Cost Benefit of Prevention/Control of Zebra Mussels in Lakes

By Jack Kohlbeck

Abstract: Zebra mussels are an invasive species that are detrimental to the environment and as a consequence, costs communities a lot of money. Property values along lakes infested with zebra mussels are falling, causing lake home owners to lose money and creating a long-term economic threat to county treasuries. In addition, infested lakes cause damage to boats, docks, and other infrastructure. By calculating the cost benefit of preventing zebra mussels from invading a lake and comparing it to the cost benefit of controlling the zebra mussels if detected early; it was determined that prevention requires much less investment to achieve the same benefits. Spending money on prevention and early detection of zebra mussels is worthwhile because at this time there is no way to eradicate zebra mussels if the lake is fully infested.

Motivation

When brainstorming an idea for a topic for my project in IE 403 (Introduction to Sustainable Production Systems); I asked myself, "What do I enjoy outside?" My parents live on Square Lake in Minnesota and when I am not at college; I spend time boating, fishing, and swimming there. I recalled seeing signs at the launch site reminding boaters to clean their trailers and watercraft thoroughly to avoid spreading aquatic invasive species. I wondered why this was important. I began by reading about the different aquatic invasive species in Minnesota and discovered the ecological, economic and recreational problems zebra mussels cause. It would be disappointing to see the lake my parents live on become dangerous for recreational use, observe other animals and fish die, and watch their real estate value decrease due to zebra mussels. I wanted to learn more about zebra mussels; how to prevent/control them and what research is being done to totally eradicate them in the future. I wondered if the prevention measures taken by Square Lake are worth the cost and if all lakes that haven't been infested should start taking the same steps.

Background

Zebra Mussels (Dreissena polymorpha) originated in drainage basins of the Black, Caspian, and Aral Seas in Eastern Europe and Western Asia. As trading increased, this small animal moved west. According to the Cary Institute of Ecosystem Studies, zebra mussels reached North America in the mid-1980s in ballast water of a ship. They soon settled in the Great Lakes and the waters draining them (Cary Institute 2019). They have rapidly spread to over 32 states in the United States; being transported by water currents or by attaching themselves to hard surfaces like boats and then releasing in other lakes (USGS 2019). Zebra mussels have the ability to reproduce rapidly making them hard to control. Beds of zebra mussels can reach tens-of-thousands within a square yard (Minnesota DNR 2019). Zebra mussels cause environmental and economic damage. They threaten a city's water supply by clogging pipes, alter the food chain critical to aquatic life, coat docks, boats and other hard surfaces causing damage, leave sharp shells that can cut swimmer's feet and reduce lakefront property values (USGS 2019). Prevention and

early detection is best because it is difficult to completely eradicate zebra mussels unless there is only a few in one small area.

Prevention

Signs should be posted at all boat launches reminding boaters to clean their trailers and watercraft thoroughly, to avoid spreading zebra mussels. Hiring boat inspectors to look at watercrafts before they enter the water also helps. To try to catch an infestation early, lake samples should be tested. If a lake sample tests positive for zebra mussel veligers (larval stage), then employing an active scuba diver to search for the zebra mussels should occur. If there are only a few zebra mussels, then it is possible to control them.

Control

Contained populations of mussels can be treated with various forms of molluscicide, but this is not possible over large areas. Right now, the three most popular treatment options are Zequanox, EarthTec QZ (copper), and potassium chloride. To learn more about these treatment options see Table 4. None of them have completely eradicated zebra mussels but have helped lakes manage them. The Minnesota Aquatic Invasive Species Research Center is researching the genetic make-up of the zebra mussel. Scientists at the University's Biotechnology Institute believe knowing the DNA profile of the zebra mussel will help them find a naturally occurring bacteria or parasite that could kill them (Kennedy 2017). No one knows how long it will take to discover a solution that will completely eradicate zebra mussels. While waiting for this discovery, is it worth investing in preventing and controlling zebra mussels in recreational lakes? The primary goal of this study is to perform a cost benefit analysis to help answer that question.

Model-Cost Benefit Analysis

Cost benefit analysis is the best way to determine whether it is justifiable to spend money on preventing and/or controlling zebra mussels in a lake. For my cost-benefit analysis I am using the Net Present Value equation to determine a ten year cost benefit analysis. The formula is NPV= Value/ (1+r)^t. NPV is the annual net present value in monetary terms for costs and benefits for a specific year. The formula factors in a discount rate for future years. Value is the total costs or benefits for a specific year for each option. The letter r stands for the discount rate and t is the year being analyzed. Microsoft Excel was used for the calculations.

According to Matt Downing from the Washington Conservation District, Square Lake spent $6,900.00 on 276 hours of watercraft inspection and $1200.00 on a targeted search and lake water sample testing in 2018 (M.Downing, personal communication, February 20, 2019). The Square Lake Association would like to see inspectors at the boat launch forty hours a week (during peak days and times)(J. Josephson, personal communications, February 15, 2019), so in future years this figure was used. A discount rate of 5% was applied.

There are many benefits to not having zebra mussels in a lake; but real estate value benefit, the improved lake user experience, and the reduction in infrastructure or watercraft damage was utilized here. Patrick Welle, a natural resources economic consultant said lakeshore properties lose about 16 percent of their value when the lakes are contaminated with invasive species (Kennedy 2017). $800,000 was used as the average home value on Square Lake. The metropolitan council estimates 45,000 people pay $7.00 to visit Square Lake County Park each summer (Metropolitan Council 2016). Visitors may not come if the water and beach are not safe. Zebra mussels can pose risks and costs to boat owners; such as ruining the engine by blocking the cooling system and causing overheating, jamming the steering equipment, and requiring the repainting of the boat's hull (California Department of Fish and Game, 2009). Zebra mussels attached to a dock can cause corrosion. A boat owner will have to pay between $1,000 and $2,500 a year for boat maintenance (Murawski 2016). $1,000 savings per year per home owner on a zebra mussel free lake was applied in the calculations. The savings visiting boaters would get was not included. See Table 1 for the cost benefit analysis of prevention of zebra mussels on Square Lake.

To help determine the cost benefit analysis for treatment, Christmas Lake in Excelsior, Minnesota which is approximately the same size as Square Lake was called into play. Christmas Lake uses the same prevention protocols as Square Lake, but is also in control mode. In 2014, four tiny zebra mussels were discovered near the boat launch. They quickly closed off the area and applied Zequanox, copper, and potash (see Table 4) which cost $70,000 (Dupey 2015). The following fall, sixteen zebra mussels were found despite ongoing treatments. Those living on Christmas Lake are willing to spend their own money to continue trying to control the amount of zebra mussels in their lake until researchers are able to find a way to permanently eradicate them. Square Lake has 44 homes and Christmas Lake has 115 homes on the same size lake which skews the cost benefit analysis, so creating a hypothetical cost benefit analysis (see Table 2) if Square Lake had an early detection of zebra mussels and decided to treat them made sense. Treatment costs are based from actual costs incurred by Christmas Lake to control zebra mussels once they were found.

For the last possible option a cost benefit analysis (see Table 3) assuming Square Lake does nothing and becomes infested with zebra mussels was generated. The probability of this is difficult to determine and is beyond the scope of this paper.

Analysis

Based on the cost benefit analysis, the Prevention option (see Figure 1) is the best for Square Lake because it has the highest ten year NPV (see Figure 4) and also a reasonable investment amount. The Treatment option (see Figure 2) has a high ten year NPV and obtains the same benefits, but it requires a higher level of investment to do annual treatments which may be an issue if these treatments are not budgeted by whoever will pay these costs. The "Do Nothing" option (see Figure 3) assumes the lake will become contaminated with zebra mussels during the 10 year analysis period which results in a negative ten year NPV (see Figure 4). This paper does not address the probability of the lake not being contaminated with the Do Nothing option which would have the highest NPV. However, the risk of doing nothing was determined to be too high for the Square Lake Association.

Figure 1. Prevention - Square Lake – Cost and Benefit NPV for 10 years

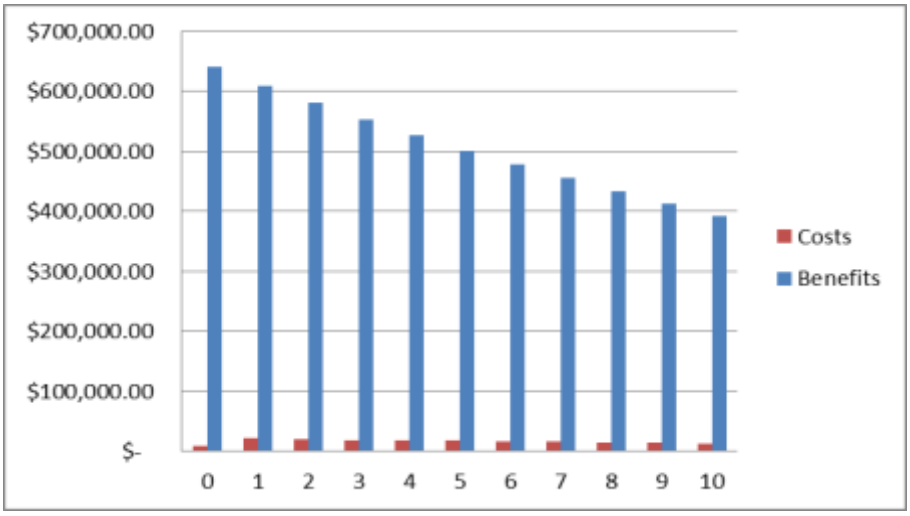


Figure 2. Hypothetical Treatment – Square Lake – Cost and Benefit NPV for 10 years

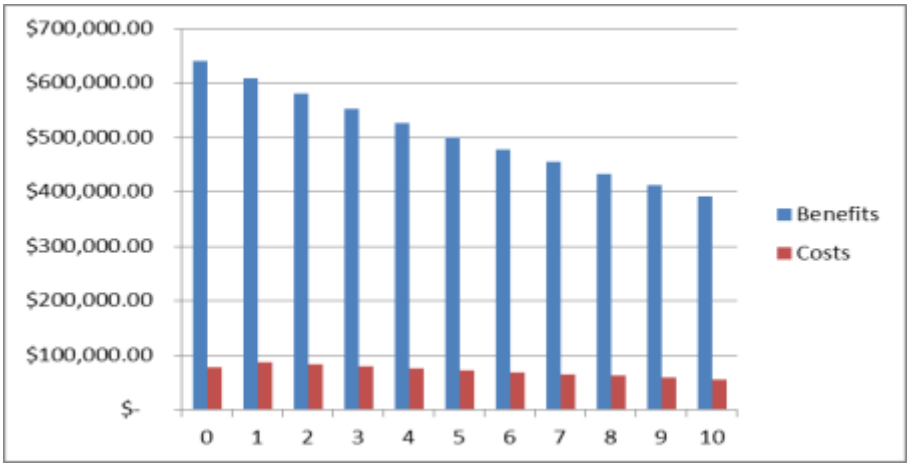


Figure 3. Do Nothing – Square Lake – Cost and Benefit NPV for 10 years (assumes lake gets infested)

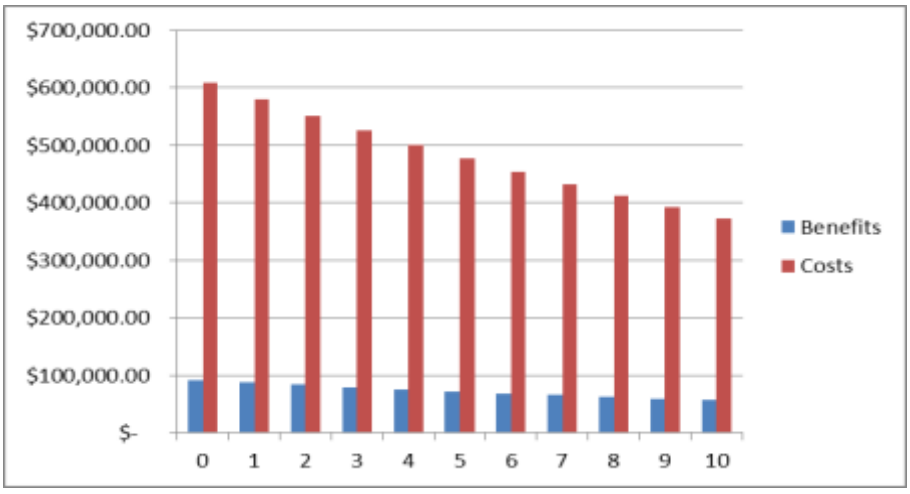
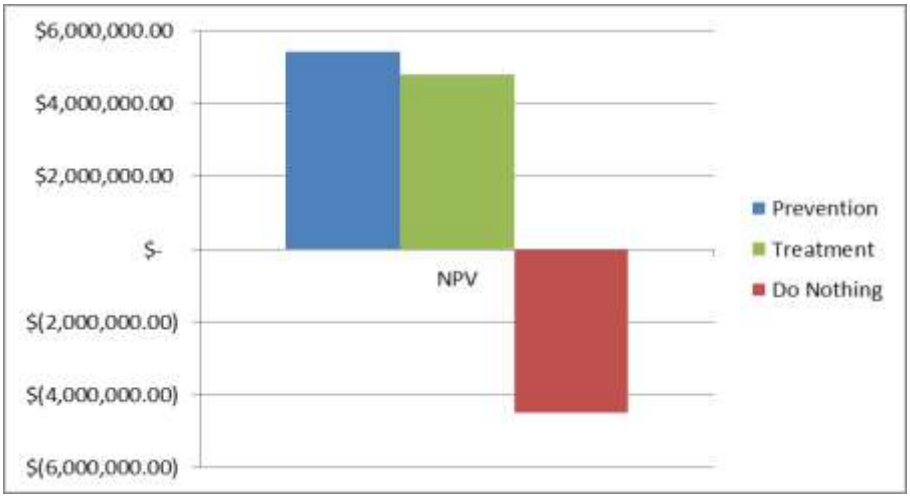


Figure 4. 10 year NPV Comparison for Options



Worth

Zebra mussels in a lake can affect recreational use, real estate values, and the lake's trophic (feeding and nutrition) status. Prevention and early detection is best because it is very difficult to completely eradicate zebra mussels unless there is only a few in a targeted area. Currently, it is not possible to treat an entire lake. According to Christine Lee, communication specialist for the Minnesota Aquatic Invasive Species Research Center, the genome of zebra mussels will be completed and released publicly in May (C.Lee, personal communication, February 20, 2019). Once the data is released, researchers from around the world will be able to review it and look for ways to better rid waterways of zebra mussels. A solution to eradicate zebra mussels from an entire lake is still years and probably decades away. Should lake associations and counties sit and wait for this breakthrough or is it worth the money to stop zebra mussels before they infest their lake? The information provided in this report is evidence that all lakes in the United States that haven't been infested with zebra mussels should have preventative measures in place to keep zebra mussels out and/or catch infestations early so they can be controlled. It is worth the money and will help slow down the spread of zebra mussels until a better solution is discovered.

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Table 1. Cost Benefit Analysis for Prevention - Square Lake

Discount Rate				5%	
Costs					
2018 Periodic Manual Boat Inspections (276 hours, $25/hour)				$ 6,900.00	
Full Time Manual Boat Inspections/Signs (21 weeks, 40 hours/week, $25/hour)				$ 21,000.00	
One Time Annual Survey				$ 1,200.00	
Year	**Cost-Prevention**	**Cost-Surveyor**	**Total Cost**	**Net Present Value**	
0	$ 6,900.00	$ 1,200.00	$ 8,100.00	$ 8,100.00	
1	$ 21,000.00	$ 1,200.00	$ 22,200.00	$ 21,142.86	
2	$ 21,000.00	$ 1,200.00	$ 22,200.00	$ 20,136.05	
3	$ 21,000.00	$ 1,200.00	$ 22,200.00	$ 19,177.19	
4	$ 21,000.00	$ 1,200.00	$ 22,200.00	$ 18,263.99	
5	$ 21,000.00	$ 1,200.00	$ 22,200.00	$ 17,394.28	
6	$ 21,000.00	$ 1,200.00	$ 22,200.00	$ 16,565.98	
7	$ 21,000.00	$ 1,200.00	$ 22,200.00	$ 15,777.13	
8	$ 21,000.00	$ 1,200.00	$ 22,200.00	$ 15,025.83	
9	$ 21,000.00	$ 1,200.00	$ 22,200.00	$ 14,310.32	
10	$ 21,000.00	$ 1,200.00	$ 22,200.00	$ 13,628.87	
			Net Present Value - Cost	**$ 179,522.52**	
Benefits					
No Impact to Lake Home Prices(44 homes, $800,000 Avg. Value, 16% Reduced Value, Annual benefit)					$ 563,200.00
Lake User Experience (45,000 Lake Users, $7 admission to County park, 10% improvement in experience)					$ 31,500.00
No zebra mussel damage to infrastructure ($1000 per home for boats/docks,$1000 for Park and Scuba Diving Platforms					$ 45,000.00
Year	**Home Value Benefit**	**Lake User Benefit**	**No damage to infrastructure**	**Total Benefit**	**Net Present Value**
0	$ 563,200.00	$ 31,500.00	$ 45,000.00	$ 639,700.00	$ 639,700.00
1	$ 563,200.00	$ 31,500.00	$ 45,000.00	$ 639,700.00	$ 609,238.10
2	$ 563,200.00	$ 31,500.00	$ 45,000.00	$ 639,700.00	$ 580,226.76
3	$ 563,200.00	$ 31,500.00	$ 45,000.00	$ 639,700.00	$ 552,596.91
4	$ 563,200.00	$ 31,500.00	$ 45,000.00	$ 639,700.00	$ 526,282.77
5	$ 563,200.00	$ 31,500.00	$ 45,000.00	$ 639,700.00	$ 501,221.69
6	$ 563,200.00	$ 31,500.00	$ 45,000.00	$ 639,700.00	$ 477,353.99
7	$ 563,200.00	$ 31,500.00	$ 45,000.00	$ 639,700.00	$ 454,622.85
8	$ 563,200.00	$ 31,500.00	$ 45,000.00	$ 639,700.00	$ 432,974.14
9	$ 563,200.00	$ 31,500.00	$ 45,000.00	$ 639,700.00	$ 412,356.32
10	$ 563,200.00	$ 31,500.00	$ 45,000.00	$ 639,700.00	$ 392,720.31
				Net Present Value-Benefits	**$ 5,579,293.83**
				Net Present Value (NPV)	$ 5,399,771.32

Table 2. Cost Benefit Analysis for Hypothetical Treatment – Square Lake

Discount Rate	5%

Costs

2018 Periodic Manual Boat Inspections (276 hours, $25/hour)	$ 6,900.00
Treatment product (Zequanox, copper, potash)	$ 70,000.00
Full Time Manual Boat Inspections/Signs (21 weeks, 40 hours/week, $25/hour)	$ 21,000.00
One Time Annual Survey	$ 1,200.00

Year	Cost-Prevention	Cost-Survey	Cost-Treatment	Total Cost	Net Present Value
0	$ 6,900.00	$ 1,200.00	$ 70,000.00	$ 78,100.00	$ 78,100.00
1	$ 21,000.00	$ 1,200.00	$ 70,000.00	$ 92,200.00	$ 87,809.52
2	$ 21,000.00	$ 1,200.00	$ 70,000.00	$ 92,200.00	$ 83,628.12
3	$ 21,000.00	$ 1,200.00	$ 70,000.00	$ 92,200.00	$ 79,645.83
4	$ 21,000.00	$ 1,200.00	$ 70,000.00	$ 92,200.00	$ 75,853.17
5	$ 21,000.00	$ 1,200.00	$ 70,000.00	$ 92,200.00	$ 72,241.11
6	$ 21,000.00	$ 1,200.00	$ 70,000.00	$ 92,200.00	$ 68,801.06
7	$ 21,000.00	$ 1,200.00	$ 70,000.00	$ 92,200.00	$ 65,524.82
8	$ 21,000.00	$ 1,200.00	$ 70,000.00	$ 92,200.00	$ 62,404.59
9	$ 21,000.00	$ 1,200.00	$ 70,000.00	$ 92,200.00	$ 59,432.94
10	$ 21,000.00	$ 1,200.00	$ 70,000.00	$ 92,200.00	$ 56,602.80
				Net Present Value - Costs	**$ 790,043.96**

Benefits

No Impact to Lake Home Prices(44 homes, $800,000 Avg. Value, 16% Reduced Value, Annual benefit)	$ 563,200.00
Lake User Experience (45,000 Lake Users, $7 admission to County park, 10% improvement in experience)	$ 31,500.00
No zebra mussel damage to infrastructure ($1000 per home boats/docks, $1000 for Park and Scuba Diving Platforms	$ 45,000.00

Year	Home Value Benefit	Lake User Benefit	No damage to infrastructu	Total Benefit	Net Present Value
0	$ 563,200.00	$ 31,500.00	$ 45,000.00	$ 639,700.00	$ 639,700.00
1	$ 563,200.00	$ 31,500.00	$ 45,000.00	$ 639,700.00	$ 609,238.10
2	$ 563,200.00	$ 31,500.00	$ 45,000.00	$ 639,700.00	$ 580,226.76
3	$ 563,200.00	$ 31,500.00	$ 45,000.00	$ 639,700.00	$ 552,596.91
4	$ 563,200.00	$ 31,500.00	$ 45,000.00	$ 639,700.00	$ 526,282.77
5	$ 563,200.00	$ 31,500.00	$ 45,000.00	$ 639,700.00	$ 501,221.69
6	$ 563,200.00	$ 31,500.00	$ 45,000.00	$ 639,700.00	$ 477,353.99
7	$ 563,200.00	$ 31,500.00	$ 45,000.00	$ 639,700.00	$ 454,622.85
8	$ 563,200.00	$ 31,500.00	$ 45,000.00	$ 639,700.00	$ 432,974.14
9	$ 563,200.00	$ 31,500.00	$ 45,000.00	$ 639,700.00	$ 412,356.32
10	$ 563,200.00	$ 31,500.00	$ 45,000.00	$ 639,700.00	$ 392,720.31
				Net Present Value - Benefits	**$ 5,579,293.83**

Net Present Value (NPV)	$ 4,789,249.87

Table 3. Cost Benefit Analysis for Do Nothing – Square Lake

Discount Rate				5%	
Costs					
Impact to Lake Home Values(44 homes, $800,000 Avg. Value, 16% Reduced Value, Annual benefit)				$ 563,200.00	
Damage to infrastructure ($1000 per home for Boats/Docks, $1000 Park and Scuba Diving Platforms)				$ 45,000.00	
Year	**Reduced Home Values**	**Infrastructure Damage**	**Total Cost**	**Present Value**	
0	$ 563,200.00	$ 45,000.00	$ 608,200.00	$ 608,200.00	
1	$ 563,200.00	$ 45,000.00	$ 608,200.00	$ 579,238.10	
2	$ 563,200.00	$ 45,000.00	$ 608,200.00	$ 551,655.33	
3	$ 563,200.00	$ 45,000.00	$ 608,200.00	$ 525,386.03	
4	$ 563,200.00	$ 45,000.00	$ 608,200.00	$ 500,367.65	
5	$ 563,200.00	$ 45,000.00	$ 608,200.00	$ 476,540.61	
6	$ 563,200.00	$ 45,000.00	$ 608,200.00	$ 453,848.20	
7	$ 563,200.00	$ 45,000.00	$ 608,200.00	$ 432,236.38	
8	$ 563,200.00	$ 45,000.00	$ 608,200.00	$ 411,653.70	
9	$ 563,200.00	$ 45,000.00	$ 608,200.00	$ 392,051.14	
10	$ 563,200.00	$ 45,000.00	$ 608,200.00	$ 373,382.04	
			Net Present Value - Costs	**$ 5,304,559.18**	
Benefits					
No investment required for Treatment(Zequanox, copper, potash)				$ 70,000.00	
No investment for Boat Inspections/Signs (21 weeks, 40 hours/week, $25/hour)				$ 21,000.00	
No investment for One Time Annual Survey				$ 1,200.00	
Year	**No Investment Treatment**	**No Investment Inspection**	**No Investment Survey**	**Total Benefit**	**Present Value**
0	$ 70,000.00	$ 21,000.00	$ 1,200.00	$ 92,200.00	$ 92,200.00
1	$ 70,000.00	$ 21,000.00	$ 1,200.00	$ 92,200.00	$ 87,809.52
2	$ 70,000.00	$ 21,000.00	$ 1,200.00	$ 92,200.00	$ 83,628.12
3	$ 70,000.00	$ 21,000.00	$ 1,200.00	$ 92,200.00	$ 79,645.83
4	$ 70,000.00	$ 21,000.00	$ 1,200.00	$ 92,200.00	$ 75,853.17
5	$ 70,000.00	$ 21,000.00	$ 1,200.00	$ 92,200.00	$ 72,241.11
6	$ 70,000.00	$ 21,000.00	$ 1,200.00	$ 92,200.00	$ 68,801.06
7	$ 70,000.00	$ 21,000.00	$ 1,200.00	$ 92,200.00	$ 65,524.82
8	$ 70,000.00	$ 21,000.00	$ 1,200.00	$ 92,200.00	$ 62,404.59
9	$ 70,000.00	$ 21,000.00	$ 1,200.00	$ 92,200.00	$ 59,432.94
10	$ 70,000.00	$ 21,000.00	$ 1,200.00	$ 92,200.00	$ 56,602.80
				Net Present Value - Benefits	**$ 804,143.96**
				Net Present Value (NPV)	$ (4,500,415.22)