Inuvik to Tuktoyaktuk Highway EIRB Technical Sessions: Granular Resources

August 2012

INUVIK TUKTOYAKTUK HIGHWAY
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There is sufficient material to build and maintain the Highway for 50 years or more.

Source	Construction Embankment (m3)	Construction Surfacing (m3)	Operational Common & Crush - Year 1 to 20 (m3)	Operational Common & Crush - Year 21 to 40 (m3)	Operational Common & Crush - Year 41 to 50 (m3)	Estimated Total Requirement (m3)	Estimated Amount Available in Source (m3)
PW2	676,000	-	-	-	-	676,000	reported as "unlimited"
325/314	919,000	82,300	558,750	300,000	89,000	1,949,050	2,170,000
309	979,000	82,300	220,000	175,000	-	1,456,300	1,500,000
174	741,250	82,400	700,000	487,250	207,500	2,218,400	3,280,000
170	462,750	-	-	-	-	462,750	1,000,000
177	677,000	-	438,500	300,000	89,000	1,504,500	1,910,000
Totals	4,455,000	247,000	1,917,250	1,262,250	385,500	8,267,000	9,860,000

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Information Sources:

Source	Reference
PW2	Public Works Canada, 1976. Report : geotechnical investigation mile 970 (km 0) to mile 1059 (km 143) (Inuvik to Tuktoyaktuk), Mackenzie Highway : combined data - 1976 to 1980 / Canada. Public Works Canada. Western Region. October 1976. ASTIS 35303
325/314	Kavik-Stantec Inc., 2012. Inuvik - Tuktoyaktuk Highway 2012 Borrow Source Investigation, Borrow Source 314/325 Summary Report. Prepared for E Gruben's Transport Ltd. July 2012
309	Ripley, Klohn & Leonoff International Limited , 1972. Granular materials inventory, Zone III. Prepared for Department of Indian Affairs and Northern Development. 1972.
174	R.M Hardy & Associates Ltd., 1977. Granular Materials Inventory, Tuktoyaktuk, Northwest Territories. Prepared for Department of Indian and Northern Development. August 1977.
170	Kavik-Stantec Inc., 2012. Inuvik - Tuktoyaktuk Highway 2012 Borrow Source Investigation, Borrow Source 170 Summary Report. Prepared for E Gruben's Transport Ltd. July 2012
177	R.M Hardy & Associates Ltd., 1977. Granular Materials Inventory, Tuktoyaktuk, Northwest Territories. Prepared for Department of Indian and Northern Development. August 1977.

Other sources considered: 172, 173/305, 307 and 2.45

- Sources 172, 173/305, 307 and 2.45 have been identified by KAVIK-STANTEC (2012) as having material quantity estimates of 2,279,200 m^3 and are additional candidate sources for construction and/or maintenance of the Highway.

Other sources considered: 312

- The far west portion of Source 312 may be a candidate for further investigation (Ripley, Klohn & Leonoff International Limited , 1972); however, area around Hans Creek is considered sensitive for hunting, fishing and other activities.
- A portion of 312 was investigated in the vicinity of the alignment and found to be not favourable.

Other sources considered: 308

- Source 308 is a candidate for further investigation. It is reported by Ripley, Klohn & Leonoff International Limited (1972) as having material quantity estimates of 15,000 m^3; however, visual investigation (both by air and on the ground) show that Source 308 is likely to have greater quantities of material and that a ridge of potential material extends south from Source 308 and into Source 309.

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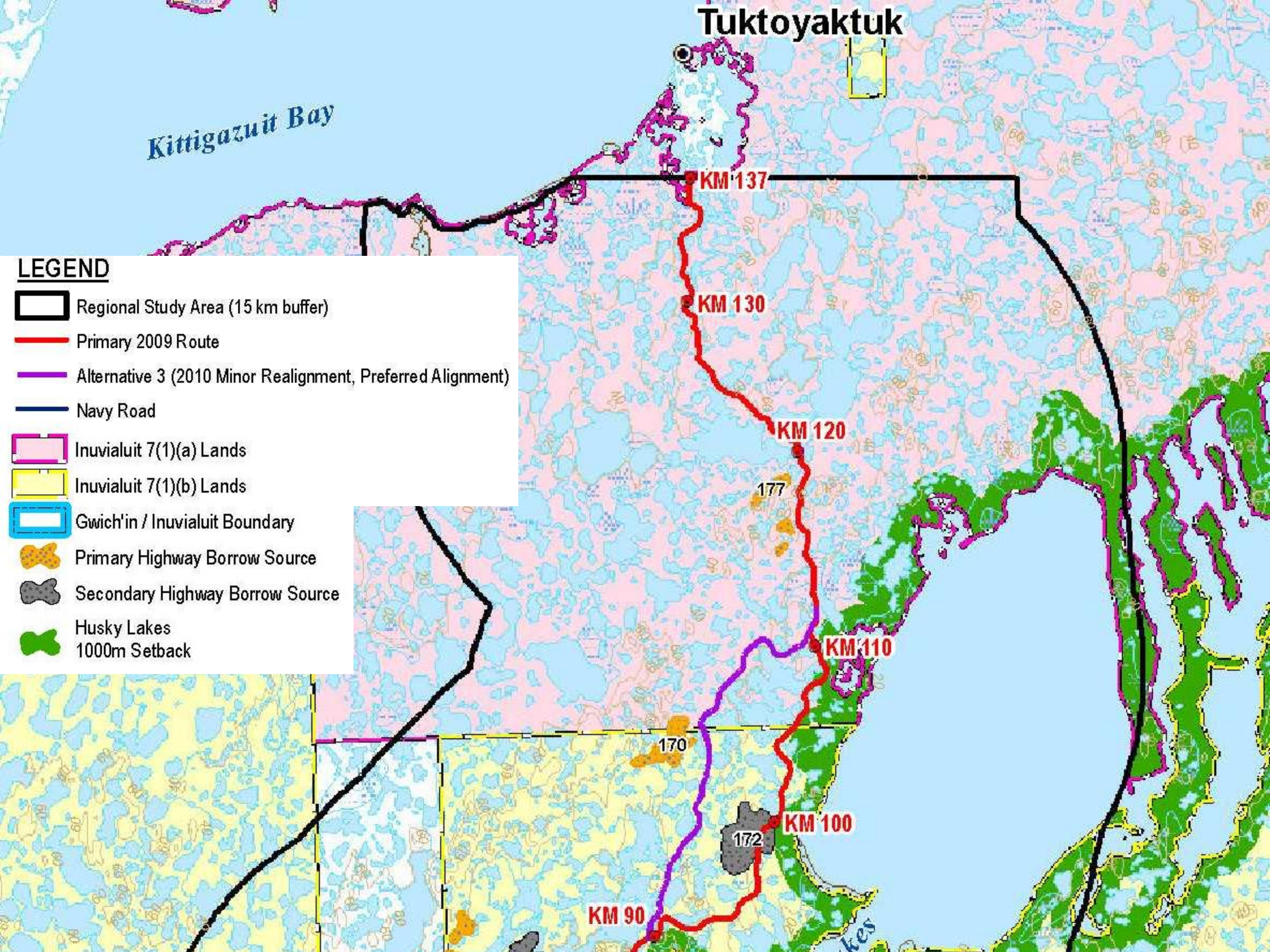
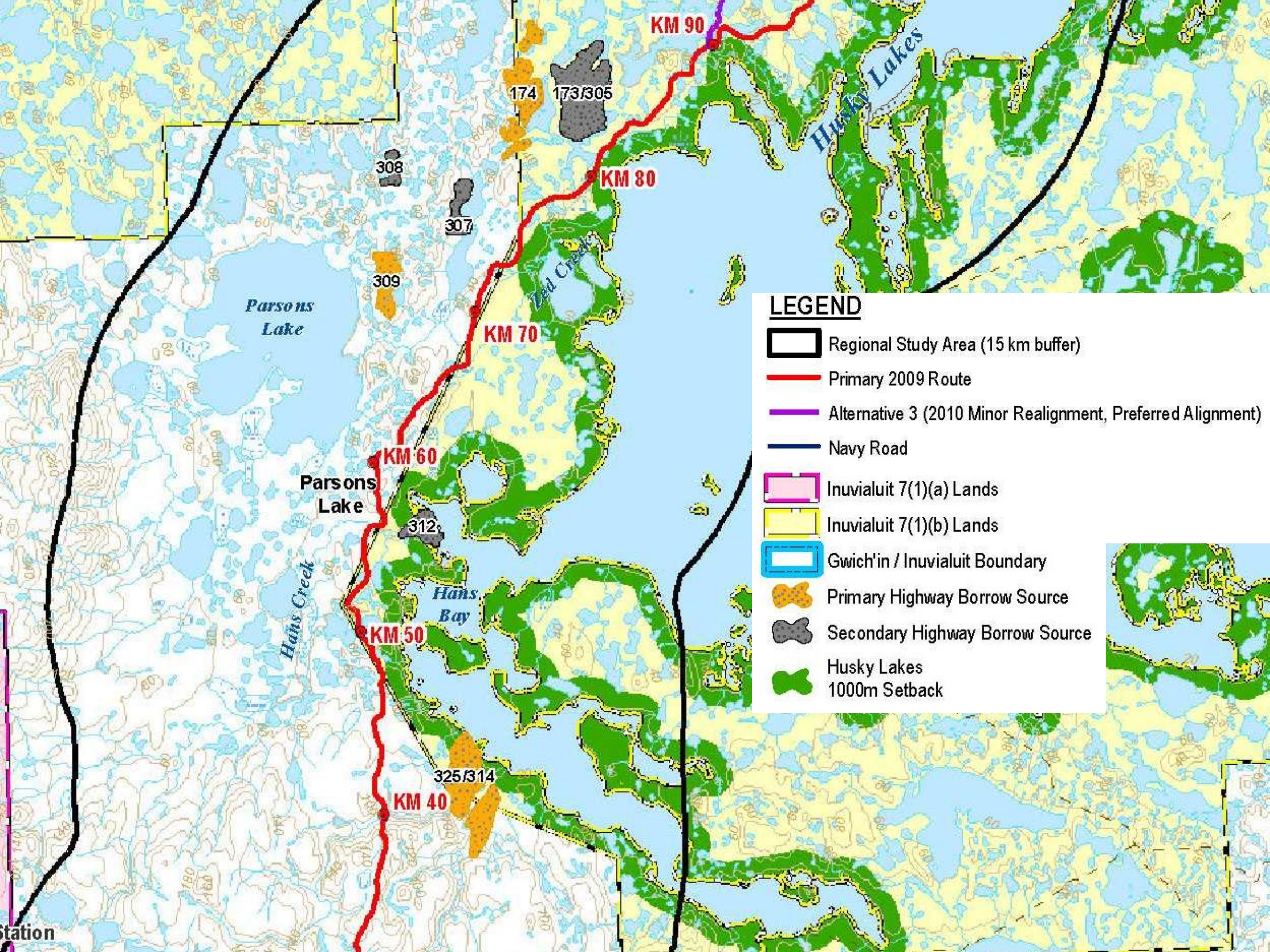
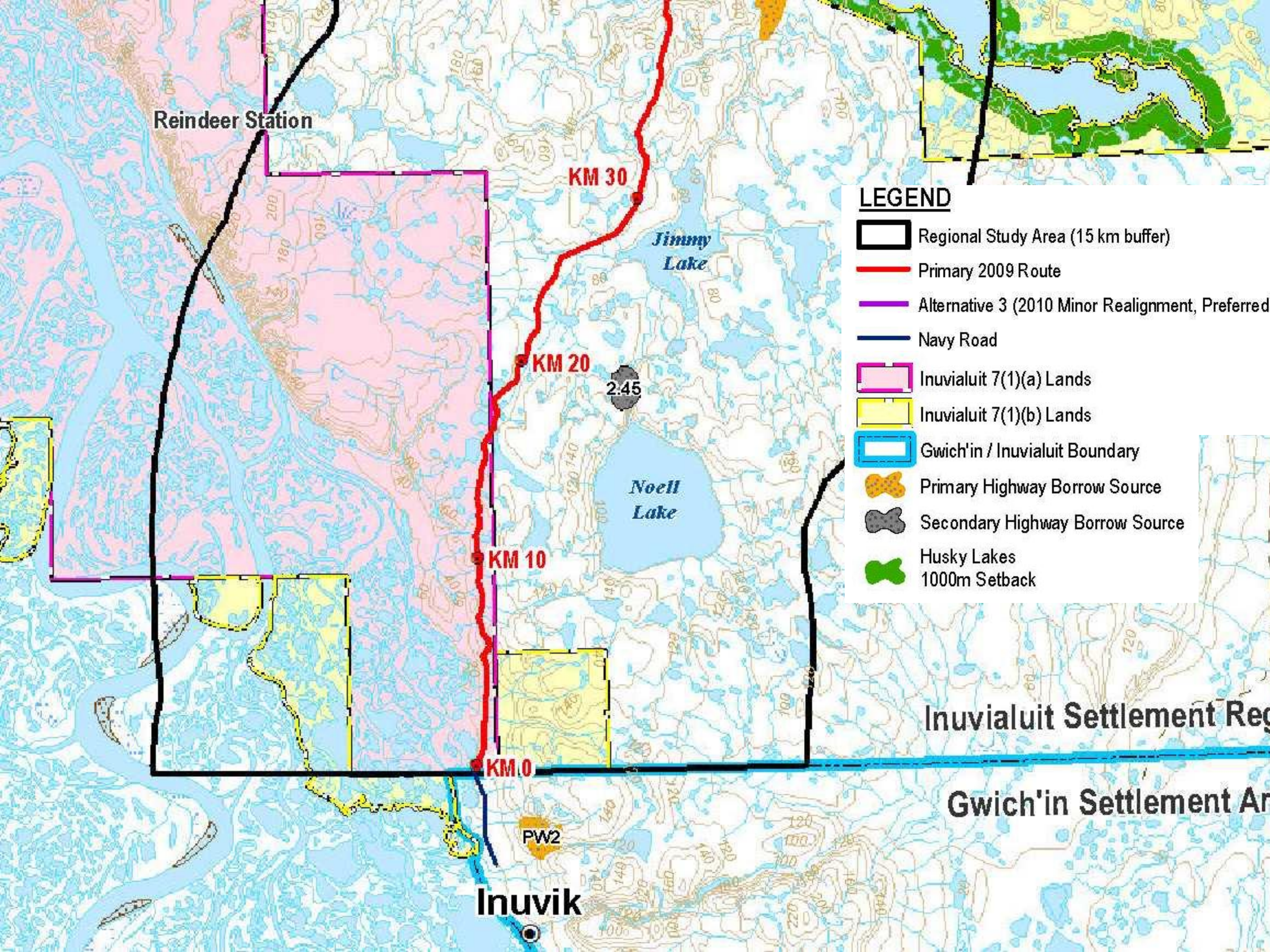
Surfacing Material

- Material suitable to crush for surfacing is expected to be found at Sources 174 and 309. If suitable material is not found at these sources, existing sources for surfacing material (Ya Ya Lake and Inuvik Airport Quarry) will be utilized.


Tuktoyaktuk
Kittigazuit Bay
KM 137
KM 130
KM 120
177
KM 110
170
KM 100
172
KM 90
LEGEND
Regional Study Area (15 km buffer)
Primary 2009 Route
Alternative 3 (2010 Minor Realignment, Preferred Alignment)
Navy Road
Inuvialuit 7(1)(a) Lands
Inuvialuit 7(1)(b) Lands
Gwich'in / Inuvialuit Boundary
Primary Highway Borrow Source
Secondary Highway Borrow Source
Husky Lakes
1000m Setback


KM 90
KM 80
KM 70
KM 60
KM 50
KM 40
174
173/305
308
307
309
312
325/314
Husky Lakes
Parsons Lake
Parsons Lake
Zed Creek
Hans Creek
Hans Bay
Station
LEGEND
Regional Study Area (15 km buffer)
Primary 2009 Route
Alternative 3 (2010 Minor Realignment, Preferred Alignment)
Navy Road
Inuvialuit 7(1)(a) Lands
Inuvialuit 7(1)(b) Lands
Gwich'in / Inuvialuit Boundary
Primary Highway Borrow Source
Secondary Highway Borrow Source
Husky Lakes
1000m Setback



Reindeer Station
KM 30
KM 20
KM 10
KM 0
Jimmy Lake
Noell Lake
2.45
PW2
Inuvik
Inuvialuit Settlement Reg
Gwich'in Settlement Ar
LEGEND
Regional Study Area (15 km buffer)
Primary 2009 Route
Alternative 3 (2010 Minor Realignment, Preferred
Navy Road
Inuvialuit 7(1)(a) Lands
Inuvialuit 7(1)(b) Lands
Gwich'in / Inuvialuit Boundary
Primary Highway Borrow Source
Secondary Highway Borrow Source
Husky Lakes
1000m Setback

Bulking and Compaction

- Estimated quantities shown for construction and operations are compacted/in place quantities. Estimated available quantities in the sources are in-situ. Bulking of the materials once removed from the source is anticipated to be greater than the impact of compaction on quantities when the material is placed in the road, resulting in the in-situ measure of material removed from a source to be less than the estimated quantities for construction and operations shown.

Using Tills:

- Most of the sources identified for use are reported to have materials that are better quality than the till sources in the area. This is one of the main reasons why they have been chosen over other sources.
- The sources in the area that contain tills have higher moisture contents. Materials with higher moisture contents are difficult to work with during construction. They are more expensive to drill and blast to obtain the size and shape that can efficiently be handled and do not hold shape and structure in the road (embankment) when they are subject to thaw.
- For the southern portion of the Highway (km 0 to km 40), Source PW2 is described by PWC 1977 to contain till. If the moisture content in the tills are high then it may be necessary to stockpile the material in the pit, allow it to thaw and lose moisture, then place it in the following season. This has its own disadvantages in that it introduces drainage problems in the pit and a single season may not be sufficient to allow for drying of the materials. With these materials, a larger spread area along the alignment may be required to allow for evaporation.

Next Steps

- Investigation (drilling) of Sources PW2, 308, 309, 174, 177 to confirm material quantity and quality estimates and conduct site-specific studies, as needed, to support the regulatory approvals process (land use and quarry permits).
- Develop Pit Management Plans and secure Land Use and Quarry Permits prior to construction.

Pit Management Plans:

- Development of Pit Management Plans include:
  - Estimated volume to be extracted
  - Consultations with land owners and other stakeholders
  - Discussions with regulators
  - Environmental constraints
  - Area to be developed
  - Pit development phasing plans for reclamation
- Pits will be developed following the applicable guidelines to mitigate impacts, minimize the footprint and best serve reclamation.

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Respecting Husky Lakes

- Sources 314 and 325 are considered as a common source and the 1000 m setback from Husky Lakes will be respected.

Sharing of Resources:

- Town of Inuvik: no common sources identified
- Hamlet of Tuktoyaktuk: Source 177
- Mackenzie Gas Project: Sources 308 (2.025) & 309 (2.028)
- Tuktoyaktuk Harbour Improvements: no common sources identified.

Terrain:

- The availability of LiDAR data and imagery provided the opportunity to undertake the next steps in detailed terrain review along the alignment.

- Detailed identification and delineation of terrain types and geoprocesses within 1 km study area was presented in terrain report and mapbook (Kavik-Stantec 2012).

Terrain:

- Additional desktop review and a field verification of specific locations where terrain constraints have been identified, has been completed. Potential mitigative actions have been identified and will be will be evaluated further and confirmed during detailed engineering design.

Terrain:

- There is substantial evidence, confirmed by field, geotechnical and geophysical surveys as well as related scientific studies in the area, that the terrain in the area is complex and ice-rich. We acknowledge that construction will be challenging.

- The surficial deposits throughout the project study area are ice-rich. However, areas of ice-rich terrain may be stable or unstable. Alignment will continue to be optimized to avoid unstable terrain where engineering design considerations allow.

Terrain:

- Terrain constraints identified in table 3-2 of the 2012 KAVIK-STANTEC Terrain Report, have been confirmed by additional field and desktop studies.
- Specific identified segments of the preferred route have been reviewed by the design team to propose further action:
  - No further action or mitigation required (15)
  - Constraint can be addressed by engineered mitigation during detailed design (17)
  - Route optimization or relocation is being considered, and will be evaluated during detailed design (31)

Inuvik to Tuktoyaktuk Highway EIRB Technical Sessions: Lessons Learned

August 2012

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Summary of Lessons Learned: Tuk to Source 177 Access Road

- Winter construction is preferable
- Materials with lower moisture content are preferable
- Culvert design and installation needs improvement
- Use of “fill only” design is essential
- Cooperative approaches maximize local and regional benefits

Lessons Learned – Tuk to Source 177

1. Winter embankment construction is viable, even preferable in many circumstances. The use of a “side of embankment” winter road to allow return traffic from the working face allows high truck delivery rates to be maintained without interference with returning trucks, while preventing damage to the original ground cover.

Lessons Learned – Tuk to Source 177

2. Winter construction results in a smaller environmental footprint as gravel truck turnarounds and graveled access roads to borrow sources do not need to be constructed.
3. Winter construction results in less potential environmental risk and less potential permafrost damage as equipment or trucks which “slide” or “wander” slightly off the road course do not damage the permafrost.

Lessons Learned – Tuk to Source 177

4. Using drill / blast to excavate material from a source deposit in winter allows production rates sufficient to build the ITH project.
5. Placing relatively dry frozen material in winter with minimal compaction does result in a reasonably stable embankment base. The embankments with larger fills on Tuk to Source 177 show good stability in the near term years since completion of construction.

Lessons Learned – Tuk to Source 177

6. Production from high moisture content sources in winter would be challenging, and is unlikely to be successful. Material from Source 177 with higher silt and moisture content came out as "nuggets", which were pushed aside and allowed to thaw in the summer. Sources with higher moisture contents may require summer stockpiling to allow moisture to drain before winter placement. This may be unsuccessful because, in the Arctic, minimal drying occurs and moisture may actually concentrate within the summer gravel piles making them more difficult to manage the following winter when refreezing occurs. Materials with lower moisture content are preferable.

Lessons Learned – Tuk to Source 177

7. Shaping sideslopes and grading/compacting the thawed surface layers of the embankment in the summer can produce a finished product of reasonable quality.
8. Culvert design and installation needs improvement for ITH project. Issues such as end projection length, use of insulation, design elevations with or without subcut, design glaciation levels, all need greater analysis and planning than was undertaken during the design of the Tuk to Source 177 Access Road project. Such increased analysis at planning is currently underway.

Lessons Learned – Tuk to Source 177

9. The use of a geotextile fabric between the embankment and the original ground is feasible with winter construction, and appears to achieve its intended purposes of maintaining roadbed stability and integrity.
10. Crossing polygonal terrain (unstable ice-rich terrain) remains a challenge, and it may require additional design features such as thicker or additional geotextiles, insulation, and increased embankment height.

Lessons Learned – Tuk to Source 177

11. The Tuk 177 design, as a lower speed access road, was constructed to a design 0.9 m minimum embankment height, with the finishing gravel in place. The current as constructed roadway has a 0.7 m high minimum embankment height and has no road surfacing gravels in place. This structural height is much less than the 1.4 m minimum embankment height proposed for the ITH. The currently constructed roadway is; however, performing quite well in terms of stability in areas even though it was constructed at minimum embankment depths and without a surfacing gravel course other than where there is polygonal terrain.

Lessons Learned – Tuk to Source 177

12. The use of a "fill only" design section is essential with no cuts in the traditional ditch areas adjacent to the embankment as it fully maintains the ground vegetation adjacent to the roadway. This intact vegetation cover provides excellent silt control for runoff from the roadway embankment, minimizing material transport into waterways.
13. The lack of available material for rip rap for erosion control at crossings will be a challenge with construction of the ITH. Manufactured products could be considered.

Lessons Learned – Tuk to Source 177

14. The culvert erosion control end treatment of the Tuk to Source 177 road appears to be working well, and can be considered for use on the ITH.
15. A gravel road construction project can deliver extremely high levels of local and aboriginal employment, training and business participation. Due to the availability of a relatively skilled local workforce and experienced local contractors it is likely that this type of development Project provides more local economic benefits than any other type of development Project of a similar size.

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Lessons Learned – Tuk to Source 177

16. Cooperative approaches to development projects between the local communities, the local aboriginal organizations and corporations and the territorial and federal governments best achieves both a maximization of local and regional benefits as well as minimizes environmental impacts

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Summary of Lessons Learned: Dempster Highway

- Good quality materials sources are essential even if haul distances are greater.
- Thermal analysis is key at the early stages of design to optimize the cross section over unstable ice-rich terrain.
- Planning and budgeting for maintenance is important.
- A “fill only” design approach is now good practice in ice-rich areas.

Lessons Learned – Dempster Highway

1. It makes good sense to have fewer, well established material sites despite longer haul distances and higher construction costs.
   - The Dempster Highway was the first real test case where a different approach for planning material sources was needed. At first, mineral soils along the right-of-way were used but were lost or eroded the next summer. Eventually, discrete, deep quarries were used.
   - Higher class materials (quality) are important to provide expected design life.

Lessons Learned – Dempster Highway

2. Sections of the Dempster Highway normally considered to be underlain by cold permafrost conditions have experience thermal degradation caused by the effect of drifted snow on the lea side of higher embankments. Basic principles for thermal design of embankments to preserve the permafrost include:
   - Favourable thermal conditions should be imposed and maintained underneath the structural core of the embankment
   - Thermal design is required to ensure raised or at least maintained permafrost level underneath the core of the embankment considering the geometry of the cross section of the embankment and the quality of the material.
   - Embankment failures caused by slides could be reduced by use of high strength granular material and gentler sideslopes.

Lessons Learned – Dempster Highway

3. The Dempster highway generally has an east-west alignment. The prevailing winds from the north causes deep snow drifts to form on the southern lea sideslope, gradually raising its temperature. These conditions continue until longitudinal cracking is observed on the crest of higher sideslopes. These sideslopes become unstable as thaw weakens the foundation soils below the embankment slopes and they creep outward. The combination of subgrade warming and ice-rich soils can also result in catastrophic failure of the roadbed. Such a failure occurred in late fall of 1985, when water percolated under the embankment, thermally eroding a wedges of ground ice. The embankment collapsed into the void causing a roadbed failure that resulted in a fatal collision.

Lessons Learned – Dempster Highway

4. Maintenance:
   - Planning and budgeting for maintenance activities in advance of issues is key to ensuring preservation of the original investment.
   - Nothing can replace the vigilance of maintenance personnel in managing performance risk. Implementation of a simple monitoring program can provide information about the performance of the immediate infrastructure and performance data that could be used elsewhere in the system.
   - Increasing the width of the cleared lane of snow, and extending snow removal to the should and sideslopes where possible will minimize the insulating effects of snow and subsequent thawing of underlying solids.

Lessons Learned – Dempster Highway

5. "Fill Only Approach":
   - Massive cuts in unstable ice-rich areas expose the underlying ground to thaw.
   - Exposed faces of cut are in particular, are subject to thaw slides, erosion and instability.
   - A "fill only" design approach is now good practice in ice-rich areas.

Lessons Learned – Dempster Highway

6. Construction at optimum moisture content in the borrow materials is recommended in obtaining compaction and stability of the embankment.
7. Toe berms are to be considered in engineering solutions at vulnerable locations where side slope stability could be an issue. Should shoulder rotation and translation failures occur, high quality materials should be used in sideslope restoration.

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Northwest Territories

Town of Inuvik

Material Quantities
Dempster Highway Reconstruction
YT/NWT Border to Peel River

Hwy Km	GRANULAR QUANTITY OF AGGREGATE (m3) FOR EACH 10 Km OR PART
0 - 10	158,898
20 - 30	127,973
20 - 30	150,338
30 - 40	317,723
40 - 50	180,583
50 - 60	240,410
60 - 70	254,591
70 - 80	174,644*
80 - 85	72,668
IN TOTAL	1,677,828

*300 m Gap at River
** Per km in Peel Plateau 19,832 m3