# 7.0 COMPARISON MATRIX OF FLOOD MITIGATION OPTIONS

An evaluation matrix was developed in order to objectively compare each flood mitigation option against the base case using a defined set of criteria. The feasibility of each option was evaluated based on the estimated reduction of inflow to the lake, the estimated change in water level on the lake, estimated costs, various environmental and social factors, and implementation time. The criteria used in the evaluation are described in further detail below:

***Average Reduction of Inflows to the Lake***

The average potential reduction of inflows to the lake represents the average reduction in runoff volume that could potentially be produced by the option over the next 50 years. These values are compared to the base case, where the reduction of inflow is zero.

***Change in Average Lake Level***

The change in average lake level is the difference in average lake level between the base case and each option. This metric helps to identify options that would result in the largest overall reduction of lake level. Averages were calculated over the short term (next 5 years) and long term (next 50 years) of simulated water levels.

***Project Cost***

As discussed in Section 6.1, the project costs for each of the options were estimated at a very high level. In order to compare the capital cost of each option on a magnitude basis, cost ranges were assigned a rating of “low”, “moderate”, “high”, or “very high”. The definition of these cost ranges is provided in Table 12.

**TABLE 12**
**RATING CATEGORIES FOR PROJECT COST**

| RATING | COST RANGE |
|---|---|
| Low | $0 - $50 M |
| Moderate | $50 M - $200 M |
| High | $200 M - $500 M |
| Very High | >$500 M |

As previously mentioned, some of the options will likely require the treatment of the Quill Lakes water before it can be discharged into another watershed or used for other purposes. These costs are likely significant, but were not included in this analysis.

***Operation Cost***

As discussed in Section 6.2, the operation costs of the various options were only compared qualitatively. Rather than assigning a dollar value to the operation of each option, a rating was assigned to reflect the amount of effort or resources that would be required to maintain operation of the option. The assigned ratings were defined as follows:

- **Low operating costs** – for projects that have minimal operating requirements.
- **Moderate operating costs** – for projects that have regular operation requirements that are seasonal dependant or for parts of the year only.
- **High operating costs** – for projects that have daily operational requirements on an annual basis.

***Environmental Considerations & Social Acceptance***

Many of the options evaluated in this study have significant environmental concerns that must be considered should WSA choose to move forward with any of the options. In most cases, a full scale environmental impact assessment will likely be required. The social acceptance of the options was based on how the public may perceive each option and what concerns they might have. The following general considerations were identified and used for comparison in the matrix:

- **Percentage of Simulated Water Levels Exceeding Natural Spill Point –** Shows the percentage of simulated water levels that exceed El. 521.47 m over the next 50 years. If the Big Quill Lake water level exceeds El. 521.47 m, there is potential for the saline Quill Lakes water to spill into the Qu'Appelle River basin. The increase in flow in the receiving basin could potentially result in water quality issues or an increase in flooding downstream.

- **Average Annual Volume of Natural Overflow –** A measure of the average volume of water, over the next 50 years, that spills from the Quill Lakes into the Qu'Appelle River basin. Years where no overflows occur were excluded from the average volume calculation.

- **Transfer of Water –** Many options require water from the Quill Lakes basin to be discharged into another location, including the Qu'Appelle River basin, the Red Deer River basin, or the Mannville or Basal Deadwood Aquifers. The water in the Quill Lakes is saline and contains a relatively high concentration of TDS. As a result, transferring water from the Quill Lakes to another watershed or using it for other means (such as in the Jansen Lake Mine) will generally require the water to be treated. Without treatment, water quality in the receiving watersheds could be compromised. In addition, the increase in flow in the receiving basin could potentially result in an increase in flooding downstream. This could be met with some social resistance since it could potentially flood downstream properties that were not previously prone to flooding concerns. Further, many of the flood mitigation options require transferring water from the Quill Lakes basin to the Qu'Appelle River basin, which flows into Manitoba. The addition of flows into Manitoba will likely be met with social resistance, as the Qu'Appelle River (and Assiniboine River) are already prone to flooding. The transfer of water from Ponass Lake Diversion would result in increased flow to the Red Deer River, which ultimately discharges into Lake Manitoba. Given the recent high water levels on Lake Manitoba, additional flows into this watershed are undesirable.

- **Average Annual Volume of Water Diverted or Removed –** The average volume of water that is diverted away from the Quill Lakes over the next 50 years.

- **Potential for Increased Flooding of Headlands –** Flooding on the Quill Lakes could potentially be mitigated by creating storage areas or restoring wetlands upstream of the lakes. However, these actions may result in an increase of flooding upstream of the storage areas and potentially resulting in property damage.

- **Potential for Increased Flooding around the Quill Lakes –** Some options, particularly the options that involve holding water in the Quill Lakes, could increase flooding around the lakes, resulting in damages to property and agricultural land. Further, should water levels continue to increase, critical infrastructure (including highways and the CP rail line) could be overtopped, negatively impacting transportation area.

- **Average Annual Volume of Available Storage –** The average storage volume that is available over the next 50 years.

- **Wetland Restoration –** Some of the flood mitigations options involve the restoration of wetlands to increase storage area in the basin. Although this could produce some upstream flooding, it is viewed as a positive environmental aspect since it is a step towards returning the basin to its natural conditions. The restoration of wetlands could offer many benefits, including filtering nutrients from water, providing habitat for aquatic species, and erosion control.

- **Reduction of Land Drainage –** Some options, including restoring wetlands, creating storage areas, and closing agricultural drains, will reduce the land drainage. This will likely be met with a lot of social resistance as a reduction in land drainage could lead to flooding of land or a reduction in crop productivity on agricultural properties.

The evaluation matrix that includes each of the criteria described above and is presented in Table 13. Overall, the reduction of water level on the lakes resulting from the flood mitigation options was small and the costs, particularly in comparison to the flood mitigation cost savings, were high. The matrix does not indicate a clear choice for the optimum flood mitigation option to proceed with. All options considered have significant cost associated with them, and provide a range of benefits including reductions to the overall water levels on the Quill Lakes. The selection of the preferred alternative by WSA should consider all of the categories outlined in the evaluation matrix.

In addition to the different criteria items considered on the evaluation matrix, the change in average Quill Lakes flooded area between the base case and each flood mitigation option is summarized on Table 14. Averages were calculated over the short term (next 5 years) and long term (next 50 years) of simulated water levels.

Although a significant portion of the flood mitigation measures result in a reduction in the average Quill Lakes flooded area, most of the area remains at risk of future flooding and does not necessarily become suddenly useful. The actual short and long term flooded extents will depend on future weather conditions.

## TABLE 13
## EVALUATION MATRIX

| Flood Mitigation Option | | Average Annual Modelled Inflow to Quill Lakes ($dam^3$/year) | Average[2] Percent Reduction of Inflows to Lake from Base Case | Change in Average[2] Big Quill Lake Water Level (m) | | Change in Average[2] Little Quill Lake Water Level (m) | | Project Cost | Operation Cost | Environmental Considerations and Social Acceptance | | | | | | | | | Implementation Time |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | 5 Years | 50 Years | 5 Years | 50 Years | | | Percentage of Simulated Water Levels[2] Exceeding Natural Spill Point (El. 521.47 m) | Average[2] [5] Annual Volume of Natural Overflow ($dam^3$) | Transfer of Water | Average[2] Annual Volume of Water Diverted or Removed ($dam^3$) | Potential for Increased Flooding of Headlands | Potential for Increased Flooding around Quill Lakes | Average[2] Annual Volume of Available Storage ($dam^3$) | Wetland Restoration | Reduction of Land Drainage | |
| **Do Nothing (Base Case) – Water Levels** | | 231,000 | n/a | 520.64 | 519.59 | 520.64 | 519.82 | n/a | n/a | 14% | 62,000 | Qu'Appelle Basin | | | | | | | 0 Years |
| **Hold Water in Quill Lakes** | **Block Natural Outlet** | 231,000 | n/a | 0.00 | 0.15 | 0.00 | 0.15 | Low | Low | No Spill | n/a | | | | X | | | | 3-5 Years |
| | **Isolate Little Quill Lake** | 231,000 | n/a | -0.13 | -0.59 | 0.24 | 1.17 | High | Low | 7% | 38,000 | Qu'Appelle Basin | | | X | | | | 3-5 Years |
| **Diversion Options** | **Ponass Lakes** | 226,000 | 2.2% | -0.02 | -0.08 | -0.02 | -0.08 | Moderate | Low | 13% | 61,000 | Red Deer Basin | 5,000 | | | | | | 3-5 Years |
| | **Kutawagan Creek** | 204,000 | 11.7% | -0.10 | -0.42 | -0.10 | -0.23 | Moderate | Low | No Spill | n/a | Qu'Appelle Basin | 27,000 | | X | | | | 3-5 Years |
| | **Kutawagan Creek + Hwy 16** | 199,000 | 13.9% | -0.12 | -0.52 | -0.12 | -0.29 | Moderate | Low | No Spill | n/a | Qu'Appelle Basin | 32,000 | | X | | | | 3-5 Years |
| | **Jansen Lake** | 224,000 | 3.0% | -0.03 | -0.12 | -0.03 | -0.08 | Moderate | Low | 12% | 60,000 | Qu'Appelle Basin | 7,000 | | | | | | 3-5 Years |
| | **Jansen Lake + Romance Creek** | 220,000 | 4.8% | -0.04 | -0.20 | -0.04 | -0.13 | High | Low | 12% | 60,000 | Qu'Appelle Basin | 11,000 | | | | | | 3-5 Years |
| | **Jansen Lake + Romance Creek + Ironspring Creek** | 201,000 | 13.0% | -0.11 | -0.56 | -0.11 | -0.34 | Very High | Low | 8% | 53,000 | Qu'Appelle Basin | 30,000 | | | | | | 3-5 Years |
| | **Jansen Lake + Romance Creek + Ironspring Creek + Wimmer Brook** | 196,000 | 15.1% | -0.13 | -0.66 | -0.13 | -0.40 | Very High | Low | 8% | 52,000 | Qu'Appelle Basin | 35,000 | | | | | | 3-5 Years |
| **Storage Options** | **Ponass Lakes** | 222,000 | 4.0% | -0.04 | -0.15 | -0.04 | -0.15 | Low | Low | 12% | 63,000 | | | X | | 9,000 | | | 1-2 Years |
| | **Other Storage** | 202,000 | 12.6% | -0.14 | -0.46 | -0.14 | -0.61 | High | Low | 10% | 65,000 | | | X | | 29,000 | | | 3-5 Years |
| **Remove Water from Quill Lakes** | **Landowner Proposal** | 231,000 | 21.9%[3] | -0.16 | -0.44 | -0.16 | -0.38 | Moderate | Moderate | 6% | 38,000 | Qu'Appelle Basin | 51,000 | | X | | | | 3-5 Years |
| | **Deep Well Injection (0.47 $m^3/s$)** | 231,000 | 6.4% | -0.04 | -0.32 | -0.04 | -0.17 | Low to Moderate | High | 12% | 63,000 | Mannville/Basal Deadwood Aquifer[4] | 15,000 | | | | | | 3-5 Years |
| | **Deep Well Injection (4.4 $m^3/s$)** | 231,000 | 51.8% | -0.42 | -3.24 | -0.42 | -1.11 | High to Very High | High | 2% | 66,000 | Mannville/Basal Deadwood Aquifer[4] | 119,000 | | | | | | 3-5 Years |
| | **Pump Water to another Watershed (0.47 $m^3/s$)** | 231,000 | 6.4% | -0.04 | -0.32 | -0.04 | -0.17 | High | High | 12% | 63,000 | Qu'Appelle Basin[4] | 15,000 | | | | | | 3-5 Years |
| | **Pump Water to another Watershed (4.4 $m^3/s$)** | 231,000 | 51.8% | -0.42 | -3.24 | -0.42 | -1.11 | High | High | 2% | 66,000 | Qu'Appelle Basin[4] | 119,000 | | | | | | 3-5 Years |
| | **Withdraw Water for BHP Jansen Lake Mine** | 231,000 | 3.0% | -0.02 | -0.14 | -0.02 | -0.08 | High | High | 13% | 63,000 | BHP Jansen Lake Mine[4] | 7,000 | | | | | | 3-5 Years |
| | **Withdraw Water for Karnalyte Potash Mine** | 231,000 | 3.8% | -0.03 | -0.18 | -0.03 | -0.10 | Low to Moderate | High | 13% | 63,000 | Karnalyte Potash Mine[4] | 8,000 | | | | | | |
| **Reduce Inflows** | **Restoration of 5,000 $dam^3$ of Drained and Partially Drained Wetlands** | 226,000 | 2.3% | -0.02 | -0.10 | -0.02 | -0.08 | Low | Low | 13% | 63,000 | | | X | | 5,000 | X | X | 3-5 Years |
| | **Restoration of 15,000 $dam^3$ of Drained and Partially Drained Wetlands** | 216,000 | 6.8% | -0.06 | -0.31 | -0.06 | -0.24 | Low | Low | 12% | 64,000 | | | X | | 15,000 | X | X | 3-5 Years |
| | **Closure of Drainage Works** | 142,000 | 38.6%[7] | -0.03 | -1.69 | -0.03 | -1.34 | High | Low | 7% | 64,000 | | | X | | 89,000 | X | X | 1-30 Years |
| **Legislative Policy** | **Drainage Enforcement** | n/a | n/a | n/a | n/a | n/a | n/a | n/a | Moderate | n/a | | | | | | | X | X | 1-30 Years |
| | **Drainage Moratorium** | n/a | n/a | n/a | n/a | n/a | n/a | n/a | Moderate | n/a | | | | | | | | X | 3-5 Years |
| | **Develop Watershed Management Policy** | n/a | n/a | n/a | n/a | n/a | n/a | n/a | Moderate | n/a | | | | | | | | X | 3-5 Years |
| | **Responsible Drainage** | n/a | n/a | n/a | n/a | n/a | n/a | n/a | Low | n/a | | | | | | | | | 3-5 Years |

**Notes:**
1. Refer to Section 7.0 for description of matrix categories
2. Based on model results over next 50 years
3. When water level is below El. 521.47 m
4. Treatment of water is assumed to be included with option
5. Excludes years with no overflow
6. 1 m = 3.28 ft; 1 $dam^3$ = 0.81 ac-ft
7. Reduction in runoff volume averaged over 50 years. Runoff reduction would vary significantly on an annual basis depending on meteorological and hydrologic conditions in the basin. Assumptions are discussed in detail in Section 4.5.2.

**TABLE 14**
**CHANGE IN AVERAGE QUILL LAKES FLOODED AREA**

| Flood Mitigation Option | | Change in Average Quill Lakes Flooded Area (ha) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Short Term (5 years) | | | | | Long Term (50 years) | | | | |
| | | Private Land | Public Land | Wetland / Marginal Land | Pasture / Grassland | Cropland | Private Land | Public Land | Wetland / Marginal Land | Pasture / Grassland | Cropland |
| Do Nothing (Base Case) – Total Flooded Area | | 10,800 | 29,700 | 16,800 | 16,300 | 8,000 | 4,000 | 23,900 | 15,800 | 9,800 | 2,300 |
| Hold Water in Quill Lakes | Block Natural Outlet | 0 | 0 | 0 | 0 | 0 | 800 | 800 | 100 | 800 | 700 |
| | Isolate Little Quill Lake (2) | -100 | -70 | -40 | -80 | -150 | 1790 | -4680 | -1070 | -2460 | 790 |
| Diversion Options | Ponass Lakes | -100 | -100 | -100 | 0 | -100 | -400 | -400 | 0 | -400 | -400 |
| | Kutawagan Creek (3) | -800 | -300 | -100 | -300 | -800 | -1,200 | -6,500 | -1,300 | -4,700 | -1,700 |
| | Kutawagan Creek + Hwy 16 (3) | -900 | -300 | -100 | -400 | -900 | -1,400 | -8,300 | -1,700 | -6,000 | -2,000 |
| | Jansen Lake | -200 | -100 | -100 | -100 | -200 | -500 | -1,000 | -100 | -800 | -500 |
| | Jansen Lake + Romance Creek | -300 | -100 | -100 | -100 | -300 | -700 | -2,400 | -400 | -1,800 | -800 |
| | Jansen Lake + Romance Creek + Ironspring Creek | -900 | -300 | -100 | -400 | -900 | -1,500 | -9,000 | -1,900 | -6,500 | -2,200 |
| | Jansen Lake + Romance Creek + Ironspring Creek + Wimmer Brook | -1,000 | -400 | -100 | -500 | -1,000 | -1,600 | -9,900 | -2,100 | -7,100 | -2,300 |
| Storage Options | Ponass Lakes | -300 | -100 | -100 | -100 | -300 | -500 | -1,500 | -200 | -1,200 | -600 |
| | Other Storage | -1,100 | -400 | -100 | -500 | -1,100 | -1,300 | -7,200 | -1,500 | -5,200 | -1,800 |
| Remove Water from Quill Lakes | Landowner Proposal | -1,200 | -500 | -100 | -700 | -1,200 | -1,200 | -6,800 | -1,400 | -5,000 | -1,700 |
| | Deep Well Injection (0.47 $m^3$/s) | -300 | -100 | -100 | -100 | -300 | -1,000 | -4,600 | -900 | -3,400 | -1,300 |
| | Deep Well Injection (4.4 $m^3$/s) | -3,200 | -2,300 | -500 | -2,700 | -3,200 | -800 | -19,700 | -8,500 | -9,700 | -2,300 |
| | Pump Water to another Watershed (0.47 $m^3$/s) | -300 | -100 | -100 | -100 | -300 | -1,000 | -4,600 | -900 | -3,400 | -1,300 |
| | Pump Water to another Watershed (4.4 $m^3$/s) | -3,200 | -2,300 | -500 | -2,700 | -3,200 | -800 | -19,700 | -8,500 | -9,700 | -2,300 |
| | Withdraw Water for BHP Jansen Lake Mine | -100 | -100 | -100 | 0 | -100 | -500 | -1,300 | -200 | -1,000 | -600 |
| | Withdraw Water for Karnalyte Potash Mine | -200 | -100 | -100 | -100 | -200 | -600 | -2,100 | -400 | -1,600 | -700 |
| Reduce Inflows | Restoration of 5,000 $dam^3$ of Drained and Partially Drained Wetlands | -100 | -100 | -100 | 0 | -100 | -400 | -600 | 0 | -500 | -400 |
| | Restoration of 15,000 $dam^3$ of Drained and Partially Drained Wetlands | -400 | -200 | -100 | -200 | -400 | -900 | -4,400 | -900 | -3,300 | -1,200 |
| | Closure of Drainage Works | -200 | -100 | -100 | -100 | -200 | -1,700 | -14,100 | -4,400 | -9,000 | -2,300 |

Notes:
1. Breakdown of the flooded area based on data from Golder Associates, April 13, 2015. [6]
2. Assumes the Little Quill Lake flooded area is 30% of the total Quill Lakes flooded area when both lakes are at a common elevation.
3. Assumes water levels along Kutawagan Creek and the Quill Lakes are similar. Lower water levels along Kutawagan Creek due to the construction of a dike east of Highway 6 would result in a larger reduction in flooded area.