

UBC SEEDS program

**Environmental Impact and Cost Assessment of Paper
Document Created on UBC Campus**

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Summary

The report uses green house gas (GHG) emission amount as an indicator to evaluate the environmental impact and cost of current information storage system utilized within UBC campus. GHG emission of producing, transporting, and storing paper is compared with equivalent storage capacity of Compact Disc (CD). Total GHG emissions for using paper as storage media was calculated to be 822 ton in 2006, which includes production pollution 814 ton, transportation emission 5.96 ton, and storage pollution 1.71 ton. To save the same amount of information on CD, total GHG emission is only 25.6 ton for 2006. The cost of the paper storage method is more than \$1.3 million per year while the cost of CD-storage method being only around \$10,000 per year. Every time a document is produced and stored using digital device instead of using printing paper, GHG mission can be reduced by 97.0% and cost can be reduced by 98.7%. It is recommended that UBC departments and offices switch from using printing paper as information storage media to using digital data storage device when applicable.

Introduction

UBC currently has a partnership with Iron Mountain (a storage facility company) to house paper and other media type materials as part of the need for record retention. Every year Iron Mountain picked up thousands of paper boxes from UBC. Documents are recalled from Iron Mountain periodically and are physically transported from Coquitlam to UBC in order to be viewed then transported back when the departments from UBC are finished viewing the files. UBC pays fees to Iron Mountain for this type of record retention service, material cost, and monthly storage fees. The problem is that the frequency of transportation and the storage of paper create great amount of carbon emissions, and UBC sustainability office likes to be carbon neutral. The suggestion to improve the carbon emissions is that all the record can be stored electronically. This project will include full life cycle accounting and identify the resources associated with paper document storage procedures on campus as well as in Iron Mountain, and full life cycle on compact disc (one way to store records electronically). Contribution to sustainability at UBC will be potential to reduce the need for paper by storing data electronically, to reduce carbon emissions by eliminating the transportation of documents between UBC and Iron Mountain; to reduce all the costs associated to box, house transport and rent out space at Iron Mountain storage facilities. The purpose of this project is to calculate the CO₂ emissions associated with the production, transportation and storage of paper documents created by UBC and stored at Iron Mountain, and to compare the emissions and costs to electronic data storage on site or off site.

Scope

The objective of this study is to compare green house gas (GHG) emission of UBC paper storage system to another alternative, which is electronic storage system. The scope of GHG emission for paper storage system includes production of paper that stored by UBC in 2006, transportation of all documents to paper storage facility (i.e. Iron Mountain Inc.), and paper storage utility. Factors which are not included but may contribute to more GHG emissions are: Paper printing factors including ink and cartridge consumption and printer utility and depreciation; Paper binding factors including binding covers, staples, coils, etc; Paper handling factors including labelling, packing, packages, and security sealing; Paper destroying factors including shredding paper recycling, machine utility and depreciation. It should be pointed out that storage facility Iron Mountain Inc. provides a chance for sharing storage resources. For example document delivery vehicles from Iron Mountain Inc. delivers documents to multiple destinies on a trip, so UBC shares delivery GHG emission with other Iron Mountain customers. This factor is not included in this report.

In this report, compact disc (CD) of equivalent storage capacity to paper is chosen as an electronic storage alternative. More options are available in current market. DVDs (digital video disc) and HD-DVDs (high definition DVD) have larger storage capacity per disc, in application they are preferred over CDs. However studies on life cycle analysis and GHG emission factor for producing DVD or HD-DVD are not available. For comparison reasons, CD is chosen in this report. Hard disc drives is also a potential option for electronic information storage; however due to the rewritable nature of hard disc drives, they are not suitable for storing all information and thus it is not chosen in this report. GHG emission of CD is calculated as GHG emission during CD production. There is no CD transportation GHG emission because due to final calculation results, CD storage volume is small enough for on-campus storage. To be consistent with paper storage system, following GHG emission factors are not considered in calculation: CD burning factor including computer utility and depreciation; Document scanning factor including scanning labour, scanning machine utility and depreciation; CD handling factors including labelling, packing, packages, and security sealing; CD destroying factors including landfill cost, shredding machine utility and depreciation . It should be

pointed out that CDs have shorter life span than paper. If storage information on one CD is used on a high frequency with little care taken on this CD's reading surface, it is likely that this CD gets worn out and needs to be replaced. In this report, this replacing factor is considered to be not significant.

Investigation data

Data used in this report come from three main sources: UBC Supply Management Office, Iron Mountain Inc. on site investigation tour and literature review. It is known that UBC paper consumption is about 400 ton in 2006 (Rouhany, 2006) and GHG emission factor for paper is 2.53 tonne GHG per tonne paper; GHG emission factor for gasoline is 2.443 kg GHG per Liter gasoline ; GHG emission factor for electricity is 84.00 tonne CO₂/GWh (including imports) (Rouhany, 2006). During investigation tour, the student team found out that paper storage from UBC are distributed over seven facilities of Iron Mountain Inc. Paper documents from UBC are generally stored over a seven-year period before they are destroyed. There is no statistics shown total paper storage amount from UBC in Iron Mountain Inc, or average document pick-up delivery frequency. Document pick-up frequency varies a lot from different department/offices. Usually financial department and UBC hospital requires higher pick-up delivery service. UBC hospital requires daily document transfer service; in comparison, UBC Supply Management Offices has document pick-up service once per week. In 2007, out of 80 boxes of paper document from UBC Supply Management Office that stored in Iron Mountain, 17 boxes were recalled for pick-up. Generally, UBC ordered gasoline supplied van for next-day delivery service from Iron Mountain Inc. By watching online video posted on Iron Mountain Inc. website, students found out van type is Ford E350 (Iron Mountain, 2009). In city condition, Ford E350Van fuel consumption is 18.1 L/100km (Natural Resources Canada, 2006). Calculated by Google Map, a single travel distance from Iron Mountain Burnaby facility to UBC campus is 25.8km. In Iron Mountain Inc. Burnaby facility, about 1.3 Million cubic feet paper is stored in a five-story- high building (about 50 meters). Documents are stored on about 2 meter high shelves, and a narrow walking aisle lays between each shelf. (see FigureA1 and Figure A2 in Appendix). Medium lightings are provided on each aisle of each story of storage; while lights on main walking aisle are left on 24 hours per day, lights on side aisles have controlled timers. Storage facility has low temperature and low humidity, automatic controlled all year round.

Student team carried out CD investigation on a pack of “Staples CD-R, printable” purchased from Staples Office Depot, UBC branch. It is found that Standard CD usable

storage space is 680MB, and dimensions of a CD are 120mm in diameter and 1.5mm in thickness. By scanning files using Xerox Photocopier YII-2A located in Chemical and Biological Engineering Building, UBC, it is determined that a piece of black and white A4 paper takes 60kb storage volume. GHG emission factor for producing a CD is 1.8 kg GHG per 1 CD(INICIATIVA VERDE,2008)

It is found that retail price of 500 sheets paper is \$7.99, 50 pack CD is \$44.92. From a contrast that UBC Supply Management Office made with Iron Mountain Inc., the price for new deposit box of paper files (receiving and entry) is \$1.54 per cubic foot; price for secure space of deposit is \$0.255 per cubic foot monthly on a more than 5 years storage term agreement; file retrievals is \$2.50 per cubic foot. UBC general policy requires documents to be stored for more than seven years before they can be destroyed.

Assumption

Eventhough students obtained most of the information needed for calculation; reasonable assumptions still need to be made in order to complete the calculation. Following are all the assumptions used: Of all the paper consumed on UBC campus in 2006, about 80% is stored at Iron Mountain Inc. facility; Iron Mountain Burnaby facility is used to stand for all the seven Iron Mountain Inc. storage facilities in Great Vancouver Area, BC; Document pick up van travels a round trip between UBC and Iron Mountain Burnaby facility once every working day; A4 Paper of type 20lb to 24 lb (about 80g/m²) is used; Average volume of 500 sheet paper is 0.003 m³ (estimate measurement of a pack of paper) ; Storage space for every cubic meter paper is 1.5 m³ (estimate from facility lay out, see FigureA1 and Figure A2 in Appendix) ; EPI (Energy Performance Index) is about 1138kWh/m² annually on average for museum and library environments in North America applies to Iron Mountain facility (Bell, 2008)

For convenient reasons, storage volume on each CD disc may not fully used, thus average used capacity per CD is estimated to be 650 MB; All stored paper are scanned in black and white format; One CD discs takes 4.32×10^{-5} m³ space, that is a cubic volume with length equivalent to a CD diameter, and thickness equals twice of a CD disc.

In paper transportation cost estimation, average document pick-up frequency is missing because it varies a lot from different UBC department/offices. Pick-up frequency is assumed to be 10% of total UBC paper storage volume monthly. Assume average paper storage life is seven years.

Approach

The objective of this report is to find a better way to store backup files in UBC. To achieve this, the current storage method, which uses paper as the storage media are compared with CD-storage method. The CD-storage method is suggested because one CD can store a lot of information and the method is now widely applied in many companies for file-keeping purposes. The total GHG emission and cost for both the current iron mountain storage method and the CD storage are calculated. The resulted data are compared to find which option is better.

The GHG emission from paper storage method comes mainly from three parts. They are the paper production emissions, the transportation emissions and the ventilation emissions. The paper emission is calculated simply using the equation:

$$E_{(\text{paper production})} = m * f * 0.8 \quad (1)$$

where $E_{(\text{paper production})}$ represents total the paper emission in ton, m the amount of paper UBC produced in tons per year, and f the emission factor of paper in ton GHG/ton paper.

To calculate the transportation emissions, the following equation is used:

$$E_{(\text{trans})} = \text{annual traveling distance (km)} * \text{gas consumption rate(L/km)} * (f_{\text{gas}}) \quad (2)$$

Where $E_{(\text{trans})}$ represents the GHG emission due to transportation in ton, f_{gas} the emission factor of gasoline in ton GHG/L gasoline.

The ventilation emission takes 7 years storage period in to consideration

$$E_{(\text{ven})} = (\text{energy performance index}) * (\text{storage area/floor}) * 5 \text{ floors} * 7 \text{ years} \quad (3)$$

The total GHG emission for paper is the sum of the three emissions found above

$$E_{\text{paper total}} = E_{(\text{paper production})} + E_{(\text{trans})} + E_{(\text{ven})} \quad (4)$$

The emission of CD storage method is obtained with the following equation:

$$E_{\text{CD}} = (\text{number of CD needed}) * (f_{\text{cd}}) \quad (5)$$

where E_{CD} represents the total GHG emission of CD in ton and f_{cd} the emission factor of CD in ton GHG/CD

From contrast of UBC Supply Management Office with Iron Mountain, paper storage cost can be divided to four parts. They are cost of purchasing blank paper, the cost of long term security storing the paper in Iron Mountain Inc. storage facility, the cost of first time deposit of the paper and the cost of retrieving the paper from storage facility. The cost of buying the paper is calculated with the following equation:

$$\text{Cost of buying the paper} = (\$/\text{paper}) * 0.8 * \text{ sheets of paper needed} \quad (6)$$

The cost of the paper calculated based on the cost of the “5000 pack staple's multipurpose printing paper” (\$54/5000 sheets paper). The number 0.8 in the equation is used to convert the retail price to wholesale price.

The cost of the paper storage is calculated in following equation, taking 7 years storage period into account:

$$\text{Cost of storing paper} = \text{storage cost rate } (\$/\text{ft}^3) * \text{ total volume of paper} * 7 \text{ years} \quad (7)$$

The cost of initial deposit is calculated by:

$$\text{Cost of initial deposit} = \text{initial deposit rate } (\$/\text{ft}^3) * \text{total volume of paper} \quad (8)$$

The cost of retrieving paper is calculated by:

$$\text{Cost of retrieving the paper} = \text{retrieving rate } (\$/\text{ft}^3) * \text{ total volume of paper} * 0.1 \quad (9)$$

The total cost of paper is found by taking the sum of the all the cost allocated above.

The cost of CD is found by:

$$\text{Cost of CD} = (\text{cost per CD}) * \text{ number of CD need} \quad (10)$$

The cost per CD is found by:

$$\text{Cost per CD} = \$44.92 / 50 \text{CD} * 0.8 \quad (11)$$

In the above equation, \$44.92 is the common current price to buy a pack of 50 CDs and 0.8 is used to convert the retail price to wholesale price.

Results and Discussion:

The obtained results are summarized in the following tables:

Table 1 GHG emissions of paper storage system

Amount of paper stored at Iron Mountain from UBC	tonne	322
GHG emission for producing paper	tonne	814
Fuel consumption of transferring all document from UBC campus to Iron Mountain storage facility	L/year	2438
Total GHG emission for document transportation fuel	tonne/year	5.96
Ventilation energy required to store paper from UBC	kwh/year	2911
GHG emission for ventilation	tonne	1.71
Total volume space required for storage	m ³	670
Total paper GHG emissions	tonne	822

Table 2 GHG emissions of CD storage system with same storage capacity as paper storage system

Amount of CD needed	CDs/year	14239
GHG emission for producing CDs	tonne	25
Fuel consumption of transporting	L/year	0
Total GHG emission for transportation fuel	tonne/year	0
Ventilation energy to store CD required	kwh/year	0
GHG emission for ventilation	tonne	0
Total volume space required for storage	m ³	0.62
Total CD GHG emissions	tonne	25

It can be seen that the CD storage method generates much less GHG emission than the paper storage method does. Among the 7,014 tons GHG emission generated from the paper storage method, about 6,000 ton is contributed to the emission of transportation. This emission is inevitable for the paper storage method because UBC does not have space to store the paper. In contrast, the CD storage method does not have

this problem. One CD can store information that equals to 10,000 sheets of scanned paper; and it only takes about 0.62 m³ to store all the information on UBC campus using CDs. Each office will be able to keep all the CDs that contained desired information. Thus, the GHG emission from transportation can be completely eliminated and the fuel used in the transportation can be saved.

The costs of the two methods are summarized below:

Table 3 Cost of Paper storage method

purchasing cost of paper	\$	550,929
cost of storage over 7 years	\$	762,229
cost of retrieving documents	\$	8,877
Total cost	\$	1,322,034

Table 4 Cost of CD storage method

purchasing cost of CD	\$	10,234
cost of storage	\$	0
cost of transportation	\$	0
Total cost	\$	10,234

It is found that the cost of the CD-storage method is much lower than that of the paper-storage method. The main cost of the paper storage method is the cost of buying the paper. This fits the hypothesis that papers are expensive. In contrast to that, the cost of buying the CD is much less because it requires a relatively little amount of CDs to store the same amount of information.

A visual comparison of the two methods is given in the following figures:

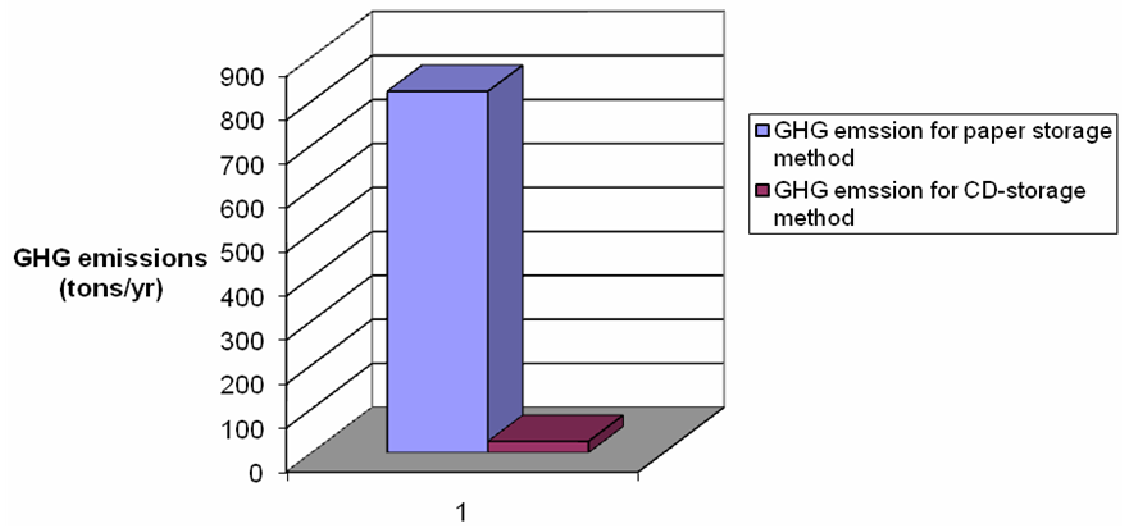


Figure 1: GHG emission comparison of the two methods

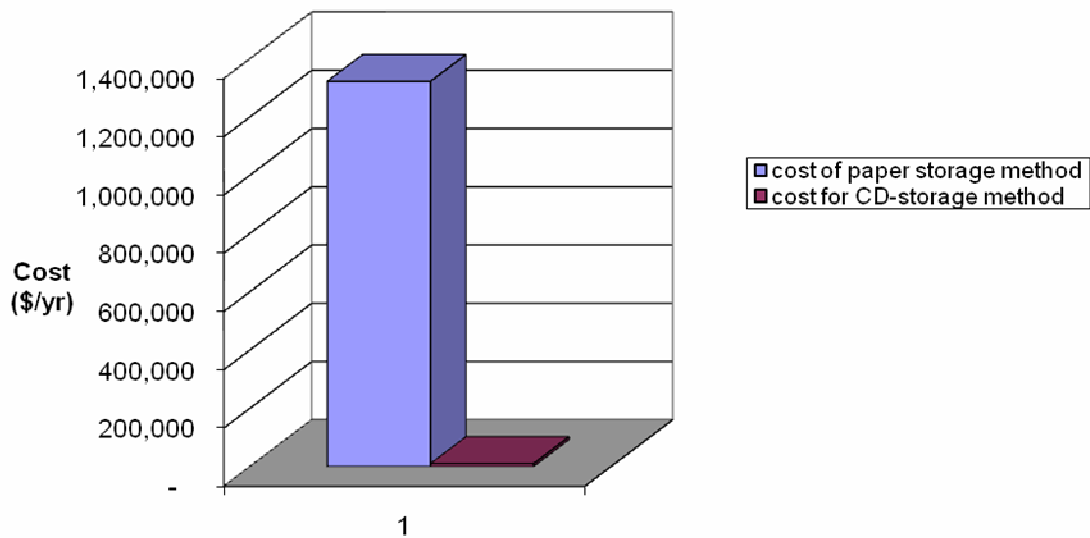


Figure 2: Cost comparison of the two methods

Conclusion

In conclusion, using CD as information storage media is more environmental friendly and economic than current paper backup storage system. If current paper storage method is completely replaced by CD-storage method, almost 800 ton green house gas can be reduced and \$1.3 million can be saved each year. For every bit of effort that made to switching using paper to using CD, 97.0% of green house gas reduction and 98.7% cost reduction can be achieved.

Future work and Recommendations:

In this report, students compared environmental impact of information storage management using greenhouse gas emission as indicator, because global warming is one of a major concern in today's society. Further comparisons on other indicators, such as toxic release and natural resource (e.g. electricity) deduction can be performed.

Paper storage system and CD storage is only compared in aspects of production, transportation pollution and storage. It is recommended that future study on comparison of functioning (printing paper, burning CD) and composting to be performed to complete life cycle analysis of paper storage system and CD storage alternative.

Other electronic system alternatives should be considered, life cycle analysis of DVD and HD-DVD needs to be performed.

In order to improve the accuracy of results presented in this report, it is recommended that campus-wide surveys to be performed and accurate measurements in Iron Mountain Inc. storage facility to be performed. Surveys all UBC departments and offices on the stored amount of paper, average document pick-up frequency, and paybill amount to Iron Mountain Inc. Random samples should be drawn to obtain average sheets of paper in each storage box.

Information obtained from UBC Supply Management Office shows that about 60% of the purchasing efforts in this office have electronic duplicates using Laserfiche© imaging system. However the hardcopies are still kept as backups and stored using Iron Mountain facility because electronic copies are not entrusted. It is an example showing that current technology already allows implication of electronic file storage; but paper storage method is not replaced yet because the reliability of electronic copy needs to be improved. To switch from using printed paper to using digital data system, imaging system and imaging procedure need to be made legally entrusted. This involves efforts on improving technology of imaging system and legislation system.

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Appendix A
Tables and Figures



Figure A1 Inside view of Iron Mountain Inc. storage facility

Reference : Iron Mountain Inc. Website Video Tour www.ironmountain.ca/en/services/tours/



Figure A2 Arrangement of paper storage in Iron Mountain Inc. storage facility

Reference : Iron Mountain Inc. Website Video Tour www.ironmountain.ca/en/services/tours/

Appendix B
Sample calculation

To calculate the GHG emission for paper production:

$$E_{(\text{paper})} = m \cdot f = 886651 \text{ lb paper/yr} \cdot 0.8 \cdot 0.454 \text{ lb/kg} / 1000 \text{ kg/ton} \cdot 2.53 \text{ kg GHG/ton} = 1018 \text{ ton GHG/yr}$$

To calculate the transportation emission for storing paper:

$$E_{(\text{trans})} = 25.8 \text{ km/day} \cdot 2 \cdot 261 \text{ workdays/yr} \cdot 18.1 \text{ L/100km} \cdot 2.443 \text{ kg GHG/L gas} = 5.96 \text{ ton GHG/yr}$$

To calculate the space needed for paper storage:

$$\text{Mass of storing paper} = 886651 \text{ lb paper/yr} \cdot 0.8 \cdot 0.4536 \text{ kg/lb} = 322 \text{ ton}$$

$$\text{Basis weight of '20lb' paper} = 80 \text{ g/m}^2$$

$$\text{Storing paper in area} = 322 \text{ ton} / (80 \text{ g/m}^2) = 4021781 \text{ m}^2$$

$$\text{Area of each sheet of paper} = 8.5 \text{ in} \cdot 11.5 \text{ in} = 0.063 \text{ m}^2/\text{sheet}$$

$$\text{Total sheets of paper used} = 4021781 \text{ m}^2 / (0.063 \text{ m}^2/\text{sheet}) = 6.37 \cdot 10^7 \text{ sheets}$$

$$\text{Total volume of paper} = 321742.5 \text{ kg} / (720 \text{ kg/m}^3) = 670 \text{ m}^3$$

To calculate GHG emission during of paper storage

Ventilation energy for whole Iron Mountain storage building

$$= 1153 \text{ kWh/year/m}^2 \cdot 1000 \text{ m}^2/\text{floor} \cdot 5 \text{ floors} = 5.69 \cdot 10^6 \text{ kWh/year}$$

Ventilation energy for UBC paper storage

$$= (5.69 \cdot 10^6 \text{ kWh/year}) / (1.3 \cdot 10^3 \text{ m}^3) \cdot (670 \text{ m}^3) = 2911 \text{ kWh/year}$$

$$E_{\text{ven}} = 2911 \text{ kWh/year} \cdot 84 \text{ ton/GWh} \cdot 10^{-6} \text{ GWh/kWh} \cdot 7 \text{ years} = 1.71 \text{ ton/year}$$

To calculate the GHG emission for CD method:

$$\text{Equivalent storage capacity of one CD} = 650 \text{ Mb} / (60 \text{ kb/page}) = 11093 \text{ page/CD}$$

$$\text{Number of page produced from UBC} = 321743 / (0.00449 \text{ kg/page}) = 157958049 \text{ pages}$$

$$\text{Number of CD needed} = 157958049 \text{ pages} / 11093 \text{ page/CD} = 14239 \text{ CD/yr}$$

$$E_{\text{CD}} = 14239 \text{ CD/yr} \cdot 1.8 \text{ kg/CD} / (1000 \text{ kg/ton}) = 25.6 \text{ ton/yr}$$

To calculate the cost for paper method:

$$\text{Cost of purchasing paper} = \$54/5000 \text{ sheets paper} \cdot 6.37 \cdot 10^7 \text{ sheets/yr} = \$550,929$$

$$\text{Cost of storing the paper} = \$0.255/\text{ft}^3/\text{month} \cdot 670 \text{ m}^3 \cdot 12 \text{ months/yr} \cdot 7 \text{ yrs} = \$762,229/\text{yr}$$

$$\text{Cost of initial deposit} = \$1.54/\text{ft}^3 / (0.0283 \text{ ft}^3/\text{m}^3) \cdot 670 \text{ m}^3 = \$36,454/\text{yr}$$

$$\text{Cost of retrieving the paper} = \$2.5/\text{ft}^3 / (0.0283 \text{ ft}^3/\text{m}^3) \cdot 670 \text{ m}^3 \cdot 0.15 = \$8,877/\text{yr}$$

$$\text{Total cost the paper method} = \$550,929/\text{yr} + \$762,229/\text{yr} + \$36,454/\text{yr} + \$8,877/\text{yr} = \$1,322,034/\text{yr}$$

To calculate the cost of CD storage method:

$$\text{Cost per CD} = \$44.92/50 \text{ CD} \cdot 0.8 = \$0.719/\text{CD}$$

$$\text{Total Cost of CD} = \$0.719/\text{CD} \cdot 14239 = \$10,234$$