Table 1.1 Diversion Path Analysis: Generic Route: U-235, Declared Civilian, Dual-Purpose and Dedicated Nuclear Weapon Facilities

POTENTIAL FACILITY / SOURCES OF MATERIALS		URANIUM MINE	URANIUM MILLING	URANIUM CONVERSION	URANIUM ENRICHMENT FACILITIES						RESEARCH/TEST REACTOR/ ISOTOPE PROGRAM USING HEU	ENRICHED URANIUM CONVERSION/ FUEL FABRICATION FACILITIES	NAVAL PROPULSION REACTOR		EXISTING STOCKPILES
RISK RELEVANT PARAMETERS					Electromagnetic Separation (UCl4/calutron)	Gaseous Diffusion (UF6) [1]	High Speed Gas Centrifuge (UF6)	Laser Separation Methods [2]	Chemical Exchange Methods [3]	Aerodynamic Separation Methods [4]			Submarine [5]	Surface Vessel [5]	
LIKELIHOOD	NWS	low	low	low	Figure 1.1.1a	Figure 1.1.1b	Figure 1.1.1c	medium	low	low	very low	high	low	low	high
OF FACILITY	NNWSD	low	low	low	Figure 1.1.1a	Figure 1.1.1b	Figure 1.1.1c	medium	low	medium	medium	high	low	low	high
ANOMALY (L)	NNWSU	high	high	high	Figure 1.1.1a	Figure 1.1.1b	Figure 1.1.1c	very low	very low	medium	medium	high	no undeveloped states with technology	no undeveloped states with technology	low
IMPORTANCE OF FACILITY ANOMALY TO FINAL MATERIAL ACQUISITION (I)		low	low	medium	high	high	high	medium (NWS, NNWSD): low (NWS)	low, (technology not developed)	high	high	high	medium	medium	high
DIVERSION SIGNATURES		•ore quantity accountancy, 100kg HEU requires 20tons ore at 0.1% U with 0.2% U tails (100 tonnes ore per year needed for a 1000MWe reactor)	•accountancy anomalies in product shipments	•accountancy of product shipments •production of a final chemical form which is not used in declared facility	•reconfiguration for high enrichment capacity is easier than diffusion plant •clean out frequency of collectors •detection of HEU on collectors •depleted U tails assay.	•rearrangemant of piping: changing/adding stages from parallel to series •batch recycle mode changes plant operations •HEU presence in final stages •depleted U tails assay	•refeed of product to cascade •power consumption changes •rearrangemant of piping: changing/adding stages from parallel to series •replacement/ speed change of centrifuge •feed flow rate changes	•unknown	•unknown	•batch recycling	•fuel management scheme accountancy •fresh/spent-fuel accountancy	• product enrichment, chemical form assay	•refuelling frequency •fresh/spent fuel accountancy •enrichment of spent fuel	•refuelling frequency •fresh/spent fuel accountancy •enrichment of spent fuel	•intelligence information
VERIFICATION	Technical Means	•remote/local optical surveillance not too useful, as difficult to identify or quantify extent of diversion	•local camera surveillance very limited effectiveness	•local camera surveillance very limited effectiveness	•local camera surveillance to detect production process operations ineffective as process not too visible	•local camera surveillance to detect configuration changes in process stages	•local camera surveillance to confirm interconnection status of centrifuges	•unknown	•unknown	•unknown	•local camera surveillance on fuelling operations and fresh/spent-fuel storage	•none very effective	•local camera surveillance on fresh/spent-fuel storage	•local camera surveillance on fresh/spent-fuel storage	•local camera surveillance of stockpiles
	Routine Inspections	•ore quantity accountancy not too useful, due to varying ore contents and large volumes involved	•product drum shipment accountancy •product drum seals possible, but large quantities involved •product assay inconclusive	•conversion facility shipment accountancy •product seal verification •chemical product assay verification •weighing of UF6 cylinders	•on-line gas phase enrichment monitor (for feed, product and tails) •materials balance accountancy	•non destructive enrichment monitoring of feed, product and scrap •materials balance accountancy •sampling of feed, product and tails •visual inspection of piping configuration	•non-destructive enrichment monitoring of process piping content •materials balance accountancy •sampling of feed, product and tails	•non-destructive enrichment monitoring •materials balance accountancy (assay/ enrichment), details unknown	•materials balance accountancy (assay), details unknown	•equilibrium time between that of GD and GC •materials balance accountancy (assay), details unknown	•fresh/spent-fuel materials balance accountancy (assay)	•materials balance accountancy •non-destructive enrichment monitoring	•materials balance accounting of spent fuel •refuelling outage frequency •spent-fuel containment seals	•same as adjacent left	•stockpile materials balance accountancy •seal inspection (initial and periodic) •non-destructive assay verification
METHODS	Special Inspections	•SI's have no advantages over routine inspections	•SI's have no advantages over routine inspections	•SI's have no advantages over routine inspections, due to time scale of process operation	•SI's limited value, due to time scale of process operation	•design /operation of plant designed for LEU is inflexible for HEU (batch recycling) operation, routine inspections adequate •process equilibrium time ≈weeks •SI limited value	•SI's limited value	•would depend on adequacy of RI's	•would depend on adequacy of RI's	•would depend on adequacy of RI's	•SI's limited value	•SI's for enrichment monitoring	•SI's limited value	•SI's limited value	•SI's limited value
EFFECTIVENESS OF VERIFICATION METHODS		•not very effective, due to large ore quantities also needed for civilian reactors and monitoring of varying ore concentrations	•not very effective, due to shipment quantities, no. of drum seals and possibility of previously hidden stockpiles	•assay effective for diversion of undeclared compound type for undeclared facility, not very effective for potential diversion to a declared enrichment facility	•RI's should be conclusive •SI's limited value	•if facility designed for LEU, routine inspections are conclusive	•RI's should be conclusive •SI's limited value	•inadequate information to date	•inadequate information available	•inadequate information available	•RI's should be effective	•RI's should be conclusive	•RI's, fuel accountancy should be adequate	•RI's, fuel accountancy should be adequate	•RI should be conclusive, if storage locations fixed
RISK OF DIVERSION (L x I)		See Figure 2 for the risk ranking hierarchy variables and Figures 2.1.1a, b and c for the relative rankings for NWS, NNWSD and NNWSU, respectively.													
	NWS	10	11	12	9	13	8	2	4	5	6	3	7	7	1
	NNWSD	11	12	13	9	10	6	1	5	2	7	4	8	8	3
	NNWSU	9	10	11	1	7	2	8	12	3	6	4	N/A	N/A	5

[1] Mass diffusion and thermal diffusion facilities are omitted as there are no declared facilities of these types. Thermal diffusion, a demonstrated method, is listed under undeclared U-235 facilities, Table 2.1.

[2] There are two main laser isotope separation techniques; molecular and atomic vapour. No distinctions are made between them for the purposes of this analysis.

[3] There are two main methods; solvent extraction and ion exchange. No distinctions are made between them for the purposes of this analysis. Risk rankings imply all types of R &D enrichment facilities.

[4] A large number of aerodynamic isotope separation techniques are possible. The demonstrated Helikon method is implied here.

[5] These facilities also imply the fresh and spent-fuel handling and storage locations, as well as the vessels.