest away from it is as close as possible. The median is that vertice in the network that is located in such a way that the total distance to all the other vertices in the network is a minimum.

The shortest distance matrix was calculated by using Floyd's shortest-path algorithm. To allow for the weights, every column in the shortest distance matrix is multiplied by the weight of the corresponding vertice. The result is a weighted shortest distance matrix that can be used in the calculation of the median and centre.

An Excel spreadsheet was used to calculate the median and centre. The median showed no difference between the first two vertices, namely Midrand and Kempton Park, with a difference of only 0.1 percent. The centre is much more clear-cut with Kempton Park being more than 4% better than Midrand. These answers were not surprising keeping in mind the results of the regional model.

Qualitative analysis

A qualitative analysis of Midrand and Kempton Park has shown that the latter would be the most suitable location for the routine pathology laboratory. The main reasons for this are:

- Kempton Park provides easy access to the road infra structure (N1, N3, N12, N17, R21, R24 and R28) that form the arteries for the courier network.
- The laboratory technologists and technicians are as a rule more mobile than the non-technical staff and not so dependent on public transport.
- The Kempton Park laboratory is less than 5 kilometres from the Johannesburg International Airport that has the highest frequency of incoming domestic flights and will ensure a TAT of less than 24 hours.
- In Kempton Park additional floor space can be acquired at less than 50% of the cost of equivalent floor space in the Midrand area.
- The existing facility at Kempton Park is less than two years old and was designed as a laboratory.
- If the inbound transportation is considered it is quite clear that reagents and equipment form a major component. The delivery to the laboratories closely resembles a JIT (just in time) system with deliveries directly from the Airport.

Conclusions and recommendations

Future trends will include the formation of larger central pathology laboratories owned by health care groups instead of the traditional pathologist owned laboratories. Notwithstanding the compelling arguments in favour of centralised routine pathology testing, decentralised testing will always have its rightful place in the pathology-testing matrix.

The very strong demand in terms of time, cost and quality has had an impact on all laboratories. Firstly, the financial pressure influences the number and type of tests requested by physicians, specialist and other professionals using pathology laboratories, and it will increasingly lead to a reduction in the income of pathology laboratories. Secondly, despite these cost pressures patients are much more informed and demand a better service, both in terms of TAT and increased information content of the report.

These demands mean that the managers of the centralised laboratories will remain under continued pressure.

- They will have to reduce their fixed and variable cost. Due to the relatively high fixed cost to variable cost ratio it is very difficult for a decentralised laboratory to perform many of the routine pathology tests profitably. Economies of scale can be achieved by centralising these tests to a centralised facility.
- They will have to ensure that their TAT stays within acceptable levels.
- They will have to undergo accreditation to ensure compliance with international standards, applicable to pathology laboratories, in order to limit non-analytical sources of error.
- They will have to install rapid delivery systems to ensure agility in a rapidly changing diagnostic environment.

As a result of the high cost of achieving TLA (Total Laboratory Automation), Business Process Re-engineering of the central routine pathology laboratory should be focussed on Flexible Automation to achieve the required savings and operational efficiencies in the short, medium and long term.

Centralisation will provide the routine pathology laboratories with the following advantages.

- Low variable, incremental, and process control cost per test.
- Low total error rate in an operator neutral and automated environment.
- Quality improvement philosophy.
- Operational and administrative advantages of centralised management.
- Easier communication in a centralised laboratory environment.

The calculation of the centre and median from the weighted shortest distance matrix, calculated by means of Floyd's shortest-path algorithm, of the laboratory network has shown that the central routine pathology laboratory should be located at the Kempton Park laboratory. This recommendation is supported by a number of factors that was taken into consideration by the qualitative analysis:

- Less than 25% of Ampath's total turnover originates from outside this region.
- This site is in close proximity (less than 5 kilometres) to Johannesburg International Airport that has the highest frequency of incoming domestic flights.
- This site provides easy access to the road infrastructure that forms the arteries of the specimen collection system.
- The existing facility is a well-designed laboratory with enough space to expand with an increase in patient volumes at a relative low cost compared to other sites.

- All the major suppliers of diagnostic products have their head offices in Gauteng and this ensures short lead-times for equipment, reagents and consumables.

Terms Of Reference

The interim board of directors of Ampath commissioned this project. It will be used as a guideline for the rationalisation of the operations of the newly formed Ampath. The results of this project will be used in the strategic decision making process of centralisation versus decentralisation.

The board's specific instructions were:

1. To do a literature study on the subject.
2. To undertake a tour of some of the major American and European laboratories in order to address and incorporate the trends in the diagnostic industry.
3. To make appropriate recommendations on the location of the reference laboratory.
4. To deliver interim reports as frequently as possible and to make the necessary recommendations pertaining to centralisation.
5. To complete the project by no later than 31 March 1998.

Acknowledgements

Dr. Johan C Senekal, Core Laboratory Pathologist, Drs. du Buisson & Partners Inc.

Dr. Lourens M du Toit, Pathology Director, Ampath

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Glossary

AST	Alternative site testing is a term used to include all testing that is performed outside of the pathology laboratory.
City regional laboratory	The city regional laboratory acts as the reference laboratory for a number of regional laboratories.
Depot	This is the facility where phlebotomy is performed.
FTE	A full time equivalent is equivalent to a 40 hour per week post.
Hospital laboratory	This is the smallest laboratory in the pathology laboratory network. It has a very limited test menu that usually includes only those tests that require a TAT of less than 30 minutes.
LIS	Laboratory information system
Peripheral laboratory	For the purpose of this document a peripheral laboratory refers to all those laboratories where work originates, that have a limited test menu and where usually only STAT and urgent pathology tests are performed.
Reference laboratory	A reference laboratory is that laboratory in the laboratory network with the most extensive pathology test menu in the pathology testing matrix. All the work that cannot be performed at the site (hospital laboratory or peripheral laboratory) where the work is generated, due to the absence of specialised skills or equipment, is referred to the reference laboratory where the specialised skills and equipment are available to handle the specialised routine work.
Regional laboratory	The regional laboratory act as the main laboratory for a specific region. Due to its geographical separation from the city regional laboratory it is necessary to perform urgent pathology tests at this laboratory due to potential TAT problems with tests that require a TAT of between 4 and 6 hours.
Routine test	A TAT of more than 30 minutes is required, but in most cases a 24 hour TAT and longer will be acceptable since the result is not required for the immediate diagnosis of the patient.
STAT test	A TAT of no more than 30 minutes is required and these will be tests

	that are important in the immediate diagnosis of patient illnesses.
TAT	TAT (turn-around-time) is measured from the time that the specimen is collected to the time that the result is delivered to the professional that requested the test.
TLA	Total laboratory automation refers to the total automation of the pathology laboratory by means of automatic sample centrifugation, automatic decapping, automatic aliquotting, automatic bar coding of secondary tubes, automatic recapping, automatic testing and automatic storage and retrieval of specimens.
Urgent test	These tests include those tests that are not STAT in nature but that require urgent resulting for reasons other than immediate diagnosis for the prescription of therapy.

1. Introduction and Literature Study

1.1 History

The past 50 years have seen the world-wide establishment of large and centralised facilities providing clinical laboratory services to the health care market. In South Africa the major pathology practices came into the market some thirty years ago and they experienced phenomenal growth that exceeded all expectations. An example is the Drs. du Buisson & Partners practice that opened its doors in 1969 with only 5 patients per day. This figure has since grown to an average of more than 5 500 patients per day.

All the major private pathology laboratories are of the independent type with a network of city regional laboratories, regional laboratories, hospital laboratories and depots. Up to now the private pathology laboratories have only targeted the private health care market, but this situation will change as the drive to venture into new markets gains momentum. This is necessary because the private health care market in South Africa, with a total of only 6 million private members, is serviced to its maximum by a very competitive pathology market.

The past 2 years have seen the amalgamation of independent pathology groups, nationally and internationally, to form bigger groups that can utilise their volumes and regional networks to achieve economies of scale and scope. The combination of their regional networks will provide national networks that can support their bid to negotiate good contracts with other national and international health care groups. The larger amalgamated groups will have more muscle, and that will create the barrier to entry that is needed to keep international competition at bay.

1.2 Challenges facing pathology laboratories

The managers of pathology laboratories face a number of opposing challenges that require a fine balance between the needs and expectations of the medical practitioners on the one side, and the cost pressure exerted by the funders of the service on the other side. The challenge is to maintain or improve the competitive advantage while ensuring the containment of, or even the reduction in, operating cost.

1.2.1 Increased expectations

Pathology laboratories in general are subject to increased expectations from doctors and other professionals that use pathology services. Amongst these expectations are the requirements for an increase in the information contents of laboratory data to be used for the diagnosis of patients and the tracking of patient history that is necessary for the curing of illnesses.

1.2.2 Funders of health care

The health care market, especially the funders of health care, demand a service that is fast, accurate and at low cost in order to meet the expectations of their shareholders. The shorter the TAT (turn-around-time) and the more accurate the result, the shorter and more effective the treatment of the patient will be. This will reduce the cost of providing health care, since it will shorten the length of stay in hospitals and reduce the number of visits to medical professionals.

1.2.3 Impact of challenges

In his article *Impact of cost cutting on laboratories: New business strategies for laboratories* Owen Ash [1996:822-826] had the following to say on the subject of increased pressure on laboratory management to contain cost in the pathology laboratory. He said: "Too many laboratories do not know the cost of the services they provide; such laboratories are at a high risk of failure as competition and cost-cutting efforts continue to drive revenues per test downward."

To survive the challenges laboratory management is adopting the following remedial actions:

- There is a whole range of organisational changes taking place that are all geared to improve the efficiency of the business, with a very strong emphasis on the formation of bigger groups (amalgamation) and the employment of specialists, other than medical technologist and pathologist, to run the business.
- There is a new drive towards flexible automation to achieve economies through a more efficient mix of technology and staff. Since both technology and personnel (especially skilled personnel) are very expensive, laboratory management finds it extremely difficult to defend decentralisation that requires the duplication of these resources.
- Economic viability is greatly affected by both test volume and test variety. It is more strongly affected by volume because of the high percentage of fixed cost to variable

cost. Large volumes are needed to bring the fixed cost per test down to such a level where these tests can be performed profitably. Most of the peripheral (decentralised) laboratories have insufficient volumes to cover even the direct fixed cost. By managing these laboratories as business units, these costs are becoming more evident and it is expected that there will be a renewed drive towards the centralisation of routine pathology tests.

1.3 Value chain

To gain a better insight into the workings of pathology laboratories it is important to consider the construction of the value chain and the opportunities that are being created by means of the addition of the virtual value chain. Porter identified inbound logistics, operations, outbound logistics, marketing and sales and service as the primary activities in the value chain of firms. The value chain for pathology laboratory services can be seen in figure 1.1.

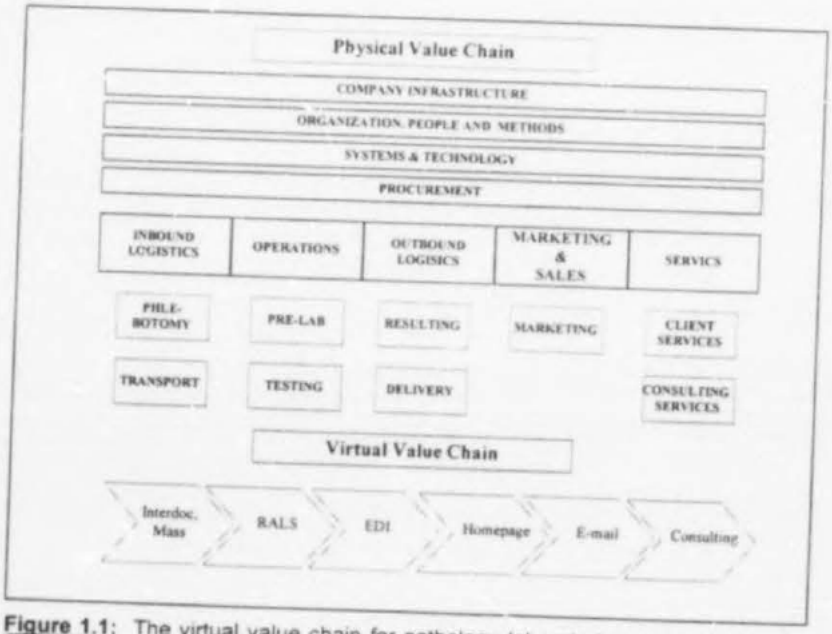

Figure 1.1: The virtual value chain for pathology laboratories to the analogy of Porter's value chain.

For pathology service providers the inbound logistics consist of phlebotomy and transportation. The blood, urine and other specimens arrive at the laboratory together with a request. The operations include the pre-analytical laboratory

function and the testing or analyses of the specimens. The function of the pre-analytical laboratory is to prepare the specimen (centrifugation, aliquotting, bar-coding, etc.) for the analyses phase and to capture the request so that all the patient demographics and test requirements can be forwarded to the laboratory where the worksheets and orders are downloaded to the analysers for the automatic processing of the specimen. The outbound logistics include resulting and delivery of the results to the clients. The marketing function has the important role of alerting the laboratory management of changes and needs in the market and to sell the advantages of new and existing tests to the clients. There are a number of services that are offered to the client in order to add value that may distinguish the pathology laboratory from others. These include, amongst others, the consulting services of highly specialised pathologists that will interpret the results for other medical specialist in order to determine the best possible treatment of patient illnesses.

Like in all other businesses the primary activities are supported by a set of secondary activities. These secondary activities include infrastructure, human resource management, systems, technology and procurement.

1.3.1 Physical value chain

With the construction of the value chain for the pathology laboratory it is important to keep Porter's value chain in mind. Pathology laboratories are under threat and the survival of pathology laboratories can only be guaranteed if the laboratory gains a competitive advantage over its competitors, whilst reducing cost without impacting negatively on the quality of the result that is reported to the client. Competitive advantage can only be achieved if the activities of the pathology laboratory are perceived as adding value to the activities of its customers. The value chain is constructed of those activities that the pathology laboratory performs to create value for their clients (doctors, patients and brokers) and their suppliers. The latter are often ignored, since the focus is usually on the client, but a relationship between a company and its suppliers can only be lasting if it is a case of mutualism. The successful implementation of the value chain concept requires a reach out to suppliers, affinity organisations and customers.

The physical value chain identifies those areas on the inbound logistics, operations, outbound logistics, marketing and services where costs can be cut and where an improvement in the TAT can be achieved.

1.3.2 Virtual value chain

The virtual value chain is running in parallel with the physical value chain and offers a whole range of useful alternatives for today's laboratory. The first signs of the existence of the virtual value chain are the introduction of *Interdoc*, *MASS* and other similar software into the consulting rooms of the physicians. This software will integrate the different parts of the physical value chain in the provision of health services in general. It will map the components of the physical value chain onto the virtual value chain. By using the above-mentioned software it is possible for the client to access the LIS (Laboratory Information System) and to obtain results at their convenience. It is also possible to download results directly into the patient file on the doctor's system. This will cut down on administration and human errors.

Clearly the virtual value chain is very useful in the opening up of new markets as well as the gaining of a competitive advantage in existing markets. New markets (drug trials, special projects, etc.) open up due to the exposure given by the marketing value of the virtual value chain. It is possible to serve the existing markets better, due to an increase in accessibility to the Internet. Through the Internet it is possible to download data to another LIS that are compatible with the in-house LIS.

1.3.3 Integration of the value chain

Numerous tools are available to the pathology service provider to integrate the components of the value chain. Apart from *Interdoc* and *MASS* mentioned in the previous paragraph there are also a number of other tools that can be used.

- EDI: Electronic Data Interchange made it possible to negotiate better and closer ties between the laboratory and its clients (medical aids in particular). It is possible to download accounts directly into the software of the providers of medical aid. This has led to a reduction in the usage of paper and related administrative cost. It decreased the average time for payment of an invoice.
- Mobile computing: Mobile computing paves the way for AST (Alternative Site Testing) and the resultant improvement in TAT, since it cuts down on time consuming capturing of patient demographics.
- E-mail: E-mail is making communication, internally and externally (nationally and internationally), much easier and faster. Ideas are now communicated more efficiently with a resultant reduction in lead-time for the implementation of new technology and systems.

- Tele-pathology and digital dictation: Histopathology is very labour intensive and requires the presence of very expensive histopathologists in peripheral laboratories. At the Medica exhibition in Dusseldorf in Germany there were many exhibitors showing the progress in technology that would make it possible to centralise this previously decentralised function.

- RALS: The Remote Automated Laboratory System of Prof. Robin Felder at the University of Virginia is a perfect example of technology being used to reduce the need for expensive senior technologists in peripheral laboratories where it is often difficult to appoint technical personnel. This system allows for remote verifying and releasing of results after the specimen was presented to an analyser by a non-technical person, often a nursing staff member, employed by the hospital.

It is obvious that the use of the value chain (physical and virtual) will identify opportunities to make centralisation even more attractive. It will allow providers of pathology services to restructure their laboratories on a national basis. Value added, through testing at peripheral sites, is declining as the cost of providing the service at the peripheral site increases. Through centralisation of routine pathology tests the cost of producing the result can be contained whilst the virtual value chain, and other tools used to integrate the value chain, can increase the value added through the service that the laboratory provides.

1.4 *Reasons for using pathology laboratories*

In order to determine the necessity for resulting on tests within a certain time frame (TAT) it is important to study the reasons why physicians, specialists and other professionals request tests from pathology laboratories. This knowledge will allow us to design the test menus for the different laboratories. These reasons can be classified into primary (objective) and secondary (subjective) reasons.

Primary (objective) reasons include:

- case finding in individuals;
- monitoring of a patient's condition;
- making of a prognosis; and
- selection of the correct therapy

Secondary (subjective) reasons include:

- curiosity;
- "making sure" and protection against professional liability;
- habit; and
- patient peace of mind or emotional security.

1.5 Classification of service

Theoretically the TAT required for the provision of a test result will fall into one of two categories. The two categories are STAT and routine. For STAT tests a TAT of no more than 30 minutes is required, and these will be tests that are important in the immediate diagnosis of patient illnesses. An example would be blood gas analysis to determine, amongst others, the CO_2 content of a patient's blood while the patient is on the operation table. Another example includes tests that are required for organ transplantations to determine compatibility of donor and receptor tissue. When a patient is critically ill and in urgent need of an organ, no time can be wasted, and therefore results are required with a TAT of less than 30 minutes. The other category includes those tests that are not needed for immediate diagnosis of the patient's condition. By default these tests require a TAT of more than 30 minutes, but in most cases a 24-hour TAT and longer will be acceptable. An example would be tumour markers, where the immediate diagnosis and therapy will not have a critical effect on the prognosis for the patient. Appendix C includes a list of the routine tests.

Unfortunately for pathology laboratories, market forces have skewed this categorisation of STAT and routine tests. The reason for this being that there are a large number of tests that although strictly routine in nature, are required urgently for reasons other than the immediate diagnosis for the prescription of a suitable therapy. The time lapse between the receipt of the result and the start of the corrective therapy can usually be quite significant. An example is a pregnancy test where the immediate knowledge of the positive outcome of a pregnancy test has no clinical significance other than the emotional security of the patient. Another example of such an exception is in the case of HIV testing where the insecurity regarding the outcome of the result will have an emotional effect on the patient. These exceptions therefore have led to the additional category of urgent tests.

1.6 Trends in the diagnostic industry

1.6.1 Technology

The past five years have seen a great deal of optimism for the concept, and a move towards, TLA (Total Laboratory Automation). A recent visit to the Mount Sinai hospital in New York has shown that for a laboratory with about 6 000 to 10 000 patients per day it will cost between R50 million and R70 million to install a TLA system. This is too expensive, and is now replaced by flexible laboratory automation that will provide a means to achieve the expected cost savings in the short, medium and long term. For TLA the major cost of the system is dedicated to the specimen transport system. Argent Consulting of Dallas in the USA has calculated that only 2% of the total saving achievable through TLA can be attributed to the specimen transport system. Flexible laboratory automation that focuses on the workcell concept (multiple analysers with a single computer interface that combines different technologies) will achieve up to 88% of the potential savings, at a fraction of the cost.

1.6.1.1 Drives

Pathology providers are always looking for new technology to replace existing technology. Behind this drive is the primary objective of cost effectiveness and better productivity. That is to reduce cost and improve profitability for the shareholders. Better accuracy is the secondary drive, but also a [illegible]nt one since the provision of better accuracy contributes to the achievement of a competitive advantage over the competitors in the highly competitive health care market.

1.6.1.2 Implementation

Although the drive for new technology is an ongoing one there is always the factor of financial pressure determining whether new technology is affordable, as is the case with TLA. The second under-estimated factor governing the implementation of new technology is regulation. This factor is not as important in South Africa as there is no regulatory body like the FDA (Food and Drug Administration) that determines the acceptability of new technology. Union participation makes it more difficult to adopt new technologies, since new technology often has the effect of improving productivity through the reduction in FTE's (full time equivalents) required to perform certain tasks.

1.6.2 Consolidation (Laboratories and equipment)

The functional barriers between the different departments Serology, Endocrinology, Chemistry and Haematology are disappearing and they are being consolidated into Core Laboratories with multi-skilled medical technologists and other personnel. Workcells are designed to do more work (volumes and menus) at higher speeds with less reagents, consumables and labour on smaller and fewer equipment.

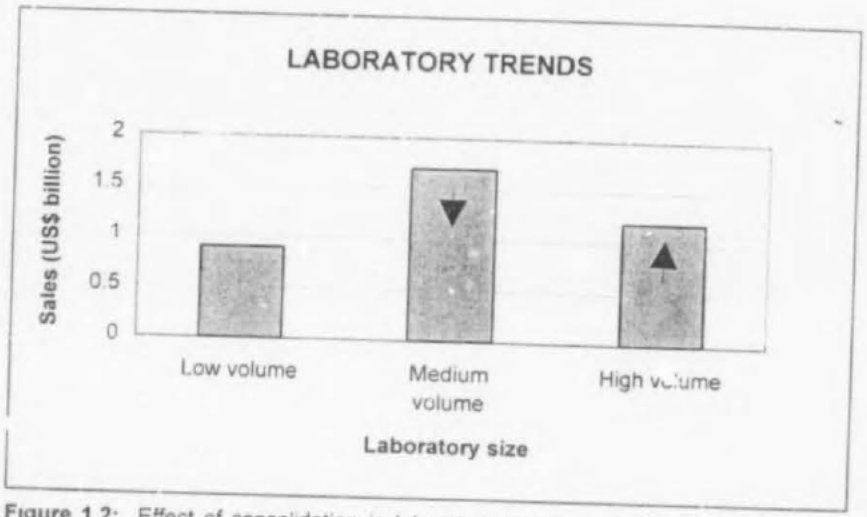

Figure 1.2: Effect of consolidation in laboratory trends according to Abbott Diagnostic Division. [1998: Argent Consulting Services]

These workcells are high throughput analysers that require high volumes to achieve the advantages for which they are designed. These volumes can only be created by the centralisation of the routine pathology tests. It is expected that the number of instruments (or total value of sales) in the high volume laboratories (5000 and more tests per day) will grow at the expense of the medium volume laboratories (1000 to 5000 tests per day). The market share of the low volume laboratories (less than 1000 tests per day) will stay constant due to the need for STAT and urgent testing in peripheral sites. The effect of consolidation can be seen in figure 1.2.

1.6.3 Modularity and scalability

Modularity and scalability will ensure that the requirements of individual laboratories (centralised and decentralised) relating to space, volumes and menus will be met. It will however require a minimum test volume to provide an acceptable return on investment.

1.6.4 Commutable results

Tests done on different analysers will have results that can be uniformly understood and interpreted. This is currently a problem since different size analysers are placed in different size laboratories. The effect of this is that, when a test is sent to a central facility, the format of the result (reference range) differs to that which the physician in the peripheral site is used to.

1.6.5 Low-cost producers

Generalist laboratories as we know them today are under threat from focused low-cost laboratories that might or might not be international. With the focus on service the pathology laboratories have in the past decentralised at great cost. Decentralisation led to a duplication in personnel, analysers, facilities, inventory, etc. It is generally accepted that centralisation of pathology laboratories can achieve savings of up to 30% in personnel expenditure alone.

1.6.6 Fe[illegible]s

Bec[illegible]ne geographical distribution of the laboratories in a decentralised environment there is often a duplication of suppliers for the same inventory item because of lead-time constraints. Therefor there is a renewed drive for fewer suppliers that will bring along the following advantages:

- standardisation;
- easier administration;
- better quality; and
- more attractive pricing policies.

1.7 Decentralisation

The debate regarding whether an approach of centralisation should be adopted should under no circumstances exclude decentralisation. There is definitely a place for decentralisation in the pathology testing matrix. The question is how decentralisation, and the efforts that are put into it to make it more cost effective, can be harnessed to support the centralised routine pathology laboratory.

A survey of United States hospitals [Bickford, 1990:623:645] has shown that there is a move out of the central hospital laboratory to other areas of the hospital. The reason for this is the drive towards faster TAT for STAT testing. In this instance AST [Bachner, 1995:881-885] is becoming a reality and it provides pathology service providers with the means to take testing to the patient's bedside whether it be in emergency rooms, operating rooms, intensive cares or in their homes. This technology is becoming so advanced that it can be used even by non-technical laboratory personnel. The only disadvantage up to now is that it is still very expensive and it is available only for a limited number of tests. Although AST does not require specialised technical staff it still requires a large investment in people and therefore it will not provide the answer to lower cost and sustained profitability. It is doubtful that it will ever have an effect on the centralisation efforts in general since it will only be applied to specific areas with specific needs.

On the technology side there is a drive to provide newer instruments that are compact, portable, transportable, stable, pre-calibrated or auto-calibrated. These instruments will require limited operator intervention and process control, low sample volume and can be operated by non-laboratory personnel. These analysers cater for a small portion of the market that actually require instruments of this nature due to operational and not financial constraints. These instruments will cater for the hospital laboratories and other STAT laboratories where factors such as geographical isolation, market demands due to competitive forces and the nature of the testing required is such that a decentralised facility is required.

Decentralisation will only be feasible when decentralised testing will lead to the following:

- A substantial reduction in TAT.
- If implementation leads to lower total operating cost.
- If the accuracy and precision achieved through decentralisation is sufficient for the intended clinical purposes.
- If definable operational and clinical advantages can be achieved.
- If an increase of the market share can be realised through the acquisition of additional routine work that can be sent to centralised facilities.
- If strategic advantages, through the provision of a national or international network, can be achieved.

1.8 Centralisation

Internationally the centralisation of routine pathology tests has led to the establishment of big centralised facilities where large numbers of tests are being performed at a relatively low cost per test. This is exactly what the funders of health care wanted and it led to an increased drive in the centralisation effort.

In South Africa the potential reduction in operating cost through the amalgamation of large independent practices has not yet materialised. Personnel cost and consumable cost account for 38% and 22% of the total cost respectively. There are mainly three reasons for the above-mentioned situation that prevail. Firstly, there is a continuous devaluation of the Rand against other international currencies with no prospect of any change in this trend. Since the providers of pathology services are heavily dependent on the importation of equipment, consumables and reagents the devaluation of the Rand has had a serious adverse affect on their cost containment strategies and therefore their profitability. Secondly, SA experiences an inflation rate of just below 6%, which ensures that the PSP's (pathology service providers) are faced with an ever increasing salary bill. Although the current inflation rate is very satisfactory, given the double figure legacy of the past, it is still much higher than the inflation rate of the competitive international community. Thirdly, due to the complexity of the pathology environment and historical reasons it will be very difficult for the pathology practices to change from within. A paradigm shift in the way pathology services are provided is therefore necessary to ensure their long term viability.

Another drive for centralisation was the development of expensive automated batch analysers and LIS (Laboratory Information System) needing highly trained laboratory personnel. Pathology laboratory management has been the sole responsibility of technologists and pathologists in the past. The duplication of these specialised skills in a decentralised laboratory setting can not be afforded in the light of above-mentioned pressures and therefore a further stimulus for centralisation was created.

Although decentralisation is now possible with compact portable or transportable instruments, characterised by relative ease of operation and robust performance in the hands of inexperienced personnel, it is doubtful whether the pressures that originally led to the need for centralisation will ever disappear. The existing infrastructure of facilities, equipment, knowledge, skilled personnel and communication capability can not easily be duplicated in favour of decentralisation.

The following advantages of centralised pathology laboratories remain valid:

- Low variable, incremental, and process control cost per test.
- Low total error rate in an operator neutral and automated environment.
- Quality improvement philosophy.
- Operational and administrative advantages of centralised management.
- Communication is easier in a centralised laboratory environment.

1.9 Transformation of the public health system in South Africa

Both the private and public pathology service providers are faced with the same challenges and therefore it will be interesting to have a look at the specific actions that are proposed for the public pathology services. According to the recent *White Paper for the Transformation of the Health System in South Africa* it became evident that there are a number of problems facing the public pathology laboratories. These can be summarised as follows:

- There is an excessive fragmentation of laboratory services.
- This fragmentation led to the costly duplication of infrastructure, support services, equipment, personnel and management.
- Due to historical reasons there is a geographic inequity in the provision of pathology services to the previously disadvantaged communities.
- Due to normal government bureaucracy there is a lack of service co-ordination.

These problems are very difficult to address and it will at best be a very costly exercise. Due to the cost cuts in the national health budget it is not quite clear where the money will come from to address these issues. There are a number of options available to address these problems:

- Private pathology laboratories should be used to provide the public sector services with certain routine testing. This can be done by outsourcing certain tests to private laboratories. These tests will provide the private laboratories with additional volumes that will drive the fixed cost down and good prices can therefore be negotiated. These cost savings can then be used to address the inequities of service provision.
- The public sector can get a partner in the private sector to provide the necessary capital required to remedy the problems facing them.
- The private laboratories can use the facilities of the public sector laboratories to drive its fixed cost down. A recent study by the student on the possibility of outsourcing of routine biochemistry tests to the public pathology laboratories has shown that the cost structure of the public services is such that a decision can not easily be made based on sound economical principles.

The white paper proposed a four level implementation strategy to address the problems facing the public pathology laboratory:

1. On the lowest level they propose a PHC (Primary Health Care) oriented service with a very limited repertoire of tests, i.e. within community health centres.
2. On the intermediate level peripheral laboratories (largely hospital-based) at district/subregional/regional level with an extended, but still limited test repertoire.
3. On the provincial level there will be more automated, specialised and centralised services that will interact with academic departments for some referred tests and consultations.
4. On the national level highly specialised or non-reproducible services, i.e. the activities of the National Institute for Virology (NIV) will be located.

This four level strategy is nothing less than the centralised laboratory service proposed by the literature and the importance of this can be seen in the trends of the diagnostic industry world-wide.

Pathology laboratories (public and private) must comply with the cost and competitive pressures or face the erosion of their market share by other laboratories that have overcome the resistance to centralisation. The only risk associated with the centralisation of routine testing is the loss in political power by individual pathologists and laboratory managers. The decision makers will have to be aware of this and make sure that sound economical sense will prevail over emotion providing the shareholders, managers, staff and everybody concerned with the figures of the cost involved in not centralising that can be centralised. It is not the cost of centralisation that should be the focus of the debate, but rather the cost of not complying with the cost pressures.

2. Economic Analysis of Routine Testing

2.1 Cost structure

The following analysis shows that personnel cost and consumable cost account for up to 60% of the total cost of pathology laboratories. It should be possible to reduce this cost through centralisation, as it would cut out unnecessary duplication. It is widely accepted that personnel cost can be cut by up to 30% if centralisation is adopted. Another cost that could be reduced through centralisation is rent and levies. Since the saving here is evident it will not be discussed any further. Table 2.1 shows the percentage contribution to the total cost of the different cost items. This table is a summarised version of a spreadsheet prepared by Deloitte & Touche for Ampath.

Table 2.1: Cost structure for the provision of pathology services.

COST CATEGORY	PERCENTAGE
Personnel	38%
Consumables	22%
Rent & levies	7%
Other	6%
Finance cost	6%
Bad debt	5%
Depreciation	4%
Maintenance	3%
IT & communication	3%
Transport	2%
Stationary	1%
Equipment	1%
Marketing	1%
Travel & accomodation	1%
Insurance	1%
TOTAL	**100%**

2.1.1 Personnel cost

There are mainly two reasons why the pathology laboratory has to contend with ever increasing personnel cost:

- The first reason is not only restricted to patnology laboratories but it is the cause for high personnel cost in almost every other South African industry. Double figure

inflation rates of the past forced the providers of pathology services to give percentage salary increases that compare favourably with the inflation rate.

- It becomes increasingly difficult and expensive to find qualified n... ...l technologists and nursing staff (phlebotomy) to provide the services that the health care market demands. This is especially evident in the peripheral laboratories where it is often extremely difficult to appoint technical staff, and even in the city regional laboratories there is a high turnover of staff.

2.1.2 Consumable cost

The second biggest expenditure for pathology laboratories is their consumable cost. Under consumables we include reagents and disposables (i.e. cuvettes). Apart from the annual increase from the suppliers the laboratories had to contend with the devaluation of the Rand against the American Dollar and other major European currencies. The latter has had a very serious impact since the pathology laboratory is very heavily dependent on the importation of consumables and equipment.

2.2 Pricing policy

Unlike other industries, pathology laboratories cannot determine their own pricing policies. The maximum allowable tariff per test or group of tests is published in the Government Gazette and the income of the laboratory is determined by these tariffs.

2.3 Break-even point for routine testing

It is obvious that the laboratory management in general does not know the cost involved in performing certain routine tests. This is evident in the large number of routine tests that are performed at a loss in the peripheral laboratories. The reasons for this situation that prevails are numerous and can be summarised as follow:

- In the past there has been an emphasis on patient volumes and turnover rather than on the profitability of the tests that are performed.
- The pathology organisations are often not structured in business units.

- The information necessary to calculate the profitability of the tests is either not available or could not be retrieved from the LIS in a format that can be understood by the laboratory manager.
- Often the laboratory manager is a medical technologist without any formal training or experience in financial management and costing procedures.

To illustrate this point we will investigate the AFP, CA 19-9, CA 15-3, CA 125 and Ferritin tests that are available on the Axsym analyser. This is a relevant selection of tests since they are all routine tests that are ideally suited to be performed in a centralised laboratory.

2.3.1 Direct consumable cost

Only the direct cost will be used to illustrate the point as it is relatively easy to isolate these costs and they are all available on the standard price lists of the suppliers. Certain reagent costs can be allocated directly to the test. The investigation into these costs will give us an insight into the cost advantages of centralisation. All the fixed costs in the following paragraphs have been calculated for a period of 6 months and then averaged to arrive at an average monthly cost.

2.3.1.1 Fixed cost per test

This fixed cost is dependent on the type of test to be performed on the automated instrument. It is however independent on the number of tests to be performed. Equation 2.1 is the equation that can be used to determine the fixed cost of performing any of the selected tests. Table 2.2 shows the direct fixed cost associated with the selected tests. The values in this table were calculated by using the specifications and standard price lists of the diagnostic suppliers.

$$FC_i = M_i + S_i + C_i \qquad \textbf{[Equation 2.1]}$$

Where:

- FC_i = The fixed cost associated with performing test i
- M_i = Master calibrator and calibration for test i
- S_i = Standard calibrator and calibration for test i
- C_i = Control purchase and control run for test i

Table 2.2: The fixed cost for the selected tests

FIXED COST FOR TESTS	AFP	CA 19-9	CA 15-3	CA 125	FERRITIN
Master calibrator	R51.67	R51.67	R51.67	R51.67	R51.67
Master calibration	R24.80	R34.40	R37.20	R37.20	R15.39
Standard calibrators	R25.83	R25.83	R25.83	R25.83	R25.83
Standard calibration	R12.40	R17.20	R18.60	R18.60	R7.70
Control purchase	R100.00	R100.00	R100.00	R100.00	R100.00
Control run	R1,134.60	R1,573.80	R1,701.90	R1,701.90	R704.55
TOTAL	**R1,349.30**	**R1,802.90**	**R1,935.20**	**R1.935.20**	**R905.14**

2.3.1.2 *Variable cost per test*

The variable cost is dependent on both the type of test and the volume of tests to be performed on the automated instrument. The reagents are purchased in kit sizes that can vary and it is for this reason that the number of tests per kit is build into the equation. Another important cost that is built into the variable cost is the cost of repeating tests. This is necessary to make provision for quality control purposes as well as to allow for operator error. Depending on the number of variables, amongst which operator experience, these repeats can be as high as 20%. Equation 2.2 calculates the variable cost that is associated with a test. Table 2.3 shows the variable cost based on a kit size of a 100 and a repeat rate of 20%.

$$VC_i = \frac{K_i}{n_i}(1 + r_i) \qquad \textbf{[Equation 2.2]}$$

Where;

- VC_i = Variable cost per test for test i
- K_i = Cost per kit for test i
- n_i = Number of tests per kit for test i
- r_i = Percentage of repeats for test i

Table 2.3: Variable cost for the selected tests

VARIABLE COST PER INSTRUMENT	AFP	CA 19-9	CA 15-3	CA 125	Ferritin
Cost per kit (K_i)	R620.00	R860.00	R930.00	R930.00	R385.00
Number of tests per kit (n_i)	100	100	100	100	100
Percentage of repeats (r_i)	20.00%	20.00%	20.00%	20.00%	20.00%
Variable cost per test (VC_i)	**R7.44**	**R10.32**	**R11.16**	**R11.16**	**R4.62**

2.3.1.3 *Instrument cost*

This cost is independent of the type or variety of the tests to be performed on the automated instrument. Equation 2.3 calculates the instrument consumable cost associated with the instrument. Table 2.4 shows the instrument cost for the Axsym analyser.

$$IC = M + S + F + P + D \qquad \textbf{[Equation 2.3]}$$

Where;

IC	=	The instrument consumable cost for the analyser
M	=	The cost of the MUP solution for the analyser
S	=	The cost of solution 3 and 4 for the analyser
F	=	The cost of fluidics for the analyser
P	=	The cost of probe cleaner for the analyser
D	=	The cost of decontamination for the analyser

Table 2.4: The monthly instrument cost for the selected analyser.

FIXED COST PER INSTRUMENT	COST
MUP Solution	R130.00
Solution 3 and 4	R45.00
Fluidics	R91.67
Probe clean	R92.50
Decontamination	R72.50

2.3.1.4 Total reagent cost

For the ease of this discussion the instrument cost will be left out of the total reagent cost equation, as it will have a very small impact on the break-even point. Equation 2.4 calculates the total reagent cost as discussed.

$$TC_i = FC_i + (VC_i * t_i)$$ **[Equation 2.4]**

Where:

TC_i = Total reagent cost for test i

FC_i = Fixed cost for test i

VC_i = Variable cost for test i

t_i = Number of test i

2.3.2 Income

The income per test for each one of the selected tests can be seen in table 2.5. Equation 2.5 can be used to calculate the income for the test.

$$I_i = T_i * t_i$$ **[Equation 2.5]**

Where:

I_i = Income for test i

T_i = Published tariff for test i

t_i = Number of test i

Table 2.5: The income per test for the selected routine tests.

TEST	AFP	CA 19-9	CA 15-3	CA 125	Ferritin
Income	R46.50	R74.80	R74.80	R74.80	R46.50

2.3.3 Break-even graph

With the information of the previous paragraphs it is possible to draw the break-even graphs for the selected tests. For this discussion we will use the values of the AFP test. The break-even graphs of the other tests can be seen in Appendix B at the back of this

document. The total cost and income for the AFP test are summarised in table 2.6. Appendix B also includes a summary of the cost of performing these 5 routine tests in the city regional laboratory and the peripheral laboratory. This table also shows the cost saving on reagents that can be achieved by centralising these tests for this peripheral laboratory.

Table 2.6: Total direct cost for performing routine AFP tests

AFP	1	20	40	60	80	100
Total Cost	R1,356.74	R1,498.10	R1,646.90	R1,795.70	R1,944.50	R2,093.30
Income	R46.50	R930.00	R1,860.00	R2,790.00	R3,720.00	R4,650.00
Cost per test	R1,356.74	R74.91	R41.17	R29.93	R24.31	R20.93

From the break-even chart in figure 2.1 it can be seen that the break-even point is at 35 tests per month for direct reagent cost only. To operate this analyser it requires some dedicated time from a technologist. The effect of adding the labour, maintenance, additional air-conditioning, etc. moves this break-even point into the region where these tests can definitely not be performed profitably in the peripheral laboratory. In fact from Appendix D it can be seen that only 6 of the peripheral laboratories have sufficient volumes of the AFP test to do it profitably in the peripheral laboratories. This is without even bringing the effect of labour, maintenance, air-conditioning, etc. into account.

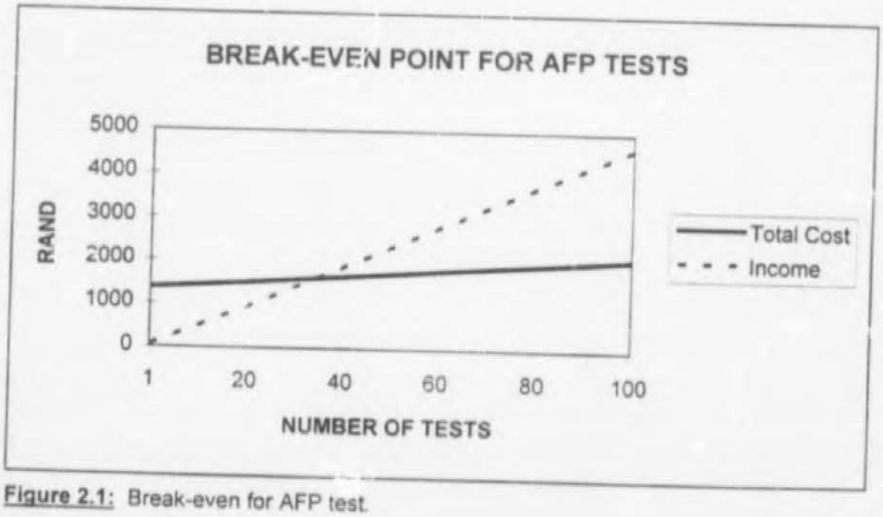

Figure 2.1: Break-even for AFP test.

It is true however that for certain tests with sufficient volumes the cost line in the graph may exhibit a step function due to the capacity constraints of the analysers. An evaluation of the volumes has shown that no single peripheral laboratory generated enough tests to warrant an investigation into this region of the break-even graph. For the central laboratory we will definitely enter this region of the graph but as discussed in the introduction other instrumentation (higher throughput) will be used here.

It is clear that routine tests should be centralised. This will ensure volumes that are high enough to operate the analyser in the profitable region of the break-even graph.

Appendix D indicates the total number of tests per month for the selected tests for each of the peripheral laboratories. It can be seen that the total monthly number of tests is often much lower than the number of tests required for the break-even point. The reagent kits also have a limited shelve life and therefor the wastage due to the fact that kits have to be discarded is even more than the losses due to operating below the break-even point. Centralisation of these tests will ensure volumes that will be sufficient to operate in the profitable region of the break-even chart and it will also ensure that kits will be used before their shelve life expire.

By using equation 2.4 to calculate the total direct reagent cost of performing a test, given the specifications and standard price lists of the suppliers, it was calculated that a total annual direct reagent saving of R500 000 can be realised if an extensive menu of Thyroids, Tumour Markers and Ovarian tests are considered. These tests are all considered as routine tests and therefor fall in the category of those that can be centralised without affecting the expected TAT. The calculation of the total saving, including the labour saving and the effect of the new technology, discussed in the chapter on trends in the diagnostic industry, can be seen in Appendix E.

3. Description of the Location Problem

The location of the routine pathology laboratory should ensure the collection of specimens from the peripheral laboratories in the national network, and the reporting of the results back to the physicians and other professionals, in the shortest possible TAT and at the lowest possible total cost.

The location of the routine pathology laboratory must address a number of factors that must be kept in mind with the final selection of the site. The discussion that follows is by no means complete but will address the most important issues.

3.1 Location

The location of the routine laboratory in the pathology network is supported by a number of facilities that will not be taken out of the network once the routine laboratory is in operation. The following must therefore be taken into consideration:

- The geographical distribution of physicians and other medical professionals forms the basis for the existing location of laboratories within the pathology network.
- The population density surrounding each of the laboratories is an indication of the relative importance of the location of that specific laboratory.
- Depots act as POS (point of service) for the patients and therefore the pathology network can be expanded through the addition of depots.
- STAT laboratories that cater for a very fast TAT will always have a role to play in the pathology network. They may however be scaled down to perform only a limited repertoire of tests in order to cater for critically ill patients.
- The location of the current city regional laboratories will act as hubs for the pathology network since the capital investment in these facilities will make it impossible to relocate them in the short and medium term. They will be provided with a limited, but larger, repertoire of tests than the STAT laboratories.

3.2 Integration

It is important to discuss those activities that support the location issues mentioned in the previous paragraph. These activities make it possible for facilities to be located at certain points. The following activities will have an impact on the final location and will provide, if necessary, certain flexibility in the exact location of the central routine pathology laboratory:

- The placing of couriers and the usage of independent courier services within the pathology network will ensure a fast TAT. In-house couriers could be used to collect STAT and routine specimens within the urban areas (intra-regional) while outsourcing can be used to collect specimens from the different urban areas (inter-regional).
- The format of the specimens and the way in which they are transported are very important since the quality of the specimens is very important for accurate resulting. By preparing the specimen (centrifuging, aliquotting, data capturing, etc.) at the peripheral laboratory, or point of collection, it will cut down on the handling of the specimens at the central facility. This would ensure the integrity of the specimen.
- Since the laboratories are dependent on the back-up provided by the maintenance teams and procurement departments of the suppliers, it is important to consider where the interaction between the laboratory and its suppliers will be most effective and with the shortest possible lead time.

3.3 Agility

Agility is the ability of the laboratory network to adapt to changes in its environment. These changes include:

- Changes in the market through the migration or loss of traditional markets (patient basis). It should also be able to react positively to the emergence of new markets (patient basis).
- Changes in the availability and affordability of labour. An unaffordable increase in labour cost will result in the implementation of TLA (Total Laboratory Automation) rather than flexible automation.
- A decrease in the number of suppliers as are envisaged by the trends in the diagnostic industry will limit the location possibilities.
- Changes in technology (emergence of the workcell concept mentioned in the first chapter) will provide more flexibility and less dependence on the availability of labour.

3.4 Measurement

Applicable performance measurements should be put in place to evaluate the performance of the system. The current performance measures are not sufficient to measure the performance effectively. The optimal location for the routine pathology laboratory should be evaluated on the combination of TAT and total cost.

4. Scenarios

There are basically only two alternatives that need to be considered, and this simplifies the problem to a certain extent.

4.1 Scenario 1

Each one of the existing three city regional laboratories (Johannesburg, Pretoria and Durban) will act as a reference laboratory for the routine work in the regions in which it is located. Specialised work will be sent from one city regional laboratory to another to achieve economies of scale by combining volumes.

4.2 Scenario 2

One central routine laboratory in Gauteng will act as a reference laboratory for all the routine pathology tests. This scenario can be implemented in one of two ways.

- A new laboratory can be designed and built at an optimal location.
- One of the existing two city regional laboratories in Gauteng can be transformed into a reference laboratory.

This second alternative does not exclude the possibility that this scenario can be phased in over time. It does however exclude the possibility of having more than one reference laboratory in future.

4.3 Evaluation of scenarios

These two scenarios will be evaluated with reference to the technology, infrastructure, resource, logistics, communication, political and strategic constraints that are inherent to the organisation.

For the evaluation of the scenarios each of the constraints was assigned a weight that is an indication of the relative importance of each one. These weights were discussed with the shareholders (pathologists) to ensure buy-in. The most applicable scenario for each constraint was awarded 4 points and the other one 1 point. The weights as well as the results of this evaluation are summarised in table 4.1.

4.3.1 Technology

The technology is available to implement any one of the two scenarios. The cost of duplication of technology and the current trends in the diagnostic industry to consolidate different analysers into single workstations or workcells will make the cost of implementing scenario one very expensive. The existing and future analysers and equipment will lead to a saving on the total cost of providing pathology services if scenario two is implemented.

4.3.2 Infrastructure

Infrastructure is very expensive and therefore it seems reasonable that some or other form of rationalisation of infrastructure will be required in order to achieve cost savings. Rent and levies alone contribute 7% of the total cost. The city regional laboratory in Pretoria is experiencing capacity constraints in terms of available floor space, which is making it difficult for the facility to accommodate all the functions that are required from a reference laboratory. The city regional laboratory in Johannesburg is in the centre of town, where the rising crime statistics are making it less desirable as a facility to house the reference laboratory. Scenario two is preferred, since it will address the problems associated with the current location of the city regional laboratories.

4.3.3 Resources

Labour (38%) and equipment are major contributors to the total cost of providing pathology services. With the increased cost pressure on pathology providers it will be very difficult to afford the unnecessary duplication of resources in a decentralised laboratory environment. Scenario two will lead to a rationalisation of the resource cost and is therefore the preferred alternative.

4.3.4 Logistics

A decentralised laboratory environment will provide a very attractive TAT for its physicians and other professionals. In terms of TAT it will provide the pathology service provider with a competitive advantage. The competitive advantage will be a result of subjective criteria, since TAT is not of critical importance in routine pathology testing. A decentralised collection network will also be more cost effective and provide the individual laboratories with more flexibility.

Because of the perceived TAT advantage and possible saving in collection cost, scenario one will be the preferred alternative for this constraint.

4.3.5 Communication

A centralised laboratory environment will provide for more reliable communication (voice and data). This is mainly due to the fact the LIS in use by almost all the pathology groups in South Africa run on a main frame. This discussion however is restricted to routine testing, and this changes the advantages and disadvantages somewhat. Because of the long distance of the communication lines between the central routine laboratory and the regional laboratories it can easily be influenced by external factors, of which the unreliable service of the telephone cabling network supplier is the main concern. Scenario one is the preferred alternative, unless the reliability of our communication network can be solved or if distributed processing is available for the LIS.

4.3.6 Political

Another very important factor is the internal organisational politics. The partners as the decision makers have already informally agreed that scenario 2 will be the most acceptable alternative from their perspective.

Table 4.1: Weighted evaluation of constraints inherent to the organisation.

CONSTRAINT	WEIGHT	SCENARIO 1 (RAW)	SCENARIO 2 (RAW)	SCENARIO 1 (WEIGHTED)	SCENARIO 2 (WEIGHTED)
TECHNOLOGY	0.15	1	4	0.15	0.60
INFRASTRUCTURE	0.20	1	4	0.20	0.80
RESOURCES	0.15	1	4	0.15	0.60
LOGISTICS	0.20	4	1	0.80	0.20
COMMUNICATION	0.20	4	1	0.80	0.20
POLITICAL	0.05	1	4	0.05	0.20
STRATEGIC	0.05	1	4	0.05	0.20
				2.20	**2.80**

4.3.7 Strategic

A centralised laboratory handling the bulk of the routine testing will strategically be more vulnerable to factors such as labour action and natural disasters. The centralised laboratory will however be able to produce results at a much lower cost than is possible in a decentralised laboratory environment. This low cost will provide the barrier to entry that is necessary to keep international competition at bay. Scenario two will be the preferred alternative because of the low cost advantage.

4.4 Evaluate the scenarios against risks

Michelle Cooney [1995 s50-s53] has identified business risks, financial risks, insurable risks and clinical risks as the four risks that should be managed by the providers of pathology services. These risks will now be used to evaluate the selected scenarios.

4.4.1 Business risks

These are the risks associated with the legal and operational structures that are required to support the business. There is no legal risk in centralising the routine pathology tests. The operational structures to support both the scenarios of a centralised and decentralised laboratory environment can be put in place.

4.4.2 Financial risks

Financial risks are associated with profits, losses and future accountability. Although it seems that an increase in logistics cost is inevitable, the advantages gained by economies of scale and scope will far outweigh the increase in logistics costs. A decentralised laboratory will increase the financial risk to the organisation given the cost of providing a decentralised service. If the TAT provided by the centralised clinical laboratory is appropriate and if the cost is substantially less than using decentralised testing methods the financial risk to the organisation must be less.

4.4.3 Insurable risks

Insurable risks can be managed with the aid of insurance products. The strategic disadvantage that was associated with scenario 2 can be addressed with insurance products.

4.4.4 Clinical risks

Clinical risks are associated with the quality of the result generated by the pathology service that is provided to the physician and other professionals. This indeed is a very important risk if we keep in the mind the reasons why patients are referred to pathology laboratories by their physicians and other professionals. In a centralised laboratory it will be easier to ensure the quality of the result that is generated. Any problems that may arise will be identified and remedied immediately. Since only routine work will be done in the centralised reference laboratory the disadvantage of an increase in the TAT will not have an effect on the clinical risk. With proper logistical planning the TAT will stay within acceptable limits.

4.5 Selection of the appropriate scenario

The weighted table has indicated that the second scenario, in which a central routine laboratory will be used, is preferred above the existing scenario of three city regional laboratories.

All the problems associated with scenario two as apposed to scenario one can be overcome with the selection of suitable technology and proper planning. Insurance products will address the issue of strategic risk associated with natural disasters and labour action.

5. Location of the Central Routine Laboratory

The location of the central routine laboratory will now be determined. A two-way approach will be used to find the solution. A simple network consisting of only four points will be used to conceptualise the problem. It will be easier to demonstrate the final solution to the decision makers with the aid of this four point network since there are fewer variables to contend with. This network will be referred to as the regional model. Network and graph theory will be used to solve the complete network representing the 22 laboratory regions of the Ampath pathology network. This chapter will be concluded with a qualitative discussion on the results obtained from both networks.

5.1 Regional Model

5.1.1 Construction of the model

The two city regional laboratories in Johannesburg and Pretoria as well the Pomona laboratory in Kempton Park will form the corners of the triangle representing this network since they are the existing facilities that are best suited to accommodate a central routine laboratory. Midrand forms the fourth point and is located on the line connecting Johannesburg and Pretoria. Midrand is included because it is perceived as being one of the best locations for a central facility due the fact that many other companies are moving their main facilities here. It is in close proximity to both Johannesburg and Pretoria. It has also been discussed for some time now whether the construction of a large facility will be feasible in Midrand.

Figure 5.1 on the following page shows the regional model. The lines between the points represent the shortest actual distance between the facilities. Since the Kempton Park, Johannesburg and Pretoria facilities act as reference facilities for the East Rand, Drs. Bruinette Kramer & Partners and Drs. du Buisson & Partners respectively, it was very easy to determine the total patient value for each point. The total monthly patient volume for each facility divided by 1 000 was used as a weight to represent the relative importance of each point. The total monthly patient volume for Pretoria, Johannesburg and Kempton Park is 75 116, 37 789 and 73 346 respectively.

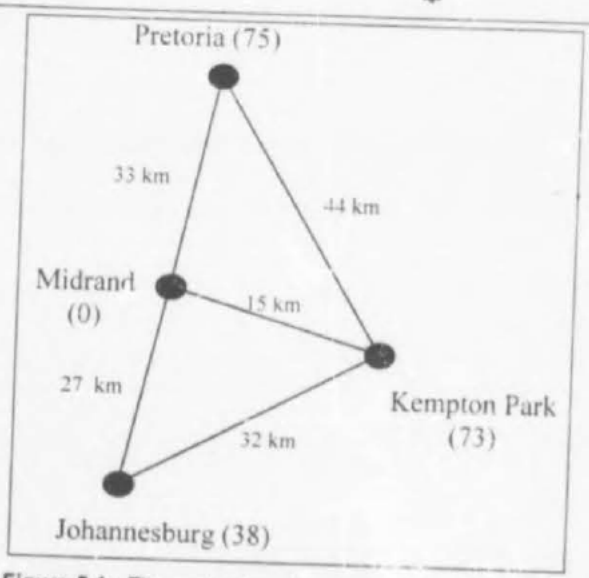

Figure 5.1: The regional model as depicted by the 4 points

5.1.2 Solving the model

The cost of collecting specimens from any point in the network is equal to the product of the weight of that point and the actual distance between that point and the central location in the network. The total cost of collecting specimens from all points in the network to a central point is the sum of the above mentioned products for all points in the network. Table 5.1 shows the total collection cost associated with each point in the network. To make the evaluation of the total cost easier it is expressed as a percentage of the smallest value

Table 5.1: The total collection cost associated with each point.

	PATIENTS	TOTAL COST	PERCENTAGE
JOHANNESBURG	38	6,854	152%
PRETORIA	75	5,494	122%
KEMPTON PARK	73	4,514	100%
MIDRAND	0	4,599	102%

According to this total cost method the best location for the central facility will be at Kempton Park. Midrand will be second best with a total cost that is 2% higher than that

of Kempton Park. The total collection cost at both Johannesburg (52%) and Pretoria (22%) will be much higher than that of Kempton Park and Midrand.

Since the fairness of the allocation of patients (weights) to the points could be questioned, it is necessary to do a sensitivity analysis. (The fairness can be questioned due to uncertainty of future market trends. Therefor the possible market outcomes must be evaluated.)

5.1.3 Sensitivity Analysis

The sensitivity analysis will address two issues. Firstly, we will investigate the sensitivity of the result for a variance in patient volumes. Secondly, the traffic density through Midrand will have to be evaluated since this is one of the major concerns raised by the decision makers.

5.1.3.1 Varying the patients volumes

The patient volumes for each of the points will be varied by 20% to ensure confidence in the results. Table 5.2 will show the result of varying the patient volumes of Kempton Park while keeping the patient volumes of the other points constant. It can be seen that the decision of whether Kempton Park or Midrand is the best location hinges very strongly on the patient volume of Kempton Park. A reduction in the number of patients at Kempton Park would tip the balance in favour of Midrand. The chances are actually better that the patient volumes at Kempton Park will increase due to the possibility of work being flown in from other regions not yet serviced by Ampath.

Table 5.2: The result of varying the Kempton Park patient volumes.

	-20%	-10%	10%	20%
JOHANNESBURG	146%	147%	157%	162%
PRETORIA	111%	115%	129%	136%
KEMPTON PARK	103%	101%	100%	100%
MIDRAND	100%	100%	104%	107%

The effect of varying the patient volumes in Pretoria can be seen in table 5.3 on the following page. A fairly small increase in the patient volumes at Pretoria will change the decision in favour of Midrand. It is however very unlikely that there will be any significant rise in the patient volumes due to fact that Drs. du Buisson & Partners are

percentage wise the strongest pathology practice in the region with very little scope in increasing its market share.

Table 5.3: The result of varying the Pretoria patient volumes

	-20%	-10%	10%	20%
JOHANNESBURG	154%	153%	151%	152%
PRETORIA	143%	131%	113%	108%
KEMPTON PARK	100%	100%	100%	102%
MIDRAND	106%	104%	100%	100%

If the patient volume at Pretoria is increased significantly it will change the decision in favour of Midrand. According to this calculation Kempton Park will remain the best location, even if the Johannesburg patient volumes are increased by 20%, as can be seen in table 5.4.

Table 5.4: The result of varying the Johannesburg patient volumes

	-20%	-10%	10%	20%
JOHANNESBURG	160%	156%	148%	144%
PRETORIA	118%	120%	123%	125%
KEMPTON PARK	100%	100%	100%	100%
MIDRAND	103%	102%	101%	101%

5.1.3.2 Varying the traffic density

The model is based on the assumption of ideal traffic flow. This means that the traffic density along all the roads on the network is exactly the same. This assumption is not valid since the N1 between Johannesburg and Pretoria experiences chronic traffic problems in and out of Midrand during peak hours. We will build this traffic problem into the model by changing the distances between Midrand and Pretoria as well as the distance between Midrand and Johannesburg. The effect of doubling the distances between the locations can be seen in table 5.5. By bringing the traffic densities into the equation the feasibility of Midrand as location is reduced quite significantly. Table 5.5 shows that Kempton Park is the only location unaffected by the traffic density through Midrand.

Table 5.5: The result of varying the traffic density through Midrand

	JHB to MIDRAND	PTA to MIDRAND
JOHANNESBURG	152%	152%
PRETORIA	122%	122%
KEMPTON PARK	100%	100%
MIDRAND	124%	157%

5.1.4 Results

If the existing patient numbers at Johannesburg, Pretoria and Kempton Park are used as an indication of their relative importance, and the total costs are calculated as defined in paragraph 5.1.2, then it can be seen that Kempton Park is the best location for the central routine laboratory. Midrand will be second best with a cost that is 2% higher than that of Kempton Park.

The sensitivity analysis has shown that the following events, or changes in markets, will cause Midrand to be a better location than Kempton Park.

- A reduction of patient numbers at Kempton Park.
- A significant increase of patient numbers at Pretoria.

The traffic through Midrand has a negative impact on Midrand with Kempton Park now being the best location by a greater margin. Midrand will be 24% more expensive if the traffic between Johannesburg and Midrand is doubled, and Midrand will be 57% more expensive if the traffic between Pretoria and Midrand is doubled.

5.2 Network and Graph theory to solve the location problem

In finding the correct location for the centralised routine laboratory it is very important to consider the TAT for the specimens. When the value chain is kept in mind it is obvious that the transportation leg of the value chain has a very significant role to play in the reduction of the TAT and therefore the provision of a competitive pathology service. The greatest part of the effort in pathology laboratory management is focused on the analytical side, and it is therefore not surprising that most of the available R&D funding is spent on technology improvement. The literature therefore has dedicated very little to the understanding of the location problem of pathology services.

5.2.1 Construction of the network

Since network and graph theory have a wide application in the solution of location problems it was decided that it would also be used in investigating the location of the central routine pathology laboratory. After an extensive visit to laboratories in Germany and the United States it was obvious that advanced algorithms, provided by network and graph theory are seldom, if ever, used in establishing or evaluating the location of the pathology laboratory.

The locations of pathology laboratories are often, amongst others, the result of the following:

- A perceived idea of a central location relative to markets and major hospitals.
- Historic reasons that may or may not reflect the geographic distribution of the market.
- Financial reasons such as the affordability of laboratory space.
- The availability of qualified laboratory personnel.

We will now construct the network that is used in solving the problem. Vertices will represent the possible locations for laboratories in the laboratory regions. These vertices will be linked by lines referred to as edges. Since we are only concerned with the end points of each edge - traffic can move in any direction between the vertices - the resultant graph will be an undirected graph.

5.2.1.1 Vertices

To identify all the vertices of the undirected graph it was necessary to study all the laboratories within Ampath in Gauteng (Drs Bruinette, Kramer & Partners and Drs du

Bursson & Partners) and their respective markets. In those regions where more than one of the practices had laboratories they were combined to form one vertex. By combining these locations it was possible to reduce the number of vertices significantly. This ensures a less complicated model without significantly interfering with the outcome of the result. This assumption is valid for the following reasons:

- In most regions the laboratories are located in close proximity, since the location of pathology laboratories is dependent on the location of hospitals, clinics, physician's offices, specialist's offices, etc.
- In centralised routine laboratory testing both laboratories will send their work to the same central facility. Since the distance from the peripheral laboratories to the central laboratory is much greater than the distance between the peripheral laboratories, in the same region, the model will not be influenced significantly.

The 22 laboratory regions forming the vertices of the graph are the Brits-, Rustenburg-, Pretoria-, Potgietersrus-, Pietersburg-, Tzaneen-, Louis Trichardt-, Midrand-, Krugersdorp-, Johannesburg-, Kempton Park-, Boksburg-, Benoni-, Witbank-, Middelburg-, Nelspruit-, Potchefstroom-, Alberton-, Germiston-, Trichardt-, Springs- and Ermelo laboratories.

5.2.1.2 Edges

The edges connecting the vertices in the graph represent the routes used by the couriers to collect the specimens from the laboratories. Since traffic is allowed in both directions, for the routes concerned, the edges are undirected. The length of the edges used in the model is equal to the actual travel distances between the points. The length associated with each edge can be seen in the distance matrix in Appendix A.

5.2.1.3 Weights

Since different size populations are represented by each of these vertices it is important that their relative importance in the network will be indicated by assigning a weight to every vertice. The average number of patients per month originating from each vertice will be used as an indication of their relative importance.

The weights assigned to each laboratory can be seen in Table 5.6.

Table 5.6: Weights assigned to the laboratory regions in the network

LABORATORY	BRUINETTE	DU BUISSON	TOTAL
BRITS	0	1385	1385
RUSTENBURG	0	13319	13319
PRETORIA	2248	48557	50805
POTGIETERSRUS	644	0	644
PIETERSBURG	2175	5117	7292
TZANEEN	0	1271	1271
LOUIS TRICHARDT	0	400	400
MIDRAND	0	952	952
KRUGERSDORP	6276	0	6276
JOHANNESBURG	23800	5342	29142
KEMPTON PARK	3992	8466	12458
BOKSBURG	831	3394	4225
BENONI	1732	5703	7435
WITBANK	0	3506	3506
MIDDELBURG	0	3680	3680
NELSPRUIT	524	6448	6972
POTCHEFSTROOM	0	2860	2860
ALBERTON	3853	4306	8159
GERMISTON	609	269	878
TRICHARDT	0	6831	6831
SPRINGS	996	5169	6165
ERMELO	0	1304	1304
EASTERN CAPE	0	11488	11488
TOTAAL	47679	139767	187446

5.2.2 Data collection

5.2.2.1 Edges

The length of the edges, the values in the distance matrix, was obtained from the actual odometer readings of the vehicles servicing these routes. The couriers were asked to physically write down the odometer reading at each stop. The data was collated by the transport manager and different couriers were sent on the same route to attain a high degree of confidence in the accuracy.

5.2.2.2 Weights

The average number of patients per month was collected from standard reports generated by the common Meditech LIS (Laboratory Information System) that is used by both practices. Extensive spreadsheet manipulation was required to standardise the way in which patients are counted.

The reason for this difference is due to the different philosophies of each individual practice. The Drs. Bruinette, Kramer & Partners practice counts the patient at the location where the tests are actually performed, and not at the location that the patient sample actually entered into the pathology network. This means that if a patient sample entered the pathology system at the Krugersdorp laboratory, but the actual test is performed in Johannesburg due to a degree of specialisation required that is not available at the peripheral laboratory, then the patient will be counted at the Johannesburg laboratory. The Drs. du Buisson & Partners LIS is set-up to count the patient at the location where it entered the Pathology network, and this method is referred to as the origination method. To standardise this the data was manipulated to conform to the origination method, as this will give us a much better indication of the relative weight of the different locations.

5.2.3 Weighted map

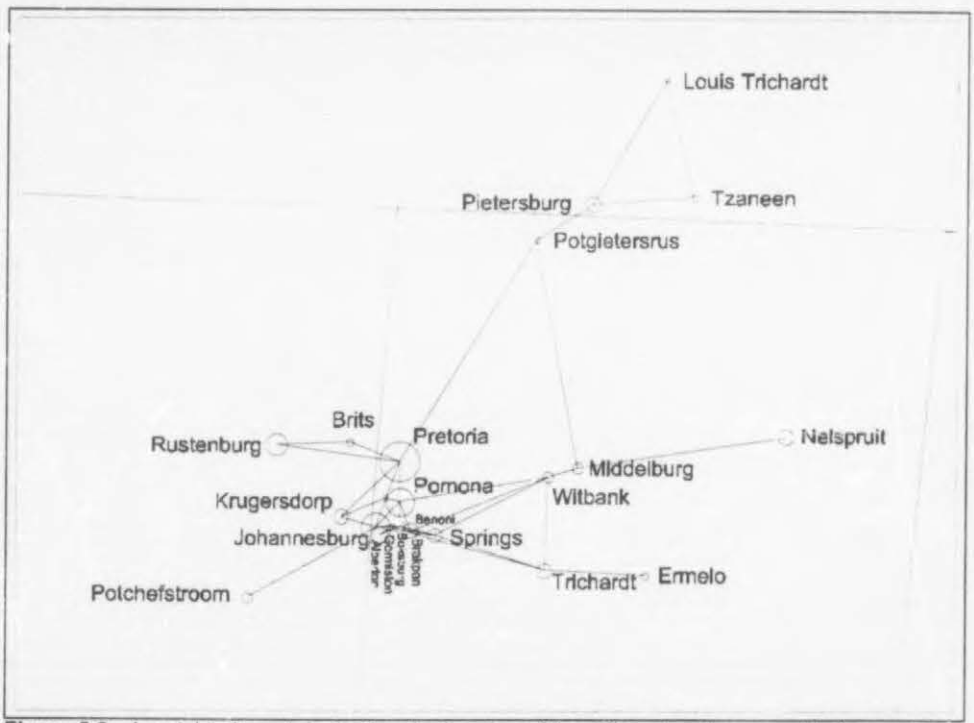

Figure 5.2: A weighted graph indicating the location of the different vertices used in the model.

For the correct interpretation of the output of the model it was necessary to draw the map on scale. A Mapstudio map was used as basis and the relevant points were drawn in a TurboCad drawing program. The scaled drawing makes it easier to communicate the results to the decision-makers and it also facilitates the visual validation of the results. The number of patients originating at each region is indicated by the area of the circle with its centre on the laboratory. The map can be seen in figure 5.2.

5.2.4 Classification of the location problem

To understand the reasoning for the specific route followed to establish the location of the central routine facility it is important to classify the location according to the three characteristics as explained in *Optimisation Algorithms for Networks and Graphs* [Evans, 1992:364].

5.2.4.1 Potential location of the facility

It would theoretically be possible to establish the facility on the vertex or anywhere on the network. In the location problem of emergency services this is how it should be, but it must be kept in mind that this is only the routine facility and there the advantages of having it located at the vertices rather than somewhere on the edges far outweighs the added advantage in TAT. The support services that the routine laboratory must rely on include suppliers, reliable power and water supply, telephones, warehousing, etc. and these are usually located at the vertices.

5.2.4.2 The location of demand

The health services (hospitals, clinics, physician's offices, etc.) are more likely to be found on the vertices, as they will tend to service higher density populations and it is only in very specialised health services that patients from outside the community will play an important role. Since the pathology laboratories are dependent on the location of the other health services they are bound to be in the same proximity.

5.2.4.3 Objective function

The objective function for this specific problem is twofold. Firstly, as a health service or emergency service the objective will be to minimise the maximum travel cost. This is

necessary in order to provide the peripheral laboratory with the best possible TAT. Secondly, for a central routine pathology laboratory the cost pressure exercised by a changing health care environment creates the need to minimise the total maximum cost.

It will therefore be necessary to find a solution that satisfies both the objectives as discussed in the previous paragraph. Since both the location and the demand occur at the vertices in this model it is necessary to calculate the centre and the median for this problem.

5.2.5 Calculation of centre and median

The centre is that vertex in the network that is located in such a way that the vertex in the network that is the furthest away from it is as close as possible. The median is that vertice in the network that is located in such a way that the total distance to all the other vertices in the network is a minimum.

5.2.5.1 Floyd's shortest-path algorithm

In order to calculate the centre and median it is necessary to first calculate the shortest distance matrix. This shortest distance matrix is the matrix that indicates the shortest distance between all pairs of vertices in the network. This matrix can be very efficiently calculated by using Floyd's shortest-path algorithm. The resultant shortest distance matrix can be seen in table 22 of Appendix A.

The algorithm was solved by using an Excel spreadsheet. The spreadsheet was used since it would be easy to allow interactive participation from the decision makers. The total printout of the spreadsheet can be seen in Appendix A.

5.2.5.2 Weighted matrix

The measure of the cost for the central laboratory of collecting the specimens from the different laboratories is a function of the distance between the laboratories and the number of patients originating at each laboratory.

$$C_i = f(d_i; p_i) \qquad \textbf{[Equation 5.1]}$$

Where:

- C_i = Measure of cost of collecting specimens from laboratory i
- d_i = Actual distance travelled in kilometre between laboratory i and the central laboratory
- p_i = Number of patients originating at laboratory i

To allow for the weights, every column in the shortest distance matrix is multiplied by the weight of the corresponding vertex. The result is a weighted shortest distance matrix that can be used in the calculation of the median and centre.

5.2.5.3 Median

The total cost for the central laboratory, of collecting specimens from the n-1 other laboratories in the network with n vertices, is equal to the sum of the cost of collecting specimens from the individual laboratories.

$$TC = \sum_{i=1}^{n-1} f(d_i, p_i)$$ **[Equation 5.2]**

Where:

- TC = Measure of total cost of collecting specimens from all laboratories in the network.
- d_i = Shortest actual distance travelled in kilometre between laboratory i and the central laboratory
- p_i = Number of patients originating at laboratory i
- n = Number of laboratories in network

The laboratory for which the sum of the products of the weight of each laboratory and the distance between those laboratories and the central routine pathology laboratory is the smallest will be the median.

5.2.5.4 Centre

The laboratory for which the maximum of the products of the weight of each laboratory and the distance between those laboratories and the central routine pathology laboratory is the smallest will be the centre.

5.2.6 Results

In table 5.7 is the result of the spreadsheet calculations. To make it easier to evaluate the results they are ranked in order, from the smallest value to the biggest value.

Table 5.7: The results of the spreadsheet calculation

	MEDIAN		CENTER	
LABORATORY	WEIGHTED SUM	RANK	WEIGHTED MAX	RANK
BRITS	27712962	11	3788395	9
RUSTENBURG	35538544	14	6096620	12
PRETORIA	16410567	5	2830429	3
POTGIETERSRUS	50345952	17	11431163	16
PIETERSBURG	59669583	18	14225447	18
TZANEEN	75729421	21	18645496	20
LOUIS TRICHARDT	80115474	22	19814015	21
MIDRAND	15615742	1	2628256	2
KRUGERSDORP	21948382	10	3556362	7
JOHANNESBURG	16766559	6	3048310	6
KEMPTON PARK	15631512	2	2523683	1
BOKSBURG	16245445	3	2997505	5
BENONI	16259097	4	2895895	4
WITBANK	30627750	12	8484463	13
MIDDELBURG	35035637	13	10008618	14
NELSPRUIT	71297741	20	20626898	22
POTCHEFSTROOM	42208184	15	10161033	15
ALBERTON	18891964	8	3962803	10
GERMISTON	18460271	7	3556362	7
TRICHARDT	42700902	16	11990019	17
SPRINGS	19582088	9	4115219	11
ERMELO	61184691	19	17070536	19

If we look at the median it is very interesting to see that there is almost no difference between the first two laboratories, namely Midrand and Kempton Park. The difference is only 0,1% and therefore both these locations can be taken as optimal. The centre is much more clear-cut with Kempton Park being more than 4% better than Midrand.

These answers are not surprising, keeping in mind the results of the previous method. If these results are compared with our practical experience we would have expected Midrand and Kempton Park to be the better locations for a centralised laboratory. Each one of these locations has its own unique characteristics that will be evaluated in the qualitative analysis.

5.3 Qualitative analysis

The testing of blood, urine and other specimens closely resembles manufacturing and the same broad criteria that apply to the location of manufacturing plants will therefore also apply to the location of a central pathology laboratory. The following discussion will address the selection of the market region and the physical site by taking into account the market share, market potential, infrastructure, transportation (inbound and outbound), labour and suppliers.

5.3.1 Steps in deciding on the final location

5.3.1.1 Market

The decision to locate the central routine laboratory in Gauteng was taken for a number of good reasons. Firstly, there is no doubt that Gauteng is the economic hub of South Africa with 18,9% of the economically active population residing here. This large, high density, patient base will potentially provide the central routine laboratory with the volumes required to achieve economies of scale. Secondly, less than 25% of the total turnover of Ampath is generated outside of this region. It makes good business sense to locate the central routine laboratory in this region since it would ensure the retention of the existing market share that Ampath would not like to put at risk due to competitive forces.

Ampath's share of the total private pathology market currently stands at 45% with a great growth opportunity in the Western Cape and Eastern Cape. To capture these potential markets, close proximity to an airport is essential to ensure a fast TAT. It is clear from table 5.8 that Johannesburg International Airport is the South African airport with the highest frequency of incoming domestic flights that covers all other major national airports. Therefor it will be very easy to collect specimens from all other regions in the country on a daily basis with more than 5 daily incoming flights from each region. Since Cape Town, East London and Durban have their last flight to Johannesburg leaving after 19H00 in the evening it is possible to send all the routine work collected on that day to ensure a TAT of less than 24 hours.

Because of its proximity to the Johannesburg International Airport, Kempton Park will be the location of choice for the central routine laboratory ahead of Midrand.

Table 5.8: Weekly South African Airways domestic flights between major South African airports

	JHB INT	BLM INT	CPT INT	EL INT	DBN INT	TOTAL
JOHANNESBURG INT	0	47	98	34	87	**266**
BLOEMFONTEIN INT	38	0	22	24	32	**116**
CAPE TOWN INT	95	17	0	25	59	**196**
EAST LONDON	36	30	25	0	25	**116**
DURBAN INT	98	50	62	24	0	**234**
TOTAL	**267**	**144**	**207**	**107**	**203**	**928**

5.3.1.2 Road infrastructure

The road infrastructure forms the arteries of the courier system. Easy access to the major highways and airports are therefore essential in choosing the correct location. The main highways in this region include the N1, N3, N12, N17, R21, R24 and R28. Both Midrand and Kempton Park provide relatively easy access to these highways. The heavy congestion in and around Midrand, especially during peak traffic hours, disqualifies Midrand, and therefore Kempton Park will be preferred.

5.3.1.3 Public transport

A reliable public transport system is seriously lacking in South Africa. Public transport, however limited, is more readily available in Midrand than in Kempton Park. It will therefore be easier for the laboratory personnel, who are dependent on public transport, to commute to Midrand. The technologists and technicians, who are essential to the operation of the central routine facility, are as a rule more mobile than the non-technical staff and therefore not as dependent on public transport. The non-technical staff will be required in the regional and peripheral laboratories to operate the pre-analytical laboratories and courier networks of the regions. The nursing staff will be responsible for the depots and will not be affected by the centralisation at all. For this reason, public transport will not have a serious impact on the location decision.

5.3.1.4 Facility infrastructure

The existing facility at Kempton Park is less than two years old and was originally designed to become an automated laboratory. It has an open plan design that will facilitate the efficient flow of the specimens through the laboratory. It differs from the existing facilities (614 Pretorius Street, Bosman Building and Durdoc Building) in that all the laboratory activities can be accommodated on the ground floor. In Total Laboratory Automation (TLA), the single most expensive part of the specimen transport system is the vertical transportation of specimens. Multi-storey buildings lead to a focus on

functions rather than focusing on technology. The masterplan for the facility makes provision to add another 1 650 m^2 to the current laboratory floor space of 1 600 m^2 to ensure enough capacity to cope with any increase in specimen volumes. In Kempton Park additional floor space can be acquired at less than 50% of the cost of equivalent floor space in the Midrand area. With the pressure on cost containment this a very important factor to consider, since 7% of the total cost is spent on rent and levies.

5.3.1.5 Logistics

The inbound logistics of the value chain will provide us with an opportunity to improve the TAT. The inbound transportation primarily includes the collection of specimens and request forms, and this function is performed by our in-house courier department. Another important component, which is sometimes underestimated, is the delivery of equipment, reagents and consumables to the laboratory. All the major suppliers of pathology equipment, reagents and consumables are net importers. Since most of the equipment, reagents and consumables are imported directly from Europe and the United States, with very short lead times, none of the major suppliers carry any stock in South Africa. The delivery to the laboratories resembles a JIT (Just In Time) system with deliveries directly from the Airport. The location at Kempton Park will therefore be ideal, especially for the refrigerated reagents.

The logistics companies on the premises adjacent to the facility in Kempton Park can provide counter-to-laboratory services that will expedite the retrieval of specimens from the incoming flights. Currently it takes more than two hours from the time the flight has landed to the time that the specimens are received at the Pretoria and Johannesburg regional laboratories. This time can be cut by more than 50% to have a significant impact (between 15 and 20% depending on the origination of the specimen) on the TAT for specimens flown in from the other regions.

The output of the pathology laboratory is a test result that is mostly sent electronically, and therefore it has a negligible impact on the TAT. The balance of the reports (results) is distributed to the clients via the same courier network that collects the specimens and request forms. The same criteria that were used previously can now be used to indicate that Kempton Park will be the preferred location. EDI takes care of most of the invoices and statements that are sent to the medical aids. Medical waste, which is a product of the analytical process, is becoming less with the introduction of the new technology and is of no real concern in choosing the location.

5.3.1.6 Services

The supply of services (electricity, voice and data lines) is of critical importance. Because the Meditech LIS is a mainframe system, with the hardware located off-site, the theft of copper cables poses a real threat to the operation of the laboratory. Moving the hardware to the central routine facility can reduce this risk.

Unfortunately Kempton Park is prone to power failures due to heavy thunderstorm activities. This problem has been successfully resolved with the installation of generators and UPS's (Uninterruptable Power Supplies).

5.3.2 Results

This qualitative analysis supports the calculation of the centre and median earlier in this chapter which indicated that Kempton Park will form the centre (4% cheaper according to our definition than Midrand) of the laboratory network. Kempton Park is chosen as the most suitable location for the routine pathology laboratory for the following reasons:

- This site is in close proximity (less than 5 kilometres) to Johannesburg International Airport that has the highest frequency of incoming domestic flights.
- This site provides easy access to the road infrastructure that forms the arteries of the specimen collection system.
- The existing facility is a well-designed laboratory with enough space to expand with an increase in patient volumes at a relative low cost compared to other sites.
- All the major suppliers of diagnostic products have their head offices in Gauteng and this ensures short lead-times for equipment, reagents and consumables.

6. Conclusions and Recommendations

Future trends will include the formation of larger central pathology laboratories owned by health care groups instead of the traditional pathologist owned laboratories. The SmithKline Beecham and Quest Laboratories are already proof of this increased drive towards the centralisation of pathology laboratories managed by business people. The issue of whether the laboratories should be centralised or decentralised is not an either or case, but rather one of where the optimal performance will be achieved, since decentralised testing will always have its rightful place in the pathology testing matrix.

The very strong demand in terms of time, cost and quality has had an impact on all laboratories. Firstly, the financial pressure influences the number and type of tests requested by physicians, specialist and other professionals using pathology laboratories, and it will increasingly lead to a reduction in the income of pathology laboratories. Secondly, despite these cost pressures patients are much more informed and demand a better service, both in terms of TAT and increased information content of the report.

These demands mean that the managers of the centralised laboratories will remain under continued pressure.

- They will have to reduce their fixed and variable cost. Due to the relatively high fixed cost to variable cost ratio it is very difficult for a decentralised laboratory to perform many of the routine pathology tests profitably. Economies of scale can be achieved by centralising these tests to a centralised facility where it can be performed profitably.
- They will have to ensure that their TAT stays within acceptable levels, as this is the performance measure used by their clients.
- They will have to undergo accreditation to ensure compliance with international standards, applicable to pathology laboratories, in order to limit non-analytical sources of error.
- They will have to install rapid delivery systems to ensure agility in a rapidly changing diagnostic environment.

As a result of the high cost of achieving TLA (Total Laboratory Automation), Business Process Re-engineering of the central routine pathology laboratory should be focussed on flexible automation to achieve the required savings and operational efficiencies in the short, medium and long term.

Centralisation will provide the routine pathology laboratories with the following advantages:

- Low variable, incremental, and process control cost per test.
- Low total error rate in an operator neutral and automated environment.
- Quality improvement philosophy.
- Operational and administrative advantages of centralised management.
- Easier communication in a centralised laboratory environment.

The calculation of the centre and median from the weighted shortest distance matrix, calculated by means of Floyd's shortest-path algorithm, of the laboratory network has shown that the central routine pathology laboratory should be located at the Kempton Park laboratory. This recommendation is supported by a number of factors that was taken into consideration by the qualitative analysis:

- Less than 25% of Ampath's total turnover originates from outside this region.
- This site is in close proximity (less than 5 kilometres) to Johannesburg International Airport that has the highest frequency of incoming domestic flights.
- This site provides easy access to the road infrastructure that forms the arteries of the specimen collection system.
- The existing facility is a well-designed laboratory with enough space to expand with an increase in patient volumes at a relative low cost compared to other sites.
- All the major suppliers of diagnostic products have their head offices in Gauteng and this ensures short lead-times for equipment, reagents and consumables.

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Appendix A: Network and graph theory

SPREADSHEET

This is a short introduction to Floyd's shortest-path algorithm and the calculation of the centre and the median. It shortly refers to the different worksheets (tables) in this spreadsheet (appendix).

1. Introduction

Floyd's shortest-path algorithm can be used to calculate the shortest path be ween every pair of vertices in the graph. The following is only a definition of Floyd's shortest-path algorithm and it is by no means a complete discussion. A comprehensive discussion of this algorithm can be found in *Optimization Algorithms for Networks and Graphs* by James R Evans and Edward Minieka. [1992:93-99]

Floyd's shortest-path algorithm

Step 1: Number the vertices of graph $1, 2, \ldots, m$. Determine the matrix D^0 whose i, jth element equals the length of the shortest arc from vertex i to vertex j, if any. If no such arc exists, let $d^0_{ij} = X$. Let $d^0_{ij} = 0$ for each i.

Step 2: For $k = 1, 2, \ldots, m$, successively determine the elements of D^k from the elements of D^{k-1} using the following recursive formula:

$$d^k_{ij} = \min\{d^{k-1}_{ik} + d^{k-1}_{kj}, d^{k-1}_{ij}\}$$

As each element is determined, record the path that it represents. Upon termination, the i, jth element of matrix D^m represents the length of a shortest path from vertex i to vertex j.

2. Weights of laboratories

The weights of the different laboratories are calculated here by adding the volumes of the two practices (Drs. du Buisson & Partners and Drs. Bruinette, Kramer & Partners) concerned.

3. Floyd's Algorithm

Weights: The weights seen at the top of the shortest distance matrix are used as an indication of the importance of the laboratory. It follows directly from the "total" column in worksheet number 2.
Distance Matrix: This table shows the actual distance travelled between the different laboratories.
Tables 1 - 22: Calculation of the shortest distance matrix (table 22) by means of Floyd's Algorithm.
Table 22 Weighted: This table is calculated by using the weights (worksheet 2) of the different laboratories and the shortest distance matrix (table 22).

4. Centre and Median Calculation

Centre: For each row (table 22 weighted) the maximum value is taken. The laboratory for which the maximum is a minimum will be at the centre. For ease of use the maximum values are ranked.
Median: For each row (table 22 weighted) the sums are calculated. The laboratory for which the sum is a minimum will be at the median. For ease of use the sums are ranked.

WEIGHTS OF THE DIFFERENT LABORATORIES			
LABORATORY	BRUINETTE	DU BUISSON	TOTAL
BRITS	0	1385	1385
RUSTENBURG	0	13319	13319
PRETORIA	2248	48557	50805
POTGIETERSRUS	644	0	644
PIETERSBURG	2175	5117	7292
TZANEEN	0	1271	1271
LOUIS TRICHARDT	0	400	400
MIDRAND	0	952	952
KRUGERSDORP	6276	0	6276
JOHANNESBURG	23800	5342	29142
KEMPTON PARK	3992	8466	12458
BOKSBURG	831	3394	4225
BENONI	1732	5703	7435
WITBANK	0	3506	3506
MIDDELBURG	0	3680	3680
NELSPRUIT	524	6448	6972
POTCHEFSTROOM	0	2860	2860
ALBERTON	3853	4306	8159
GERMISTON	609	269	878
TRICHARDT	0	6831	6831
SPRINGS	996	5169	6165
ERMELO	0	1304	1304
EASTERN CAPE	0	11488	11488
TOTAAL	**47679**	**139767**	**187446**

FLOYD'S ALGORITHM

DISTANCE MATRIX	BRITS	RUSTENBURG	PRETORIA	POTGIETERSRUS	PIETERSBURG	TZANEEN	LOUIS TRICHARDT	MIDRAND	KRUGERSDORP	JOHANNESBURG	KEMPTON PARK	BOKSBURG	BENONI	WITBANK	MIDDELBURG	NELSPRUIT	POTCHEFSTROOM	ALBERTON	GERMISTON	TRICHARDT	SPRINGS	ERMELO			
WEIGHTS	1365	18319	50805	644	7292	1271	400	952	6276	29142	23946	4225	7435	3506	3680	6972	2860	8159	876	6831	5165	1304			
BRITS	0	68	70	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	0	0	0
RUSTENBURG	68	0	120	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	0	0	0
PRETORIA	70	120	0	225	1E+10	1E+10	1E+10	33	70	1E+10	44	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	0	0	0
POTGIETERSRUS	1E+10	1E+10	225	0	55	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	200	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	0	0	0
PIETERSBURG	1E+10	1E+10	1E+10	55	0	87	110	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	0	0	0
TZANEEN	1E+10	1E+10	1E+10	1E+10	87	0	130	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	0	0	0
LOUIS TRICHARDT	1E+10	1E+10	1E+10	1E+10	110	130	0	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	0	0	0
MIDRAND	1E+10	1E+10	33	1E+10	1E+10	1E+10	1E+10	0	60	27	15	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	0	0	0
KRUGERSDORP	1E+10	1E+10	70	1E+10	1E+10	1E+10	1E+10	60	0	45	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	0	0	0
JOHANNESBURG	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	27	45	0	32	18	1E+10	1E+10	1E+10	1E+10	140	1E+10	10	1E+10	1E+10	1E+10	0	0	0
KEMPTON PARK	1E+10	1E+10	44	1E+10	1E+10	1E+10	1E+10	15	1E+10	32	0	15	13	159	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	0	0	0
BOKSBURG	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	18	15	0	10	1E+10	1E+10	1E+10	1E+10	19	1E+10	1E+10	30	1E+10	0	0	0
BENONI	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	13	10	0	[illegible]	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	24	1E+10	0	0	0
WITBANK	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	159	1E+10	110	0	30	1E+10	1E+10	1E+10	1E+10	110	114	1E+10	0	0	0
MIDDELBURG	1E+10	1E+10	1E+10	200	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	30	0	209	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	0	0	0
NELSPRUIT	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	209	0	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	0	0	0
POTCHEFSTROOM	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	140	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	0	1E+10	1E+10	1E+10	1E+10	1E+10	0	0	0
ALBERTON	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	19	1E+10	1E+10	1E+10	1E+10	1E+10	0	12	1E+10	1E+10	1E+10	0	0	0
GERMISTON	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	12	0	1E+10	1E+10	1E+10	0	0	0
TRICHARDT	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	110	1E+10	1E+10	1E+10	1E+10	1E+10	0	155	100	0	0	0
SPRINGS	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	30	24	114	1E+10	1E+10	1E+10	1E+10	1E+10	155	0	1E+10	0	0	0
ERMELO	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	100	1E+10	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

FLOYD'S ALGORITHM

TABLE 1	BRITS	RUSTENBURG	PRETORIA	POTGIETERSRUS	PIETERSBURG	TZANEEN	LOUIS TRICHARDT	MIDRAND	KRUGERSDORP	JOHANNESBURG	KEMPTON PARK	BOKSBURG	BENONI	WITBANK	MIDDELBURG	NELSPRUIT	POTCHEFSTROOM	ALBERTON	GERMISTON	TRICHARDT	SPRINGS	ERMELO	#REF!	#REF!	#REF!
BRITS	0	66	70	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	0	0	0
RUSTENBURG	68	0	120	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	0	0	0
PRETORIA	70	120	0	225	1E+10	1E+10	1E+10	33	70	1E+10	44	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	0	0	0
POTGIETERSRUS	1E+10	1E+10	225	0	55	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	200	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	0	0	0
PIETERSBURG	1E+10	1E+10	1E+10	55	0	87	110	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	0	0	0
TZANEEN	1E+10	1E+10	1E+10	1E+10	87	0	130	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	0	0	0
LOUIS TRICHARDT	1E+10	1E+10	1E+10	1E+10	110	130	0	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	0	0	0
MIDRAND	1E+10	1E+10	33	1E+10	1E+10	1E+10	1E+10	0	60	27	15	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	0	0	0
KRUGERSDORP	1E+10	1E+10	70	1E+10	1E+10	1E+10	1E+10	60	0	45	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	0	0	0
JOHANNESBURG	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	27	45	0	32	18	1E+10	1E+10	1E+10	1E+10	140	1E+10	10	1E+10	1E+10	1E+10	0	0	0
KEMPTON PARK	1E+10	1E+10	44	1E+10	1E+10	1E+10	1E+10	15	1E+10	32	0	15	13	159	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	0	0	0
BOKSBURG	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	18	15	0	10	1E+10	1E+10	1E+10	1E+10	19	1E+10	1E+10	30	1E+10	0	0	0
BENONI	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	13	10	0	110	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	24	1E+10	0	0	0
WITBANK	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	159	1E+10	110	0	30	1E+10	1E+10	1E+10	1E+10	110	114	1E+10	0	0	0
MIDDELBURG	1E+10	1E+10	1E+10	200	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	30	0	209	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	0	0	0
NELSPRUIT	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	209	0	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	0	0	0
POTCHEFSTROOM	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	140	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	0	1E+10	1E+10	1E+10	1E+10	1E+10	0	0	0
ALBERTON	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	19	1E+10	1E+10	1E+10	1E+10	1E+10	0	12	1E+10	1E+10	1E+10	0	0	0
GERMISTON	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	12	0	1E+10	1E+10	1E+10	0	0	0
TRICHARDT	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	110	1E+10	1E+10	1E+10	1E+10	1E+10	0	155	100	0	0	0
SPRINGS	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	30	24	114	3	1E+10	1E+10	1E+10	1E+10	155	0	1E+10	0	0	0
ERMELO	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	0	1E+10	1E+10	1E+10	1E+10	100	1E+10	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

FLOYD'S ALGORITHM

TABLE 2	BRITS	RUSTENBURG	PRETORIA	POTGIETERSRUS	PIETERSBURG	TZANEEN	LOUIS TRICHARDT	MIDRAND	KRUGERSDORP	JOHANNESBURG	KEMPTON PARK	BOKSBURG	BENONI	WITBANK	MIDDELBURG	NELSPRUIT	POTCHEFSTROOM	ALBERTON	GERMISTON	TRICHARDT	SPRINGS	ERMELO	#REF!	#REF!	#REF!
BRITS	0	68	70	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	0	0	0
RUSTENBURG	68	0	120	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	0	0	0
PRETORIA	70	120	0	225	1E+10	1E+10	1E+10	33	70	1E+10	44	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	0	0	0
POTGIETERSRUS	1E+10	1E+10	225	0	55	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	200	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	0	0	0
PIETERSBURG	1E+10	1E+10	1E+10	55	0	87	110	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	0	0	0
TZANEEN	1E+10	1E+10	1E+10	1E+10	87	0	130	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	0	0	0
LOUIS TRICHARDT	1E+10	1E+10	1E+10	1E+10	110	130	0	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	0	0	0
MIDRAND	1E+10	1E+10	33	1E+10	1E+10	1E+10	1E+10	0	60	27	15	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	0	0	0
KRUGERSDORP	1E+10	1E+10	70	1E+10	1E+10	1E+10	1E+10	60	0	45	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	0	0	0
JOHANNESBURG	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	27	45	0	32	18	1E+10	1E+10	1E+10	1E+10	140	1E+10	10	1E+10	1E+10	1E+10	0	0	0
KEMPTON PARK	1E+10	1E+10	44	1E+10	1E+10	1E+10	1E+10	15	1E+10	32	0	15	13	159	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	0	0	0
BOKSBURG	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	18	15	0	10	1E+10	1E+10	1E+10	1E+10	19	1E+10	1E+10	30	1E+10	0	0	0
BENONI	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	13	10	0	110	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	24	1E+10	0	0	0
WITBANK	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	159	1E+10	110	0	30	1E+10	1E+10	1E+10	1E+10	110	114	1E+10	0	0	0
MIDDELBURG	1E+10	1E+10	1E+10	200	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	30	0	209	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	0	0	0
NELSPRUIT	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	209	0	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	0	0	0
POTCHEFSTROOM	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	140	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	0	1E+10	1E+10	1E+10	1E+10	1E+10	0	0	0
ALBERTON	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	19	1E+10	1E+10	1E+10	1E+10	1E+10	0	12	1E+10	1E+10	1E+10	0	0	0
GERMISTON	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	12	0	1E+10	1E+10	1E+10	0	0	0
TRICHARDT	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	110	1E+10	1E+10	1E+10	1E+10	1E+10	0	155	100	0	0	0
SPRINGS	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	30	24	114	1E+10	1E+10	1E+10	1E+10	1E+10	155	0	1E+10	0	0	0
ERMELO	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	100	1E+10	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

FLOYD'S ALGORITHM

TABLE 3

	BRITS	RUSTENBURG	PRETORIA	POTGIETERSRUS	PIETERSBURG	TZANEEN	LOUIS TRICHARDT	MIDRAND	KRUGERSDORP	JOHANNESBURG	KEMPTON PARK	BOKSBURG	BENONI	WITBANK	MIDDELBURG	NELSPRUIT	POTCHEFSTROOM	ALBERTON	GERMISTON	TRICHARDT	SPRINGS	ERMELO	[illegible]	[illegible]	[illegible]
BRITS	0	68	70	295	1E+10	1E+10	[illegible]	[illegible]	140	1E+10	114	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	0	0	0
RUSTENBURG	68	0	120	345	1E+10	1E+10	[illegible]	[illegible]	190	1E+10	164	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	0	0	0
PRETORIA	70	120	0	225	1E+10	1E+10	[illegible]	[illegible]	70	1E+10	44	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	0	0	0
POTGIETERSRUS	295	345	225	0	55	1E+10	[illegible]	[illegible]	295	1E+10	289	1E+10	1E+10	1E+10	200	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	0	0	0
PIETERSBURG	1E+10	1E+10	1E+10	55	0	87	[illegible]	[illegible]	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	0	0	[illegible]
TZANEEN	1E+10	1E+10	1E+10	1E+10	87	0	[illegible]	[illegible]	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	0	0	0
LOUIS TRICHARDT	1E+10	1E+10	1E+10	1E+10	110	130	[illegible]	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	0	0	0
MIDRAND	103	153	33	258	1E+10	1E+10	1E+10	0	60	27	15	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	0	0	0
KRUGERSDORP	140	190	70	295	1E+10	1E+10	1E+10	60	0	45	114	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	0	0	0
JOHANNESBURG	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	27	45	0	32	18	1E+10	1E+10	1E+10	1E+10	140	1E+10	10	1E+10	1E+10	1E+10	0	0	0
KEMPTON PARK	114	164	44	289	1E+10	1E+10	1E+10	15	114	32	0	15	13	159	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	0	0	0
BOKSBURG	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	18	15	0	10	1E+10	1E+10	1E+10	1E+10	19	1E+10	1E+10	30	1E+10	0	0	0
BENONI	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	13	10	0	110	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	24	1E+10	0	0	0
WITBANK	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	159	1E+10	110	0	30	1E+10	1E+10	1E+10	1E+10	110	114	1E+10	0	0	0
MIDDELBURG	1E+10	1E+10	1E+10	200	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	30	0	209	1E+10	1E+10	1E+10	[illegible]	1E+10	1E+10	0	0	0
NELSPRUIT	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	209	0	1E+10	1E+10	1E+10	[illegible]	1E+10	1E+10	0	0	0
POTCHEFSTROOM	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	[illegible]	[illegible]	140	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	0	1E+10	1E+10	[illegible]	1E+10	1E+10	0	0	0
ALBERTON	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	[illegible]	[illegible]	1E+10	1E+10	19	1E+10	1E+10	1E+10	1E+10	1E+10	0	17	1E+10	1E+10	1E+10	0	0	0
GERMISTON	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	[illegible]	[illegible]	10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	12	[illegible]	1E+10	1E+10	1E+10	0	0	0
TRICHARDT	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	[illegible]	[illegible]	1E+10	1E+10	1E+10	1E+10	110	1E+10	1E+10	1E+10	1E+10	[illegible]	0	155	100	0	0	0
SPRINGS	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	[illegible]	[illegible]	1E+10	1E+10	30	24	114	1E+10	1E+10	1E+10	1E+10	[illegible]	155	0	1E+10	0	0	0
ERMELO	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	[illegible]	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	[illegible]	100	1E+10	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

FLOYD'S ALGORITHM

TABLE 4	BRITS	RUSTENBURG	PRETORIA	POTGIETERSRUS	PIETERSBURG	TZANEEN	LOUIS TRICHARDT	MIDRAND	KRUGERSDORP	JOHANNESBURG	KEMPTON PARK	BOKSBURG	BENONI	WITBANK	MIDDELBURG	NELSPRUIT	POTCHEFSTROOM	ALBERTON	GERMISTON	TRICHARDT	SPRINGS	ERMELO	#REF!	#REF!	#REF!
BRITS	0	68	70	295	350	1E+10	1E+10	103	140	1E+10	114	1E+10	1E+10	1E+10	495	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	0	0	0
RUSTENBURG	68	0	120	345	400	1E+10	1E+10	153	190	1E+10	164	1E+10	1E+10	1E+10	545	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	0	0	0
PRETORIA	70	120	0	225	280	1E+10	1E+10	33	70	1E+10	44	1E+10	1E+10	1E+10	425	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	0	0	0
POTGIETERSRUS	295	345	225	0	55	1E+10	1E+10	258	295	1E+10	269	1E+10	1E+10	1E+10	200	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	0	0	0
PIETERSBURG	350	400	280	55	0	87	110	313	350	1E+10	324	1E+10	1E+10	1E+10	255	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	0	0	0
TZANEEN	1E+10	1E+10	1E+10	1E+10	87	0	130	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	0	0	0
LOUIS TRICHARDT	1E+10	1E+10	1E+10	1E+10	110	130	0	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	0	0	0
MIDRAND	103	153	33	258	313	1E+10	1E+10	0	60	27	15	1E+10	1E+10	1E+10	458	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	0	0	0
KRUGERSDORP	140	190	70	295	350	1E+10	1E+10	60	0	45	114	1E+10	1E+10	1E+10	495	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	0	0	0
JOHANNESBURG	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	27	45	0	32	18	1E+10	1E+10	1E+10	1E+10	140	1E+10	10	1E+10	1E+10	1E+10	0	0	0
KEMPTON PARK	114	164	44	269	324	1E+10	1E+10	15	114	32	0	15	13	159	469	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	0	0	0
BOKSBURG	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	18	15	0	10	1E+10	1E+10	1E+10	1E+10	19	1E+10	1E+10	30	1E+10	0	0	0
BENONI	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	13	10	0	110	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	24	1E+10	0	0	0
WITBANK	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	159	1E+10	110	0	30	1E+10	1E+10	1E+10	1E+10	110	114	1E+10	0	0	0
MIDDELBURG	495	545	425	200	255	1E+10	1E+10	458	495	1E+10	469	1E+10	1E+10	30	0	209	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	0	0	0
NELSPRUIT	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	209	0	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	0	0	0
POTCHEFSTROOM	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	140	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	0	1E+10	1E+10	1E+10	1E+10	1E+10	0	0	0
ALBERTON	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	19	1E+10	1E+10	1E+10	1E+10	1E+10	0	12	1E+10	1E+10	1E+10	0	0	0
GERMISTON	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	12	0	1E+10	1E+10	1E+10	0	0	0
TRICHARDT	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	110	1E+10	1E+10	1E+10	1E+10	1E+10	0	155	100	0	0	0
SPRINGS	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	30	24	114	1E+10	1E+10	1E+10	1E+10	1E+10	155	0	1E+10	0	0	0
ERMELO	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	100	1E+10	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

FLOYD'S ALGORITHM

TABLE 5	BRITS	RUSTENBURG	PRETORIA	POTGIETERSRUS	PIETERSBURG	TZANEEN	LOUIS TRICHARDT	MIDRAND	KRUGERSDORP	…URG	…K	BOKSBURG	BENONI	WITBANK	MIDDELBURG	NELSPRUIT	POTCHEFSTROOM	ALBERTON	GERMISTON	TRICHARDT	SPRINGS	ERMELO	#REF!	#REF!	#REF!
BRITS	0	68	70	295	350	437	460	103	140	1E+1		1E+10	1E+10	1E+10	495	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	0	0	0
RUSTENBURG	68	0	120	345	400	487	510	153	190	1E+10		E+10	1E+10	1E+10	545	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	0	0	0
PRETORIA	70	120	0	225	280	367	390	33	70	1E+10		1E+10	1E+10	1E+10	425	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	0	0	0
POTGIETERSRUS	295	345	225	0	55	142	165	258	295	1E+10	269	1E+10	1E+10	1E+10	200	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	0	0	0
PIETERSBURG	350	400	280	55	0	87	110	313	350	1E+10	324	1E+10	1E+10	1E+10	255	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	0	0	0
TZANEEN	437	487	367	142	87	0	130	400	437	1E+10	411	1E+10	1E+10	1E+10	342	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	0	0	0
LOUIS TRICHARDT	460	510	390	165	110	130	0	423	460	1E+10	434	1E+10	1E+10	1E+10	365	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	0	0	0
MIDRAND	103	153	33	258	313	400	423	0	60	27	15	1E+10	1E+10	1E+10	458	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	0	0	0
KRUGERSDORP	140	190	70	295	350	437	460	60	0	45	114	1E+10	1E+10	1E+10	495	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	0	0	0
JOHANNESBURG	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	27	45	0	32	18	1E+10	1E+10	1E+10	1E+10	140	1E+10	10	1E+10	1E+10	1E+10	0	0	0
KEMPTON PARK	114	164	44	269	324	411	434	15	114	32	0	15	13	159	469	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	0	0	0
BOKSBURG	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	18	15	0	10	1E+10	1E+10	1E+10	1E+10	19	1E+10	1E+10	30	1E+10	0	0	0
BENONI	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	13	10	0	110	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	24	1E+10	0	0	0
WITBANK	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	159	1E+10	110	0	30	1E+10	1E+10	1E+10	1E+10	110	114	1E+10	0	0	0
MIDDELBURG	495	545	425	200	255	342	365	458	495	1F+10	469	1E+10	1E+10	30	0	209	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	0	0	0
NELSPRUIT	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	209	0	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	0	0	0
POTCHEFSTROOM	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	140	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	0	1E+10	1E+10	1E+10	1E+10	1E+10	0	0	0
ALBERTON	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	19	1E+10	1E+10	1E+10	1E+10	1E+10	0	12	1E+10	1E+10	1E+10	0	0	0
GERMISTON	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	12	0	1E+10	1E+10	1E+10	0	0	0
TRICHARDT	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	110	1E+10	1E+10	1E+10	1E+10	1E+10	0	155	100	0	0	0
SPRINGS	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	30	24	114	1E+10	1E+10	1E+10	1E+10	1E+10	155	0	1E+10	0	0	0
ERMELO	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	100	1E+10	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

FLOYD'S ALGORITHM

TABLE 6

	BRITS	RUSTENBURG	PRETORIA	POTGIETERSRUS	PIETERSBURG	TZANEEN	LOUIS TRICHARDT	MIDRAND	KRUGERSDORP	JOHANNESBURG	KEMPTON PARK	BOKSBURG	BENONI	WITBANK	MIDDELBURG	NELSPRUIT	POTCHEFSTROOM	ALBERTON	GERMISTON	TRICHARDT	SPRINGS	ERMELO	#REF!	#REF!	#REF!
BRITS	0	68	70	295	350	437	460	103	140	1E+10	114	1E+10	1E+10	1E+10	495	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	0	0	0
RUSTENBURG	68	0	120	345	400	487	510	153	190	1E+10	164	1E+10	1E+10	1E+10	545	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	0	0	0
PRETORIA	70	120	0	225	280	367	390	33	70	1E+10	44	1E+10	1E+10	1E+10	425	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	0	0	0
POTGIETERSRUS	295	345	225	0	55	142	165	258	295	1E+10	269	1E+10	1E+10	1E+10	200	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	0	0	0
PIETERSBURG	350	400	280	55	0	87	110	313	350	1E+10	324	1E+10	1E+10	1E+10	255	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	0	0	0
TZANEEN	437	487	367	142	87	0	130	400	437	1E+10	411	1E+10	1E+10	1E+10	342	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	0	0	0
LOUIS TRICHARDT	460	510	390	165	110	130	0	423	460	1E+10	434	1E+10	1E+10	1E+10	365	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	0	0	0
MIDRAND	103	153	33	258	313	400	423	0	60	27	15	1E+10	1E+10	1E+10	458	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	0	0	0
KRUGERSDORP	140	190	70	295	350	437	460	60	0	45	114	1E+10	1E+10	1E+10	495	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	0	0	0
JOHANNESBURG	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	27	45	0	32	18	1E+10	1E+10	1E+10	1E+10	140	1E+10	10	1E+10	1E+10	1E+10	0	0	0
KEMPTON PARK	114	164	44	269	324	411	434	15	114	32	0	15	13	159	469	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	0	0	0
BOKSBURG	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	18	15	0	10	1E+10	1E+10	1E+10	1E+10	19	1E+10	1E+10	30	1E+10	0	0	0
BENONI	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	13	10	0	110	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	24	1E+10	0	0	0
WITBANK	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	159	1E+10	110	0	30	1E+10	1E+10	1E+10	1E+10	110	114	1E+10	0	0	0
MIDDELBURG	495	545	425	200	255	342	365	458	495	1E+10	469	1E+10	1E+10	30	0	209	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	0	0	0
NELSPRUIT	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	209	0	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	0	0	0
POTCHEFSTROOM	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	140	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	0	1E+10	1E+10	1E+10	1E+10	1E+10	0	0	0
ALBERTON	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	19	1E+10	1E+10	1E+10	1E+10	1E+10	0	12	1E+10	1E+10	1E+10	0	0	0
GERMISTON	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	12	0	1E+10	1E+10	1E+10	0	0	0
TRICHARDT	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	110	1E+10	1E+10	1E+10	1E+10	1E+10	0	155	100	0	0	0
SPRINGS	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	30	24	114	1E+10	1E+10	1E+10	1E+10	1E+10	155	0	1E+10	0	0	0
ERMELO	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	100	1E+10	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

FLOYD'S ALGORITHM

TABLE 7	BRITS	RUSTENBURG	PRETORIA	POTGIETERSRUS	PIETERSBURG	TZANEEN	LOUIS TRICHARDT	MIDRAND	KRUGERSDORP	JOHANNESBURG	KEMPTON PARK	BOKSBURG	BENONI	WITBANK	MIDDELBURG	NELSPRUIT	POTCHEFSTROOM	ALBERTON	GERMISTON	TRICHARDT	SPRINGS	ERMELO	#REF!	#REF!	#REF!
BRITS	0	68	70	295	350	437	460	103	140	1E+10	114	1E+10	1E+10	1E+10	495	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	0	0	0
RUSTENBURG	68	0	120	345	400	487	510	153	190	1E+10	164	1E+10	1E+10	1E+10	545	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	0	0	0
PRETORIA	70	120	0	225	280	367	390	33	70	1E+10	44	1E+10	1E+10	1E+10	425	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	0	0	0
POTGIETERSRUS	295	345	225	0	55	142	165	258	295	1E+10	269	1E+10	1E+10	1E+10	200	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	0	0	0
PIETERSBURG	350	400	280	55	0	87	110	313	350	1E+10	324	1E+10	1E+10	1E+10	255	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	0	0	0
TZANEEN	437	487	367	142	87	0	130	400	437	1E+10	411	1E+10	1E+10	1E+10	342	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	0	0	0
LOUIS TRICHARDT	460	510	390	165	110	130	0	423	460	1E+10	434	1E+10	1E+10	1E+10	365	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	0	0	0
MIDRAND	103	153	33	258	313	400	423	0	60	27	15	1E+10	1E+10	1E+10	458	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	0	0	0
KRUGERSDORP	140	190	70	295	350	437	460	60	0	45	114	1E+10	1E+10	1E+10	495	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	0	0	0
JOHANNESBURG	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	27	45	0	32	18	1E+10	1E+10	1E+10	1E+10	140	1E+10	10	1E+10	1E+10	1E+10	0	0	0
KEMPTON PARK	114	164	44	269	324	411	434	15	114	32	0	15	13	159	469	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	0	0	0
BOKSBURG	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	18	15	0	10	1E+10	1E+10	1E+10	1E+10	19	1E+10	1E+10	30	1E+10	0	0	0
BENONI	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	13	10	0	110	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	24	1E+10	0	0	0
WITBANK	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	159	1E+10	110	0	30	1E+10	1E+10	1E+10	1E+10	110	114	1E+10	0	0	0
MIDDELBURG	495	545	425	200	255	342	365	458	495	1E+10	469	1E+10	1E+10	30	0	209	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	0	0	0
NELSPRUIT	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	209	0	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	0	0	0
POTCHEFSTROOM	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	140	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	0	1E+10	1E+10	1E+10	1E+10	1E+10	0	0	0
ALBERTON	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	19	1E+10	1E+10	1E+10	1E+10	1E+10	0	12	1E+10	1E+10	1E+10	0	0	0
GERMISTON	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	12	0	1E+10	1E+10	1E+10	0	0	0
TRICHARDT	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	110	1E+10	1E+10	1E+10	1E+10	1E+10	0	155	100	0	0	0
SPRINGS	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	30	24	114	1E+10	1E+10	1E+10	1E+10	1E+10	155	0	1E+10	0	0	0
ERMELO	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	100	1E+10	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

FLOYD'S ALGORITHM

TABLE 8	BRITS	RUSTENBURG	PRETORIA	POTGIETERSRUS	PIETERSBURG	TZANEEN	LOUIS TRICHARDT	MIDRAND	KRUGERSDORP	JOHANNESBURG	KEMPTON PARK	BOKSBURG	BENONI	WITBANK	MIDDELBURG	NELSPRUIT	POTCHEFSTROOM	ALBERTON	GERMISTON	TRICHARDT	SPRINGS	ERMELO	#REF!	#REF!	#REF!
BRITS	0	68	70	295	350	437	460	103	140	130	114	1E+10	1E+10	1E+10	495	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	0	0	0
RUSTENBURG	68	0	120	345	400	487	510	153	190	180	164	1E+10	1E+10	1E+10	545	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	0	0	0
PRETORIA	70	120	0	225	280	367	390	33	70	60	44	1E+10	1E+10	1E+10	425	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	0	0	0
POTGIETERSRUS	295	345	225	0	55	142	165	258	295	285	269	10	1E+10	1E+10	200	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	0	0	0
PIETERSBURG	350	400	280	55	0	87	110	313	350	340	324	1E+10	1E+10	1E+10	255	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	0	0	0
TZANEEN	437	487	367	142	87	0	130	400	437	427	411	1E+10	1E+10	1E+10	342	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	0	0	0
LOUIS TRICHARDT	460	510	390	165	110	130	0	423	460	450	434	1E+10	1E+10	1E+10	365	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	0	0	0
MIDRAND	103	153	33	258	313	400	423	0	60	27	15	1E+10	1E+10	1E+10	458	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	0	0	0
KRUGERSDORP	140	190	70	295	350	437	460	60	0	45	75	1E+10	1E+10	1E+10	495	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	0	0	0
JOHANNESBURG	130	180	60	285	340	427	450	27	45	0	32	18	1E+10	1E+10	485	1E+10	140	1E+10	10	1E+10	1E+10	1E+10	0	0	0
KEMPTON PARK	114	164	44	269	324	411	434	15	75	32	0	15	13	159	469	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	0	0	0
BOKSBURG	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	18	15	0	10	1E+10	1E+10	1E+10	1E+10	19	1E+10	1E+10	30	1E+10	0	0	0
BENONI	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	13	10	0	110	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	24	1E+10	0	0	0
WITBANK	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	159	1E+10	110	0	30	1E+10	1E+10	1E+10	1E+10	110	114	1E+10	0	0	0
MIDDELBURG	495	545	425	200	255	342	365	458	495	485	469	1E+10	1E+10	30	0	209	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	0	0	0
NELSPRUIT	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	209	0	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	0	0	0
POTCHEFSTROOM	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	140	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	0	1E+10	1E+10	1E+10	1E+10	1E+10	0	0	0
ALBERTON	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	19	1E+10	1E+10	1E+10	1E+10	1E+10	0	12	1E+10	1E+10	1E+10	0	0	0
GERMISTON	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	12	0	1E+10	1E+10	1E+10	0	0	0
TRICHARDT	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	110	1E+10	1E+10	1E+10	1E+10	1E+10	0	155	100	0	0	0
SPRINGS	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	30	24	114	1E+10	1E+10	1E+10	1E+10	1E+10	155	0	1E+10	0	0	0
ERMELO	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	100	1E+10	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

FLOYD'S ALGORITHM

TABLE 9

	BRITS	RUSTENBURG	PRETORIA	POTGIETERSRUS	PIETERSBURG	TZANEEN	LOUIS TRICHARDT	MIDRAND	KRUGERSDORP	JOHANNESBURG	KEMPTON PARK	BOKSBURG	BENONI	WITBANK	MIDDELBURG	NELSPRUIT	POTCHEFSTROOM	ALBERTON	GERMISTON	TRICHARDT	SPRINGS	ERMELO	#REF!	#REF!	#REF!
BRITS	0	68	70	295	350	437	460	103	140	130	114	1E+10	1E+10	1E+10	495	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	0	0	0
RUSTENBURG	68	0	120	345	400	487	510	153	190	180	164	1E+10	1E+10	1E+10	545	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	0	0	0
PRETORIA	70	120	0	225	280	367	390	33	70	60	44	1E+10	1E+10	1E+10	425	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	0	0	0
POTGIETERSRUS	295	345	225	0	55	142	165	258	295	285	269	1E+10	1E+10	1E+10	200	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	0	0	0
PIETERSBURG	350	400	280	55	0	87	110	313	350	340	324	1E+10	1E+10	1E+10	255	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	0	0	0
TZANEEN	437	487	367	142	87	0	130	400	437	427	411	1E+10	1E+10	1E+10	342	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	0	0	0
LOUIS TRICHARDT	460	510	390	165	110	130	0	423	460	450	434	1E+10	1E+10	1E+10	365	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	0	0	0
MIDRAND	103	153	33	258	313	400	423	0	60	27	15	1E+10	1E+10	1E+10	458	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	0	0	0
KRUGERSDORP	140	190	70	295	350	437	460	60	0	45	75	1E+10	1E+10	1E+10	495	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	0	0	0
JOHANNESBURG	130	180	60	285	340	427	450	27	45	0	32	18	1E+10	1E+10	485	1E+10	140	1E+10	10	1E+10	1E+10	1E+10	0	0	0
KEMPTON PARK	114	164	44	269	324	411	434	15	75	32	0	15	13	159	469	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	0	0	0
BOKSBURG	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	18	15	0	10	1E+10	1E+10	1E+10	1E+10	19	1E+10	1E+10	30	1E+10	0	0	0
BENONI	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	13	10	0	110	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	24	1E+10	0	0	0
WITBANK	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	159	1E+10	110	0	30	1E+10	1E+10	1E+10	1E+10	110	114	1E+10	0	0	0
MIDDELBURG	495	545	425	200	255	342	365	458	495	485	469	1E+10	1E+10	30	0	209	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	0	0	0
NELSPRUIT	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	209	0	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	0	0	0
POTCHEFSTROOM	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	140	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	0	1E+10	1E+10	1E+10	1E+10	1E+10	0	0	0
ALBERTON	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	19	1E+10	1E+10	1E+10	1E+10	1E+10	0	12	1E+10	1E+10	1E+10	0	0	0
GERMISTON	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	12	0	1E+10	1E+10	1E+10	0	0	0
TRICHARDT	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	110	1E+10	1E+10	1E+10	1E+10	1E+10	0	155	100	0	0	0
SPRINGS	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	30	24	114	1E+10	1E+10	1E+10	1E+10	1E+10	155	0	1E+10	0	0	0
ERMELO	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	100	1E+10	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

FLOYD'S ALGORITHM

TABLE 10	BRITS	RUSTENBURG	PRETORIA	POTGIETERSRUS	PIETERSBURG	TZANEEN	LOUIS TRICHARDT	MIDRAND	KRUGERSDORP	JOHANNESBURG	KEMPTON PARK	BOKSBURG	BENONI	WITBANK	MIDDELBURG	NELSPRUIT	POTCHEFSTROOM	ALBERTON	GERMISTON	TRICHARDT	SPRINGS	ERMELO	#REF!	#REF!	#REF!
BRITS	0	68	70	295	350	437	460	103	140	130	114	148	1E+10	1E+10	495	1E+10	270	1E+10	140	1E+10	1E+10	1E+10	0	0	0
RUSTENBURG	68	0	120	345	400	487	510	153	190	180	164	198	1E+10	1E+10	545	1E+10	320	1E+10	190	1E+10	1E+10	1E+10	0	0	0
PRETORIA	70	120	0	225	280	367	390	33	70	60	44	78	1E+10	1E+10	425	1E+10	200	1E+10	70	1E+10	1E+10	1E+10	0	0	0
POTGIETERSRUS	295	345	225	0	55	142	165	258	295	285	269	303	1E+10	1E+10	200	1E+10	425	1E+10	295	1E+10	1E+10	1E+10	0	0	0
PIETERSBURG	350	400	280	55	0	87	110	313	350	340	324	358	1E+10	1E+10	255	1E+10	480	1E+10	350	1E+10	1E+10	1E+10	0	0	0
TZANEEN	437	487	367	142	87	0	130	400	437	427	411	445	1E+10	1E+10	342	1E+10	567	1E+10	437	1E+10	1E+10	1E+10	0	0	0
LOUIS TRICHARDT	460	510	390	165	110	130	0	423	460	450	434	468	1E+10	1E+10	365	1E+10	590	1E+10	460	1E+10	1E+10	1E+10	0	0	0
MIDRAND	103	153	33	258	313	400	423	0	60	27	15	45	1E+10	1E+10	458	1E+10	167	1E+10	37	1E+10	1E+10	1E+10	0	0	0
KRUGERSDORP	140	190	70	295	350	437	460	60	0	45	75	63	1E+10	1E+10	495	1E+10	185	1E+10	55	1E+10	1E+10	1E+10	0	0	0
JOHANNESBURG	130	180	60	285	340	427	450	27	45	0	32	18	1E+10	1E+10	485	1E+10	140	1E+10	10	1E+10	1E+10	1E+10	0	0	0
KEMPTON PARK	114	164	44	269	324	411	434	15	75	32	0	15	13	159	469	1E+10	172	1E+10	42	1E+10	1E+10	1E+10	0	0	0
BOKSBURG	148	198	78	303	358	445	468	45	63	18	15	0	10	1E+10	503	1E+10	158	19	28	1E+10	30	1E+10	0	0	0
BENONI	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	13	10	0	110	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	24	1E+10	0	0	0
WITBANK	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	159	1E+10	110	0	30	1E+10	1E+10	1E+10	1E+10	110	114	1E+10	0	0	0
MIDDELBURG	495	545	425	200	255	342	365	458	495	485	469	503	1E+10	30	0	209	625	1E+10	495	1E+10	1E+10	1E+10	0	0	0
NELSPRUIT	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	209	0	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	0	0	0
POTCHEFSTROOM	270	320	200	425	480	567	590	167	185	140	172	158	1E+10	1E+10	625	1E+10	0	1E+10	150	1E+10	1E+10	1E+10	0	0	0
ALBERTON	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	19	1E+10	1E+10	1E+10	1E+10	1E+10	0	12	1E+10	1E+10	1E+10	0	0	0
GERMISTON	140	190	70	295	350	437	460	37	55	10	42	28	1E+10	1E+10	463	1E+10	150	12	0	1E+10	1E+10	1E+10	0	0	0
TRICHARDT	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	110	1E+10	1E+10	1E+10	1E+10	1E+10	0	155	100	0	0	0
SPRINGS	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	30	24	114	1E+10	1E+10	1E+10	1E+10	1E+10	155	0	1E+10	0	0	0
ERMELO	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	100	1E+10	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

FLOYD'S ALGORITHM

TABLE 11	BRITS	RUSTENBURG	PRETORIA	POTGIETERSRUS	PIETERSBURG	TZANEEN	LOUIS TRICHARDT	MIDRAND	KRUGERSDORP	JOHANNESBURG	KEMPTON PARK	BOKSBURG	BENONI	WITBANK	MIDDELBURG	NELSPRUIT	POTCHEFSTROOM	ALBERTON	GERMISTON	TRICHARDT	SPRINGS	ERMELO	#REF!	#REF!	#REF!
BRITS	0	68	70	295	350	437	460	103	140	130	114	129	127	273	495	1E+10	270	1E+10	140	1E+10	1E+10	1E+10	0	0	0
RUSTENBURG	68	0	120	345	400	487	510	153	190	180	164	179	177	323	545	1E+10	320	1E+10	190	1E+10	1E+10	1E+10	0	0	0
PRETORIA	70	120	0	225	280	367	390	33	70	60	44	59	57	203	425	1E+10	200	1E+10	70	1E+10	1E+10	1E+10	0	0	0
POTGIETERSRUS	295	345	225	0	55	142	165	258	295	285	269	284	282	428	200	1E+10	425	1E+10	295	1E+10	1E+10	1E+10	0	0	0
PIETERSBURG	350	400	280	55	0	87	110	313	350	340	324	339	337	483	255	1E+10	480	1E+10	350	1E+10	1E+10	1E+10	0	0	0
TZANEEN	437	487	367	142	87	0	130	400	437	427	411	426	424	570	342	1E+10	567	1E+10	437	1E+10	1E+10	1E+10	0	0	0
LOUIS TRICHARDT	460	510	390	165	110	130	0	423	460	450	434	449	447	593	365	1E+10	590	1E+10	460	1E+10	1E+10	1E+10	0	0	0
MIDRAND	103	153	33	258	313	400	423	0	60	27	15	30	28	174	458	1E+10	167	1E+10	37	1E+10	1E+10	1E+10	0	0	0
KRUGERSDORP	140	190	70	295	350	437	460	60	0	45	75	63	88	234	495	1E+10	185	1E+10	55	1E+10	1E+10	1E+10	0	0	0
JOHANNESBURG	130	180	60	285	340	427	450	27	45	0	32	18	45	191	485	1E+10	140	1E+10	10	1E+10	1E+10	1E+10	0	0	0
KEMPTON PARK	114	164	44	269	324	411	434	15	75	32	0	15	13	159	469	1E+10	172	1E+10	42	1E+10	1E+10	1E+10	0	0	0
BOKSBURG	129	179	59	284	339	426	449	30	63	18	15	0	10	174	484	1E+10	158	19	28	1E+10	30	1E+10	0	0	0
BENONI	127	177	57	282	337	424	447	28	88	45	13	10	0	110	482	1E+10	185	1E+10	55	1E+10	24	1E+10	0	0	0
WITBANK	273	323	203	428	483	570	593	174	234	191	159	174	110	0	30	1E+10	331	1E+10	201	110	114	1E+10	0	0	0
MIDDELBURG	495	545	425	200	255	342	365	458	495	485	469	484	482	30	0	209	625	1E+10	495	1E+10	1E+10	1E+10	0	0	0
NELSPRUIT	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	209	0	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	0	0	0
POTCHEFSTROOM	270	120	200	425	480	567	590	167	185	140	172	158	185	331	625	1E+10	0	1E+10	150	1E+10	1E+10	1E+10	0	0	0
ALBERTON	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	19	1E+10	1E+10	1E+10	1E+10	1E+10	0	12	1E+10	1E+10	1E+10	0	0	0
GERMISTON	140	190	70	295	350	437	460	37	55	10	42	28	55	201	495	1E+10	150	12	0	1E+10	1E+10	1E+10	0	0	0
TRICHARDT	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	110	1E+10	1E+10	1E+10	1E+10	1E+10	0	155	100	0	0	0
SPRINGS	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	30	24	114	1E+10	1E+10	1E+10	1E+10	1E+10	155	0	1E+10	0	0	0
ERMELO	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	100	1E+10	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

FLOYD'S ALGORITHM

TABLE 12	BRITS	RUSTENBURG	PRETORIA	POTGIETERSRUS	PIETERSBURG	TZANEEN	LOUIS TRICHARDT	MIDRAND	KRUGERSDORP	JOHANNESBURG	KEMPTON PARK	BOKSBURG	BENONI	WITBANK	MIDDELBURG	NELSPRUIT	POTCHEFSTROOM	ALBERTON	GERMISTON	TRICHARDT	SPRINGS	ERMELO	#REF!	#REF!	#REF!
BRITS	0	68	70	295	350	437	460	103	140	130	114	129	127	273	495	1E+10	270	148	140	1E+10	159	1E+10	0	0	0
RUSTENBURG	68	0	120	345	400	487	510	153	190	180	164	179	177	323	545	1E+10	320	198	190	1E+10	209	1E+10	0	0	0
PRETORIA	70	120	0	225	280	367	390	33	70	60	44	59	57	203	425	1E+10	200	78	70	1E+10	89	1E+10	0	0	0
POTGIETERSRUS	295	345	225	0	55	142	165	258	295	285	269	284	282	428	200	1E+10	425	303	295	1E+10	314	1E+10	0	0	0
PIETERSBURG	350	400	280	55	0	87	110	313	350	340	324	339	337	483	255	1E+10	480	358	350	1E+10	369	1E+10	0	0	0
TZANEEN	437	487	367	142	87	0	130	400	437	427	411	426	424	570	342	1E+10	567	445	437	1E+10	456	1E+10	0	0	0
LOUIS TRICHARDT	460	510	390	165	110	130	0	423	460	450	434	449	447	593	365	1E+10	590	468	460	1E+10	479	1E+10	0	0	0
MIDRAND	103	153	33	258	313	400	423	0	60	27	15	30	28	174	458	1E+10	167	49	37	1E+10	60	1E+10	0	0	0
KRUGERSDORP	140	190	70	295	350	437	460	60	0	45	75	63	73	234	495	1E+10	185	82	55	1E+10	93	1E+10	0	0	0
JOHANNESBURG	130	180	60	285	340	427	450	27	45	0	32	18	28	191	485	1E+10	140	37	10	1E+10	48	1E+10	0	0	0
KEMPTON PARK	114	164	44	269	324	411	434	15	75	32	0	15	13	159	469	1E+10	172	34	42	1E+10	45	1E+10	0	0	0
BOKSBURG	129	179	59	284	339	426	449	30	63	18	15	0	10	174	484	1E+10	156	19	28	1E+10	30	1E+10	0	0	0
BENONI	127	177	57	282	337	424	447	28	73	28	13	10	0	110	482	1E+10	168	29	38	1E+10	24	1E+10	0	0	0
WITBANK	273	323	203	428	483	570	593	174	234	191	159	174	110	0	30	1E+10	331	193	201	110	114	1E+10	0	0	0
MIDDELBURG	495	545	425	200	255	342	365	458	495	485	469	484	482	30	0	209	625	503	495	1E+10	514	1E+10	0	0	0
NELSPRUIT	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	209	0	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	0	0	0
POTCHEFSTROOM	270	320	200	425	480	567	590	167	185	140	172	156	168	331	625	1E+10	0	177	150	1E+10	188	1E+10	0	0	0
ALBERTON	148	198	78	303	358	445	468	49	82	37	34	19	29	193	503	1E+10	177	0	12	1E+10	49	1E+10	0	0	0
GERMISTON	140	190	70	295	350	437	460	37	55	10	42	28	38	201	495	1E+10	150	12	0	1E+10	58	1E+10	0	0	0
TRICHARDT	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	110	1E+10	1E+10	1E+10	1E+10	1E+10	0	155	100	0	0	0
SPRINGS	159	209	89	314	369	456	479	60	93	48	45	30	24	114	514	1E+10	188	49	58	155	0	1E+10	0	0	0
ERMELO	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	100	1E+10	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

FLOYD'S ALGORITHM

TABLE 13

	BRITS	RUSTENBURG	PRETORIA	POTGIETERSRUS	PIETERSBURG	TZANEEN	LOUIS TRICHARDT	MIDRAND	KRUGERSDORP	JOHANNESBURG	KEMPTON PARK	BOKSBURG	BENONI
BRITS	0	58	70	295	350	437	460	103	140	130	114	129	127
RUSTENBURG	68	0	120	345	400	487	510	153	190	180	164	179	177
PRETORIA	70	120	0	225	280	367	390	33	70	60	44	59	57
POTGIETERSRUS	295	345	225	0	55	142	165	258	295	285	269	284	282
PIETERSBURG	350	400	280	55	0	87	110	313	350	340	324	339	337
TZANEEN	437	487	367	142	87	0	130	400	437	427	411	426	424
LOUIS TRICHARDT	460	510	390	165	110	130	0	423	460	450	434	449	447
MIDRAND	103	153	33	258	313	400	423	0	60	27	15	30	28
KRUGERSDORP	140	190	70	295	350	437	460	60	0	45	75	63	73
JOHANNESBURG	130	180	60	285	340	427	450	27	45	0	32	18	28
KEMPTON PARK	114	164	44	269	324	411	434	15	75	32	0	15	13
BOKSBURG	129	179	59	284	339	426	449	30	63	18	15	0	10
BENONI	127	177	57	282	337	424	447	28	73	28	13	10	0
WITBANK	237	287	*67	392	447	534	557	138	183	138	123	120	110
MIDDELBURG	495	545	425	200	255	342	365	458	495	485	469	484	482
NELSPRUIT	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10
POTCHEFSTROOM	270	320	200	425	480	587	590	167	185	140	172	158	168
ALBERTON	148	198	78	303	358	445	468	49	82	37	34	19	29
GERMISTON	140	190	70	295	350	437	460	37	55	10	42	28	38
TRICHARDT	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10
SPRINGS	151	201	81	306	361	448	471	52	93	48	37	30	24
ERMELO	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10
	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0

	WITBANK	MIDDELBURG	NELSPRUIT	POTCHEFSTROOM	ALBERTON	GERMISTON	TRICHARDT	SPRINGS	ERMELO	#REF!	#REF!	#REF!
BRITS	237	495	1E+10	270	148	140	1E+10	151	1E+10	0	0	[illegible]
RUSTENBURG	287	545	1E+10	320	198	190	1E+10	201	1E+10	0	0	[illegible]
PRETORIA	167	425	1E+10	200	78	70	1E+10	81	1E+10	0	0	[illegible]
POTGIETERSRUS	392	200	1E+10	425	303	295	1E+10	306	1E+10	0	0	0
PIETERSBURG	447	255	1E+10	480	358	350	1E+10	361	1E+10	0	0	0
TZANEEN	534	342	1E+10	587	445	437	1E+10	448	1E+10	0	0	0
LOUIS TRICHARDT	557	365	1E+10	590	468	460	1E+10	471	1E+10	0	0	0
MIDRAND	138	458	1E+10	167	49	37	1E+10	52	1E+10	0	0	0
KRUGERSDORP	183	495	1E+10	185	82	55	1E+10	93	1E+10	0	0	0
JOHANNESBURG	138	485	1E+10	140	37	10	1E+10	48	1E+10	0	0	0
KEMPTON PARK	123	469	1E+10	172	34	42	1E+10	37	1E+10	0	0	0
BOKSBURG	120	484	1E+10	158	19	28	1E+10	30	1E+10	0	0	0
BENONI	110	482	1E+10	168	29	38	1E+10	24	1E+10	0	0	0
WITBANK	0	30	1E+10	278	139	148	110	114	1E+10	0	0	0
MIDDELBURG	30	0	209	625	503	495	1E+10	506	1E+10	0	0	0
NELSPRUIT	1E+10	209	0	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	0	0	0
POTCHEFSTROOM	278	625	1E+10	0	177	150	1E+10	188	1E+10	0	0	0
ALBERTON	139	503	1E+10	177	0	12	1E+10	49	1E+10	0	0	0
GERMISTON	148	495	1E+10	150	12	0	1E+10	58	1E+10	0	0	0
TRICHARDT	110	1E+10	1E+10	1E+10	1E+10	1E+10	0	155	100	0	0	0
SPRINGS	114	506	1E+10	188	49	58	155	0	1E+10	0	0	0
ERMELO	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	100	1E+10	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0

FLOYD'S ALGORITHM

TABLE 14

	BRITS	RUSTENBURG	PRETORIA	POTGIFTERSRUS	PIETERSBURG	TZANEEN	LOUIS TRICHARDT	MIDRAND	KRUGERSDORP	JOHANNESBURG	KEMPTON PARK	BOKSBURG	BENONI	WITBANK	MIDDELBURG	NELSPRUIT	POTCHEFSTROOM	ALBERTON	GERMISTON	TRICHARDT	SPRINGS	ERMELO	#REF!	#REF!	#REF!
BRITS	0	68	70	295	350	437	460	103	140	130	114	129	127	237	267	1E+10	270	148	140	347	151	1E+10	0	0	0
RUSTENBURG	68	0	120	345	400	487	510	153	190	180	164	179	177	287	317	1E+10	320	198	190	397	201	1E+10	0	0	0
PRETORIA	70	120	0	225	280	367	390	33	70	60	44	59	57	167	197	1E+10	200	78	[illegible]	277	81	1E+10	0	0	0
POTGIETERSRUS	295	345	225	0	55	142	165	258	295	285	269	284	282	392	200	1E+10	425	303	295	502	306	1E+10	0	0	0
PIETERSBURG	350	400	280	55	0	87	110	313	350	340	324	339	337	447	255	1E+10	480	356	350	557	361	1E+10	0	0	0
TZANEEN	437	487	367	142	87	0	130	400	437	427	411	426	424	534	342	1E+10	567	445	437	644	448	1E+10	0	0	0
LOUIS TRICHARDT	460	510	390	165	110	130	0	423	460	450	434	449	447	557	365	1E+10	590	468	460	667	471	1E+10	0	0	0
MIDRAND	103	153	33	258	313	400	423	0	60	27	15	30	28	138	188	1E+10	167	49	37	248	52	1E+10	0	0	0
KRUGERSDORP	140	190	70	295	350	437	460	60	0	45	75	63	73	183	213	1E+10	185	82	55	293	93	1E+10	0	0	0
JOHANNESBURG	130	180	60	285	340	427	450	27	45	0	32	18	28	138	168	1E+10	140	37	10	248	46	1E+10	0	0	0
KEMPTON PARK	114	164	44	269	324	411	434	[illegible]	75	32	0	15	13	123	153	1E+10	172	34	42	233	37	1E+10	0	0	0
BOKSBURG	129	179	59	284	339	426	449	30	63	18	15	0	10	120	150	1E+10	158	19	28	230	30	1E+10	0	0	0
BENONI	127	177	57	282	337	424	447	28	73	28	13	10	0	110	140	1E+10	168	29	38	220	24	1E+10	0	0	0
WITBANK	237	287	167	392	447	534	557	138	183	138	123	120	110	0	30	1E+10	278	139	148	110	114	1E+10	0	0	0
MIDDELBURG	267	317	197	200	255	342	365	[illegible]	213	168	153	150	140	30	0	209	308	169	178	140	144	1E+10	0	0	0
NELSPRUIT	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	209	0	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	0	0	0
POTCHEFSTROOM	270	320	200	425	480	567	590	167	185	140	172	158	168	278	308	1E+10	0	177	150	388	188	1E+10	0	0	0
ALBERTON	148	198	78	303	358	445	468	49	82	37	34	19	29	139	169	1E+10	177	0	12	249	49	1E+10	0	0	0
GERMISTON	140	190	70	295	350	437	460	37	55	10	42	28	38	146	178	1E+10	150	12	0	258	58	1E+10	0	0	0
TRICHARDT	347	397	277	502	557	644	667	248	293	248	233	230	220	110	140	1E+10	388	249	258	0	155	100	0	0	0
SPRINGS	151	201	81	306	361	448	471	52	93	48	37	30	24	114	144	1E+10	188	49	58	155	0	1E+10	0	0	0
ERMELO	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	100	1E+10	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

FLOYD'S ALGORITHM

TABLE 15

	BRITS	RUSTENBURG	PRETORIA	POTGIETERSRUS	PIETERSBURG	TZANEEN	LOUIS TRICHARDT	MIDRAND	KRUGERSDORP	JOHANNESBURG	KEMPTON PARK
BRITS	0	68	70	295	350	437	460	103	140	130	114
RUSTENBURG	68	0	120	345	400	487	510	153	190	180	164
PRETORIA	70	120	0	225	280	367	390	33	70	60	44
POTGIETERSRUS	295	345	225	0	55	142	165	258	295	285	269
PIETERSBURG	350	400	280	55	0	87	110	313	350	340	324
TZANEEN	437	487	367	142	87	0	130	400	437	427	411
LOUIS TRICHARDT	460	510	390	165	110	130	0	423	460	450	434
MIDRAND	103	153	33	258	313	400	423	0	60	27	15
KRUGERSDORP	140	190	70	295	350	437	460	60	0	45	75
JOHANNESBURG	130	180	60	285	340	427	450	27	45	0	32
KEMPTON PARK	114	164	44	269	324	411	434	15	75	32	0
BOKSBURG	129	179	59	284	339	426	449	30	63	18	15
BENONI	127	177	57	282	337	424	447	28	73	28	13
WITBANK	237	287	167	230	285	372	395	138	183	138	123
MIDDELBURG	267	317	197	200	255	342	365	168	213	168	153
NELSPRUIT	476	526	406	409	464	551	574	377	422	377	362
POTCHEFSTROOM	270	320	200	425	480	567	590	167	185	140	172
ALBERTON	148	198	78	303	358	445	468	49	82	37	34
GERMISTON	140	190	70	295	350	437	460	37	55	10	42
TRICHARDT	347	397	277	340	395	482	505	248	293	248	233
SPRINGS	151	201	81	306	361	448	471	52	93	48	37
ERMELO	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10
	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0

	BOKSBURG	BENONI	WITBANK	MIDDELBURG	NELSPRUIT	POTCHEFSTROOM	ALBERTON	GERMISTON	TRICHARDT	SPRINGS	ERMELO	PREF	PREF	PREF
BRITS	129	127	237	267	476	270	148	140	347	151	1E+10	0	0	0
RUSTENBURG	179	177	287	317	526	320	198	190	397	201	1E+10	0	0	0
PRETORIA	59	57	167	197	406	200	78	70	277	81	1E+10	0	0	0
POTGIETERSRUS	284	282	230	200	409	425	303	295	340	306	1E+10	0	0	0
PIETERSBURG	339	337	285	255	464	480	358	350	395	361	1E+10	0	0	0
TZANEEN	426	424	372	342	551	567	445	437	482	448	1E+10	0	0	0
LOUIS TRICHARDT	449	447	395	365	574	590	468	460	505	471	1E+10	0	0	0
MIDRAND	30	28	138	168	377	167	49	37	248	52	1E+10	0	0	0
KRUGERSDORP	63	73	183	213	422	185	82	55	293	93	1E+10	0	0	0
JOHANNESBURG	18	25	138	168	377	140	37	10	248	48	1E+10	[illegible]	0	0
KEMPTON PARK	15	13	123	153	362	172	34	42	233	37	1E+10	0	0	0
BOKSBURG	0	10	120	150	359	158	19	28	230	30	1E+10	0	0	0
BENONI	10	0	110	140	349	168	29	38	220	24	1E+10	0	0	0
WITBANK	120	110	0	30	239	278	139	148	110	114	1E+10	0	0	0
MIDDELBURG	150	140	30	0	209	308	169	178	140	144	1E+10	0	0	0
NELSPRUIT	359	349	239	209	0	517	378	387	349	353	1E+10	0	0	0
POTCHEFSTROOM	158	188	278	308	517	0	177	150	388	188	1E+10	0	0	0
ALBERTON	19	29	139	169	378	177	0	12	249	49	1E+10	0	0	0
GERMISTON	28	38	148	178	387	150	12	0	258	58	1E+10	0	0	0
TRICHARDT	230	220	110	140	349	388	249	258	0	155	100	0	0	0
SPRINGS	30	24	114	144	353	188	49	58	155	0	1E+10	0	0	0
ERMELO	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	100	1E+10	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0

FLOYD'S ALGORITHM

TABLE 16	BRITS	RUSTENBURG	PRETORIA	POTGIETERSRUS	PIETERSBURG	TZANEEN	LOUIS TRICHARDT	MIDRAND	KRUGERSDORP	JOHANNESBURG	KEMPTON PARK	BOKSBURG	BENONI	WITBANK	MIDDELBURG	NELSPRUIT	POTCHEFSTROOM	ALBERTON	GERMISTON	TRICHARDT	SPRINGS	ERMELO	#REF!	#REF!	#REF!
BRITS	0	68	70	295	350	437	460	103	140	130	114	129	127	237	267	476	270	148	140	347	151	1E+10	0	0	0
RUSTENBURG	68	0	120	345	400	487	510	153	190	180	164	179	177	287	317	526	320	198	190	397	201	1E+10	0	0	0
PRETORIA	70	120	0	225	280	367	390	33	70	60	44	59	57	167	197	406	200	78	70	277	81	1E+10	0	0	0
POTGIETERSRUS	295	345	225	0	55	142	165	258	295	285	269	284	282	230	200	409	425	303	295	340	306	1E+10	0	0	0
PIETERSBURG	350	400	280	55	0	87	110	313	350	340	324	339	337	285	255	464	480	358	350	395	361	1E+10	0	0	0
TZANEEN	437	487	367	142	87	0	130	400	437	427	411	426	424	372	342	551	567	445	437	482	448	1E+10	0	0	0
LOUIS TRICHARDT	460	510	390	165	110	130	0	423	460	450	434	449	447	395	365	574	590	468	460	505	471	1E+10	0	0	0
MIDRAND	103	153	33	258	313	400	423	0	60	27	15	30	28	138	168	377	167	49	37	248	52	1E+10	0	0	0
KRUGERSDORP	140	190	70	295	350	437	460	60	0	45	75	63	73	183	213	422	165	82	55	293	93	1E+10	0	0	0
JOHANNESBURG	130	180	60	285	340	427	450	27	45	0	32	18	28	138	168	377	140	37	10	248	48	1E+10	0	0	0
KEMPTON PARK	114	164	44	269	324	411	434	15	75	32	0	15	13	123	153	362	172	34	42	233	37	1E+10	0	0	0
BOKSBURG	129	179	59	284	339	426	449	30	63	18	15	0	10	120	150	359	158	19	28	230	30	1E+10	0	0	0
BENONI	127	177	57	282	337	424	447	28	73	28	13	10	0	110	140	349	168	29	38	220	24	1E+10	0	0	0
WITBANK	237	287	167	230	285	372	395	138	183	138	123	120	110	0	30	239	278	139	148	110	114	1E+10	0	0	0
MIDDELBURG	267	317	197	200	255	342	365	168	213	168	153	150	140	30	0	209	308	169	178	140	144	1E+10	0	0	0
NELSPRUIT	476	526	406	409	464	551	574	377	422	377	362	359	349	239	209	0	517	378	387	349	353	1E+10	0	0	0
POTCHEFSTROOM	270	320	200	425	480	567	590	167	165	140	172	158	168	278	308	517	0	177	150	388	188	1E+10	0	0	0
ALBERTON	148	198	78	303	358	445	468	49	82	37	34	19	29	139	169	378	177	0	12	249	49	1E+10	0	0	0
GERMISTON	140	190	70	295	350	437	460	37	55	10	42	28	38	148	178	387	150	12	0	258	58	1E+10	0	0	0
TRICHARDT	347	397	277	340	395	482	505	248	293	248	233	230	220	110	140	349	388	249	258	0	155	100	0	0	0
SPRINGS	151	201	81	306	361	448	471	52	93	48	37	30	24	114	144	353	188	49	58	155	0	1E+10	0	0	0
ERMELO	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	100	1E+10	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

FLOYD'S ALGORITHM

TABLE 17	BRITS	RUSTENBURG	PRETORIA	POTGIETERSRUS	PIETERSBURG	TZANEEN	LOUIS TRICHARDT	MIDRAND	KRUGERSDORP	JOHANNESBURG	KEMPTON PARK	BOKSBURG	BENONI	WITBANK	MIDDELBURG	NELSPRUIT	POTCHEFSTROOM	ALBERTON	GERMISTON	TRICHARDT	SPRINGS	ERMELO	BREF	BREF	BREF
BRITS	0	68	70	295	350	437	460	103	140	130	114	129	127	237	267	476	270	148	140	347	151	1E+10	0	0	0
RUSTENBURG	68	0	120	345	400	487	510	153	190	180	164	179	177	287	317	526	320	198	190	397	201	1E+10	0	0	0
PRETORIA	70	120	0	225	280	367	390	33	70	60	44	59	57	167	197	406	200	78	70	277	81	1E+10	0	0	0
POTGIETERSRUS	295	345	225	0	55	142	165	258	295	285	269	284	282	230	200	409	425	303	295	340	306	1E+10	0	0	0
PIETERSBURG	350	400	280	55	0	87	110	313	350	340	324	339	337	285	255	464	480	358	350	395	361	1E+10	0	0	0
TZANEEN	437	487	367	142	87	0	130	400	437	427	411	426	424	372	342	551	567	445	437	482	448	1E+10	0	0	0
LOUIS TRICHARDT	460	510	390	165	110	130	0	423	460	450	434	449	447	395	365	574	590	468	460	505	471	1E+10	0	0	0
MIDRAND	103	153	33	258	313	400	423	0	60	27	15	30	28	138	168	377	167	49	37	248	52	1E+10	0	0	0
KRUGERSDORP	140	190	70	295	350	437	460	60	0	45	75	63	73	183	213	422	185	82	55	293	93	1E+10	0	0	0
JOHANNESBURG	130	160	60	285	340	427	450	27	45	0	32	18	28	138	168	377	140	37	10	248	48	1E+10	0	0	0
KEMPTON PARK	114	164	44	269	324	411	434	15	75	32	0	15	13	123	153	362	172	34	42	233	37	1E+10	0	0	0
BOKSBURG	129	179	59	284	339	426	449	30	63	18	15	0	10	120	[illegible]	359	156	19	28	230	30	1E+10	0	0	0
BENONI	127	177	57	262	337	424	447	28	73	28	13	10	0	110	140	349	168	29	38	220	24	1E+10	0	0	0
WITBANK	237	287	167	230	285	372	365	138	183	138	123	120	110	0	30	239	278	139	148	110	114	1E+10	0	0	0
MIDDELBURG	267	317	197	200	255	342	365	168	213	168	153	150	140	30	0	209	308	169	178	440	144	1E+10	0	0	0
NELSPRUIT	476	526	406	409	464	551	574	377	422	377	362	359	349	239	209	0	517	378	387	349	353	1E+10	0	0	0
POTCHEFSTROOM	270	320	200	425	480	567	590	167	185	140	172	156	168	278	308	517	0	177	150	388	168	1E+10	0	0	0
ALBERTON	148	198	78	303	358	445	468	49	82	37	34	19	[illegible]	139	169	378	177	0	12	249	49	1E+10	0	0	0
GERMISTON	140	190	70	295	350	437	460	37	55	10	42	28	38	148	175	387	150	12	0	258	58	1E+10	0	0	0
TRICHARDT	347	397	277	340	395	482	505	248	293	248	233	230	220	110	140	349	388	249	258	0	155	100	0	0	0
SPRINGS	151	201	81	306	361	448	471	52	93	48	37	30	24	114	144	353	168	49	58	155	0	1E+10	0	0	0
ERMELO	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	100	1E+10	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

TABLE 18

FLOYD'S ALGORITHM

	BRITS	RUSTENBURG	PRETORIA	POTGIETERSRUS	PIETERSBURG	TZANEEN	LOUIS TRICHARDT	MIDRAND	KRUGERSDORP	JOHANNESBURG	KEMPTON PARK	BOKSBURG	BENONI	WITBANK	MIDDELBURG	NELSPRUIT	POTCHEFSTROOM	ALBERTON	GERMISTON	TRICHARDT	SPRINGS	ERMELO	#REF!	#REF!	#REF!
BRITS	0	68	70	295	350	437	460	103	140	130	114	129	127	237	267	476	270	148	140	347	151	1E+10	0	0	0
RUSTENBURG	68	0	120	345	400	487	510	153	190	180	164	179	177	287	317	526	320	198	190	397	201	1E+10	0	0	0
PRETORIA	70	120	0	225	280	367	390	33	70	60	44	59	57	167	197	406	200	78	70	277	81	1E+10	0	0	0
POTGIETERSRUS	295	345	225	0	55	142	165	258	295	285	269	284	282	230	200	409	425	303	295	340	306	1E+10	0	0	0
PIETERSBURG	350	400	280	55	0	87	110	313	350	340	324	339	337	285	255	464	480	358	350	395	361	1E+10	0	0	0
TZANEEN	437	487	367	142	87	0	130	400	437	427	411	426	424	372	342	551	567	445	437	482	448	1E+10	0	0	0
LOUIS TRICHARDT	460	510	390	165	110	130	0	423	460	450	434	449	447	395	365	574	590	468	460	505	471	1E+10	0	0	0
MIDRAND	103	153	33	258	313	400	423	0	60	27	15	30	28	138	168	377	167	49	37	248	52	1E+10	0	0	0
KRUGERSDORP	140	190	70	295	350	437	460	60	0	45	75	63	73	183	213	422	185	82	55	293	93	1E+10	0	0	0
JOHANNESBURG	130	180	60	285	340	427	450	27	45	0	32	18	28	138	168	377	140	37	10	248	48	1E+10	0	0	0
KEMPTON PARK	114	164	44	269	324	411	434	15	75	32	0	15	13	123	153	362	172	34	42	233	37	1E+10	0	0	0
BOKSBURG	129	179	59	284	339	426	449	30	63	18	15	0	10	120	150	359	158	19	28	230	30	1E+10	0	0	0
BENONI	127	177	57	282	337	424	447	28	73	28	13	10	0	110	140	349	168	29	38	220	24	1E+10	0	0	0
WITBANK	237	287	167	230	285	372	395	138	183	138	123	120	110	0	30	239	278	139	148	110	114	1E+10	0	0	0
MIDDELBURG	267	317	197	200	255	342	365	168	213	168	153	150	140	30	0	209	308	169	178	140	144	1E+10	0	0	0
NELSPRUIT	476	526	406	409	464	551	574	377	422	377	362	359	349	239	209	0	517	378	387	349	353	1E+10	0	0	0
POTCHEFSTROOM	270	320	200	425	480	567	590	167	185	140	172	158	168	278	308	517	0	177	150	388	188	1E+10	0	0	0
ALBERTON	148	198	78	303	358	445	468	49	82	37	34	19	29	139	169	378	177	0	12	249	49	1E+10	0	0	0
GERMISTON	140	190	70	295	350	437	460	37	55	10	42	28	38	148	178	387	150	12	0	258	58	1E+10	0	0	0
TRICHARDT	347	397	277	340	395	482	505	248	293	248	233	230	220	110	140	349	388	249	258	0	155	100	0	0	0
SPRINGS	151	201	81	306	361	448	471	52	93	48	37	30	24	114	144	353	188	49	58	155	0	1E+10	0	0	0
ERMELO	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	100	1E+10	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

FLOYD'S ALGORITHM

TABLE 19

	BRITS	RUSTENBURG	PRETORIA	POTGIETERSRUS	PIETERSBURG	TZANEEN	LOUIS TRICHARDT	MIDRAND	KRUGERSDORP	JOHANNESBURG	KEMPTON PARK	BOKSBURG	BENONI	WITBANK	MIDDELBURG	NELSPRUIT	POTCHEFSTROOM	ALBERTON	GERMISTON	TRICHARDT	SPRINGS	ERMELO	#REF!	#REF!	#REF!
BRITS	0	68	70	295	350	437	460	103	140	130	114	129	127	237	267	476	270	148	140	347	151	1E+10	0	0	0
RUSTENBURG	68	0	120	345	400	487	510	153	190	180	164	179	177	287	317	526	320	198	190	397	201	1E+10	0	0	0
PRETORIA	70	120	0	225	280	367	390	33	70	60	44	59	57	167	197	406	200	78	70	277	81	1E+10	0	0	0
POTGIETERSRUS	295	345	225	0	55	142	165	258	295	285	269	284	282	230	200	409	425	303	295	340	306	1E+10	0	0	0
PIETERSBURG	350	400	280	55	0	87	110	313	350	340	324	339	337	285	255	464	480	358	350	395	361	1E+10	0	0	0
TZANEEN	437	487	367	142	87	0	130	400	437	427	411	426	424	372	342	551	567	445	437	482	448	1E+10	0	0	0
LOUIS TRICHARDT	460	510	390	165	110	130	0	423	460	450	434	449	447	395	365	574	590	468	460	505	471	1E+10	0	0	0
MIDRAND	103	153	33	[illegible]	[illegible]	400	423	0	60	27	15	30	28	138	166	377	167	49	37	248	52	1E+10	0	0	0
KRUGERSDORP	140	190	70	[illegible]	[illegible]	437	460	60	0	45	75	63	73	183	213	422	185	67	55	293	93	1E+10	0	0	0
JOHANNESBURG	130	180	60	[illegible]	[illegible]	[illegible]	450	27	45	0	32	18	28	138	168	377	140	22	10	248	48	1E+10	0	0	0
KEMPTON PARK	114	164	44	269	[illegible]	411	434	15	75	32	0	15	13	123	153	362	172	34	42	233	37	1E+10	0	0	0
BOKSBURG	129	179	59	284	[illegible]	426	449	30	63	18	15	0	10	120	150	359	158	19	28	230	30	1E+10	0	0	0
BENONI	127	177	57	[illegible]	[illegible]	424	447	28	73	28	13	10	0	110	140	349	168	29	38	220	24	1E+10	0	0	0
WITBANK	237	287	167	230	285	372	395	138	183	138	123	120	110	0	30	239	278	139	148	110	114	1E+10	0	0	0
MIDDELBURG	267	317	197	200	255	342	365	168	213	168	153	150	140	30	0	209	308	169	178	140	144	1E+10	0	0	0
NELSPRUIT	476	526	406	409	464	551	574	377	422	377	362	359	349	239	209	0	517	378	387	346	[illegible]	[illegible]	0	0	0
POTCHEFSTROOM	270	320	200	425	480	567	590	167	185	140	172	158	168	278	308	517	0	162	[illegible]	388	188	1E+10	0	0	0
ALBERTON	148	198	78	303	358	445	468	49	67	22	34	19	29	139	169	378	162	0	12	[illegible]	49	[illegible]	0	0	0
GERMISTON	140	190	70	295	350	437	460	37	55	10	42	28	38	148	178	387	150	12	0	258	[illegible]	1E+10	0	0	0
TRICHARDT	347	397	277	340	395	482	505	248	293	248	233	230	220	110	140	349	388	249	258	0	155	120	0	0	0
SPRINGS	151	201	81	306	361	448	471	52	93	48	37	30	24	114	144	353	188	49	58	155	0	1E+10	0	0	0
ERMELO	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	1E+10	100	1E+10	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

FLOYD'S ALGORITHM

TABLE 20

	BRITS	RUSTENBURG	PRETORIA	POTGIETERSRUS	PIETERSBURG	TZANEEN	LOUIS TRICHARDT	MIDRAND	KRUGERSDORP	JOHANNESBURG	KEMPTON PARK	BOKSBURG	BENONI	WITBANK	MIDDELBURG	NELSPRUIT	POTCHEFSTROOM	ALBERTON	GERMISTON	TRICHARDT	SPRINGS	ERMELO	#REF!	#REF!	#REF!
BRITS	0	68	70	295	350	437	460	103	140	130	114	129	127	237	267	476	270	148	140	347	151	447	0	0	0
RUSTENBURG	68	0	120	345	400	487	510	153	190	180	164	179	177	287	317	526	320	198	190	397	201	407	0	0	0
PRETORIA	70	120	0	225	280	367	390	33	70	60	44	59	57	167	197	406	200	78	70	277	81	377	0	0	0
POTGIETERSRUS	295	345	225	0	55	142	185	258	295	285	269	284	282	230	200	409	425	303	295	[illegible]	308	440	0	0	0
PIETERSBURG	350	400	280	55	0	87	110	313	350	340	324	339	337	285	255	464	480	358	350	[illegible]	361	495	0	0	0
TZANEEN	437	487	367	142	87	0	130	400	437	427	411	426	424	372	342	551	567	445	[illegible]	[illegible]	448	582	0	0	0
LOUIS TRICHARDT	460	510	390	185	110	150	0	423	460	450	434	449	447	395	365	574	590	468	[illegible]	505	471	605	0	0	0
MIDRAND	103	153	33	258	313	400	423	0	60	27	15	30	28	138	168	377	167	49	37	248	52	348	0	0	0
KRUGERSDORP	140	190	70	295	350	437	460	60	0	45	75	63	73	183	213	422	185	67	55	293	93	393	0	0	0
JOHANNESBURG	130	180	60	285	340	427	450	27	45	0	32	18	28	138	168	377	140	22	10	248	48	348	0	0	0
KEMPTON PARK	114	164	44	269	324	411	434	15	75	32	0	15	13	123	153	362	172	34	42	233	37	[illegible]	0	0	0
BOKSBURG	129	179	59	284	339	426	449	30	63	18	15	0	10	120	150	359	158	19	28	[illegible]	30	[illegible]	0	0	0
BENONI	127	177	57	282	337	424	447	28	73	28	13	10	0	110	140	349	168	29	38	[illegible]	24	320	0	0	0
WITBANK	237	287	167	230	285	372	395	138	183	138	123	120	110	0	30	239	278	139	148	110	114	210	0	0	0
MIDDELBURG	267	317	197	200	255	342	365	168	213	168	153	150	140	30	0	209	308	169	178	140	144	240	0	0	0
NELSPRUIT	476	526	406	409	464	551	574	377	422	377	362	359	349	239	209	0	517	378	387	349	353	449	0	0	0
POTCHEFSTROOM	270	320	200	425	480	567	590	167	185	140	172	158	168	278	308	517	0	162	150	388	188	488	0	0	0
ALBERTON	148	198	78	303	358	445	468	49	67	22	34	19	29	139	169	378	162	0	12	249	49	349	0	0	0
GERMISTON	140	190	70	295	350	437	460	37	55	10	42	28	38	148	178	387	150	12	0	258	58	358	0	0	0
TRICHARDT	347	397	277	340	395	482	505	248	293	248	233	230	220	110	140	349	388	249	258	0	155	100	0	0	0
SPRINGS	151	201	81	308	361	448	471	52	93	48	37	30	24	114	144	353	188	49	58	155	0	255	0	0	0
ERMELO	447	497	377	440	495	582	605	348	393	348	333	330	320	210	240	449	488	349	358	100	255	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

FLOYD'S ALGORITHM

TABLE 21

	BRITS	RUSTENBURG	PRETORIA	POTGIETERSRUS	PIETERSBURG	TZANEEN	LOUIS TRICHARDT	MIDRAND	KRUGERSDORP	JOHANNESBURG	KEMPTON PARK	BOKSBURG	BENONI	WITBANK	MIDDELBURG	NELSPRUIT	POTCHEFSTROOM	ALBERTON	GERMISTON	TRICHARDT	SPRINGS	ERMELO	#REF!	#REF!	#REF!
BRITS	0	68	70	295	350	437	460	103	140	130	114	129	127	237	267	476	270	148	140	306	151	406	0	0	0
RUSTENBURG	68	0	120	345	400	487	510	153	190	180	164	179	177	287	317	526	320	198	190	356	201	456	0	0	0
PRETORIA	70	120	0	225	280	367	390	33	70	60	44	59	57	167	197	406	200	78	70	236	81	336	0	0	0
POTGIETERSRUS	295	345	225	0	55	142	165	258	295	285	269	284	282	230	200	409	425	303	295	340	306	440	0	0	0
PIETERSBURG	350	400	280	55	0	87	110	313	350	340	324	339	337	285	255	464	480	358	350	395	361	495	0	0	0
TZANEEN	437	487	367	142	87	0	130	400	437	427	411	426	424	372	342	551	567	445	437	482	448	582	0	0	0
LOUIS TRICHARDT	460	510	390	165	110	130	0	423	460	450	434	449	447	395	365	574	590	468	460	505	471	605	0	0	0
MIDRAND	103	153	33	258	313	400	423	0	60	27	15	30	28	138	168	377	167	49	37	207	52	307	0	0	0
KRUGERSDORP	140	190	70	295	350	437	460	60	0	45	75	63	73	183	213	422	185	67	55	248	93	348	0	0	0
JOHANNESBURG	130	180	60	285	340	427	450	27	45	0	32	18	28	138	168	377	140	22	10	203	48	303	0	0	0
KEMPTON PARK	114	164	44	269	324	411	434	15	75	32	0	15	13	123	153	362	172	34	42	192	37	292	0	0	0
BOKSBURG	129	179	59	284	330	426	449	30	63	18	15	0	10	120	150	359	158	19	28	185	30	285	0	0	0
BENONI	127	177	57	282	337	424	447	28	73	28	13	10	0	110	140	349	168	29	38	179	24	279	0	0	0
WITBANK	237	287	167	230	285	372	395	138	183	138	123	120	110	0	30	239	278	139	148	110	114	210	0	0	0
MIDDELBURG	267	317	197	200	255	342	365	168	213	168	153	150	140	30	0	209	308	169	178	140	144	240	0	0	0
NELSPRUIT	476	526	406	409	464	551	574	377	422	377	362	359	349	239	209	0	517	378	387	349	353	449	0	0	0
POTCHEFSTROOM	270	320	200	425	480	567	590	167	185	140	172	158	168	278	308	517	0	162	150	343	188	443	0	0	0
ALBERTON	148	198	78	303	358	445	468	49	67	22	34	19	29	139	169	378	162	0	12	204	49	304	0	0	0
GERMISTON	140	190	70	295	350	437	460	37	55	10	42	28	38	148	178	387	150	12	0	213	58	313	0	0	0
TRICHARDT	306	356	236	340	395	482	505	207	248	203	192	185	179	110	140	349	343	204	213	0	155	100	0	0	0
SPRINGS	151	201	81	306	361	448	471	52	93	48	37	30	24	114	144	353	188	49	58	155	0	255	0	0	0
ERMELO	406	456	336	440	495	582	605	307	348	303	292	285	279	210	240	449	443	304	313	100	255	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

FLOYD'S ALGORITHM

TABLE 22	BRITS	RUSTENBURG	PRETORIA	POTGIETERSRUS	PIETERSBURG	TZANEEN	LOUIS TRICHARDT	MIDRAND	KRUGERSDORP	JOHANNESBURG	KEMPTON PARK	BOKSBURG	BENONI	WITBANK	MIDDELBURG	NELSPRUIT	POTCHEFSTROOM	ALBERTON	GERMISTON	TRICHARDT	SPRINGS	ERMELO	#REF!	#REF!	#REF!
BRITS	0	68	70	295	350	437	460	103	140	130	114	129	127	237	267	476	270	148	140	306	151	406	0	0	0
RUSTENBURG	68	0	120	345	400	467	510	153	190	180	164	179	177	287	317	526	320	198	190	356	201	456	0	0	0
PRETORIA	70	120	0	225	280	367	390	33	70	60	44	59	57	167	97	406	200	78	70	236	81	336	0	0	0
POTGIETERSRUS	295	345	225	0	55	142	165	258	295	285	269	284	282	230	200	409	425	303	295	340	306	440	0	0	0
PIETERSBURG	350	400	280	55	0	87	110	313	350	340	324	339	337	285	255	464	480	358	350	395	361	495	0	0	0
TZANEEN	437	487	367	142	87	0	130	400	437	427	411	426	424	372	342	551	567	445	437	482	448	582	0	0	0
LOUIS TRICHARDT	460	510	390	165	110	130	0	423	460	450	434	449	447	395	365	574	590	468	460	505	471	605	0	0	0
MIDRAND	103	153	33	258	313	400	423	0	60	27	15	30	28	138	168	377	167	49	37	207	52	307	0	0	0
KRUGERSDORP	140	190	70	295	350	437	460	60	0	45	75	63	73	183	213	422	185	67	55	248	93	348	0	0	0
JOHANNESBURG	130	180	60	285	340	427	450	27	45	0	32	18	28	138	168	377	140	22	10	203	48	303	0	0	0
KEMPTON PARK	114	164	44	269	324	411	434	15	75	32	0	15	13	123	153	362	172	34	42	192	37	292	0	0	0
BOKSBURG	129	179	59	284	339	426	449	30	63	18	15	0	10	120	150	359	156	19	28	185	30	285	0	0	0
BENONI	127	177	57	282	337	424	447	28	73	28	13	10	0	110	140	349	168	29	38	179	24	279	0	0	0
WITBANK	237	287	167	230	285	372	395	138	183	138	123	120	110	0	30	239	278	139	148	110	114	210	0	0	0
MIDDELBURG	267	317	197	200	255	342	365	168	213	168	153	150	140	30	0	209	308	169	178	140	144	240	0	0	0
NELSPRUIT	476	526	406	409	464	551	574	377	422	377	362	359	349	239	209	0	517	378	387	349	353	449	0	0	0
POTCHEFSTROOM	270	320	200	425	480	567	590	167	185	140	17[illegible]	156	168	278	308	517	0	162	150	343	188	443	0	0	0
ALBERTON	148	198	78	303	358	445	468	49	67	22	34	19	29	139	169	378	162	0	12	204	49	304	0	0	0
GERMISTON	140	190	70	295	350	437	460	37	55	10	42	28	38	148	178	387	150	12	0	213	58	313	0	0	0
TRICHARDT	306	356	236	340	395	482	505	207	248	203	192	185	179	110	140	349	343	204	213	0	155	100	0	0	0
SPRINGS	151	201	81	306	361	448	471	52	93	48	37	30	24	114	144	353	188	49	58	155	0	255	0	0	0
ERMELO	406	456	336	440	495	582	605	307	348	303	292	285	279	210	240	449	443	304	313	100	255	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 22 Weighted

	BRITS	RUSTENBURG	PRETORIA	POTGIETERSRUS	PIETERSBURG	TZANEEN	LOUIS TRICHARDT	MIDRAND	KRUGERSDORP	JOHANNESBURG	KEMPTON PARK
BRITS	0	905692	3556382	189980	2552083	555427	184000	98078.9	878587	3788395	2729787
RUSTENBURG	94180	0	6096620	222180	2916867	618977	204000	145690	1192503	5245470	3927082
PRETORIA	96950	1598280	0	144900	2041667	466457	156000	31423.3	438343	1748490	1053602
POTGIETERSRUS	408575	4595055	1.1E+07	0	401042	180482	66000	245673	1851516	8305328	6441340
PIETERSBURG	484750	5327600	1.4E+07	35420	0	110577	44000	298046	2196717	9908110	7758342
TZANEEN	605245	6486353	1.9E+07	91448	634375	0	52000	380689	2742758	1.2E+07	9841601
LOUIS TRICHARDT	637100	6792690	2E+07	106260	802083	165230	0	402790	2887113	1.3E+07	1E+07
MIDRAND	142655	2037807	1678571	166152	2282292	508400	169200	0	376580	786821	359183
KRUGERSDORP	193900	2530610	3556382	189980	2552083	555427	184000	57133.3	0	1311368	1795913
JOHANNESBURG	180050	2397420	3048310	183540	2479167	542717	180000	25710	282435	0	766256
KEMPTON PARK	157890	2184316	2235427	173236	2362500	522361	173600	14283.3	470725	932528	0
BOKSBURG	178865	2384101	2997505	182896	2471875	541446	179600	28566.7	395409	524547	359183
BENONI	175895	2357463	2895895	181608	2457292	538904	178800	26662.2	458172	815962	311292
WITBANK	328245	3822553	8484463	148120	2078125	472812	158000	131407	1148569	4021527	2945297
MIDDELBURG	369795	4222123	1E+07	128800	1859375	434682	148000	159973	1336859	4895772	3663062
NELSPRUIT	659260	7005794	2.1E+07	263396	3383333	700321	229600	358988	2648613	1.1E+07	8668271
POTCHEFSTROOM	373950	4262080	1E+07	273700	3500000	720657	236000	159021	1161122	4079810	4118626
ALBERTON	204980	2637162	3962803	195132	2810417	565595	187200	46658.9	420514	641113	814147
GERMISTON	193900	2530610	3556362	189980	2552083	555427	184000	35232.2	345198	291415	1005711
TRICHARDT	423810	4741564	1.2E+07	218960	2880208	612822	202000	197110	1556531	5915725	4597536
SPRINGS	209135	2677119	4115219	197064	2632292	509406	188400	49515.6	563699	1398792	885984
ERMELO	562310	6073464	1.7E+07	283360	3609375	739722	242000	292332	2184164	8829675	6992086
0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0

	BOKSBURG	BENONI	WITBANK	MIDDELBURG	NELSPRUIT	POTCHEFSTROOM	ALBERTON	GERMISTON	TRICHARDT	SPRINGS	ERMELO	#REF!	#REF!	#REF!
BRITS	545025	544203	830922	982560	3318434	772200	1207581	122920	2090286	930915	529424	0	0	0
RUSTENBURG	756275	1315936	1006222	1166560	3667009	915200	1615548	166820	2431836	1239165	594624	0	0	0
PRETORIA	249275	423776	585502	724960	2830429	572000	636428	61460	1612116	499365	438144	0	0	0
POTGIETERSRUS	1199900	2096576	808380	736000	2851344	1215500	2472278	259010	2322540	1889490	573760	0	0	0
PIETERSBURG	1432275	2505483	999210	938400	3234776	1372800	2921041	307300	2898245	2225565	645480	0	0	0
TZANEEN	1799850	3152299	1304232	1258560	3841297	1621620	3630903	383886	3292542	2761920	758928	0	0	0
LOUIS TRICHARDT	1897025	3323296	1384870	1343200	4001641	1687400	3818568	403880	3449655	2903715	788920	0	0	0
MIDRAND	126750	208171	483828	618240	2628256	477620	399807	32486	1414017	320580	400328	0	0	0
KRUGERSDORP	266175	542731	641598	783840	2941973	529100	546675	48290	1694088	573345	453792	0	0	0
JOHANNESBURG	76050	208171	483828	618240	2628256	400400	179505	8780	1386693	295920	395112	0	0	0
KEMPTON PARK	63375	96650.7	431238	563040	2523683	491920	277417	36876	1311552	228105	[illegible]	0	0	0
BOKSBURG	0	74346.7	420720	552000	2502769	451880	155027	24584	1263735	184950	[illegible]	0	0	0
BENONI	42250	0	385660	515200	2433054	480480	236621	33364	1222749	147960	[illegible]	0	0	0
WITBANK	507000	817813	0	110400	1666189	795080	1134147	129944	751410	[illegible]	273840	0	0	0
MIDDELBURG	633750	1040853	105180	0	1457044	880880	1378927	156284	956340	857760	312960	0	0	0
NELSPRUIT	1516775	2594699	837934	769120	0	1479620	3084228	339786	2384019	2176245	585496	0	0	0
POTCHEFSTROOM	667550	1249024	974668	1133440	3604266	0	1321812	131700	2343033	1159020	577672	0	0	0
ALBERTON	80275	215605	487334	621920	2635227	463320	0	10536	1393524	302085	396416	0	0	0
GERMISTON	118300	282517	518888	655040	2697971	429000	97912	0	1455003	357570	408152	0	0	0
TRICHARDT	781625	1330805	385660	515200	2433054	980980	1664504	187014	0	955575	130400	0	0	0
SPRINGS	126750	178432	399684	529920	2460940	537680	399807	50924	1058805	0	332520	0	0	0
ERMELO	1204125	2074272	736260	883200	3130204	1266980	2480437	274814	683100	1572075	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

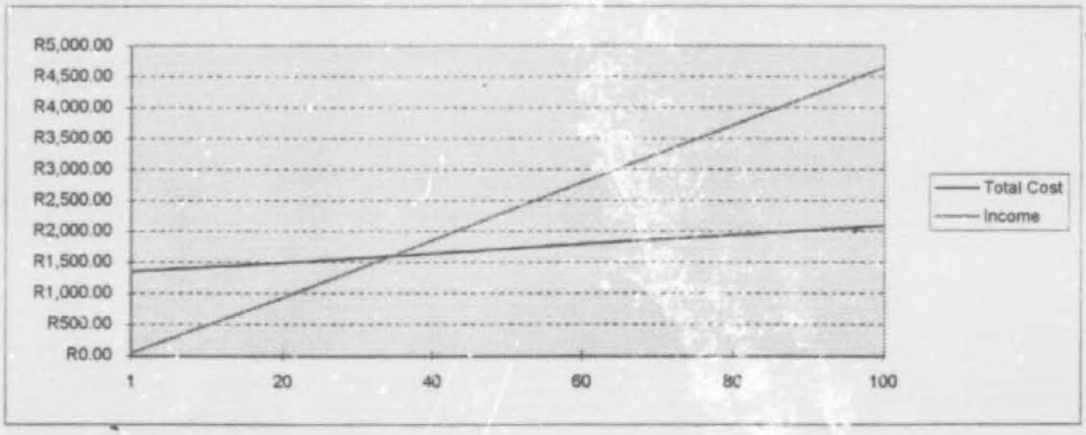
CALCULATION OF CENTER AND MEDIAN

LABORATORY	SUM	MEDIAN	MEDIAN RANK	MAXIMUM	CENTER	CENTER RANK
BRITS	27712962	177%	11	3768395	150%	9
RUSTENBURG	35538544	228%	14	6096620	242%	12
PRETORIA	16410567	105%	5	2830429	112%	3
POTGIETERSRUS	50345952	322%	17	11431163	453%	16
PIETERSBURG	59669583	382%	19	14225447	564%	18
TZANEEN	75729421	485%	21	18645496	739%	20
LOUIS TRICHARDT	80115474	513%	22	19814015	785%	21
MIDRAND	15615742	100%	1	2628256	104%	2
KRUGERSDORP	21948382	141%	10	3556362	141%	7
JOHANNESBURG	16766559	107%	6	3048310	121%	6
KEMPTON PARK	15631512	100%	2	2523683	100%	1
BOKSBURG	16245445	104%	3	2997505	119%	5
BENONI	16259097	104%	4	2995895	115%	4
WITBANK	30627750	196%	12	8484463	336%	13
MIDDELBURG	35035637	224%	13	10008618	397%	14
NELSPRUIT	71297741	457%	20	20626898	817%	22
POTCHEFSTROOM	42208184	270%	15	10161033	403%	15
ALBERTON	18891964	121%	8	3962803	157%	10
GERMISTON	18460271	118%	7	3556362	141%	7
TRICHARDT	42700902	273%	16	11990019	475%	17
SPRINGS	19582088	125%	9	4115219	163%	11
ERMELO	61184691	392%	19	17070536	676%	19
0	0	0%	#N/A	0	0%	#N/A
0	0	0%	#N/A	0	0%	#N/A
0	0	0%	#N/A	0	0%	#N/A

Appendix B: Break-even analysis of selected tests

AFP AMPATH TRUST

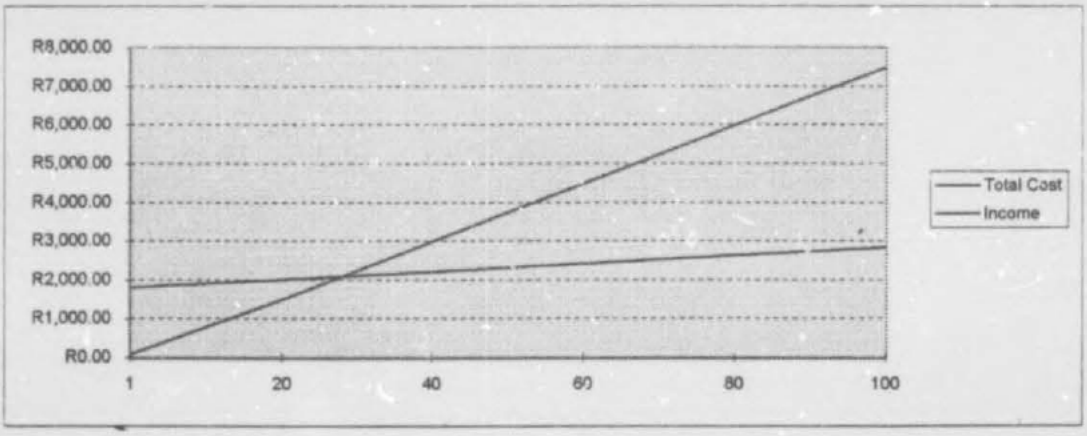
AFP	1	20	40	60	80	100
Variable cost	R7.44	R148.80	R297.60	R446.40	R595.20	R744.00
Fixed cost	R1,349.30	R1,349.30	R1,349.30	R1,349.30	R1,349.30	R1,349.30
Total Cost	R1,356.74	R1,498.10	R1,646.90	R1,795.70	R1,944.50	R2,093.30
Income	R46.50	R930.00	R1,860.00	R2,790.00	R3,720.00	R4,650.00
Cost per test	R1,356.74	R74.91	R41.17	R29.93	R24.31	R20.93



Date: 9-11-1998 Wilhelm Boshoff

CA 19-9 AMPATH TRUST

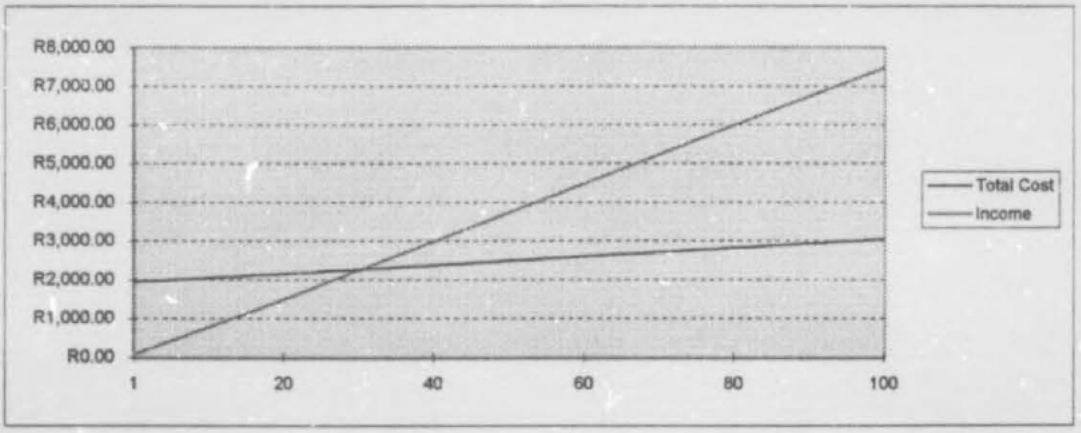
CA 19-9	1	20	40	60	80	100
Variable cost	R10.32	R206.40	R412.80	R619.20	R825.60	R1,032.00
Fixed cost	R1,802.90	R1,802.90	R1,802.90	R1,802.90	R1,802.90	R1,802.90
Total Cost	R1,813.22	R2,009.30	R2,215.70	R2,422.10	R2,628.50	R2,834.90
Income	R74.80	R1,496.00	R2,992.00	R4,488.00	R5,984.00	R7,480.00
Cost per test	R1,813.22	R100.47	R55.39	R40.37	R32.86	R28.35



Date: 9-11-1998 Wilhelm Boshoff

CA 15-3 AMPATH TRUST

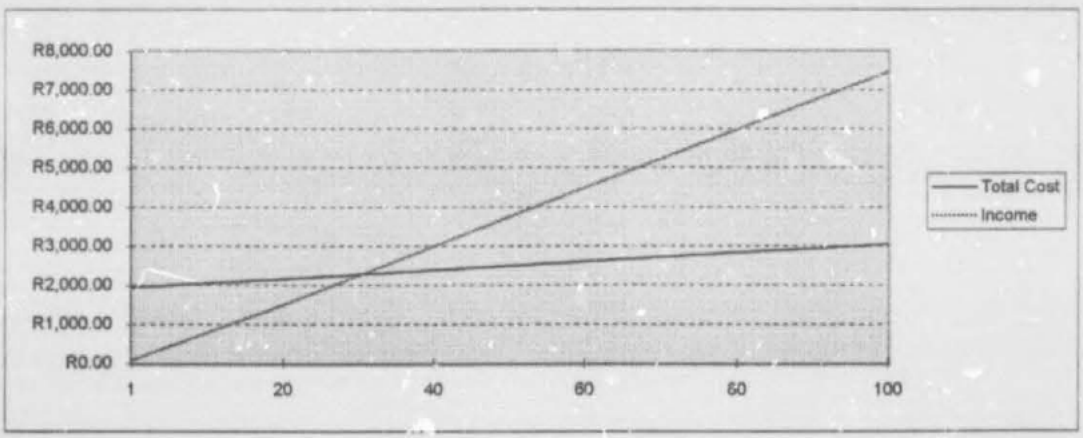
CA 15-3	1	20	40	60	80	100
Variable cost	R11.16	R223.20	R446.40	R669.60	R892.80	R1,116.00
Fixed cost	R1,935.20	R1,935.20	R1,935.20	R1,935.20	R1,935.20	R1,935.20
Total Cost	R1,946.36	R2,158.40	R2,381.60	R2,604.80	R2,828.00	R3,051.20
Income	R74.80	R1,496.00	R2,992.00	R4,488.00	R5,984.00	R7,480.00
Cost per test	R1,946.36	R107.92	R59.54	R43.41	R35.35	R30.51



Date: 9-11-1998 Wilhelm Boshoff

CA 125 AMPATH TRUST

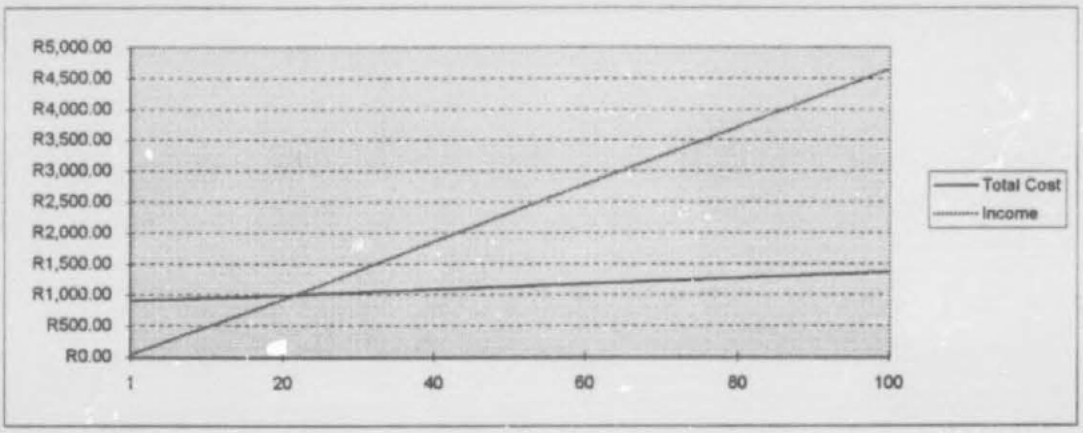
CA 125	1	20	40	60	80	100
Variable cost	R11.16	R223.20	R446.40	R669.60	R892.80	R1,116.00
Fixed cost	R1,935.20	R1,935.20	R1,935.20	R1,935.20	R1,935.20	R1,935.20
Total Cost	R1,946.36	R2,158.40	R2,381.60	R2,604.80	R2,828.00	R3,051.20
Income	R74.80	R1,496.00	R2,992.00	R4,488.00	R5,984.00	R7,480.00
Cost per test	R1,946.36	R107.92	R59.54	R43.41	R35.35	R30.51



Date: 9-11-1998 Wilhelm Boshoff

FERRITIN AMPATH TRUST

FERRITIN	1	20	40	60	80	100
Variable cost	R4.62	R92.40	R184.80	R277.20	R369.60	R462.00
Fixed cost	R905.14	R905.14	R905.14	R905.14	R905.14	R905.14
Total Cost	R909.76	R997.54	R1,089.94	R1,182.34	R1,274.74	R1,367.14
Income	R46.50	R930.00	R1,860.00	R2,790.00	R3,720.00	R4,650.00
Cost per test	R909.76	R49.88	R27.25	R19.71	R15.93	R13.67



Date: 9-11-1998 Wilhelm Boshoff

COST SUMMARY

AMPATH TRUST

AXSYM SAMPLE 5 of 46						
VARIABLE COST PER INSTRUMENT	**AFP**	**CA 19-9**	**CA 15-3**	**CA 125**	**Ferritin**	**Total**
City Regional Laboratory - Quantity	1000	620	450	320	2500	**4890**
City Regional Laboratory - Cost	R8.79	R13.23	R15.46	R17.21	R4.98	
City Regional Laboratory - Total Cost	**R8,789.30**	**R8,201.30**	**R6,957.20**	**R5,506.40**	**R12,455.14**	**R41,909.34**
Peripheral Laboratory - Quantity	16	36	5	5	4	**66**
Peripheral Laboratory - Cost	R91.77	R60.40	R398.20	R398.20	R230.91	
Peripheral Laboratory - Total Cost	**R1,468.34**	**R2,174.42**	**R1,991.00**	**R1,991.00**	**R923.62**	**R8,548.38**
Ampath - Total Cost	**R10,257.64**	**R10,375.72**	**R8,948.20**	**R7,497.40**	**R13,378.76**	**R50,457.72**
Income	R46.50	R74.80	R74.80	R74.80	R46.50	
Profit/(loss) by doing work in the peripheral labs	(R724.34)	R518.38	(R1,617.00)	(R1,617.00)	(R737.62)	**(R4,177.58)**
Profit/(loss) by doing work in the main lab	R603.37	R2,216.60	R296.70	R287.96	R166.07	**R3,570.70**
Ampath Advantage/(Disadvantage) by centralizing	R1,327.71	R1,698.22	R1,913.70	R1,904.96	R903.69	**R7,748.28**

Date: 9-11-1998 **Wilhelm Boshoff**

Appendix C: Menu of routine tests

DESCRIPTION	ROUTINE	AUTOMATED	SEROLOGY	ENDOCRINOLOGY	HAEMATOLOGY	BIOCHEMISTRY	MICROBIOLOGY	ANDROLOGY	HISTOLOGY	ARCHITECT	MODULAR BM	ELECSYS 2010	ELECSYS 1010 BM	IMMULITE	AXSYM	LX20 BECKMAN	LX4201 BECKMAN	CX9 BECKMAN	CX5 BECKMAN	CX4 BECKMAN	CX3 BECKMAN	ES700 BM	ES 300 BM	ACCESS	ARRAY	IMMAGE	GEN'S BECKMAN	STKS BECKMAN	MAXM BECKMAN	ACT DIFF BECKMAN	ACT 8 BECKMAN	CX3 DELTA BECKMAN	KEYSYS	HITACHI 902 BM	HITACHI 911/912 BM	HITACHI 917 BM	HITACHI 747 BM	CELL-DYN 3200 ABBOTT	BEHRING NEPHELOMETER	BEHRING ELISA
17OH PROG STIM	Y	N		X																																			
17OH PROGESTERONE	Y	N		X																																			
ACETYLCHOL RECEFTOR	Y	N		X																																			
ALDOSTERONE-A	Y	N		X																																			
ALDOSTERONE-R	Y	N		X																																			
ANDROSTENEDIONE	Y	N		X																																			
B PERTUSSIS DFA	Y	N	X																																				
BRUCELLA AGGLUT	Y	N	X																																				
CALCITONIN	Y	N		X																																			
CHLAMYDIA A/B	Y	N	X																																				
CHLAMYDIA DFA	Y	N	X																																				
CHROMOSOMES AMN	Y	N						X																															
F-PORPHYRINS	Y	N																																					
F-PORPHYRINS TLC	Y	N																																					
F-REDUCING SUBST.	Y	N																																					
FREE TESTOSTERONE	Y	N		X						X***																													
GASTRIN	Y	N		X																																			
GASTRIN STIM	Y	N		X																																			
GLUCOSE URINE	Y	N				X										X	X	X	X	X																			
H SIMPLEX DFA	Y	N	X																																				
INS AFTER GLU	Y	N		X										X								X	X	X															
INSULIN	Y	N		X										X								X	X	X															
INSULIN 120 MIN	Y	N		X										X								X	X	X															
INSULIN 150 MIN	Y	N		X										X								X	X	X															
INSULIN 180 MIN	Y	N		X										X								X	X	X															
INSULIN 240 MIN	Y	N		X										X								X	X	X															
INSULIN 30 MIN	Y	N		X										X								X	X	X															
INSULIN 300 MIN	Y	N		X										X								X	X	X															
INSULIN 60 MIN	Y	N		X										X								X	X	X															
INSULIN 90 MIN	Y	N		X										X								X	X	X															
INSULIN BASAL	Y	N		X										X								X	X	X															
LEGIONELLA DFA	Y	N	X																																				
MICROALBUMINURIA	Y	N		X																					X	X													
NSE	Y	N		X																		X	X																
PAUL BUNNELL	Y	N	X																																				
PNEUMO CARINII	Y	N	X																																				
RENIN RESTING	Y	N		X																																			
RENIN-ACTIVE	Y	N		X																																			

DESCRIPTION	ROUTINE	AUTOMATED	SEROLOGY	ENDOCRINOLOGY	HAEMATOLOGY	BIOCHEMISTRY	MICROBIOLOGY	ANDROLOGY	HISTOLOGY	ARCHITECT	MODULAR BM	ELECSYS 2010	ELECSYS 1010 BM	IMMULITE	AXSYM	LX20 BECKMAN	LX4201 BECKMAN	CX9 BECKMAN	CX5 BECKMAN	CX4 BECKMAN	CX3 BECKMAN	ES700 BM	ES 300 BM	ACCESS	ARRAY	IMMAGE	GEN'S BECKMAN	STKS BECKMAN	MAXM BECKMAN	ACT DIFF BECKMAN	ACT 8 BECKMAN	CX3 DELTA BECKMAN	KEYSYS	HITACHI 902 BM	HITACHI 911/912 BM	HITACHI 917 BM	HITACHI 747 BM	CELL-DYN 3200 ABBOTT	BEHRING NEPHELOMETER	BEHRING ELISA
RENIN/ALDOS (A)	Y	N		X																																				
RENIN/ALDOS (R)	Y	N		X																																				
RF AGGLUTINATION	Y	N	X																																					
ROSE WAALER	Y	N	X																																					
RPR AGGLUT	Y	N	X																																					
SEROTONIN	Y	N		X																																			
STREPTOZYME	Y	N	X																																					
THYROGLOBULIN	Y	N		X																																			
TK	Y	N		X																																				
TPA	Y	N	X																																					
TSH RECEPTOR AB	Y	N		X						X***																													X
U-VMA	Y	N				X																																	
URINE ALDOS	Y	N		X																																			
URINE CORTISOL	Y	N		X							X			X										X															
WIDAL O & H AG	Y	N	X																																					
17B OESTRADIOL	Y	Y		X						X	X**	X	X	X	X							X	X	X															
ACTH	Y	Y		X										X																									
AFP	Y	Y		X						X	X**			X	X									X														X	
AFP - AMNIOTIC	Y	Y		X						X	X**			X	X									X														X	
ANTI DNA'SE B	Y	Y	X																																				X	
APOLIPO (a)	Y	Y		X							X															X												X	
APOLIPO A1	Y	Y		X							X					X	X	X	X	X					X	X							X	X	X	X	X	X	
APOLIPO B	Y	Y		X							X					X	X	X	X	X					X	X							X	X	X	X	X	X	
APOLIPOPROTEINS	Y	Y		X																																			
AST	Y	Y	X																																				
B-2-MICROGLOB	Y	Y		X							X														X	X												X	
BHCG (MALE)	Y	Y		X						X	X**	X	X		X									X															
C-PEPTIDE	Y	Y		X																		X	X																
C-REACTIVE PROT	Y	Y	X								X														X	X													
C3,C4	Y	Y	X								X														X	X	,												
CA 125	Y	Y		X						X	X**	X	X		X							X	X	X															
CA 15-3	Y	Y		X						X	X**	X	X		X							X	X	X															
CA 19-9	Y	Y		X						X	X**	X	X		X							X	X	X															
CA 72-4	Y	Y		X							X**	X	X									X	X	X															
CDT	Y	Y		X																																			
CEA	Y	Y								X	X*	X	X	X	X							X	X	X									X	X	X	X	X		
COMPLEMENT C3	Y	Y	X								X														X	X							X	X	X	X	X	X	
COMPLEMENT C4	Y	Y	X								X														X	X							X	X	X	X	X	X	

DESCRIPTION	ROUTINE	AUTOMATED	SEROLOGY	ENDOCRINOLOGY	HAEMATOLOGY	BIOCHEMISTRY	MICROBIOLOGY	ANDROLOGY	HISTOLOGY	ARCHITECT	MODULAR BM	ELECSYS 2010	ELECSYS 1010 BM	IMMULITE	AXSYM	LX20 BECKMAN	LX4201 BECKMAN	CX9 BECKMAN	CX5 BECKMAN	CX4 BECKMAN	CX3 BECKMAN	ES700 BM	ES 300 BM	ACCESS	ARRAY	IMMAGE	GEN'S BECKMAN	STKS BECKMAN	MAXM BECKMAN	ACT DIFF BECKMAN	ACT 8 BECKMAN	CX3 DELTA BECKMAN	KEYSYS	HITACHI 902 BM	HITACHI 911/912 BM	HITACHI 917 BM	HITACHI 747 BM	CELL-DYN 3200 ABBOTT	BEHRING NEPHELOMETER	BEHRING ELISA
DHEAS	Y	Y		X						X***				X																									
DOWN SYNDROME	Y	Y		X																																			
ECP	Y	Y	X																																				
FREE PSA	Y	Y		X						X	X**				X							X	X																
FREE T3	Y	Y		X						X	X**	X	X	X	X							X	X	X															
FREE T4	Y	Y		X						X	X**	X	X	X	X							X	X	X															
FSH	Y	Y		X						X	X**	X	X	X	X							X	X	X															
GH STIM : INSULIN	Y	Y		X										X																									
GH SUPPRES GLUCOSE	Y	Y		X										X																									
GLUCOSE FASTING	Y	Y				X					X					X	X	X	X	X	X											X	X	X	X	X	X		
GLUCOSE FLUID	Y	Y				X					X					X	X	X	X	X	X											X	X	X	X	X	X		
GLUCOSE PERI	Y	Y				X					X					X	X	X	X	X	X											X	X	X	X	X	X		
GLUCOSE RANDOM	Y	Y				X					X					X	X	X	X	X	X											X	X	X	X	X	X		
GLUCOSE TOL. 2HRS	Y	Y				X					X					X	X	X	X	X	X											X	X	X	X	X	X		
GLUCOSE TOL. 6HRS	Y	Y				X					X					X	X	X	X	X	X											X	X	X	X	X	X		
GLUCOSE TOL. WHO	Y	Y				X					X					X	X	X	X	X	X											X	X	X	X	X	X		
GLUCOSE TOL 3HRS	Y	Y				X					X					X	X	X	X	X	X											X	X	X	X	X	X		
GROWTH HORMONE	Y	Y		X										X																									
HAIGM,HBSAG, HBCAB	Y	Y	X							X																													X
HAIGM,HBSAG/AB,HBCAB	Y	Y	X							X																													X
HBVCIgM, EAG,EAB	Y	Y	X																																				X
HEP B CAB	Y	Y	X							X	X**				X																								X
HEP B CAB IGM	Y	Y	X							X	X**				X																								X
HEP B EAB	Y	Y	X							X	X**				X																								X
HEP B EAG	Y	Y	X							X	X**				X																								X
HEP B SAG	Y	Y	X							X	X**				X																								X
HEP B SAG,CAB	Y	Y	X							X	X**				X																								X
HEP B SAG,CAB,SAB	Y	Y	X							X	X**				X																								X
HEPATITIS A & B ALL	Y	Y	X							X	X**				X																								X
HEPATITIS A IGG	Y	Y	X							X	X**				X																								X
HEPATITIS A IGM	Y	Y	X							X	X**				X																								X
HEPATITIS A,B & C	Y	Y	X							X	X**				X																								X
HEPATITIS B MARKERS	Y	Y	X							X	X**				X																								X
HEPATITIS B SAB	Y	Y	X							X	X**				X																								X
HEPATITIS B SAG, SAB	Y	Y	X							X	X**				X																								X
HEPATITIS B SAG,CAB	Y	Y	X							X	X**				X																								X
HEPATITIS C IGG	Y	Y	X							X	X**				X																								X
HIV A/B (ABBOTT)	Y	Y	X							X				X	X									X															

DESCRIPTION	ROUTINE	AUTOMATED	SEROLOGY	ENDOCRINOLOGY	HAEMATOLOGY	BIOCHEMISTRY	MICROBIOLOGY	ANDROLOGY	HISTOLOGY	ARCHITECT	MODULAR BM	ELECSYS 2010	ELECSYS 1010 BM	IMMULITE	AXSYM	LX20 BECKMAN	LX4201 BECKMAN	CX9 BECKMAN	CX5 BECKMAN	CX4 BECKMAN	CX3 BECKMAN	ES700 BM	ES 300 BM	ACCESS	ARRAY	IMMAGE	GEN"S BECKMAN	STKS BECKMAN	MAXM BECKMAN	ACT DIFF BECKMAN	ACT 8 BECKMAN	CX3 DELTA BECKMAN	KEYSYS	HITACHI 902 BM	HITACHI 911/912 BM	HITACHI 917 BM	HITACHI 747 BM	CELL-DYN 3200 ABBOTT	BEHRING NEPHELOMETER	BEHRING ELISA
HIV A/B "ASS"	Y	Y	X							X				X	X									X															
HIV ELISA ANTIBOD	Y	Y	X																			X	X																X
HIV TYPE I & II	Y	Y	X							X	X**											X	X																X
IGA,IGM,IGG	Y	Y	X								X														X	X						X	X	X	X	X		X	
IMMUNO IGA	Y	Y	X								X														X	X						X	X	X	X	X		X	
IMMUNO IGG	Y	Y	X								X														X	X						X	X	X	X	X		X	
IMMUNO IGM	Y	Y	X								X														X	X						X	X	X	X	X		X	
LH	Y	Y		X						X	X**	X	X	X	X							X	X	X															
LIPID PROFILE	Y	Y		X		X					X																												
LIPOGRAM	Y	Y		X		X					X																												
LIPOGRAM MODI.	Y	Y		X		X					X																												
OVARIAN PROFILE	Y	Y		X						X	X**	X	X	X	X							X	X	X															
PROGESTERONE	Y	Y		X						X	X**	X	X	X	X							X	X	X															
PROLACTIN	Y	Y		X						X	X**	X	X	X	X							X	X	X															
PROSTATE PROFILE	Y	Y		X																																			
PROT. ELECT TO PTA	Y	Y				X																																	
PROT. ELECTROPH	Y	Y				X																																	
RED CELL FOLATE	Y	Y		X							X			X										X															
RF QUANTITATIVE	Y	Y	X																																				
RUBELLA A/B	Y	Y	X							X**					X							X	X	X															
RUBELLA ANTIBODIES	Y	Y	X							X**					X							X	X																X
RUBELLA IGG	Y	Y	X							X**					X							X	X	X															X
RUBELLA IGM	Y	Y	X							X**					X							X	X	X															X
S-IRON	Y	Y				X					X					X	X	X	X	X													X	X	X	X	X		
S-LDL (CH,TRIG,HDL)	Y	Y				X					X																						X	X	X	X	X		
SERUM FOLATE	Y	Y		X						X	X	X	X	X	X							X	X	X															
SHBG	Y	Y		X										X																									
THYROID A/B	Y	Y		X						X**				X								X	X																
THYROID PROFILE	Y	Y		X																																			
TOXOPLASMA A/B	Y	Y		X																				X															X
TRH STIM: PROLACTIN	Y	Y		X						X	X**	X	X	X	X							X	X	X															
TRH STIM:THYROID	Y	Y		X						X	X**	X	X	X	X							X	X	X															
TSH	Y	Y		X						X	X**	X	X	X	X							X	X	X															
VITAMIN B12	Y	Y		X						X		X	X	X	X									X									X	X	X	X	X		
ANDROGENS (F)	Y	Y/N		X																																			
ANDROGENS (M)	Y	Y/N		X																																			
HIRSUTISM	Y	Y/N		X																																			
HORMONAL PROFILE	Y	Y/N		X																																			

DESCRIPTION	ROUTINE	AUTOMATED	INFERTILITY (F)	INFERTILITY (M)	TUMOUR MARKERS (F)	TUMOUR MARKERS (M)	LEAD
SEROLOGY							
ENDOCRINOLOGY	Y	Y/N	X	X	X	X	
HAEMATOLOGY							
BIOCHEMISTRY							
MICROBIOLOGY							
ANDROLOGY							
HISTOLOGY							
ARCHITECT							
MODULAR BM							
ELECSYS 2010							
ELECSYS 1010 BM							
IMMULITE							
AXSYM							
LX20 BECKMAN							
LX4201 BECKMAN							
CX9 BECKMAN							
CX5 BECKMAN							
CX4 BECKMAN							
CX3 BECKMAN							
ES700 BM							
ES 300 BM							
ACCESS							
ARRAY							
IMMAGE							
GEN*S BECKMAN							
STKS BECKMAN							
MAXM BECKMAN							
ACT DIFF BECKMAN							
ACT 8 BECKMAN							
CX3 DELTA BECKMAN							
KEYSYS							
HITACHI 902 BM							
HITACHI 911/912 BM							
HITACHI 917 BM							
HITACHI 747 BM							
CELL-DYN 3200 ABBOTT							
BEHRING NEPHELOMETER							
BEHRING ELISA							

Appendix D: Laboratory volumes for selected tests

REGIONAL VOLUMES FOR SELECTED TESTS

PRACTICE	Drs. Bruinette, Kramer & Partners					Drs. du Buisson & Partners				
LABORATORY	AFP	CA 125	CA 15-4	CA 19-9	Ferritin	AFP	CA 125	CA 15-4	CA 19-9	Ferritin
BRITS	0	0	0	0	0	0	0	0	0	0
RUSTENBURG	31	10	13	13	55	0	0	0	0	0
PRETORIA	660	194	240	294	1027	8	21	18	13	8
POTGIETERSRUS	0	0	0	0	0	0	0	0	0	0
PIETERSBURG	53	23	28	53	120	0	0	0	0	0
TZANEEN	8	0	3	10	3	0	0	0	0	0
LOUIS TRICHARDT	5	0	3	0	3	0	0	0	0	0
MIDRAND	18	0	0	8	8	0	0	0	0	9
KRUGERSDORP	0	0	0	0	0	78	4	13	30	133
JOHANNESBURG	45	3	0	15	328	50	41	79	147	917
KEMPTON PARK	23	18	28	18	108	4	30	9	39	90
BOKSBURG	35	3	5	8	165	13	0	4	9	13
BENONI	10	3	5	8	135	0	0	0	17	21
WITBANK	20	15	10	13	35	0	0	0	0	0
MIDDELBURG	28	8	15	8	30	0	0	0	0	0
NELSPRUIT	53	8	30	13	70	0	0	0	0	0
POTCHEFSTROOM	3	3	3	3	43	0	0	0	0	0
ALBERTON	15	5	8	10	53	0	0	13	9	189
GERMISTON	0	0	0	0	0	4	4	4	26	107
TRICHARDT	8	15	20	13	90	0	0	0	0	0
SPRINGS	53	23	31	51	71	0	0	9	4	0
ERMELO	3	0	0	0	5	0	0	0	0	0
EASTERN CAPE	48	70	60	108	53	0	0	0	0	0
TOTAAL	1119	401	502	646	2402	157	100	149	294	1487

Appendix E: Thyroid, Tumour Markers and Ovarian testing

MONTHLY DIRECT REAGENT COST OF PERFORMING THYROIDS, OVARIANS AND TUMOR MARKERS

FT3

Laboratory	Du Buisson	East Londen	Nelspruit	Pietersburg	Bruinette	Bouwer	Decentralise	Centralise	Difference
Volume	8344	511	419	0	3256	2015	14545	14545	0
Direct Reagent Cost per Test	R4.32	R5.58	R5.88	R0.00	R4.45	R4.58	R4.47	R4.29	R0.18
Total Direct Reagent Cost	R36,046	R2,851	R2,464	R0	R14,489	R9,229	R65,079	R62,398	R2,681

FT4

Laboratory	Du Buisson	East Londen	Nelspruit	Pietersburg	Bruinette	Bouwer	Decentralise	Centralise	Difference
Volume	9775	572	455	0	4203	2754	17759	17759	0
Direct Reagent Cost per Test	R4.29	R5.14	R5.38	R0.00	R4.36	R4.42	R4.38	R4.27	R0.11
Total Direct Reagent Cost	R41,935	R2,940	R2,448	R0	R18,325	R12,173	R77,820	R75,031	R1,990

TSH

Laboratory	Du Buisson	East Londen	Nelspruit	Pietersburg	Bruinette	Bouwer	Decentralise	Centralise	Difference
Volume	13335	885	549	0	5308	4309	24386	24386	0
Direct Reagent Cost per Test	R4.27	R4.82	R5.18	R0.00	R4.33	R4.36	R4.34	R4.26	R0.08
Total Direct Reagent Cost	R56,940	R4,266	R2,844	R0	R22,984	R18,787	R105,821	R103,884	R1,936

LH

Laboratory	Du Buisson	East Londen	Nelspruit	Pietersburg	Bruinette	Bouwer	Decentralise	Centralise	Difference
Volume	3796	192	212	4	1149	932	6285	6285	0
Direct Reagent Cost per Test	R6.18	R9.56	R9.23	R177.29	R6.59	R6.73	R6.65	R6.12	R0.53
Total Direct Reagent Cost	R23,459	R1,836	R1,957	R709	R7,572	R6,272	R41,805	R38,464	R3,341

Progesterone

Laboratory	Du Buisson	East Londen	Nelspruit	Pietersburg	Bruinette	Bouwer	Decentralise	Centralise	Difference
Volume	2074	150	126	0	1058	353	3761	3761	0
Direct Reagent Cost per Test	R6.33	R10.56	R11.43	R0.00	R6.64	R7.94	R6.91	R6.20	R0.71
Total Direct Reagent Cost	R13,128	R1,584	R1,440	R0	R7,025	R2,803	R25,981	R23,318	R2,662

FSH

Laboratory	Du Buisson	East Londen	Nelspruit	Pietersburg	Bruinette	Bouwer	Decentralise	Centralise	Difference
Volume	5646	263	255	0	2223	1370	9757	9757	0
Direct Reagent Cost per Test	R6.12	R8.60	R8.68	R0.00	R6.30	R6.50	R6.35	R6.08	R0.27
Total Direct Reagent Cost	R34,554	R2,262	R2,213	R0	R14,005	R8,905	R61,939	R59,323	R2,616

Prolactin

Laboratory	Du Buisson	East Londen	Nelspruit	Pietersburg	Bruinette	Bouwer	Decentralise	Centralise	Difference
Volume	2037	97	101	0	802	432	3469	3469	0
Direct Reagent Cost per Test	R6.33	R13.06	R12.78	R0.00	R6.85	R7.58	R6.98	R6.22	R0.76
Total Direct Reagent Cost	R12,894	R1,267	R1,291	R0	R5,494	R3,275	R24,220	R21,577	R2,643

Estradiol

Laboratory	Du Buisson	East Londen	Nelspruit	Pietersburg	Bruinette	Bouwer	Decentralise	Centralise	Difference
Volume	5310	0	250	4	2022	1427	9013	9013	0
Direct Reagent Cost per Test	R11.67	R0.00	R16.23	R310.70	R12.03	R12.28	R12.11	R11.60	R0.51
Total Direct Reagent Cost	R61,968	R0	R4,058	R1,243	R24,325	R17,524	R109,116	R104,551	R4,565

CEA

Laboratory	Du Buisson	East Londen	Nelspruit	Pietersburg	Bruinette	Bouwer	Decentralise	Centralise	Difference
Volume	719	56	0	0	577		1352	1352	0
Direct Reagent Cost per Test	R11.11	R28.10	R0.00	R0.00	R11.47		R11.97	R10.44	R1.53
Total Direct Reagent Cost	R7,988	R1,574	R0	R0	R6,618	R0	R16,180	R14,115	R2,065

CA 125

Laboratory	Du Buisson	East Lon	Nelspruit	Pietersburg	Bruinette	Bouwer	Decentralise	Centralise	Difference
Volume	289		0	0	186		484	484	0
Direct Reagent Cost per Test	R34.82	R3	R0.00	R0.00	R39.73		R41.84	R31.25	R10.59
Total Direct Reagent Cost	R10,063	R2,	R0	R0	R7,390	R0	R20,248	R15,125	R5,123

CA'153

Laboratory	Du Buisson	East Londen	Nelspruit	Pietersburg	Bruinette	Bouwer	Decentralise	Centralise	Difference
Volume	423	5	0	0	182		610	610	0
Direct Reagent Cost per Test	R13.87	R244.31	R0.00	R0.00	R17.52		R16.85	R13.02	R3.83
Total Direct Reagent Cost	R5,867	R1,222	R0	R0	R3,189	R0	R10,277	R7,942	R2,335

CA 19-9

Laboratory	Du Buisson	East Londen	Nelspruit	Pietersburg	Bruinette	Bouwer	Decentralise	Centralise	Difference
Volume	541	24	0	0	569		1134	1134	0
Direct Reagent Cost per Test	R12.30	R55.64	R0.00	R0.00	R12.20		R13.17	R11.24	R1.93
Total Direct Reagent Cost	R6,654	R1,335	R0	R0	R6,942	R0	R14,931	R12,746	R2,185

PSA

Laboratory	Du Buisson	East Londen	Nelspruit	Pietersburg	Bruinette	Bouwer	Decentralise	Centralise	Difference
Volume	3464	302	0	0	1492		5258	5258	0
Direct Reagent Cost per Test	R8.79	R11.58	R0.00	R0.00	R9.14		R9.05	R8.70	R0.35
Total Direct Reagent Cost	R30,449	R3,497	R0	R0	R13,637	R0	R47,583	R45,745	R1,838

FREE PSA

Laboratory	Du Buisson	East Londen	Nelspruit	Pietersburg	Bruinette	Bouwer	Decentralise	Centralise	Difference
Volume	88	29	0	0	0		117	117	0
Direct Reagent Cost per Test	R22.31	R47.12	R0.00	R0.00	R0.00		R28.46	R19.29	R9.17
Total Direct Reagent Cost	R1,963	R1,366	R0	R0	R0	R0	R3,330	R2,257	R1,073

AFP

Laboratory	Du Buisson	East Londen	Nelspruit	Pietersburg	Bruinette	Bouwer	Decentralise	Centralise	Difference
Volume	1202	0	6	0	187		1395	1395	0
Direct Reagent Cost per Test	R8.11	R0.00	R144.03	R0.00	R11.81		R9.19	R8.01	R1.18
Total Direct Reagent Cost	R9,748	R0	R864	R0	R2,208	R0	R12,821	R11,174	R1,647

HCG

Laboratory	Du Buisson	East Londen	Nelspruit	Pietersburg	Bruinette	Bouwer	Decentralise	Centralise	Difference
Volume	778	0	0	0	39		817	817	0
Direct Reagent Cost per Test	R13.93	R0.00	R0.00	R0.00	R45.01		R15.41	R13.85	R1.56
Total Direct Reagent Cost	R10,838	R0	R0	R0	R1,755	R0	R12,593	R11,315	R1,277

FERRITIN

Laboratory	Du Buisson	East Londen	Nelspruit	Pietersburg	Bruinette	Bouwer	Decentralise	Centralise	Difference
Volume	2244	0	63	0	1766		4073	4073	0
Direct Reagent Cost per Test	R4.87	R0.00	R13.44	R0.00	R4.93		R5.03	R4.76	R0.27
Total Direct Reagent Cost	R10,928	R0	R847	R0	R8,706	R0	R20,481	R19,387	R1,094

Total Direct Reagent Cost	R375,423	R28,795	R20,425	R1,952	R164,664	R78,967	R670,225	R629,153	R41,072

EVALUATION OF THYROIDS, OVARIANS AND TUMOR MARKERS

Laboratory	Du Buisson	East London	Nelspruit	Pietersburg	Bruinette	Bouwer	Decentralise	Centralise	Difference
Yearly number of tests	720780	37140	29232	96	300228	163104	1250580	1250580	0
Decentralised									
Yearly Direct Reagent Cost	R4,505,072	R345,540	R245,100	R23,424	R1,975,965	R947,603	R8,042,703	R7,549,835	R492,868
Number of Axsyms required*	5	1	1	1	2	1	11	7	4
Number of operators in total^	9	2	2	2	4	2	21	12	7
Average monthly salary per technologist	R5,500	R5,500	R5,500	R5,500	R5,500	R5,500	R5,500	R5,500	R5,500
Total monthly labour cost	R49,500	R11,000	R11,000	R11,000	R22,000	R11,000	R115,500	R66,000	R38,500
Total yearly labour cost	R594,000	R132,000	R132,000	R132,000	R264,000	R132,000	R1,386,000	R792,000	R462,000
Centralised with Architect									
Number of Architects (i-2000)*	N/A	N/A	N/A	N/A	N/A	N/A	N/A	3	N/A
Number of operators'	N/A	N/A	N/A	N/A	N/A	N/A	N/A	2	N/A
Average monthly salary per technologist	N/A	N/A	N/A	N/A	N/A	N/A	N/A	R5,500	N/A
Total monthly labour cost	N/A	N/A	N/A	N/A	N/A	N/A	N/A	R11,000	N/A
Total yearly labour cost	N/A	N/A	N/A	N/A	N/A	N/A	N/A	R132,000	N/A

Yearly Total Cost (Direct reagent cost and labour)	Rand Value	Percentage
Decentralised scenario with Axsyms	R9,428,703	
Centralised scenario with Axsyms	R8,341,835	
Centralised scenario with Architect	R7,681,835	
Yearly Labour Saving		
Saving (Centralisation versus decentralisation with Axsyms)	R594,000	42.86%
Saving (Centralisation with Architect versus decentralisation with Axsyms)	R1,254,000	90.48%
Yearly Reagent Saving		
Saving (Centralisation versus decentralisation with Axsyms)	R492,868	6.13%
Saving (Centralisation with Architect versus decentralisation with Axsyms)	R492,868	6.13%
Total Yearly Saving (Labour and Reagents)		
Saving (Centralisation versus decentralisation with Axsyms)	R1,086,868	11.53%
Saving (Centralisation with Architect versus decentralisation with Axsyms)	R1,746,868	18.53%

*** Axsym calculation assumptions**
1. 60% of volume from 19H00 to 24H00.
2. 60 tests per hour running at 75% of capacity.
3. Cannot use fractions of an analyser.

^ Personnel calculation assumptions
1. 1 Technologist per interface per shift.
2. 2 shifts per day.
3. 66.67% of staff for day shift.

*** Architect (i-2000) calculation assumption**
1. 60% of volume from 19H00 to 24H00.
2. 200 tests per hour running at 75% of capacity.
3. Cannot use fractions of an analyser.

' Personnel calculation assumption
1. Up to 4 i-2000 analysers per interface.
2. 2 Shifts per day.

Appendix F: Excel spreadsheet