The GML prototype of the new TOP10vector object model

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Summary
The GML prototype of the new TOP10vector object model has been developed by the TU Delft as part of a larger programme to improve the products and production environment of the Dutch Topographic Service. The goal of the first project within this programme is to re-engineer the Digital Landscape Model of the TOP10vector product. Other partners in this project are the Centre for Geo Information of Wageningen University (user requirements and evaluation) and the ITC Enschede (conceptual UML model). The TU Delft translated the conceptual UML model into a technical UML model based on the OpenGIS specification GML 2.0 (Geography Markup Language). Data sets provided by the Topographic Service have been converted to GML using the following tools: FME, Oracle Spatial, Java, XML Spy and various standard Unix tools. Finally, attention has been given to the usability of the prototypes through some GML visualization tests and the organisation of the GML Relay. The project has been carried out as an assignment from the Dutch Topographic Service.

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Chapter 1

Introduction

The Dutch Topographic Service (TDN) is currently improving their products and production environment. The production environment will be based on object technology [38]. The strategy to improve the products is described in [21] and the first step is to re-engineer the Digital Landscape Model of the TOP10vector product [35]. The design and development of the GML prototypes described in this report are part of the re-engineer process.

Since the creation of the first digital topographic data set there has been a need for exchange formats. This has always been a difficult issue and point of discussion. At the same time users have expressed additional requirements. Most current topographic data products are a mixture of geographic data and cartographic presentation. In the design for a renewed product in the Netherlands a clear distinction is made between a Digital Landscape Model (DLM) and a Digital Cartographic Model (DCM). The focus lies on the design of the DLM meeting current and future user requirements. In parallel the exchange problem is tackled by using a new OpenGIS standard, Geography Markup Language (GML), which will be supported in future GISs. The Dutch Topographic Service is the supplier of the TOP10vector, a digital vector file with topographical information of the Netherlands territory at a scale of 1:10,000.

1.1 Project overview

At the moment the data in TOP10vector is maintained as polygons, lines, points, and text-features. The current TOP10vector is not maintained in a relational or object-oriented database, but in (design) files. Apart from this, other limitations exist. The only attribute information available is a feature code (road, building, pasture, river, etc.) [36]. Most importantly, lines or (implied) polygons do not have (unique) object-IDs. This makes it hard to join or link the topographic data with other kinds of external geo-data such as addresses, parcel numbers or taxation records. User organisations in the Netherlands have asked the TDN to re-engineer their topographic data into a more object-oriented data model. For this purpose a new data model is defined for the TOP10vector that meets these requirements. Important characteristics of the new conceptual model are: unique object-IDs, a partitioning of the surface as the basis for geometry (exceptions occur in case of overlap, e.g. road segments in tunnels or road segments on bridges),

2.5D objects with 3D coordinates, possibility of complex features (an aggregation of road segments into one - or more - 'named' roads) and the incorporation of metadata and temporal data for each object instance (versioning). The last characteristic opens the way for 'change only' updates distributed to user organisations (see also [3]). Many of the improvements suggested for the TOP10vector bear a strong resemblance to the developments of the spatial model of the Dutch Cadastre [37].

Since there is also a growing demand to distribute the data in a more open transfer format, a prototype of this data model is implemented using GML 2.0. GML 2.0 is accepted as recommendation by the OpenGIS Consortium in February 2001 [24]. The rationale behind the choice of GML is the fact that it is based on the world-wide accepted XML standard and that a rapidly increasing number of tools is available to generate, check and interpret XML/GML [39]. The article by Reichardt [29] gives a short overview of GML 2.0 and motivation why one wants to use this. The advantages of XML in general are that it is well readable by humans and machines (in contrast to binary formats), international (support of Unicode for non-western languages), methods to process XML documents are available (e.g. develop an XML Style Sheet Transformation, XSLT to convert a DLM into a DCM), extensible with own parts (using the 'XML Schema' language [41, 42]), and is very well supported by all kinds of software in the market (ranging from the browser to the DBMS). With respect to the specific spatial data, ISO [19] and OpenGIS [7] have harmonised their models and GML 2.0 is based on this.

1.2 Partners

The project 'Object Orientation TOP10vector' [35] is carried out by the Section GIS Technology of the Delft University of Technology (TU Delft) in co-operation with the Centre for Geo Information of Wageningen University (CGI), the International Institute for Aerospace Survey and Earth Sciences Enschede (ITC) and the Dutch Topographic Service (TDN). The TDN has assigned the different parts of this project to the others. The deliverables of the different projects are:

1. an overview of user requirements and prioritization (by CGI) [12],
2. a new conceptual model for TOP10 data (by ITC) [20],
3. an XML Schema definition as implementation of the new model and some GML prototypes with real-world data (by TUD) [11, 39], and
4. an evaluation of the prototypes (by CGI).

1.3 Contribution of TU Delft

The new conceptual model by the ITC (in UML) has been converted into a technical model, also described in UML class diagrams and based on the OpenGIS Geography Markup Language (GML [24] based on OpenGIS Simple Feature specification [23]). This specification contains standards to represent geo-spatial features and geo-spatial feature

collections. Technical data modelling is described in Chapter 2, which also includes the technical UML schemas. The conversion has been done manually. Research is going on to perform automatic conversions from UML to GML [16].

The process to create a GML prototype starts with the creation of a sample data set by the Dutch Topographic Service in accordance with the new conceptual model. In the next step this data is loaded into an Oracle 8i database at TU Delft. Then database views are created to model the data after the UML schemas. More details with respect to the data conversion are given in Chapter 3.

The data is retrieved from the database and converted into GML. This is done by means of a Java program that first makes a JDBC connection to the database. Then it reads the data via SQL queries and writes the result to a GML file. The resulting XML Schema definitions based on GML 2.0 schemas, the Java program and the resulting GML data documents are described in Chapter 4.

Besides the formal checking of the GML TOP10vector prototypes against the XML Schemas, another method for checking is really using the GML data. For this reason a GML relay for GIS vendors was organised (by the Kring voor Aardobservatie & Geo-informatica (KvAG)). Further, some other visualisation efforts are described in Chapter 5. This includes viewing with a special purpose viewing tool based on a GML parser, but also converting the GML data to SVG (and then use a standard SVG-viewer).

This report is concluded in Chapter 6 with an overview of the main results and limitations of the TOP10vector GML protytype. It also gives an indication for future work.

Chapter 2

Data modelling

In order to make a GML prototype from the conceptual model described in the report of the ITC, many engineering decisions have to be taken. The first step is to make a technical UML [5] model of the conceptual UML model of the ITC [20]; also see Appendix E for one of the UML schemas. In this project, TU Delft created two alternative implementation models. The main guidelines during the development of the technical model have been:

1. the conceptual model
2. the data sets available (or 'creatable')
3. XML/GML principles
4. elegant and readable

The development of the technical model has been an iterative process, in which the topics above played an important role.

2.1 UML model of GML geometry and features

In addition to the (ITC) conceptual UML model of the new TOP10vector, the required structure of a GML model [24] has quite an impact on the final GML prototype of the new TOP10vector. GML is described by two XML Schemas: the geometry schema and the feature schema. The UML schemas belonging to these two XML Schemas of GML are shown in Figure 2.1 and Figure 2.2. As we will see in this chapter, the way GML organises features in collections has a serious impact on the overall technical model (both UML and XML Schema) of the TOP10vector prototype. For example, one thing which has quite an influence is that geometry is not represented in the application model as an attribute of an application object, but is inherited from the GML class AbstractFeature. Also the fact the TU Delft did create two technical models is related to the structure and rules of GML. Basically, two models are available in the GML specification: one model with and one model without member restrictions.

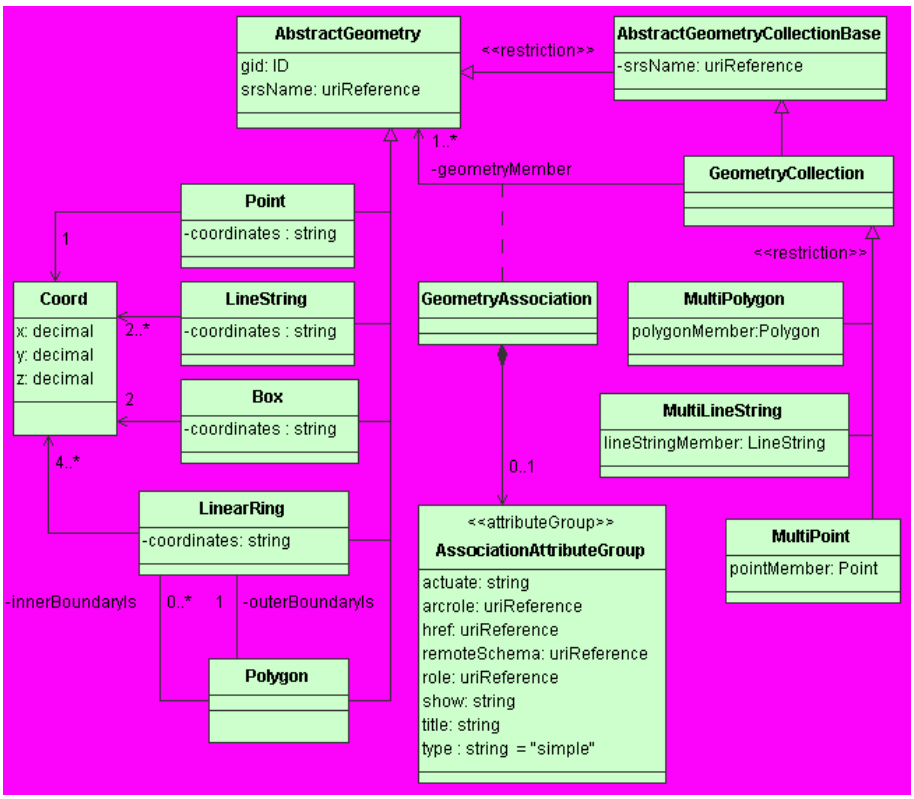

Figure 2.1: UML representation of the GML Geometry schema, taken from the GML 2.0 standard.

2.2 Technical vs. conceptual UML model of TOP10vector

The UML schema of the conceptual model (part II of the ITC report [20]) is given per main feature category. That is there are actually (independent) UML schemas for road part ('WegDeel'), railroad part ('SpoorbaanDeel'), water part ('WaterDeel'), building ('Bebouwing'), terrain ('Terrein'), providing element ('InrichtingEelement'), and regions (for 'FunctioneelGebied', 'AdministratiefGebied', and 'GeoGrafischGebied'). All these classes inherit from a generic class geographic object ('geografisch object'), which has an ID and two time attributes and a relationship to the meta data object class. Note that the dashed parts of the (ITC report) conceptual UML schemas, representing objects composed of several components, are considered to be outside the TOP10vector (and also outside the GML prototype): road ('Weg'), railroad ('Spoorbaan'), and water ('Water').

The technical model integrates the different UML schemas in one overall schema. In this process, additional (inheritance) structure is created: road, railroad and water are all derived from the more general class infrastructure ('infrastructuur'); see Figure 2.3 and the previous TU Delft TOP10vector report [40]. The main reason for this is that these classes have many attributes in common. In order to avoid repeating these all the time in the model (kind of redundancy, which may be difficult to maintain when changing the model), it was decided to introduce this addition class infrastructure. This is only visible in the (inheritance) structure of the classes and can not be observed in the final instances (that is the GML prototype data).

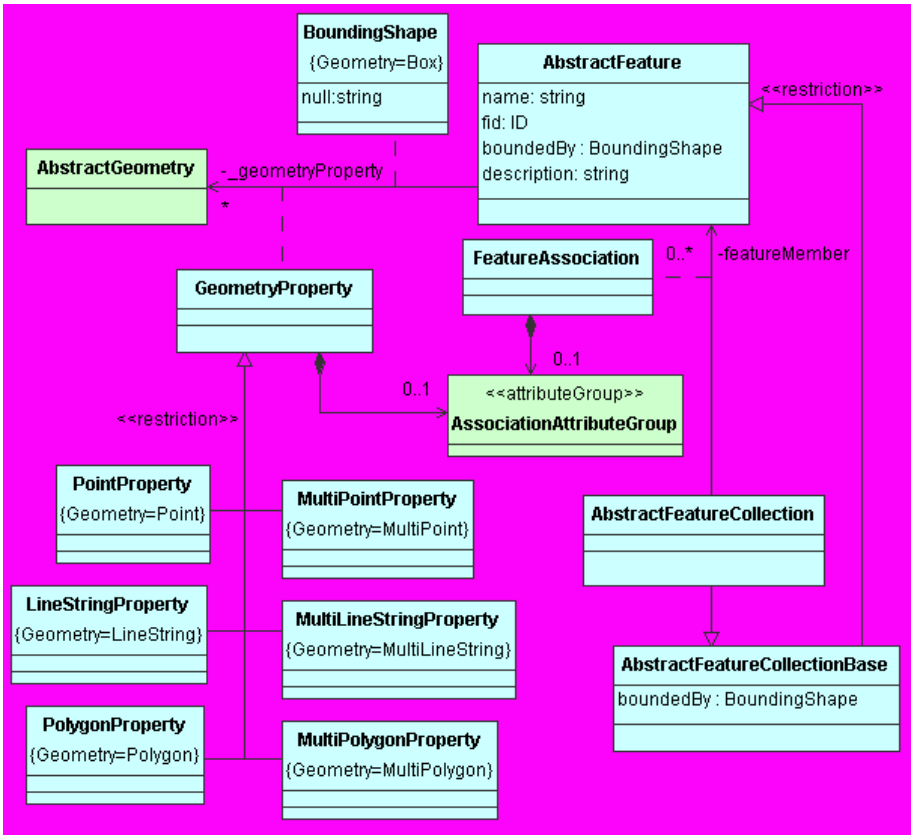

Figure 2.2: UML representation of the GML Feature schema, taken from the GML 2.0 standard.

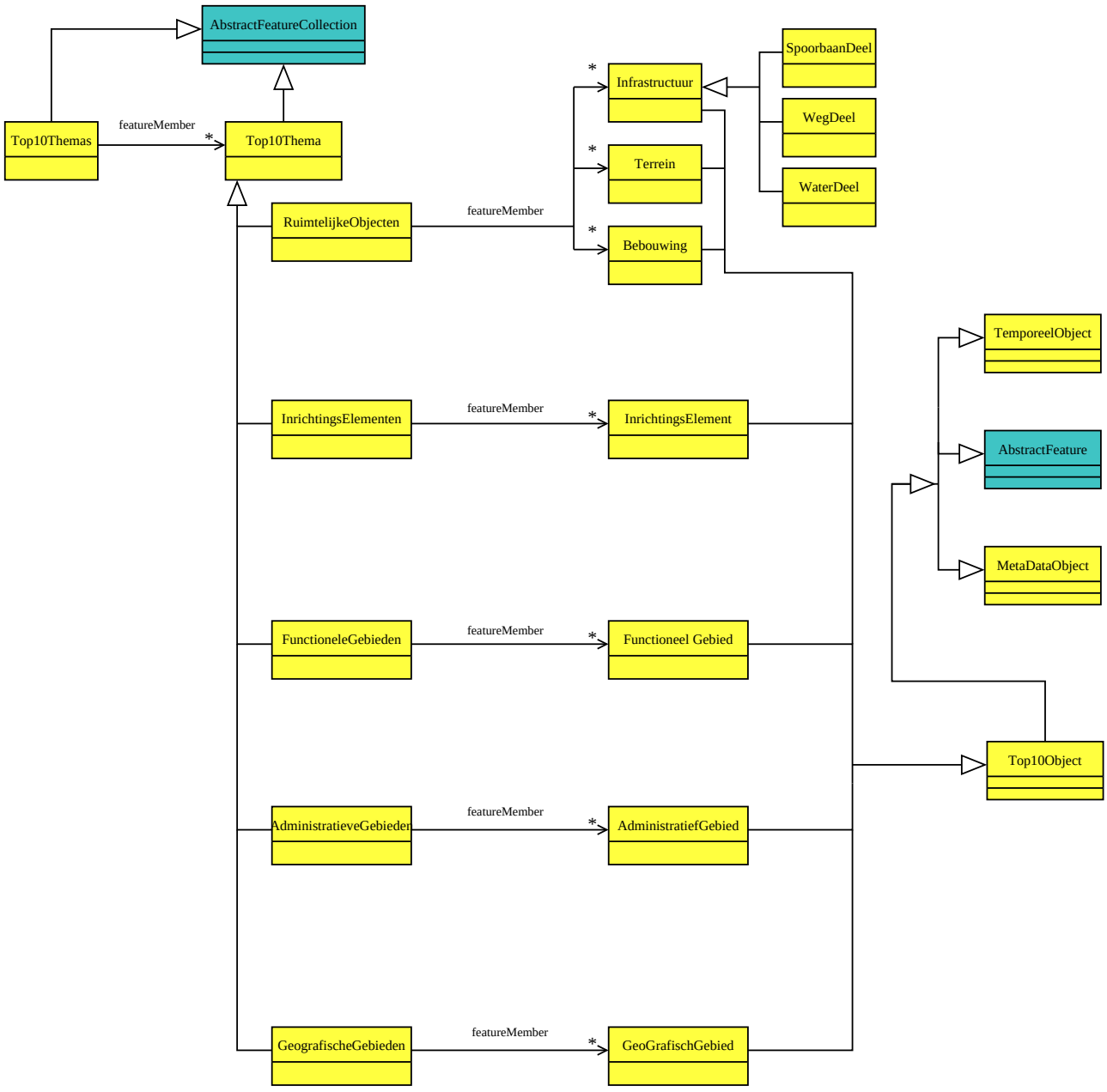

Figure 2.3: UML application model of TOP10vector without member restrictions

2.3 Explicit collections in the technical UML model

The (ITC report) conceptual model is at class level only. The instances are from these classes. In addition the technical model also recognises explicitly the sets of instances, which form the explicit collections of the classes. Five 'set' classes are modelled in the technical UML schemas:

1. spatial objects ('RuimtelijkeObjecten'), which contain instances from the classes infrastructure, terrain and buildings;
2. providing elements ('InrichtingsElementen'), which contain instances from the class providing element; note the subtle difference between plural for the set and singular for the individual element;
3. functional regions ('FunctioneleGebieden');
4. administrative regions ('AdministratieveGebieden'); and
5. geographic regions ('GeografischeGebieden').

Finally there is one set of sets in the model and this is called Top10 themes ('Top10Themas'), which has as its elements instances. These instances are from the class Top10 theme ('Top10Thema'), which are in turn again also collection (classes). Specialisations of this abstract class Top10 theme are the set classes which have already been described above: spatial objects, providing elements, functional regions, administrative regions and geographic regions. The reason for explicitly modelling Top10 themes is that an XML document can have only one 'root' element. This corresponds to the 'set of sets', that is an instance of the class Top10 themes. An alternative would be creating several GML documents, one for each collection with instances from a specific specialisation class (that is 5 in total), for one data set. This was considered to be an inferior solution.

2.4 Some differences

The term 'Geografisch object' from the (ITC report) conceptual model is replaced by the term 'Top10Object', but plays the same role. There are a few minor changes with respect to the (ITC report) conceptual model. The Top10Object now inherits from three classes: the AbstractFeature (GML basic class for a feature with geometry), MetaDataObject (contains everything related to meta data) and TemporalObject ('temporeel object', which contains the temporal aspects). Though XML only supports single inheritance (in contrast to UML which offers multiple inheritance), there are standard methods to implement this in XML, one is called the 'copy down' approach by using so-called 'group' tags in XML; see [8].

The *first* difference between the (ITC report) conceptual and the technical UML model is that meta data attributes are in the technical model part of the Top10Object (instead of the Top10Object having an explicit relationship with an meta data object). The main reason for this was the way the data was produced. It would have been more difficult to produce separate meta data objects. This is however still considered to be the best

solution as many Top10Objects may have the value for the meta data attributes, because these objects were collected within the same process. The *second* difference is that the Top10Object inherits geometry from the GML AbstractFeature class. In the original (ITC report) conceptual model geometry ('geometrie') is an attribute introduced at the specific level of the object classes, such as road, water, etc. The solution introduced in the technical model is preferred, because it corresponds with modelling rules of GML data.

2.5 Collection with or without membership restrictions

This aspect raises the discussion to the design goal of an elegant and readable form which is in harmony with the UML schemas from GML. In both the final technical UML model and the final GML/XML schema it was tried to make a readable and elegant design. Due to the different requirements (conceptual schema, actual data available, GML/XML rules) this was not always very easy. One complicating factor is that in order to have explicit control over the members of a set, the GML rules require explicit FeatureAssociation classes. The result on the technical UML schema is quite dramatic; see Figure 2.4. One additional difference between the 'non-strict' technical UML model (without explicit membership restrictions) and the 'strict' technical UML model, is that the latter introduces restrictions to the values of the attributes (instead of allowing all character strings; more details in Chapter 4).

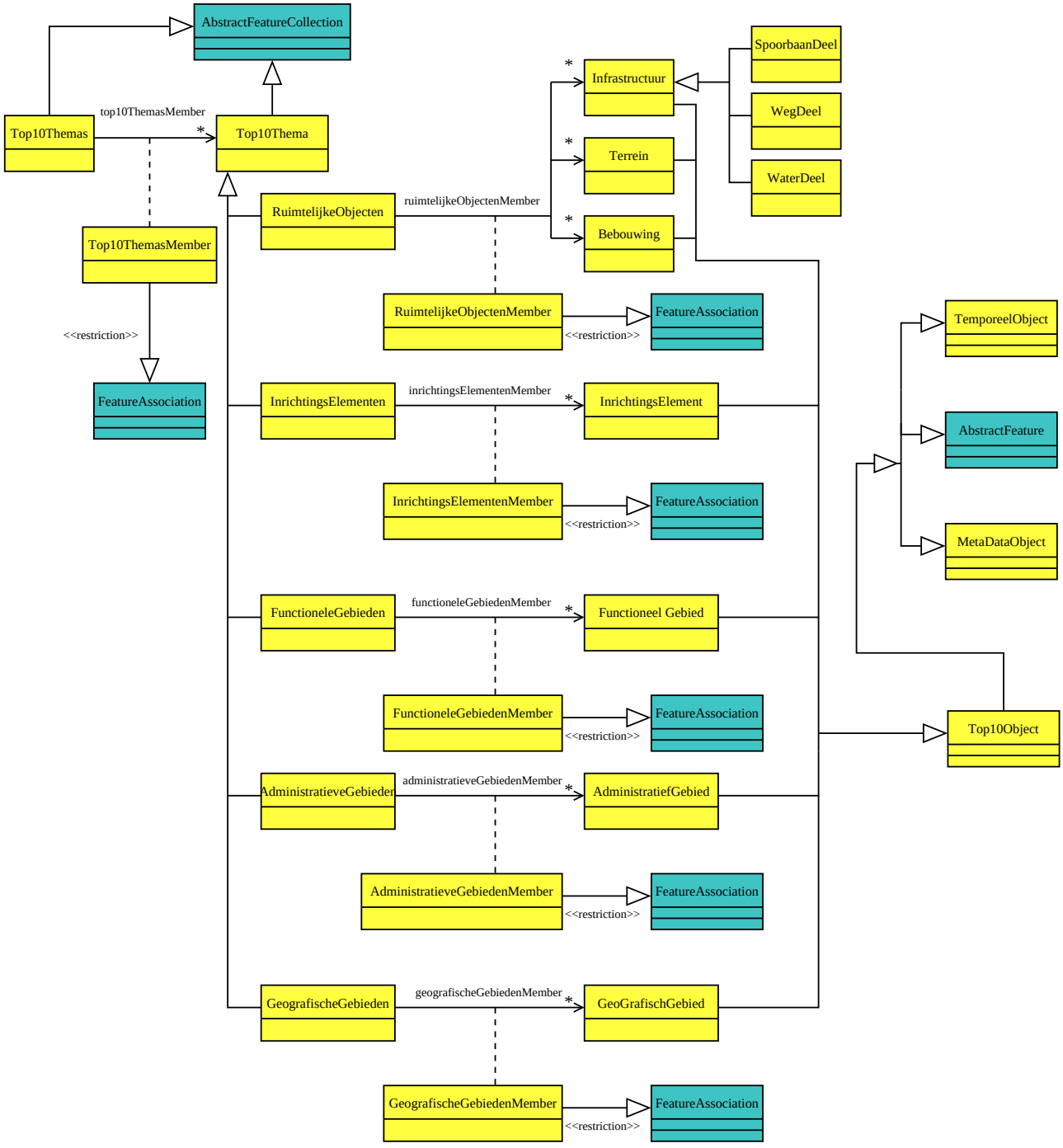

Figure 2.4: UML application model of the TOP10vector with member restrictions

Chapter 3

Data Conversion

The conversion process as described in this chapter was specifically designed for the creation of a GML prototype by TU Delft. It should not be taken as a 'production-ready' procedure for mass conversion of TDN datasets. Prototype development requires a flexible procedure. For this reason it was decided to use standard tools which can be easily adapted to new needs. The main tools used are FME (Feature Manipulation Engine), Oracle and Java. To work in combination with Oracle the Oracle Suite of FME [31, 32] was used, this version can read and write Oracle 8i spatial data (object model). The Oracle DBMS version used was Oracle Enterprise 8.1.7 [17]. FME and Oracle can be used as 'script-driven' tools, so a number of scripts were used to drive and tailor the conversion process. A Java [2] application was written to generate the prototype GML documents. This chapter is essentially an explanation of the conversion process as depicted in Figure 3.1, except the GML documents which are described in the next chapter.

3.1 Conversion process

Figure 3.1 represents the conversion process at the end of the project, initially a much simpler process was designed in which FME and Oracle are only featured once. The process became more complex when it was decided to include an editing phase, to be carried out by TDN. For this editing ArcView shapefiles were the only realistic possibility, so this required additional conversions to and from shapefiles. The decision to include additional editing was prompted by two reasons. Preparation of datasets by TDN was a complex, manual process outside the normal production line, as a result the initial prototype datasets contained relatively many errors. Another reason was the lack of realistic attribute content for most attributes of the prototype datasets (due to the difficulty to include or encode thematic attributes in design files).

The main sources of information and data for the conversion process are:

- conceptual model prepared by ITC
- Microstation design files prepared by TDN
- conversion table prepared by TDN

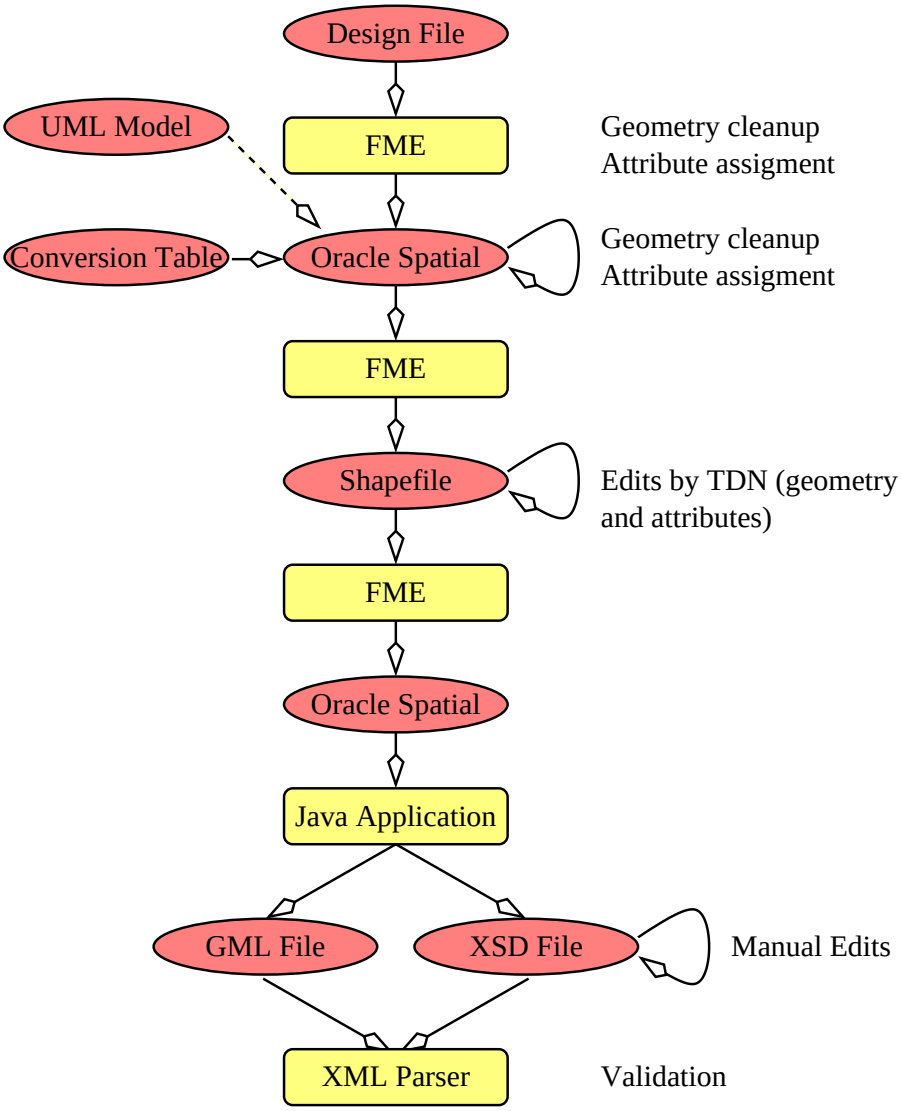

Figure 3.1: Conversion process

The data received by TU Delft consisted of 6 sets of design files, one set for each test area, and a single, global conversion table (in ASCII format). Each object class, such as road, water etc. was stored in a separate design file. It was decided to give priority to the actual data over the conceptual model in resolving contradictions between the various information sources. The means e.g. that the 'name' attribute of railroads is not included in the prototype, as well as the feature class of nature regions ('beheersgebieden') which were present in the conceptual model but not in the data received. The design file as prepared for the prototype by TDN contains geometries, accompanied by one to three codes stored in the 'user data' of each design file 'feature'. The conversion table is used to assign a feature type to features and to assign attributes and default attribute values. Each row in the conversion table represents a group of features sharing the same attributes and attribute values. As an example three rows of the conversion table are given:

```
2999;2003;;Autosnelweg;Wegdeel;Type;Kruising;Wegtype;Autosnelweg;
        Hoofdverkeersgebruik;Snelverkeer;Fysiek voorkomen;Overig;
```

```
        Kruisingstype;Overig;Verhardingsbreedteklasse;>7m;Verhardingsbreedte;
        Onbekend;Verhardingstype;Verhard;Verhardingsmateriaal;Onbekend;
        Aantal rijstroken;Onbekend;Rijrichting;Eenrichting;Toegankelijkheid;
        Openbaar;Status;In gebruik;Straatnaam;Onbekend;Wegnummer;Onbekend;
        Hoogteniveau;0
9991;2003;;Autosnelweg;Wegdeel;Type;Verbinding;Wegtype;Autosnelweg;
        Hoofdverkeersgebruik;Snelverkeer;Fysiek voorkomen;Overig;
        Kruisingstype;Overig;Verhardingsbreedteklasse;>7m;Verhardingsbreedte;
        Onbekend;Verhardingstype;Verhard;Verhardingsmateriaal;Onbekend;
        Aantal rijstroken;Onbekend;Rijrichting;Eenrichting;Toegankelijkheid;
        Openbaar;Status;In gebruik;Straatnaam;Onbekend;Wegnummer;Onbekend;
        Hoogteniveau;1
;6473;;Eiland;Geografisch gebied;Type;Eiland;Naam;Onbekend
```

The first three fields on each row are feature codes, the next two fields indicate type of feature and object class, the remaining fields are 'duals' of attribute name and attribute value. Fields, delimited by ';', can be empty. Each unique combination of codes has a particular set of attributes and attribute values. The second code ('TDNcode') is the most important one, indicating feature class and feature type. The other two codes are used to distinguish between groups of features which require different attribute values, e.g. to distinguish normal roads ('Verbinding') from crossings ('Kruising') or to separate relative height levels ('Hoogteniveau'). Using this coding scheme it is theoretically possible to assign attribute values to all unique instances, but in reality the classification stops at a level which can be derived from existing TDNcodes. After applying these codes many features exist which have identical attribute values, except for the geometry and a unique TOP10_ID. Also a large percentage of attribute values is 'unknown' ('Onbekend'). For a part of the data this was remedied in the extra editing phase by TDN. To correct coding errors and to handle additional feature types the conversion table went through numerous versions. Coding errors in the design files (resulting in features with only 'unknown' attribute values) were not corrected by TU Delft, but by TDN in the shapefile editing phase.

The goal of the conversion process is to manipulate the TOP10 data present in the input design files in such a way that GML documents can be extracted easily. Early on in the project it was decided to use an Oracle database as the source for the creation of GML documents. Oracle is available at TU Delft, it has the required (object-oriented) functionality for spatial data, is flexible (e.g. views can be used to present the same data in different ways), it offers the possibility for various checks and extraction of GML was estimated as being relatively easy (which it proved to be in the end). The first step in the conversion process now became the translation of data from MicroStation design files to an Oracle database. For this FME was chosen, a very flexible, general-purpose tool for processing of (spatial) data. In subsequent sections the steps of the conversion process are described in detail.

3.2 FME processing

Broadly speaking FME offers functionality for translating to and from numerous data formats, but also powerful functions for data manipulation are available. FME is used three times in the conversion process (Figure 3.1). Every time translation occurs, the

first time (design file to Oracle conversion) also manipulation of the data is performed. This is the more interesting use of FME, the second and third time FME is used for more or less straightforward translations.

3.2.1 Design file to Oracle conversion

The first job for FME during the design file to Oracle conversion is to retrieve the relevant TOP10 features from the set of design files and to store these objects in Oracle tables. Initially a TOP10 feature consists of geometry and 1 to 3 feature codes, at least a TDNcode is present. During this step of the conversion process the following operations are carried out (retrieval is from design files, storage is into database tables):

- selection (not everything in the design files is relevant)
- retrieval, cleanup and storage of geometry
- creation and storage of some TOP10 attributes
- assign value to TOP10_ID and startdate attributes
- retrieval and storage of feature codes

Selection is necessary because the design files contained not only TOP10 features, but also e.g. map sheet boundaries. These extraenous features can be filtered out easily because they do not have a valid TDNcode. Most of the translation is done automatically, some user interaction is required where this is impossible (e.g. sometimes ellipses in a design file must be converted to points, in other cases they must be converted to polygons).

Most of the manipulation carried out by FME is related to geometry. The conceptual model is extremely terse about geometry, the only thing stated is the fact that geometry must be present. Issues relating to geometry were discussed with the other project participants, most decisions were taken in TDN - TU Delft bilateral communication. One of the things decided was to add a z-coordinate with value 0.0 to all geometry, in the conversion process this is done at last moment when the GML document is created by the Java program. TDN also requested some geometry cleanup (removal of 'island connectors' and superfluous internal boundaries) and the creation of 'holes' in the terrain layer where buildings are present. The former is implemented in FME, the latter in Oracle. The decision to do it in this way is based on the desire to test spatial data processing functionality in both systems (everything could have been done in the one or the other). FME offers processing capabilities in the form of 'functions' (are applied to a single object) and of 'factories' (are applied to a whole dataset). As an example of the use of factories here is a small snippet of FME code in which the 'island connectors', present in design file 'areas', are removed (see also Figure 3.2, original data on the left, with removed connectors on the right):

```
# Calculate intersections
FACTORY_DEF IGDS IntersectionFactory            \
   FACTORY_NAME CalcNodes3                      \
   INPUT FEATURE_TYPE polys1                    \
```

```
    OVERLAP_COUNT_ATTRIBUTE numIntersections       \
    SELF_INTERSECTION_ONLY                         \
    OUTPUT SEGMENT FEATURE_TYPE segments3

# Now we can create clean polygons
FACTORY_DEF IGDS PolygonFactory                    \
    FACTORY_NAME CreatePolygons2                   \
    INPUT FEATURE_TYPE segments3                   \
    REMOVE_CORRIDORS                               \
    GROUP_BY objectNr                              \
    VERTEX_NODED                                   \
    OUTPUT POLYGON FEATURE_TYPE polygons2

# Create final polygons including holes
FACTORY_DEF IGDS DonutFactory                      \
    FACTORY_NAME AddHoles                          \
    INPUT FEATURE_TYPE polygons2                   \
    DROP_HOLES YES                                 \
    GROUP_BY objectNr                              \
    OUTPUT DONUT FEATURE_TYPE object_geom          \
    OUTPUT POLYGON FEATURE_TYPE object_geom
```

In this code fragment three factories are applied to the data. In the first the 'Intersection-Factory' is used to calculate all nodes where the geometry of a feature intersects itself. The second factory ('PolygonFactory') is then used to create closed circuits (base polygons) from the segments created by the first factory, at same time the 'island connectors' ('corridors' in FME terms) are removed. Finally the inner - outer boundary relationships are determined in the third factory ('DonutFactory') to create the final polygons. A complete listing of all FME scripts can be found in Appendix A.

Figure 3.2: Removal of connectors between outer and inner boundaries

The following code fragment is an illustration of the translation section of a FME script in which also some functions are used:

```
ORACLE8I $(_TabOut)                                \
    OID                 %transferId                \
    BEGINDATUM          @Timestamp("^d ^b ^Y ^X") \
```

```
TDNCODE              %tr_tdncode              \
WORD_1               %tr_word_1               \
WORD_4               %tr_word_4               \
@Arc(%igds_primary_axis,%igds_secondary_axis,0,%igds_rotation)
```

In this code fragment is defined in what way a design file feature (in this case an ellipse, which are always circles in TOP10 datasets) is translated into a feature in an Oracle table. All `$(identifier)` and `%identifier` symbols are FME 'variables' which have received a value earlier in the script (e.g. `$(_TabOut)` is the name of the Oracle table in which the feature will be stored). On the left are attributes (column names: OID, BEGINDATUM, etc.), on the right the attribute values are specified by variables or functions (the `@identifier` symbols). The `@Timestamp("^d ^b ^Y ^X")` function assigns the current time of day in a specified format to the 'BEGINDATUM' (startdate) attribute. The database creation time is used as 'birthdate' for TOP10 features. In the example the `@Arc` function (by definition applied to the geometry, so no need to specify the column name) converts an ellipse into a 'stroked' polygon. Replacing this function by `@ConvertToPoint()` results in the ellipse being converted into a point geometry. Both FME and Oracle support arcs, arc segments and circles (defined by centrepoint and radius, or by three points). GML however does not support these types of geometry, so only straight line segments were used in linestrings and polygons.

The example shows that in this phase of the conversion process the OID (later to become TOP10_ID) and 'BEGINDATUM' attributes are assigned a value. Other attributes (like enddate and the metadata attributes) are created but do not receive a value. To ensure unique IDs each feature class (roads, terrain, water, etc.) is assigned a range of IDs. Three feature codes (TDNCODE, WORD_1, WORD_4) are simply retrieved from the design file and transferred to the Oracle table. In the next phase of the conversion process these will be used to assign additional attributes and attribute values to features. Each feature class is stored in a separate table.

3.2.2 Oracle to shapefile conversion and back

As mentioned before FME occurs two more times in the conversion process, in the Oracle to shapefile and shapefile to Oracle transformations. These are described first, in the next section we jump back to the Oracle processing. The FME scripts which handle the later FME conversions (see Appendix A) do not contain any 'advanced' processing by 'functions' or 'factories', they are simple translations from database 'objects' to shapefile features and back. The translation is not 100% straightforward, mainly because of some limitations of ArcView shapefiles:

- a shapefile can only contain one type of geometry
- attribute names to be translated are limited to 10 characters
- DATE type attributes are not handled well

Oracle Spatial uses a single, generalized spatial datatype in which all conceivable spatial data must be stored. TOP10 feature classes which have more than one type of geometry (e.g. a road feature can contain points, lines and areas) are stored in Oracle in one table

in one geometry column. Conversion to a shapefile means that three separate shapefiles must be created, one for points, one for lines and one for areas. In the reverse conversion from shapefiles to Oracle (after TDN editing of the shapefiles) these files are combined again into one table. In the translation to shapefiles all attribute names are truncated to 10 characters. If this results in non-unique names, characters are automatically replaced by digits to make the attribute name unique. During the conversion back from shapefiles to Oracle the truncated names are expanded again to the original names (the names as defined by the conceptual model). Initially the startdate and enddate attributes as created by FME were stored as DATE type in Oracle. Translation of such an attribute to a shapefile results in losing the 'time' part of the date, only the 'date' part ended up in the shapefile. To avoid this, startdate and enddate attributes were converted to a String type which is transferred without loss of information. Later on in the conversion process startdate and enddate are converted again to a proper DATE type. The whole conversion to and from shapefiles was included in the project to make it possible for TDN to edit these files. Some implications of this editing are described in section 3.4.

3.3 Oracle processing

Just like FME, the more interesting Oracle processing takes place the first time it occurs in Figure 3.1. The second time Oracle occurs the database is only used to hold the data stored there after the shapefile edits by TDN. How the data is retrieved from Oracle by the Java application is described in the last section of this chapter. The starting point for Oracle processing are the 9 tables (or less if not all feature classes are present in a test area) created by FME as described in the previous section. Decisions described earlier in this chapter determine the steps which have to be carried out in Oracle:

- 'cut out' buildings from the terrain layer
- load the conversion table into the database
- combine conversion table and geometry to create additional attributes and attribute values

The operations to determine topological relations between geometries in Oracle Spatial are based on the 9-intersection model [14, 13]. In the current version of Oracle Spatial these relations are implemented as basic geometric operations which can establish the relationship between two geometries. One of the operations implemented is the (topological) difference (MINUS operation) between two objects. This is exactly the operation required to 'cut out' the buildings from the terrain layer. Because the operation in Oracle can only handle two objects at a time, to apply this to two spatial layers requires potentially $Nb.Nt$ calculations (with Nb and Nt being the number of features in the building and terrain layers). This would become unacceptably slow for a larger number of features, so to decrease the number of calculations spatial indices and filters must be used. Oracle uses a primairy filter to select potential candidates based on bounding box, a secondary filter is used to determine the exact relationiship between the two geometries. Only after it is certain that two polygons overlap the actual calculation ('subtract' one geometry from the other) is carried out. In Appendix B the PL/SQL program used to erase the

buildings from the terrain is listed. Before the program is run spatial indices (R-tree) are created for the geometry column of the buildings and terrain tables. The result is a layer from which the buildings are cut out (Figure 3.3: terrain top left, buildings top right, combination below).

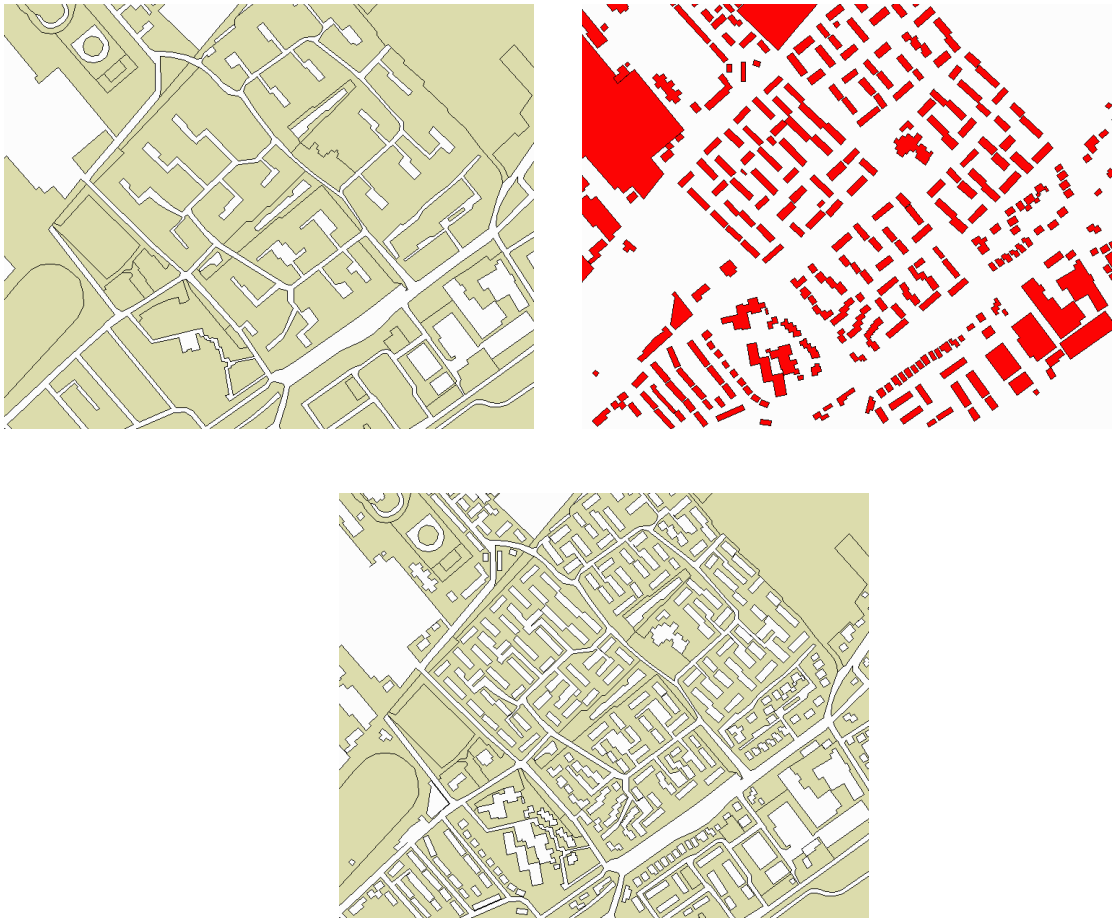

Figure 3.3: Cutting out buildings from the terrain layer

An unwanted side-effect of this operation is the creation of many, small sliver polygons (Figure 3.4). TDN must organize the production of the new TOP10 in such a way that this no longer occurs. The most optimal solution would be to enforce a planar partition for the relevant layers (terrain, buildings, infrastructure). In the prototype no further processing was done to try to remove the slivers.

Another, possibly unexpected, result of erasing the buildings from the terrain is the forming of multi-polygons (Figure 3.5). The large, diagonal polygon in the centre is split into two disjoint pieces. If this occurs it is possible to create new terrain features in such a way that only single polygons remain, but in the current implementation the multi-polygons are kept.

To accomplish the second task (load conversion table into database) the ASCII format in which this table is available is 'reorganized' by means of some scripts in such a way that the Oracle loader can process the file. This part of the process was done in a Unix environment, so tools like 'sed', 'awk' and 'perl' are available. One of the things done, as an early preparation to the final GML documents, is to replace characters which will cause

Figure 3.4: The forming of sliver polygons

problems in a XML document with XML escape sequences (e.g. the character '<', which occurs in attribute names and attribute values, is replaced by '<'). After loading the conversion table into the database two tables are available for each feature class: one containing feature codes and attribute definitions (the conversion table), another containing feature codes, some attributes and geometry. The feature codes can be used to combine these tables, the final task for this phase of the conversion process. The SQL statement to accomplish this for feature class terrain is:

```
create table terrein_t
as select
       oid,
       begindatum,
       einddatum,
       brontype,
       bronbeschrijving,
       nauwkeurigheid,
       actualiteit,
       landgebruik,
       fysiek_voorkomen,
       toegankelijkheid,
       voorkomen,
       naam,
       hoogteniveau,
       geom,
       tdncode,
       word_1,
       word_4
 from terreinen t, terreinconv c
 where
       c.code1(+) = t.word_1 and
       c.code2(+) = t.tdncode and
```

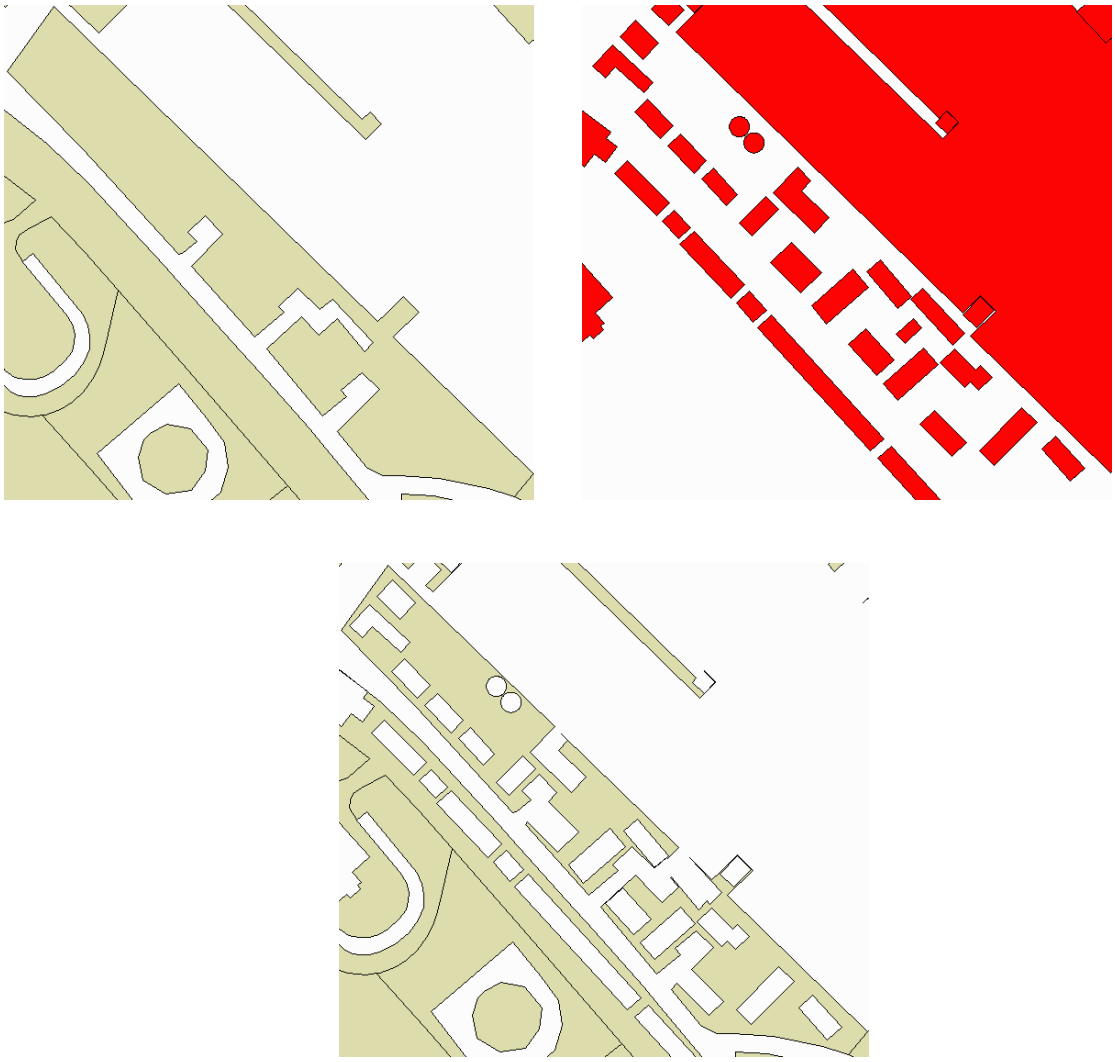

Figure 3.5: The forming of multi-polygons

```
        c.code3(+) = t.word_4
;
```

A join is executed between the 'terreinen' (terrain) and 'terreinconv' (conversion table) tables based on three feature codes. The `(+)` means in this case a 'right outer join', all rows from 'terreinen' are returned. If an inner join (simple join) is used some records from 'terreinen' would be lost because of the coding errors in design files and conversion table. Initially this join was not defined as a table but as a view. This was changed to a table because the conversion to shapefiles by FME (inserted halfway through the project) requires that. FME does not 'see' views in an Oracle database, only tables can be handled. Later on in the process the view 'terrein' is defined to change the order of the attributes, to rename some attributes (oid to TOP10_ID, geom to polygonProperty) and to leave out unnecessary attributes (WORD_1, WORD_4: these are not part of the GML document, but helped in error detection and correction).

3.4 Shapefile editing by TDN

Although the incorporation of shapefile editing by TDN 'disturbed' the initial conversion process, the prototype produced benefitted. The edited files have a more realistic content (many 'unknown' values replaced by real values) with most of the erroneous feature codes removed. Editing involved deletion of features, insertion of new features and changing attribute values of existing features. On the other hand 'new' errors and inconsistences were introduced by shapefile edits:

- inconsistent spelling of attribute values
- changed attribute types (from numeric to string and vice versa)
- non-unique IDs

These errors result from the manual editing of shapefiles by TDN outside the production environment where 'normal' quality control is not available. Also the use of shapefiles does not help, no constraints whatsoever are enforced. The fact that more shapefiles are created for a single layer if more geometry types exist is responsible for the non-unique IDs (the newly created ID is already used in another file). One of the major advantages of GML/XML is the fact that much quality control is included 'for free'. The errors mentioned became immediately apparent once the shapefiles edited by TDN were converted back to GML documents. All parsers complained about the non-unique IDs and different attribute types. The inconsistent spelling is detected if the 'strict' TOP10 model with enumeration types is used.

Besides their role in the conversion process, the shapefiles were also used in the next phase of the project, the evaluation of the prototypes by CGI. Although GML is the proper format of the new TOP10 product, shapefiles were used due to the current lack of 'open', data-driven tools to visualize and manipulate the 'content' of GML documents (as opposed to parsers which are available to handle the syntax and structure of GML/XML documents). Naturally the limitations of shapefiles mentioned in this report and the errors and unwanted elements included in the test datasets become part of the evaluation in this way.

3.5 Java application

In the final step, a Java application is used to read the data from the Oracle database and convert it into GML. Because the database model already closely reflects the UML model and hence the GML document, this step is relatively simple due to the data model driven approach. The Java program makes a JDBC connection to the database and selects all data from one of the converted tables with an SQL Query:

```
SELECT * FROM terrein
```

The `SELECT *` automatically returns all attributes in the result of this selection, which is then printed in GML format. Normally this data is printed as a list of columns:

```
FYSIEK_VOORKOMEN   TOEGANKELIJKHEID  NAAM
------------------ ----------------- ---------------- .....
Op talud           Openbaar          Onbekend
Op verhoogd vlak   Openbaar          Onbekend         .....
Op verlaagd vlak   Openbaar          Onbekend
```

For XML a different representation is needed. but now, it is printed as XML tags and will look something like:

```
<tdn:fysiek_voorkomen>Overig</tdn:fysiek_voorkomen>
<tdn:toegankelijkheid>Openbaar</tdn:toegankelijkheid>
<tdn:naam>Onbekend</tdn:naam>
```

This extra formatting is done with data model driven print-statements in the Java program. In most cases the conversion is as simple as the example above. Only some attributes need extra formatting; for example the Oracle Polygon:

```
SDO_GEOMETRY(2003, NULL, NULL, SDO_ELEM_INFO_ARRAY(1, 1003, 1),
SDO_ORDINATE_ARRAY(119828.449, 576162.969, 119832.891, 576174.521,
119825.612, 576177.705, 119820.571, 576165.749, 119828.449,
576162.969))
```

looks as follows in GML:

```
<gml:geometryProperty>
  <gml:Polygon srsName="EPSG:7408">
    <gml:outerBoundaryIs>
      <gml:LinearRing>
        <gml:coordinates>
          119828.449,576162.969,0.0 119832.891,576174.521,0.0 119825.612,57617
          119820.571,576165.749,0.0 119828.449,576162.969,0.0
        </gml:coordinates>
      </gml:LinearRing>
    </gml:outerBoundaryIs>
  </gml:Polygon>
</gml:geometryProperty>
```

All in all the Java program contains a lot of formatting code. The source code of the java program can be found in Appendix C.

3.6 Validation of GML document

Because the conversion process consists of so many steps, some of which are done manually, it is wise to check in the end whether the resulting GML file is indeed a correct GML document. The first step is to check if it is a *well formed* document (matching begin and end tags, etc.). The next step is to check if the GML document is *valid* according to its XML Schema definition. We performed these steps with two different packages: XMLSpy [43] and TurboXML [34], a screendump of the validation in XML Spy is given in Figure 3.6.

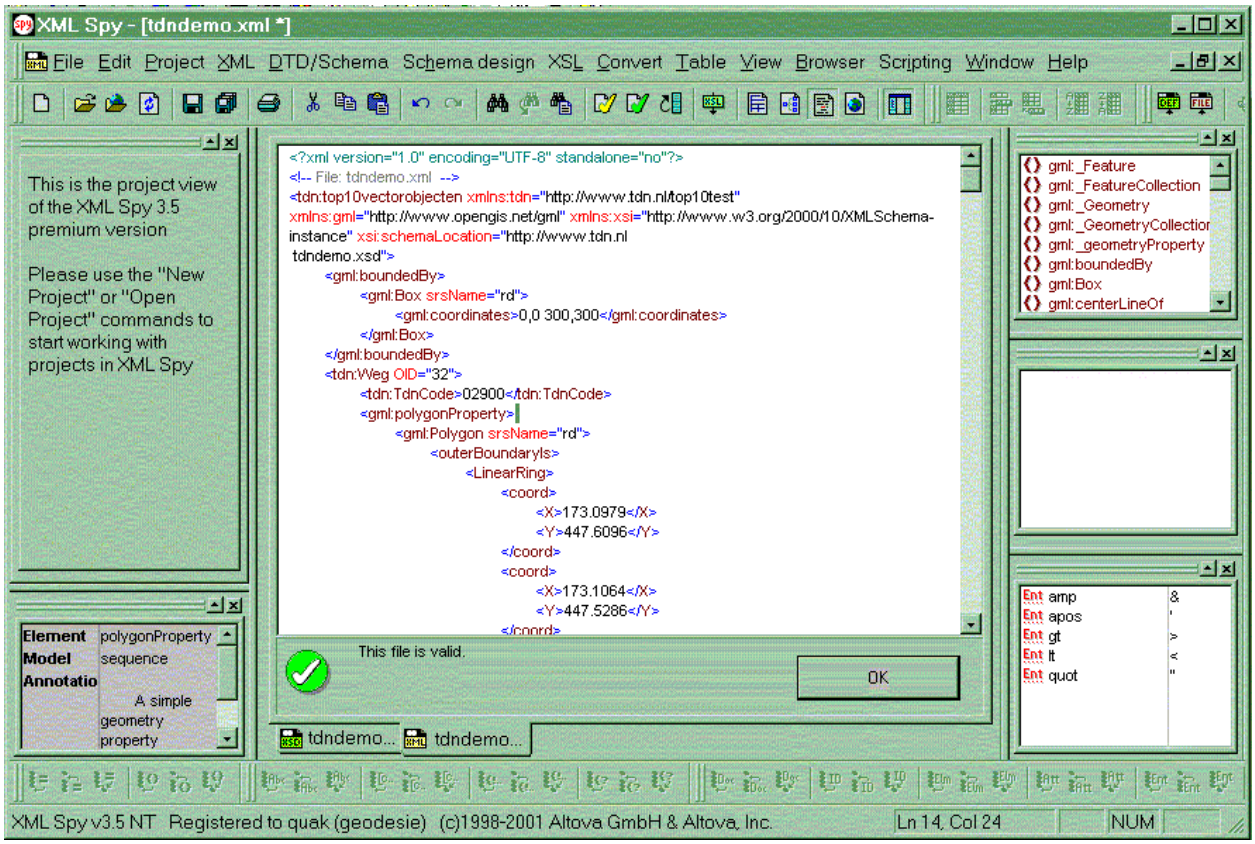

Figure 3.6: Validation of an XML document with XML Spy

Chapter 4

GML prototype

In Chapter 2 we discussed some of the issues that arose when translating the conceptual model for the new TOP10vector into a technical data model. Two UML models were created: a 'strict' one and a 'non-strict' one. In this chapter we will focus on the step from the UML models to the GML prototype files. We start with some general remarks about GML and XML Schema in Section 4.1. After this the XML Schema definitions are described: Section 4.2 (non-strict) and Section 4.3 (strict). Finally the non-strict (Section 4.4) and strict (Section 4.5 are explained. The complete XML Schema files and parts of the GML files are included in Appendix D.

4.1 GML, XML and XML Schema

GML and XML Schema are both 'coded' in XML. XML stands for eXtensible Markup Language, and is meant as a format for the storage and exchange of structured information. XML documents must obey some basic rules: they must be 'well formed' (have corresponding begin and end tags) and 'valid'. An XML document is valid when its tags and structure conform to the definitions and declarations in either a DTD document (=Document Type Description) or an XML Schema document The TOP10vector GML prototypes are based on version 2.0 of the GML specification of the OpenGIS Consortium, approved in April 2001. With version 2.0 the OpenGIS consortium decided only to use XML Schema to convey the structure of GML files.

While XML and GML documents are 'easy to look at', because of the begin and end tags that wrap the data, XML Schema proved not that easy at first. There are four basic constructs:

- declaration of elements
- definition of types (simpleTypes and complexTypes)
- the possibility to define subtypes by extending or restricting supertypes
- use of aliases (substitutionGroup mechanism)

The GML specification is basically a set of XML Schema documents with element declarations and type definitions plus an hierarchical structure for the relationships between types. In this way the specification offers a framework that can be used by organisations to make their specific XML application schemas for their GML implementations. Technically this is accomplished by including the XML Schemas feature.xsd, geometry.xsd (both from the OpenGIS consortium) and xlinks.xsd (from the W3C Consortium) in the user's application schema.

For the geometry elements and types users can decide to use the ones already present in feature.xsd and geometry.xsd. The only thing user organisations always have to do is to define their own feature elements and feature types. This is done by extending the OpenGIS basic features types. Also a root level feature collection must be defined.

GML has some 'rules' that must be obeyed when users construct their own XML application schema:

- all user defined feature types must (directly or indirectly) inherit from AbstractFeatureType
- all user defined geometry property types must (directly or indirectly) inherit from GeometryPropertyType
- all user defined geometry types must (directly or indirectly) inherit from AbstractGeometryType or GeometryCollectionType

4.2 TOP10 schema definition (non-strict version)

This Section contains big portions of the prototype schema definition for the TDN. The complete non-strict schema definition is given in Appendix D.2.

4.2.1 Header

Every XML file starts with a header line that tells that this document is an XML document and that it is encoded in `iso-8859-1`. This is an indication of the character set that is used. The choice if this set is important, because the standard character set `UTF-8` does not contain some European letters such as the 'ë' in 'geëlectrificeerd'. When validating the document we noticed that there is a difference between the strictness of the GML parsers. For example XMLSpy does not complain about 'illegal' characters (e.g. 'ë') in the document while TurboXML complains about this.

In the `<schema>` open tag, the namespaces that are used for this schema definition are given. Here we define the `tdn` workspace. The string behind it looks like an URL but in fact it is just a unique identifier for the GML namespace.

The `<annotation>` part of the header, the name and version of this prototype schema definition.

The `<import>` tag, imports other schema definitions that are used in this XSD. In this case the schema definition `feature.xsd` is included, in this definition OpenGIS features are

defined. `feature.xsd` itself other schema definitions are included again: `geometry.xsd` and `xlinks.xsd`

```
<?xml version="1.0" encoding="iso-8859-1"?>
<!-- File: tdn.xsd  -->
<schema targetNamespace="http://www.gdmc.nl/tdn"
        xmlns:tdn="http://www.gdmc.nl/tdn"
        xmlns:xlink="http://www.w3.org/1999/xlink"
        xmlns:gml="http://www.opengis.net/gml"
        xmlns="http://www.w3.org/2000/10/XMLSchema"
        elementFormDefault="qualified"
        version="1.0">

  <annotation>
    <appinfo>tdn.xsd v2.0</appinfo>
    <documentation xml:lang="en">
      GML prototype schema for the Dutch Topographic Service 1:10.000 data
    </documentation>
  </annotation>

  <!-- import constructs from the GML Feature and Geometry schemas -->
  <import namespace="http://www.opengis.net/gml" schemaLocation="feature.xsd"/>
```

4.2.2 Root element

The first `<element>` in the schema definition defines the root element of the GML file. This means that the first open tag in the GML file will be `<Top10Themas>`. As can be seen in the definition the substitutiongroup for this element is `gml:_FeatureCollection`. This means that `<Top10Themas>` is a collection of objects.

```
<element name="Top10Themas" substitutionGroup="gml:_FeatureCollection">
  <complexType>
    <complexContent>
      <extension base="gml:AbstractFeatureCollectionType">
      </extension>
    </complexContent>
  </complexType>
</element>
```

4.2.3 Shared definitions

There are some attributes that are shared by many objects in the TDN definition. In the UML structure these attributes are stored in multiple superclasses. Since XSD does not support multiple inheritance, we modelled the shared definitions with the `group` construct. We have groups for `TemporeelObject` and `MetadataObject`:

```
<group name ="TemporeelObject">
          <sequence>
             <element name="begindatum" type="string"/>
             <element name="einddatum" type="string"/>
          </sequence>
```

```
</group>

<group name ="MetadataObject">
          <sequence>
             <element name="brontype" type="string"/>
             <element name="bronbeschrijving" type="string"/>
             <element name="nauwkeurigheid" type="string"/>
             <element name="actualiteit" type="string"/>
             <element name="tdncode" type="integer"/>
          </sequence>
</group>

<complexType name="Top10ObjectType" abstract="true">
  <complexContent>
    <extension base="gml:AbstractFeatureType">
          <sequence>
             <element name="top10_id" type="integer"/>
             <group ref="tdn:TemporeelObject"/>
             <group ref="tdn:MetadataObject"/>
          </sequence>
    </extension>
  </complexContent>
</complexType>
```

4.2.4 Feature definitions

After all preliminary constructs we finally get the definitions of the feature Objects. These are the objects that are really visible on the map. Below only the definition of 'Bebouwing' is given. In the appendix definitions for 'SpoorbaanDeel', 'WegDeel', 'WaterDeel', 'Terrein', 'InrichtingsElement', 'FunctioneelGebied', 'AdministratiefGebied' and 'GeografischGebied' are given.

```
<element name="Bebouwing" type="tdn:BebouwingType"
  substitutionGroup="gml:_Feature"/>
<complexType name="BebouwingType">
    <complexContent>
       <extension base="tdn:Top10ObjectType">
          <sequence>
             <element name="type" type="string"/>
             <element name="functie" type="string"/>
             <element name="hoogteklasse" type="string"/>
             <element name="hoogte" type="string"/>
             <element name="status" type="string"/>
             <element ref="gml:geometryProperty"/>
             <element name="hoogteniveau" type="integer" minOccurs="0"/>
             <element name="naam" type="string" minOccurs="0"/>
          </sequence>
       </extension>
    </complexContent>
</complexType>
```

4.3 TOP10 schema definition (strict version)

The strict version of the schema definition is very similar to the non-strict one. Its schema definition imposes two extra constraints on the GML document: Constraints on strings and Contraints on collections. These constraints will be handled in the following sections.

4.3.1 Constraints on string attributes

Many objects in a GML document have a predefined number of allowed values. In the non-strict schema definition these attributes are of the type 'string'. In the strict version we make an enumeration type for these attributes that list the allowed entries. For example in the 'Bebouwing' feature the 'functie' (usage) element will change from:

```
<element name="functie" type="string"/>
```

into:

```
<element name="functie" type="tdn:functieBebouwing"/>
```

The definition of the type 'functieBebouwing' looks like:

```
<simpleType name="functieBebouwing">
    <restriction base="string">
      <enumeration value="Gemeentehuis"/>
      <enumeration value="Politiebureau"/>
      ...
      <enumeration value="Manege"/>
      <enumeration value="Kapel"/>
    </restriction>
</simpleType>
```

In Appendix D.1 a definition of all types is given.

4.3.2 Constraints on collections

In the strict document definition membership constraints are enforced on collections. This means for example the collection of 'RuimtelijkeObjecten' will only contain objects of type 'RuimtelijkObject'. This is done in the following manner. First we define an element for the collection of RuimtelijkeObjecten:

```
<element name="RuimtelijkeObjecten" type="tdn:Top10ThemaType"
  substitutionGroup="tdn:_Top10ThemasFeature"/>
```

Then we say that inside there must be a sequence of objects of type 'tdn:_RuimtelijkeObjectenFeature'.

```
<element name="ruimtelijkeObjectenMember" type="tdn:RuimtelijkeObjectenMemberType"
  substitutionGroup="gml:featureMember"/>
<complexType name="RuimtelijkeObjectenMemberType">
  <annotation>
  </annotation>
  <complexContent>
    <restriction base="gml:FeatureAssociationType">
      <sequence minOccurs="0">
        <element ref="tdn:_RuimtelijkeObjectenFeature"/>
      </sequence>
```

```
          <attributeGroup ref="gml:AssociationAttributeGroup"/>
        </restriction>
      </complexContent>
    </complexType>

    <element name="_RuimtelijkeObjectenFeature" type="gml:AbstractFeatureType" abstract="true"
      substitutionGroup="gml:_Feature"/>
```

If we now define which elements are of type 'tdn:_RuimtelijkeObjectenFeature', we can control the objects that are allowed inside this collection. Below we allow 'SpoorbaanDeel' and 'WegDeel' to be part of this collection.

```
<element name="SpoorbaanDeel" type="tdn:SpoorbaanDeelType"
  substitutionGroup="tdn:_RuimtelijkeObjectenFeature"/>

<element name="WegDeel" type="tdn:WegDeelType"
  substitutionGroup="tdn:_RuimtelijkeObjectenFeature"/>
```

The advantage of having these restrictions of collections is that now by only looking at the schema definition it is known what object can be expected. In Appendix D.1 the complete strict schema definition is given.

4.4 TOP10 document (non-strict version)

This section contains an annotated GML file. It starts with the standard XML header in which the character encoding is mentioned:

```
<?xml version="1.0" encoding="iso-8859-1" standalone="no"?>
<!-- File: arnhem.gml  -->
```

Then we get the root element of the GML document. In this header no default namespace is declared. This means that all tags in the gml document are prefixed by their namespace. ('gml:', 'tdn:').

```
<tdn:Top10Themas
  xmlns:tdn="http://www.gdmc.nl/tdn"
  xmlns:gml="http://www.opengis.net/gml"
  xmlns:xlink="http://www.w3.org/1999/xlink"
  xmlns:xsi="http://www.w3.org/2000/10/XMLSchema-instance"
  xsi:schemaLocation="http://www.gdmc.nl/tdn tdn.xsd">
```

The `<gml:boundedBy>` tag contains the bounding box of all the objects in the GML file.

The `srsName` attribute that is given in the geometry of the bounding box (and every other geometry in the GML document) is a reference to the EPSG database [15]. Note that this entry in the EPSG database (7408) is a compound coordinate reference system which combines RD and NAP.

In the GML2.0 specification the srsName should be provided, but a standardized format for the different Spatial Reference Systems is currently not part of the standard; it can be any URI. It is expected that GML3.0 will have a module for specifying Spatial Reference Systems.

```
  <gml:boundedBy>
```

```
      <gml:Box srsName="EPSG:7408">
        <gml:coordinates>
          190000,446000,0.0 193000,449000,0.0
        </gml:coordinates>
      </gml:Box>
    </gml:boundedBy>
```

After the bounding box of all collections we get the diffrernent collections one by one. First the collection is opened, then we get the bounding box of this sub-collection and after that there are the objects of the collection itself. Once we have had the objects of the first collection that collection is closed an we continue with the following collection untill all collections are described. Notice that all co-ordinates have three dimensions.

```
<gml:featureMember>
  <tdn:RuimtelijkeObjecten>

    <gml:boundedBy>
      <gml:Box srsName="EPSG:7408">
        <gml:coordinates>
          190000,446000,0.0 193000,449000,0.0
        </gml:coordinates>
      </gml:Box>
    </gml:boundedBy>

    <gml:featureMember>
      <tdn:SpoorbaanDeel fid="TOP10.4200001">
      ...
      </tdn:SpoorbaanDeel>
    </gml:featureMember>

    <gml:featureMember>
      <tdn:Bebouwing fid="TOP10.1200993">
      ...
      </tdn:Bebouwing>
    </gml:featureMember>

  </tdn:RuimtelijkeObjecten>
</gml:featureMember>

<gml:featureMember>
  <tdn:InrichtingsElementen>

    <gml:featureMember>
      <tdn:InrichtingsElement fid="TOP10.3200260">
       ...
      </tdn:InrichtingsElement>
    </gml:featureMember>

  </tdn:InrichtingsElementen>
</gml:featureMember>

...

</tdn:Top10Themas>
```

An examle of one complete feature is given below. In appendix D.4 a complete valid

non-strict GML document is given.

```
<gml:featureMember>
  <tdn:SpoorbaanDeel fid="TOP10.4200001">
    <tdn:top10_id>4200001</tdn:top10_id>
    <tdn:begindatum>06 Jul 2001 08:08:24</tdn:begindatum>
    <tdn:einddatum/>
    <tdn:brontype/>
    <tdn:bronbeschrijving/>
    <tdn:nauwkeurigheid/>
    <tdn:actualiteit/>
    <tdn:tdncode>4233</tdn:tdncode>
    <tdn:type>Verbinding</tdn:type>
    <tdn:toegankelijkheid>Openbaar</tdn:toegankelijkheid>
    <tdn:status>In gebruik</tdn:status>
    <tdn:verkeersgebruik>Tram</tdn:verkeersgebruik>
    <tdn:fysiek_voorkomen>Overig</tdn:fysiek_voorkomen>
    <tdn:spoorbreedte>Normaalspoor</tdn:spoorbreedte>
    <tdn:aantal_sporen>1</tdn:aantal_sporen>
    <tdn:functie>Alleen personenvervoer</tdn:functie>
    <tdn:elektrificatie>Gelektrificeerd</tdn:elektrificatie>
    <gml:geometryProperty>
      <gml:Polygon srsName="EPSG:7408">
        <gml:outerBoundaryIs>
          <gml:LinearRing>
            <gml:coordinates>
              191008.456,447232.635,0.0 190990.713,447236.938,0.0 190972.849,447239.952,0.0
              190955.904,447235.469,0.0 190940.491,447231.646,0.0 190923.831,447229.355,0.0
              190924.668,447229.093,0.0 190942.211,447223.787,0.0 190944.282,447224.343,0.0
              190957.89,447227.719,0.0 190973.223,447231.776,0.0 190989.103,447229.096,0.0
              191006.57,447224.861,0.0 191008.456,447232.635,0.0
            </gml:coordinates>
          </gml:LinearRing>
        </gml:outerBoundaryIs>
      </gml:Polygon>
    </gml:geometryProperty>
    <tdn:hoogteniveau>0</tdn:hoogteniveau>
  </tdn:SpoorbaanDeel>
</gml:featureMember>
```

4.5 TOP10 document (strict version)

Although the schema definitions of the two flavours of GML files differ considerably, the resulting GML documents are very similiar. The only difference is in the way the Collections and Features are tagged. In the non-strict version a Feature is

```
<gml:featureMember>
  <tdn:SpoorbaanDeel fid="TOP10.4200001">
```

This changes into:

```
<tdn:ruimtelijkeObjectenMember>
  <tdn:SpoorbaanDeel fid="TOP10.4200001">
```

And a collection changes from:

```
<gml:featureMember>
  <tdn:RuimtelijkeObjecten>
```

into:

```
<tdn:top10ThemasMember>
  <tdn:RuimtelijkeObjecten>
```

Chapter 5

GML viewing

One of the basic principles of the conceptual model behind the GML specification is the separation of content and presentation. This of course fits one of the design principles of the TOP10vector project: the distinction between the Digital Landscape Model and the Digital Cartographic Model. As a consequence, the GML prototype files do not contain styling information (color, fill, line width, cartographic symbols) for the feature types.

There are several ways to add style to the GML features:

- when the GML files are imported in / converted into 'normal' GIS or CAD application software, color and style can be applied after the conversion process, with the standard tools that belong to the software. This was how the participants in the GML Relay, organized by the KvAG in June 2001, handled the issue: both LaserScan and Ionic Software imported the GML first and made use of their software's classification menus and procedures after that (see section 5.3).
- when the GML files are meant to be viewed without conversion into the (native) format of existing GIS or CAD software, there are again several possibilities:
    a the organization that provides the GML files also provides one or more files with default styling information. This could itself be an XML file (for example based on the OGC Styled Layer Descriptor recommendation [25], a cascading stylesheet (.css) file (for direct use in Internet browsers) or another kind of parameter file. The viewer software reads both the GML (content) data and the styling parameters and generates the cartographic model
    b the viewer software has an interactive module by which users can select the appropriate color, fill and line width
    c combination of a and b

Because GML is still very new, there are currently not many viewers that can display GML. In order to visually inspect the developed GML prototype we experimented with ways to view the GML data. In this chapter two methods are described: a method based on Java classes that read and graphically represent the GML document (section 5.1), and a method based on transformation of GML into another XML format: SVG (section 5.2).

5.1 Viewer with simple GML parser

At the department of Geodesy a small simple viewer for spatial data is avaiable. This viewer is completely written in Java and can easily be extended. This is done by writing a new 'Loader' module for this new type of data. As a part of his Master's project [22], a student wrote a loader for GML data. The GML loader makes use of the XML parser Xerces [1]. Note that this loader is not a general GML viewer. It can currently only view GML files with a very specific structure and is in no way a generic GML viewer. The short time in which the application was developed however does show that already very useful (free) software support is available on the Internet. In Figure 5.1 a screenshot of this viewer is shown.

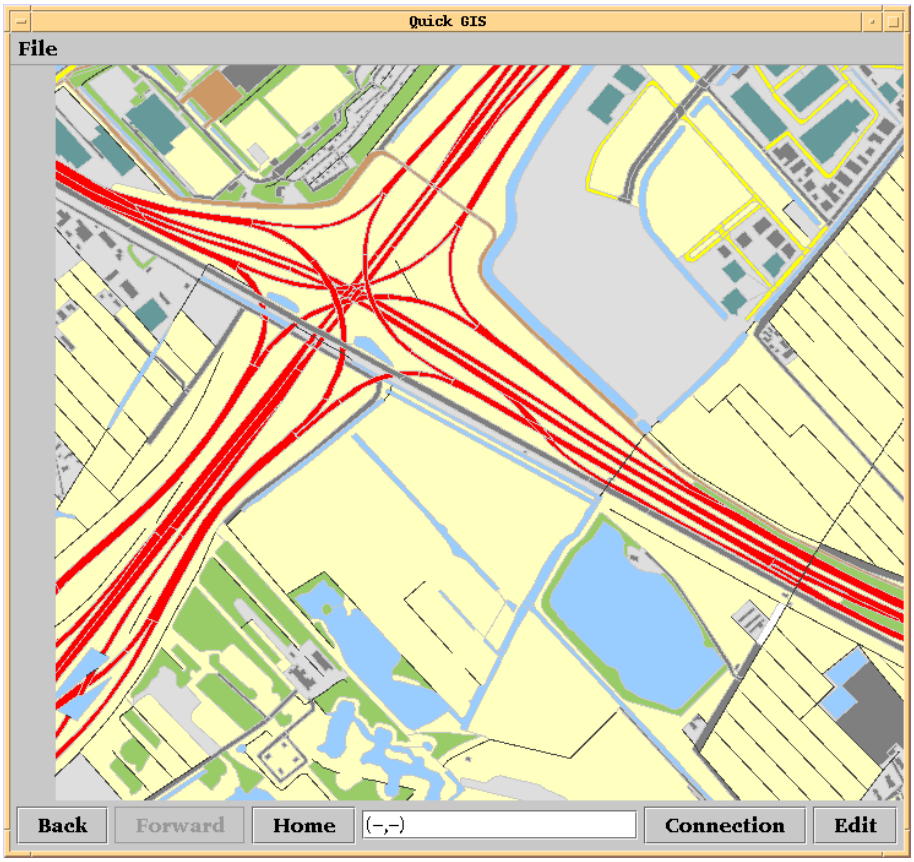

Figure 5.1: GML Viewer

5.2 Converting GML to SVG

The second viewer that was developed is based on the transformation of GML into SVG (= Scalable Vector Graphics). SVG is a new format especially developed for the display of graphic content (pictures and animation) on Internet [33]. It is a standard of the W3C Consortium and can be displayed in standard Internet browsers with the help of a plugin. The transformation from GML into SVG can be done 'on the fly' in the browser or as a batch process with a SVG file as a result. We chose XSLT (= eXtensible Stylesheet Language for Transformations) as tool for the transformation of GML into SVG [44]. The

second step is to embed the SVG in HTML pages. Basic GIS functions like 'zoom', 'pan' and 'identify' can easily be programmed with JavaScript. For the identify operation the original GML files are queried with the help of the unique top10-id (see Figure 5.2)

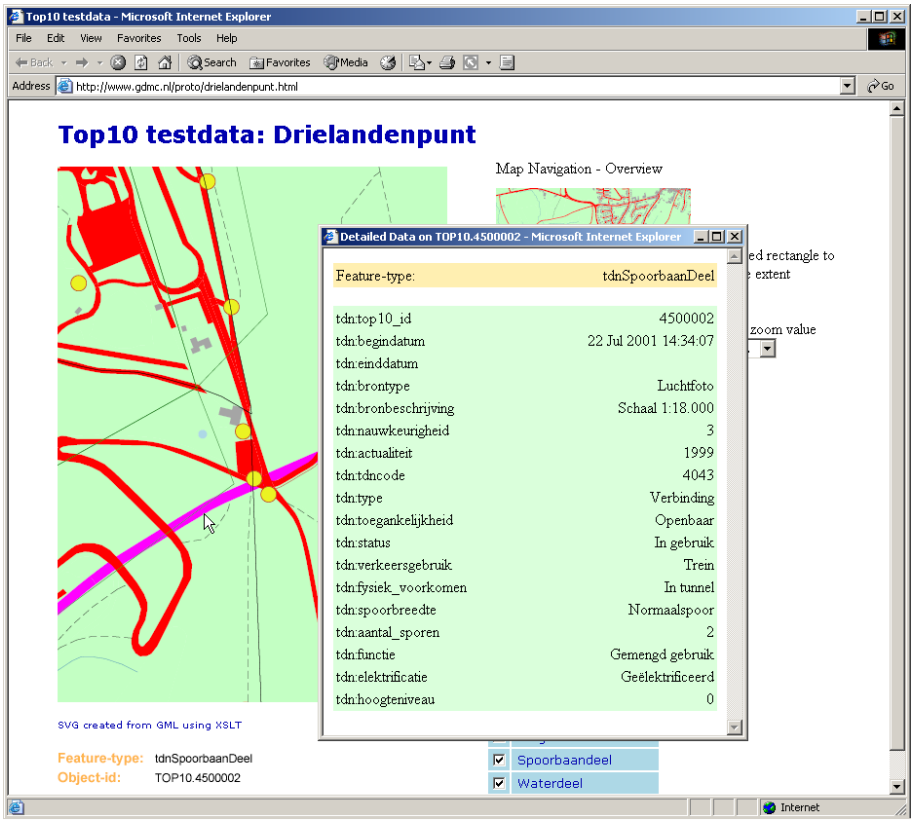

Figure 5.2: Identify functionality

The viewer was built for the TOP10vector project, in order to be able to test the conversion from the datasets provided by the TDN into GML. Some components of the viewer were 'hard coded', for example the drawing order of the map layers (or feature collections, in GML terminology) and the styling parameters (color, line width etc.). The fragment below shows part of the XSLT stylesheet: the drawing order in the output SVG file will be: Terrein as bottom layer, GeografischGebied as top layer.

```
<xsl:template match="/*">

  <xsl:element name="svg">
    <xsl:attribute name = "id">
       <xsl:value-of select = "translate(name(.),':','')"/>
    </xsl:attribute>

    <xsl:apply-templates select="gml:boundedBy" />
    <xsl:attribute name="enableZoomAndPanControls">false</xsl:attribute>
    <xsl:attribute name="zoomAndPan">disable</xsl:attribute>

    <xsl:apply-templates select="//tdn:Terrein" />
    <xsl:apply-templates select="//tdn:WaterDeel[*//gml:Polygon]"/>
    <xsl:apply-templates select="//tdn:WaterDeel[*//gml:LineString]">
```

```
      <xsl:with-param name="geometry" select="'Line'"/></xsl:apply-templates>
    <xsl:apply-templates select="//tdn:SpoorbaanDeel" />
    <xsl:apply-templates select="//tdn:WegDeel[*//gml:Polygon]"/>
    <xsl:apply-templates select="//tdn:WegDeel[*//gml:LineString]" >
       <xsl:with-param name="geometry" select="'Line'"/></xsl:apply-templates>
    <xsl:apply-templates select="//tdn:Bebouwing" />
    <xsl:apply-templates select="//tdn:InrichtingsElement[*//gml:LineString]" >
       <xsl:with-param name="geometry" select="'Line'"/></xsl:apply-templates>
    <xsl:apply-templates select="//tdn:InrichtingsElement[*//gml:Point]"/>
    <xsl:apply-templates select="//tdn:FunctioneelGebied" />
    <xsl:apply-templates select="//tdn:AdministratiefGebied" />
    <xsl:apply-templates select="//tdn:GeografischGebied" />

  </xsl:element>
</xsl:template>

<xsl:template match="gml:featureMember/*" >
  <xsl:param name="geometry"/>

    <xsl:variable name="feature_type" select="name()" />
    <xsl:variable name="style_type" select="translate($feature_type,':', '')"></xsl:variable>
    <xsl:variable name="oid" select="./@fid" />

     ...

    <xsl:apply-templates select="gml:geometryProperty">
      <xsl:with-param name="oid" select="$oid"/>
      <xsl:with-param name="style_type" select="$style_type"/>
    </xsl:apply-templates>

</xsl:template>
```

The output SVG document contains references to the actual styling attributes for each feature layer. The value of these atributes is stored in a separate file (tdn.css, a cascading stylesheet file). The fragment below shows the content of this file.

```
.tdnTerrein { fill:#c3ffc3; stroke:none }
.tdnWaterDeel { fill:lightblue; stroke:none }
.tdnWaterDeelLine { fill:none; stroke:#4f9eb6;stroke-width:0.5pt;stroke-antialiasing:true }
.tdnSpoorbaanDeel { fill:#ff00ff; stroke:none }
.tdnWegDeel { fill:#ff0000; stroke:none }
.tdnWegDeelLine { fill:none;stroke:black;stroke-dasharray:10 5;stroke-width:0.5pt;stroke-antialiasing
.tdnBebouwing { fill:#a5a5a5; stroke:none }
.tdnInrichtingsElementLine { fill:none; stroke:#BF0B22;stroke-width:0.5pt;stroke-antialiasing:true }
.tdnFunctioneelGebied { fill:#fe8240; stroke:none; opacity:0.2; }
.tdnAdministratiefGebied { fill:none; stroke:black;stroke-width:0.5pt;stroke-antialiasing:true }
.tdnGeografischGebied { fill:none; stroke:green;stroke-width:0.5pt;stroke-antialiasing:true }
```

The next step will be to make a viewer that will consist of a generic 'core' in combination with some interactive modules that make it possible for users to change the drawing order of the map layers, or to change the classification, the color, pattern or symbolset for features or feature collections. The XML application schema(s) that contain the

structure of the GML play a crucial role in this respect: the viewer software will have to read the XML Schema(s) first before it can 'understand' the content of the GML data.

This first test with SVG, HTML and JavaScript also showed some technical implementation issues:

- 'browser interoperability' is not always easy: Netscape 4 posed some limitations because it does not 'recognize' XML as a format. As a consequence the identify functionality that reads the GML directly did not work with Netscape 4. But the newer Netscape 6 was not supported yet by the SVG plugin we used (that of Adobe).
- the size in bytes of the SVG that is viewed: when larger than 2.5 Mb performance is slow. Network bandwidth and internal memory of the client computer are the limiting factors.

5.3 Proof of concept: the GML Relay

In order to prove the concept of interoperability, the Netherlands Society for Earth Observation and Geo-informatics (KvAG) has organized a GML Relay on the 12th of June 2001 at the University of Wageningen, the Netherlands [10]. One month before the seminar, each participant (Laser-Scan, Ionic Software and Intergraph) received data in GML 2.0 format (12th of May). Each participant in the relay did (try to):

- read GML (2.0) data from a diskette into the system;
- edit this data (add or modify a few features);
- save the edited data in GML 2.0 and write it to a diskette as input for the next participant.

Both Laser-Scan and Ionic were able to read the GML data with there software. Polygons with more than 100 vertices posed a problem for both products, but other practical problems could be solved. Ionic also showed how to edit and export the data back to an output GML document. (See for a demo of Ionic's visualization of the GML: [18])

Intergraph did not participate on the 12th of June but did a test with a beta-release of their software later. This beta-release did not support the nesting of feature collections and features (yet). Because the GML prototype contains 5 feature collections (besides the root level feature collection) the GML could not be easily imported.

Chapter 6

Conclusions

With the project described, the first steps have been taken to improve the (model for) topographic data in the Netherlands [38, 21, 35, 4]. After careful evaluation of user requirements by CGI [12], ITC has developed a new conceptual schema in UML [20]. The Topographic Service in the Netherlands has enriched a sample data set, which was converted into a GML (2.0) prototype by TU Delft. As much as possible, the schema of this prototype is based on the OpenGIS GML standard. However, the standard has its limits, and some aspects are not yet part of GML 2.0. So, they are currently either in the application part of the XML Schema (such as the temporal attributes at this moment) or are excluded from the prototype (such as topology structure support for a planar partition).

The drawback of putting 'knowledge' (functionality) in an application specific schema and not using a standard schema is that one can not expect implementations of the standard to automatically 'understand' the semantics of the application schemas that are created by organizations for their GML documents. The best one can hope for is that the implementation shows the values of the attributes and relationships correctly. It is too much to ask for, e.g. in the case of the temporal attributes, that any GIS edit software understands how to use and fill the application specific attributes begin date ('begindatum') and end date ('einddatum'). However, once part of the standard, one can expect correct semantical (functional) support for this.

The drawback of not having topology structure in the GML prototypes of the TOP10vector is obvious: there is quite a lot of data redundancy and it is now very difficult to make sure that there are no unwanted gaps or overlaps between the different features within an intended partition. However, it was explicitly decided to keep the model simple (by the TDN) and not to introduce topology structures support in the application schemas. It is interesting to note that the Ordnance Survey in Britain did choose to put topology structures in their application schemas [26, 27, 28]. However, once the next version of GML does support topology structures, they will have to convert their schema to the standard GML (if they want to be able to use the full benefits of the standard).

The support of the GML 2.0 standard (date April 2001) in commercial products in June 2001 during the KvAG GML Relay was somewhat dissapointing and in contrast with the activities of the major Geo-ICT vendors within the OpenGIS consortium and ISO TC211. The used GML test dataset, a predecessor of the TOP10vector GML prototype in this

report, was described in [11]. However, one has to realise that is will take a certain time before a standard is implemented in a certain product. Therefore, the KvAG decided to organise another GML Relay in December 2002. This was also the reason that parts of the evaluation by CGI were done with the ArcView shapefiles instead of the final GML documents. Note that there are some differences in content between the two sets of prototypes, e.g. the GML documents contain a z-value for every coordinate (more details in Chapter 3).

The support of GML by data producers looks very promising. One proof of this was the OEEPE Workshop on XML/GML in November (19-20 at Marne-la-Vallee, Paris, hosted by IGN France). Besides the Ordnance Survey and, of course, the Dutch Topographic Service, other geo-data providers are starting to use GML; for example US Census Bureau [9], Northrhine-Westphalia [6, 30], and again in the Netherlands the Dutch Cadastre. Further, GML is used in many web map/feature server environments created or now being created all over the world.

The OpenGIS Consortium has started GML 3.0 developments with work items such as Topology, Temporal, Geometry Extensions, Units of Measure, Spatial Reference Systems, Spatial Locator, Meta-data Mechanisms, Default Styling and Points of Interest/Areas of Interest. It is obvious that standardisation in these areas will further improve true interoperability. Very important, but not without difficulty and discussion, is the requirement to keep GML in harmony with the ISO TC211 standards. The work item 'Default Styling' may form a bridge between the DLM and DCM.

Appendix A

FME scripts

This Appendix contains the three FME scripts used in the conversion process.

A.1 Design file to Oracle conversion

```
# 21
# dgn2ora.fme  16-07-2001  TT
#
# ============================================================================
# The following line defines the title presented to the user when this
# mapping file is run through the FME GUI.

GUI TITLE TOP10 objects - IGDS to ORACLE 8i translation

# ============================================================================
# The following line names the log file to which useful statistics about
# the translation will be written.

LOG_FILENAME dgn2ora.log
LOG_APPEND YES
LOG_MAX_FEATURES 20

# ============================================================================
# The following line instructs the FME to log any features that do not
# match any of the source feature patterns listed further down in
# this file. Uncorrelated features do not match any source specification,
# ungrouped features do not have any corresponding _DEF line.
# Also additional information can be produced by factories if included here.
# FME_DEBUG UNGROUPED UNCORRELATED MAPPING_FILE
#           DonutFactory ReferenceFactory PolygonDissolveFactory

FME_DEBUG UNGROUPED UNCORRELATED ReferenceFactory PolygonDissolveFactory

# ============================================================================
# The following two lines define the type of reader and writer to be
# used for this translation.

READER_TYPE IGDS
WRITER_TYPE ORACLE8I

# ============================================================================
# ============================================================================

# The following GUI line prompts for a file to be used as the
# source of the Microstation design file.

DEFAULT_MACRO SourceDataset D:\Top10_proef\Data
```

```
GUI FILENAME SourceDataset Design_Files(*.dgn)|*.dgn|All_files(*.*)|*.* IGDS input dataset:
IGDS_DATASET "$(SourceDataset)"

# ========================================================================
# The following line controls how all the FME coordinates read from the
# design file will be interpreted. Valid values:
#   IGDS_MASTER_UNITS -- FME coordinates are treated as Master Units
#   IGDS_SUB_UNITS    -- FME coordinates are treated as Sub Units
#   IGDS_UORS         -- FME coordinates are treated as UORs
# for TDN design files: master_units=km, sub_units=m, uors=mm

DEFAULT_MACRO _IN_UNITS IGDS_SUB_UNITS
GUI CHOICE _IN_UNITS IGDS_MASTER_UNITS%IGDS_SUB_UNITS%IGDS_UORS Input units (km / m / mm):
IGDS_UNITS $(_IN_UNITS)

# ========================================================================
# Ask for input data types to process

DEFAULT_MACRO _Keep_shapes YES
GUI CHOICE _Keep_shapes YES%NO Convert shapes:

DEFAULT_MACRO _Keep_lines NO
GUI CHOICE _Keep_lines NO%YES Convert lines:

DEFAULT_MACRO _Keep_texts NO
GUI CHOICE _Keep_texts NO%YES Convert texts (as points):

DEFAULT_MACRO _Keep_ellipses NO
GUI CHOICE _Keep_ellipses NO%as_Areas%as_Points Convert ellipses:

DEFAULT_MACRO _Poly_dissolve NO
GUI CHOICE _Poly_dissolve NO%YES Dissolve polygons:

# ========================================================================
# Ask for output table name

DEFAULT_MACRO _TabOut top10_layer
GUI TEXT _TabOut Output table name:

# ========================================================================
# Ask for OID offset

DEFAULT_MACRO _Oid_offset 1400001
GUI INTEGER _Oid_offset Object ID offset:

MACRO _Top10_einddatum ""
# ========================================================================
# The following line controls whether or not cell elements are to be
# expanded by the FME as it reads the source file.

DEFAULT_MACRO _XPNDCELL YES
# GUI CHOICE _XPNDCELL YES%NO Expand Cells:
IGDS_EXPAND_CELLS $(_XPNDCELL)

# The following line controls whether or not tag elements are to be
# output as text by the FME as it reads the source file.

DEFAULT_MACRO _TEXTTAGS YES
# GUI CHOICE _TEXTTAGS YES%NO Output Tags As Text:
IGDS_TAGS_AS_TEXT $(_TEXTTAGS)

# ========================================================================
# Various layer creation parameters.

DEFAULT_MACRO _ORACLE_Dimension 2
#GUI CHOICE _ORACLE_Dimension 2%3 Geometric dimension:
ORACLE_DIM $(_ORACLE_Dimension)

DEFAULT_MACRO _ORACLE_Minx -25000
```

```
DEFAULT_MACRO _ORACLE_Miny 275000
DEFAULT_MACRO _ORACLE_Minz   -100
DEFAULT_MACRO _ORACLE_Maxx 325000
DEFAULT_MACRO _ORACLE_Maxy 650000
DEFAULT_MACRO _ORACLE_Maxz   1000

# Oracle configuration parameters

MACRO _ORACLE_Config                          \
      oracle_model          object            \
      oracle_dim            $(_ORACLE_Dimension) \
      oracle_min_x          $(_ORACLE_Minx)     \
      oracle_min_y          $(_ORACLE_Miny)     \
      oracle_min_z          $(_ORACLE_Minz)     \
      oracle_max_x          $(_ORACLE_Maxx)     \
      oracle_max_y          $(_ORACLE_Maxy)     \
      oracle_max_z          $(_ORACLE_Maxz)     \
      oracle_create_indices NO

ORACLE8I_SERVER_TYPE ORACLE8i
ORACLE8I_TRANSACTION 0

# ============================================================================
# The following GUIs prompt for the name of the Oracle Service,
# Username (and Password) to which data will be written.

DEFAULT_MACRO DestDataset igis
#GUI TEXT DestDataset Destination Oracle service:
ORACLE8I_DATASET "$(DestDataset)"

DEFAULT_MACRO _ORACLE_UserName gouda
GUI TEXT _ORACLE_UserName Oracle username:
ORACLE8I_USER_NAME "$(_ORACLE_UserName)"

DEFAULT_MACRO _ORACLE_Password gouda
GUI PASSWORD _ORACLE_Password Oracle password:
ORACLE8I_PASSWORD "$(_ORACLE_Password)"

# ============================================================================
# Some parameters for functions used later

FME_ARC_DEGREES_PER_EDGE 1
FME_ARC_EDGE_TOLERANCE 0.01

# ============================================================================
# ============================================================================

# This factory makes the feature type be the element type -- after it is looked
# up in a table -- and also saves the level in an attribute called igds_level

Lookup IgdsTypeToGroupLUT         \
     igds_cell         cells      \
     igds_point        points     \
     igds_line         lines      \
     igds_shape        shapes     \
     igds_text_node    text_nodes \
     igds_curve        curves     \
     igds_ellipse      ellipses   \
     igds_arc          arcs       \
     igds_text         text       \
     igds_multi_text   multi_text \
     igds_solid        solids

FACTORY_DEF * SamplingFactory     \
   FACTORY_NAME AssignFeatureType \
   SAMPLE_RATE 1                  \
   INPUT FEATURE_TYPE *           \
      igds_level @FeatureType()   \
      @FeatureType("@Lookup(IgdsTypeToGroupLUT,&igds_type)")
```

```
# ============================================================================
# These factories are used to filter (select) input features,
# retrieve required attributes and to assign object-id to features

# Retrieve attributes and check for TDNcode

FACTORY_DEF IGDS TestFactory                              \
   FACTORY_NAME SelectValidTdncode                        \
   INPUT FEATURE_TYPE shapes igds_element_type 14         \
      @SupplyAttributes(tdncode,&igds_linkage{1}.word{3}) \
      @SupplyAttributes(word_1, &igds_linkage{1}.word{1}) \
      @SupplyAttributes(word_4, &igds_linkage{1}.word{4}) \
   INPUT FEATURE_TYPE *                                   \
      @SupplyAttributes(tdncode,&igds_linkage{0}.word{3}) \
      @SupplyAttributes(word_1, &igds_linkage{0}.word{1}) \
      @SupplyAttributes(word_4, &igds_linkage{0}.word{4}) \
   TEST "&tdncode" != ""                                  \
      OUTPUT PASSED FEATURE_TYPE *                        \
         objectNr @Count(objectid,$(_Oid_offset))         \
      OUTPUT FAILED FEATURE_TYPE Elements_without_TDNcode
#         @Log("NoTdnCode")

FACTORY_DEF * TestFactory                      \
   FACTORY_NAME ShapeFilter                    \
   INPUT FEATURE_TYPE shapes                   \
   TEST "$(_Keep_shapes)" = "YES"              \
      OUTPUT PASSED FEATURE_TYPE shapes        \
         @KeepAttributes(objectNr,tdncode,word_1,word_4)

FACTORY_DEF * TestFactory                      \
   FACTORY_NAME LineFilter                     \
   INPUT FEATURE_TYPE lines                    \
   TEST "$(_Keep_lines)" = "YES"               \
      OUTPUT PASSED FEATURE_TYPE $(_TabOut)

FACTORY_DEF * TestFactory                      \
   FACTORY_NAME EllipseAreaFilter              \
   INPUT FEATURE_TYPE ellipses                 \
   TEST "$(_Keep_ellipses)" = "as_Areas"       \
      OUTPUT PASSED FEATURE_TYPE $(_TabOut)    \
         output_type area                      \
      OUTPUT FAILED FEATURE_TYPE *

FACTORY_DEF * TestFactory                      \
   FACTORY_NAME EllipsePointFilter             \
   INPUT FEATURE_TYPE ellipses                 \
   TEST "$(_Keep_ellipses)" = "as_Points"      \
      OUTPUT PASSED FEATURE_TYPE $(_TabOut)    \
         output_type point

FACTORY_DEF * TestFactory                      \
   FACTORY_NAME TextFilter                     \
   INPUT FEATURE_TYPE text                     \
   TEST "$(_Keep_texts)" = "YES"               \
      OUTPUT PASSED FEATURE_TYPE $(_TabOut)

# ============================================================================
# Factory pipeline to create polygons with outer/inner boundaries

# Save attributes for later use (in attribute-only copy of features)

FACTORY_DEF IGDS TeeFactory                       \
   FACTORY_NAME SaveAttributes                    \
   INPUT FEATURE_TYPE shapes                      \
   OUTPUT FEATURE_TYPE dgn_polys                  \
   OUTPUT FEATURE_TYPE object_attr                \
      @RemoveGeometry()
#      @Log("AttributesSaved")
```

```
# Determine self-intersections of polygons

FACTORY_DEF IGDS IntersectionFactory              \
   FACTORY_NAME CalcNodes1                        \
   INPUT FEATURE_TYPE dgn_polys                   \
   OVERLAP_COUNT_ATTRIBUTE numIntersections       \
   SELF_INTERSECTION_ONLY                         \
   VERBOSE                                        \
   OUTPUT SEGMENT FEATURE_TYPE segments1
#      segNr @Count(segcount1)
#      @Log("Segment1Created",-1)

# Re-calculate intersections in case we missed some the first time round

FACTORY_DEF IGDS IntersectionFactory              \
   FACTORY_NAME CalcNodes2                        \
   INPUT FEATURE_TYPE segments1                   \
   OVERLAP_COUNT_ATTRIBUTE numIntersections       \
   SELF_INTERSECTION_ONLY                         \
   VERBOSE                                        \
   OUTPUT SEGMENT FEATURE_TYPE segments2
#      segNr @Count(segcount2)
#      @Log("Segment2Created",-1)

# Create closed circuits (base polygons) from segments
# (in rare cases unwanted lines are attached to the polygons)

FACTORY_DEF IGDS PolygonFactory                   \
   FACTORY_NAME CreatePolygons1                   \
   INPUT FEATURE_TYPE segments2                   \
   REMOVE_CORRIDORS                               \
   GROUP_BY objectNr                              \
   VERTEX_NODED                                   \
   OUTPUT POLYGON FEATURE_TYPE polys1
#      @Log("Polygon1Created",-1)

# Calculate intersections for the third time (now we are really clean)

FACTORY_DEF IGDS IntersectionFactory              \
   FACTORY_NAME CalcNodes3                        \
   INPUT FEATURE_TYPE polys1                      \
   OVERLAP_COUNT_ATTRIBUTE numIntersections       \
   SELF_INTERSECTION_ONLY                         \
   VERBOSE                                        \
   OUTPUT SEGMENT FEATURE_TYPE segments3
#      segNr @Count(segcount3)
#      @Log("Segment3Created",-1)

# So now we can create clean polygons

FACTORY_DEF IGDS PolygonFactory                   \
   FACTORY_NAME CreatePolygons2                   \
   INPUT FEATURE_TYPE segments3                   \
   REMOVE_CORRIDORS                               \
   GROUP_BY objectNr                              \
   VERTEX_NODED                                   \
   OUTPUT POLYGON FEATURE_TYPE polygons2
#      @Log("Polygon2Created",-1)

# Create final polygons including holes

FACTORY_DEF IGDS DonutFactory                     \
   FACTORY_NAME AddHoles                          \
   INPUT FEATURE_TYPE polygons2                   \
   DROP_HOLES YES                                 \
   GROUP_BY objectNr                              \
   OUTPUT DONUT FEATURE_TYPE object_geom          \
   OUTPUT POLYGON FEATURE_TYPE object_geom
```

```
#      @Log("PolygonCreated")

# Join attributes again with geometry

FACTORY_DEF IGDS ReferenceFactory                \
   FACTORY_NAME JoinGeomAttr                     \
   INPUT REFERENCER FEATURE_TYPE object_geom     \
   INPUT REFERENCEE FEATURE_TYPE object_attr     \
   GROUP_BY objectNr                             \
   REFERENCEE_FIELDS objectNr                    \
   REFERENCER_FIELDS objectNr                    \
   REFERENCE_INFO ATTRIBUTES                     \
   OUTPUT COMPLETE FEATURE_TYPE top10polygons    \
      top10type polygon
#      @Log("GeomAttrJoined")

# ============================================================================
# Factory pipeline to dissolve polygons with identical attribute values
# on tdncode, word_1 and word_4

FACTORY_DEF * TestFactory                        \
   FACTORY_NAME DissolveSwitch                   \
   INPUT FEATURE_TYPE top10polygons              \
   TEST "$(_Poly_dissolve)" = "YES"              \
   OUTPUT PASSED FEATURE_TYPE top10polygons      \
   OUTPUT FAILED FEATURE_TYPE $(_TabOut)

# Calculate polygon topology

FACTORY_DEF IGDS TopologyFactory                 \
   FACTORY_NAME MakePolyTopology                 \
   INPUT FEATURE_TYPE top10polygons              \
   GROUP_BY tdncode word_1 word_4                \
   ARC_NUMBER_ATTR arcId                         \
   RIGHT_POLY_ATTR rPolyId                       \
   LEFT_POLY_ATTR lPolyId                        \
   POLYGONS_ATTR polyIds                         \
   POLYGON_NUMBER_ATTR polyNr                    \
   ARCS_ATTR arcList                             \
   OUTPUT POLYGON FEATURE_TYPE topolpolys
#      @Log("TopPolyCreated")

# Dissolve interior lines

FACTORY_DEF IGDS PolygonDissolveFactory          \
   FACTORY_NAME DissolvePolygons                 \
   INPUT FEATURE_TYPE topolpolys                 \
   GROUP_BY tdncode word_1 word_4                \
   LIST_NAME origPoly                            \
   DISSOLVE_COUNT_ATTRIBUTE polysMerged          \
   OUTPUT POLYGON FEATURE_TYPE $(_TabOut)
#      @Log("DissolvedPolyCreated")

# ============================================================================
#
# The transformation section of the mapping file starts here. Each of
# the _DEF lines describes the data model of the particular feature
# type, and the correlation lines describe how the feature is
# transformed from the source type to the destination type.
#
# ============================================================================
# ============================================================================

# Oracle table definition

ORACLE8I_DEF $(_TabOut)                      \
    $(_ORACLE_Config)                        \
    OID                 number(12,0)         \
    BEGINDATUM          varchar2(20)         \
```

```
    EINDDATUM           varchar2(20)        \
    BRONTYPE            varchar2(32)        \
    BRONBESCHRIJVING    varchar2(32)        \
    NAUWKEURIGHEID      varchar2(32)        \
    ACTUALITEIT         varchar2(20)        \
    GEOM                geometry            \
    WORD_1              number(12,0)        \
    TDNCODE             number(12,0)        \
    WORD_4              number(12,0)

########### Translation of areas ####################################

IGDS $(_TabOut)                             \
    top10type           polygon             \
    objectNr            %transferId         \
    tdncode             %tr_tdncode         \
    word_1              %tr_word_1          \
    word_4              %tr_word_4

ORACLE8I $(_TabOut)                         \
    oracle_type         oracle_area         \
    OID                 %transferId         \
    BEGINDATUM          @Timestamp("^d ^b ^Y ^X") \
    EINDDATUM           $(_Top10_einddatum) \
    TDNCODE             %tr_tdncode         \
    WORD_1              %tr_word_1          \
    WORD_4              %tr_word_4

########### Translation of lines #####################################

IGDS $(_TabOut)                             \
    igds_type           igds_line           \
    objectNr            %transferId         \
    tdncode             %tr_tdncode         \
    word_1              %tr_word_1          \
    word_4              %tr_word_4

ORACLE8I $(_TabOut)                         \
    oracle_type         oracle_line         \
    OID                 %transferId         \
    BEGINDATUM          @Timestamp("^d ^b ^Y ^X") \
    EINDDATUM           $(_Top10_einddatum) \
    TDNCODE             %tr_tdncode         \
    WORD_1              %tr_word_1          \
    WORD_4              %tr_word_4

########### Translation of points (from text elements) ##############

IGDS $(_TabOut)                             \
    igds_type           igds_text           \
    objectNr            %transferId         \
    tdncode             %tr_tdncode         \
    word_1              %tr_word_1          \
    word_4              %tr_word_4

ORACLE8I $(_TabOut)                         \
    oracle_type         oracle_point        \
    OID                 %transferId         \
    BEGINDATUM          @Timestamp("^d ^b ^Y ^X") \
    EINDDATUM           $(_Top10_einddatum) \
    TDNCODE             %tr_tdncode         \
    WORD_1              %tr_word_1          \
    WORD_4              %tr_word_4

########### Translation of ellipses ##################################

########### ellipses converted to areas

IGDS $(_TabOut)                             \
```

```
    igds_type            igds_ellipse         \
    output_type          area                 \
    objectNr             %transferId          \
    igds_primary_axis    %igds_primary_axis   \
    igds_secondary_axis  %igds_secondary_axis \
    igds_rotation        %igds_rotation       \
    tdncode              %tr_tdncode          \
    word_1               %tr_word_1           \
    word_4               %tr_word_4

ORACLE8I $(_TabOut)                           \
    oracle_type          oracle_area          \
    OID                  %transferId          \
    BEGINDATUM           @Timestamp("^d ^b ^Y ^X") \
    EINDDATUM            $(_Top10_einddatum)  \
    TDNCODE              %tr_tdncode          \
    WORD_1               %tr_word_1           \
    WORD_4               %tr_word_4           \
    @Arc(%igds_primary_axis,%igds_secondary_axis,0,%igds_rotation)

########### ellipses converted to points

IGDS $(_TabOut)                               \
    igds_type            igds_ellipse         \
    output_type          point                \
    objectNr             %transferId          \
    tdncode              %tr_tdncode          \
    word_1               %tr_word_1           \
    word_4               %tr_word_4

ORACLE8I $(_TabOut)                           \
    oracle_type          oracle_point         \
    OID                  %transferId          \
    BEGINDATUM           @Timestamp("^d ^b ^Y ^X") \
    EINDDATUM            $(_Top10_einddatum)  \
    TDNCODE              %tr_tdncode          \
    WORD_1               %tr_word_1           \
    WORD_4               %tr_word_4           \
    @ConvertToPoint()

# ================================================================================
# ================================================================================
```

A.2 Oracle to shapefile conversion

```
# 10
# ora2shape.fme  16-07-2001  TT
#
# ================================================================================
# The following line defines the title presented to the user when this
# mapping file is run through the FME GUI.

GUI TITLE TOP10 objects - ORACLE 8i to SHAPE translation

# ================================================================================
# The following line names the log file to which useful statistics about
# the translation will be written.

LOG_FILENAME ora2shape.log
LOG_APPEND YES

FME_DEBUG UNGROUPED UNCORRELATED
# ================================================================================
# The following two lines define the type of reader and writer to be
# used for this translation.
```

```
READER_TYPE ORACLE8I
WRITER_TYPE SHAPE

# ========================================================================
# ========================================================================

# The following GUI lines prompt for the username, password and service
# to use for accessing Oracle Spatial

DEFAULT_MACRO _ORACLE_UserName tiel
GUI TEXT _ORACLE_UserName Oracle username:
ORACLE8I_USER_NAME "$(_ORACLE_UserName)"

DEFAULT_MACRO _ORACLE_Password tiel
GUI PASSWORD _ORACLE_Password Oracle password:
ORACLE8I_PASSWORD "$(_ORACLE_Password)"

DEFAULT_MACRO SourceDataset igis
#GUI TEXT SourceDataset Source Oracle service:
ORACLE8I_DATASET "$(SourceDataset)"

ORACLE8I_SERVER_TYPE ORACLE8i

# ========================================================================

DEFAULT_MACRO admTable ADMINISTRATIEF_GEBIED
GUI CHOICE admTable ADMINISTRATIEF_GEBIED%No Include Administratief_gebied:

DEFAULT_MACRO bebTable BEBOUWING
GUI CHOICE bebTable BEBOUWING%No Include Bebouwing:

DEFAULT_MACRO behTable BEHEERSGEBIED
GUI CHOICE behTable BEHEERSGEBIED%No Include Beheersgebied:

DEFAULT_MACRO funTable FUNCTIONEEL_GEBIED
GUI CHOICE funTable FUNCTIONEEL_GEBIED%No Include Functioneel_gebied:

DEFAULT_MACRO geoTable GEOGRAFISCH_GEBIED
GUI CHOICE geoTable GEOGRAFISCH_GEBIED%No Include Geografisch_gebied:

DEFAULT_MACRO inrTable INRICHTINGSELEMENT
GUI CHOICE inrTable INRICHTINGSELEMENT%No Include Inrichtingselement:

DEFAULT_MACRO spoTable SPOORBAANDEEL
GUI CHOICE spoTable SPOORBAANDEEL%No Include Spoorbaandeel:

DEFAULT_MACRO terTable TERREIN
GUI CHOICE terTable TERREIN%No Include Terrein:

DEFAULT_MACRO watTable WATERDEEL
GUI CHOICE watTable WATERDEEL%No Include Waterdeel:

DEFAULT_MACRO wegTable WEGDEEL
GUI CHOICE wegTable WEGDEEL%No Include Wegdeel:

ORACLE8I_IDs $(admTable) $(bebTable) $(behTable) $(funTable) $(geoTable) \
             $(inrTable) $(spoTable) $(terTable) $(watTable) $(wegTable)

# ========================================================================
# The following GUI line prompts for a directory to be used as the
# the destination for the ESRI shapefiles.

DEFAULT_MACRO DestDataset D:\Top10_proef\Data
GUI DIRNAME DestDataset Destination shapefiles directory:
SHAPE_DATASET "$(DestDataset)"

# ========================================================================
# ========================================================================
# The main body of the mapping file starts here. Each of the
```

```
# _DEF lines describes the data model of the particular feature
# type, and the correlation lines describe how the feature is
# transformed from the source type to the destination type.

ORACLE8I_DEF ADMINISTRATIEF_GEBIED              \
    OID                 number(12)              \
    BEGINDATUM          varchar2(20)            \
    EINDDATUM           varchar2(20)            \
    BRONTYPE            varchar2(32)            \
    BRONBESCHRIJVING    varchar2(32)            \
    NAUWKEURIGHEID      varchar2(32)            \
    ACTUALITEIT         varchar2(20)            \
    TYPE                varchar2(32)            \
    NAAM                varchar2(32)            \
    TDNCODE             number(12)

SHAPE_DEF ADMINISTRATIEF_GEBIED_area            \
    SHAPE_GEOMETRY      shape_polygon           \
    OID                 number(11,0)            \
    BEGINDATUM          char(20)                \
    EINDDATUM           char(20)                \
    BRONTYPE            char(32)                \
    BRONBESCHR          char(32)                \
    NAUWKEURIG          char(32)                \
    ACTUALITEI          char(20)                \
    TYPE                char(32)                \
    NAAM                char(32)                \
    TDNCODE             number(11,0)

ORACLE8I ADMINISTRATIEF_GEBIED                  \
    oracle_type         oracle_area             \
    OID                 %OID                    \
    BEGINDATUM          %BEGINDATUM             \
    EINDDATUM           %EINDDATUM              \
    BRONTYPE            %BRONTYPE               \
    BRONBESCHRIJVING    %BRONBESCHRIJVING       \
    NAUWKEURIGHEID      %NAUWKEURIGHEID         \
    ACTUALITEIT         %ACTUALITEIT            \
    TYPE                %TYPE                   \
    NAAM                %NAAM                   \
    TDNCODE             %TDNCODE

SHAPE ADMINISTRATIEF_GEBIED_area                \
    OID                 %OID                    \
    BEGINDATUM          %BEGINDATUM             \
    EINDDATUM           %EINDDATUM              \
    BRONTYPE            %BRONTYPE               \
    BRONBESCHR          %BRONBESCHRIJVING       \
    NAUWKEURIG          %NAUWKEURIGHEID         \
    ACTUALITEI          %ACTUALITEIT            \
    TYPE                %TYPE                   \
    NAAM                %NAAM                   \
    TDNCODE             %TDNCODE

# ============================================================================

ORACLE8I_DEF BEBOUWING                          \
    OID                 number(12)              \
    BEGINDATUM          varchar2(20)            \
    EINDDATUM           varchar2(20)            \
    BRONTYPE            varchar2(32)            \
    BRONBESCHRIJVING    varchar2(32)            \
    NAUWKEURIGHEID      varchar2(32)            \
    ACTUALITEIT         varchar2(20)            \
    TYPE                varchar2(32)            \
    FUNCTIE             varchar2(32)            \
    HOOGTEKLASSE        varchar2(32)            \
    HOOGTE              varchar2(32)            \
    STATUS              varchar2(32)            \
```

```
    NAAM                varchar2(32)          \
    HOOGTENIVEAU        number(12)            \
    TDNCODE             number(12)

SHAPE_DEF BEBOUWING_area                      \
    SHAPE_GEOMETRY      shape_polygon         \
    OID                 number(11,0)          \
    BEGINDATUM          char(20)              \
    EINDDATUM           char(20)              \
    BRONTYPE            char(32)              \
    BRONBESCHR          char(32)              \
    NAUWKEURIG          char(32)              \
    ACTUALITEI          char(20)              \
    TYPE                char(32)              \
    FUNCTIE             char(32)              \
    HOOGTEKLAS          char(32)              \
    HOOGTE              char(32)              \
    STATUS              char(32)              \
    NAAM                char(32)              \
    HOOGTENIVE          number(11,0)          \
    TDNCODE             number(11,0)

ORACLE8I BEBOUWING                            \
    oracle_type         oracle_area           \
    OID                 %OID                  \
    BEGINDATUM          %BEGINDATUM           \
    EINDDATUM           %EINDDATUM            \
    BRONTYPE            %BRONTYPE             \
    BRONBESCHRIJVING    %BRONBESCHRIJVING     \
    NAUWKEURIGHEID      %NAUWKEURIGHEID       \
    ACTUALITEIT         %ACTUALITEIT          \
    TYPE                %TYPE                 \
    FUNCTIE             %FUNCTIE              \
    HOOGTEKLASSE        %HOOGTEKLASSE         \
    HOOGTE              %HOOGTE               \
    STATUS              %STATUS               \
    NAAM                %NAAM                 \
    HOOGTENIVEAU        %HOOGTENIVEAU         \
    TDNCODE             %TDNCODE

SHAPE BEBOUWING_area                          \
    OID                 %OID                  \
    BEGINDATUM          %BEGINDATUM           \
    EINDDATUM           %EINDDATUM            \
    BRONTYPE            %BRONTYPE             \
    BRONBESCHR          %BRONBESCHRIJVING     \
    NAUWKEURIG          %NAUWKEURIGHEID       \
    ACTUALITEI          %ACTUALITEIT          \
    TYPE                %TYPE                 \
    FUNCTIE             %FUNCTIE              \
    HOOGTEKLAS          %HOOGTEKLASSE         \
    HOOGTE              %HOOGTE               \
    STATUS              %STATUS               \
    NAAM                %NAAM                 \
    HOOGTENIVE          %HOOGTENIVEAU         \
    TDNCODE             %TDNCODE

# ============================================================================

ORACLE8I_DEF FUNCTIONEEL_GEBIED               \
    OID                 number(12)            \
    BEGINDATUM          varchar2(20)          \
    EINDDATUM           varchar2(20)          \
    BRONTYPE            varchar2(32)          \
    BRONBESCHRIJVING    varchar2(32)          \
    NAUWKEURIGHEID      varchar2(32)          \
    ACTUALITEIT         varchar2(20)          \
    TYPE                varchar2(128)         \
    NAAM                varchar2(32)          \
```

```
    TDNCODE             number(12)

SHAPE_DEF FUNCTIONEEL_GEBIED_area              \
    SHAPE_GEOMETRY      shape_polygon          \
    OID                 number(11,0)           \
    BEGINDATUM          char(20)               \
    EINDDATUM           char(20)               \
    BRONTYPE            char(32)               \
    BRONBESCHR          char(32)               \
    NAUWKEURIG          char(32)               \
    ACTUALITEI          char(20)               \
    TYPE                char(64)               \
    NAAM                char(32)               \
    TDNCODE             number(11,0)

ORACLE8I FUNCTIONEEL_GEBIED                    \
    oracle_type         oracle_area            \
    OID                 %OID                   \
    BEGINDATUM          %BEGINDATUM            \
    EINDDATUM           %EINDDATUM             \
    BRONTYPE            %BRONTYPE              \
    BRONBESCHRIJVING    %BRONBESCHRIJVING      \
    NAUWKEURIGHEID      %NAUWKEURIGHEID        \
    ACTUALITEIT         %ACTUALITEIT           \
    TYPE                %TYPE                  \
    NAAM                %NAAM                  \
    TDNCODE             %TDNCODE

SHAPE FUNCTIONEEL_GEBIED_area                  \
    OID                 %OID                   \
    BEGINDATUM          %BEGINDATUM            \
    EINDDATUM           %EINDDATUM             \
    BRONTYPE            %BRONTYPE              \
    BRONBESCHR          %BRONBESCHRIJVING      \
    NAUWKEURIG          %NAUWKEURIGHEID        \
    ACTUALITEI          %ACTUALITEIT           \
    TYPE                %TYPE                  \
    NAAM                %NAAM                  \
    TDNCODE             %TDNCODE

# ============================================================================

ORACLE8I_DEF GEOGRAFISCH_GEBIED                \
    OID                 number(12)             \
    BEGINDATUM          varchar2(20)           \
    EINDDATUM           varchar2(20)           \
    BRONTYPE            varchar2(32)           \
    BRONBESCHRIJVING    varchar2(32)           \
    NAUWKEURIGHEID      varchar2(32)           \
    ACTUALITEIT         varchar2(20)           \
    TYPE                varchar2(32)           \
    NAAM                varchar2(32)           \
    TDNCODE             number(12)

SHAPE_DEF GEOGRAFISCH_GEBIED_area              \
    SHAPE_GEOMETRY      shape_polygon          \
    OID                 number(11,0)           \
    BEGINDATUM          char(20)               \
    EINDDATUM           char(20)               \
    BRONTYPE            char(32)               \
    BRONBESCHR          char(32)               \
    NAUWKEURIG          char(32)               \
    ACTUALITEI          char(20)               \
    TYPE                char(32)               \
    NAAM                char(32)               \
    TDNCODE             number(11,0)

ORACLE8I GEOGRAFISCH_GEBIED                    \
    oracle_type         oracle_area            \
```

```
    OID                 %OID                \
    BEGINDATUM          %BEGINDATUM         \
    EINDDATUM           %EINDDATUM          \
    BRONTYPE            %BRONTYPE           \
    BRONBESCHRIJVING    %BRONBESCHRIJVING   \
    NAUWKEURIGHEID      %NAUWKEURIGHEID     \
    ACTUALITEIT         %ACTUALITEIT        \
    TYPE                %TYPE               \
    NAAM                %NAAM               \
    TDNCODE             %TDNCODE

SHAPE GEOGRAFISCH_GEBIED_area               \
    OID                 %OID                \
    BEGINDATUM          %BEGINDATUM         \
    EINDDATUM           %EINDDATUM          \
    BRONTYPE            %BRONTYPE           \
    BRONBESCHR          %BRONBESCHRIJVING   \
    NAUWKEURIG          %NAUWKEURIGHEID     \
    ACTUALITEI          %ACTUALITEIT        \
    TYPE                %TYPE               \
    NAAM                %NAAM               \
    TDNCODE             %TDNCODE

# ============================================================================

ORACLE8I_DEF INRICHTINGSELEMENT             \
    OID                 number(12)          \
    BEGINDATUM          varchar2(20)        \
    EINDDATUM           varchar2(20)        \
    BRONTYPE            varchar2(32)        \
    BRONBESCHRIJVING    varchar2(32)        \
    NAUWKEURIGHEID      varchar2(32)        \
    ACTUALITEIT         varchar2(20)        \
    TYPE                varchar2(32)        \
    FUNCTIE             varchar2(32)        \
    HOOGTE              varchar2(32)        \
    NAAM                varchar2(32)        \
    NUMMER              varchar2(32)        \
    STATUS              varchar2(32)        \
    HOOGTENIVEAU        number(12)          \
    TDNCODE             number(12)

SHAPE_DEF INRICHTINGSELEMENT_point          \
    SHAPE_GEOMETRY      shape_point         \
    OID                 number(11,0)        \
    BEGINDATUM          char(20)            \
    EINDDATUM           char(20)            \
    BRONTYPE            char(32)            \
    BRONBESCHR          char(32)            \
    NAUWKEURIG          char(32)            \
    ACTUALITEI          char(20)            \
    TYPE                char(32)            \
    FUNCTIE             char(32)            \
    HOOGTE              char(32)            \
    NAAM                char(32)            \
    NUMMER              char(32)            \
    STATUS              char(32)            \
    HOOGTENIVE          number(11,0)        \
    TDNCODE             number(11,0)

SHAPE_DEF INRICHTINGSELEMENT_line           \
    SHAPE_GEOMETRY      shape_polyline      \
    OID                 number(11,0)        \
    BEGINDATUM          char(20)            \
    EINDDATUM           char(20)            \
    BRONTYPE            char(32)            \
    BRONBESCHR          char(32)            \
    NAUWKEURIG          char(32)            \
    ACTUALITEI          char(20)            \
```

```
    TYPE                char(32)            \
    FUNCTIE             char(32)            \
    HOOGTE              char(32)            \
    NAAM                char(32)            \
    NUMMER              char(32)            \
    STATUS              char(32)            \
    HOOGTENIVE          number(11,0)        \
    TDNCODE             number(11,0)

ORACLE8I INRICHTINGSELEMENT                 \
    oracle_type         oracle_point        \
    OID                 %OID                \
    BEGINDATUM          %BEGINDATUM         \
    EINDDATUM           %EINDDATUM          \
    BRONTYPE            %BRONTYPE           \
    BRONBESCHRIJVING    %BRONBESCHRIJVING   \
    NAUWKEURIGHEID      %NAUWKEURIGHEID     \
    ACTUALITEIT         %ACTUALITEIT        \
    TYPE                %TYPE               \
    FUNCTIE             %FUNCTIE            \
    HOOGTE              %HOOGTE             \
    NAAM                %NAAM               \
    NUMMER              %NUMMER             \
    STATUS              %STATUS             \
    HOOGTENIVEAU        %HOOGTENIVEAU       \
    TDNCODE             %TDNCODE

SHAPE INRICHTINGSELEMENT_point              \
    OID                 %OID                \
    BEGINDATUM          %BEGINDATUM         \
    EINDDATUM           %EINDDATUM          \
    BRONTYPE            %BRONTYPE           \
    BRONBESCHR          %BRONBESCHRIJVING   \
    NAUWKEURIG          %NAUWKEURIGHEID     \
    ACTUALITEI          %ACTUALITEIT        \
    TYPE                %TYPE               \
    FUNCTIE             %FUNCTIE            \
    HOOGTE              %HOOGTE             \
    NAAM                %NAAM               \
    NUMMER              %NUMMER             \
    STATUS              %STATUS             \
    HOOGTENIVE          %HOOGTENIVEAU       \
    TDNCODE             %TDNCODE

ORACLE8I INRICHTINGSELEMENT                 \
    oracle_type         oracle_line         \
    OID                 %OID                \
    BEGINDATUM          %BEGINDATUM         \
    EINDDATUM           %EINDDATUM          \
    BRONTYPE            %BRONTYPE           \
    BRONBESCHRIJVING    %BRONBESCHRIJVING   \
    NAUWKEURIGHEID      %NAUWKEURIGHEID     \
    ACTUALITEIT         %ACTUALITEIT        \
    TYPE                %TYPE               \
    FUNCTIE             %FUNCTIE            \
    HOOGTE              %HOOGTE             \
    NAAM                %NAAM               \
    NUMMER              %NUMMER             \
    STATUS              %STATUS             \
    HOOGTENIVEAU        %HOOGTENIVEAU       \
    TDNCODE             %TDNCODE

SHAPE INRICHTINGSELEMENT_line               \
    OID                 %OID                \
    BEGINDATUM          %BEGINDATUM         \
    EINDDATUM           %EINDDATUM          \
    BRONTYPE            %BRONTYPE           \
    BRONBESCHR          %BRONBESCHRIJVING   \
    NAUWKEURIG          %NAUWKEURIGHEID     \
```

```
    ACTUALITEI          %ACTUALITEIT          \
    TYPE                %TYPE                 \
    FUNCTIE             %FUNCTIE              \
    HOOGTE              %HOOGTE               \
    NAAM                %NAAM                 \
    NUMMER              %NUMMER               \
    STATUS              %STATUS               \
    HOOGTENIVE          %HOOGTENIVEAU         \
    TDNCODE             %TDNCODE

# ========================================================================

ORACLE8I_DEF SPOORBAANDEEL                    \
    OID                 number(12)            \
    BEGINDATUM          varchar2(20)          \
    EINDDATUM           varchar2(20)          \
    BRONTYPE            varchar2(32)          \
    BRONBESCHRIJVING    varchar2(32)          \
    NAUWKEURIGHEID      varchar2(32)          \
    ACTUALITEIT         varchar2(20)          \
    TYPE                varchar2(32)          \
    VERKEERSGEBRUIK     varchar2(32)          \
    FYSIEK_VOORKOMEN    varchar2(32)          \
    SPOORBREEDTE        varchar2(32)          \
    AANTAL_SPOREN       varchar2(32)          \
    FUNCTIE             varchar2(32)          \
    ELEKTRIFICATIE      varchar2(32)          \
    TOEGANKELIJKHEID    varchar2(32)          \
    STATUS              varchar2(32)          \
    HOOGTENIVEAU        number(12)            \
    TDNCODE             number(12)

SHAPE_DEF SPOORBAANDEEL_area                  \
    SHAPE_GEOMETRY      shape_polygon         \
    OID                 number(11,0)          \
    BEGINDATUM          char(20)              \
    EINDDATUM           char(20)              \
    BRONTYPE            char(32)              \
    BRONBESCHR          char(32)              \
    NAUWKEURIG          char(32)              \
    ACTUALITEI          char(20)              \
    TYPE                char(32)              \
    VERKEERSGE          char(32)              \
    VOORKOMEN           char(32)              \
    SPOORBREED          char(32)              \
    SPOREN              char(32)              \
    FUNCTIE             char(32)              \
    ELEKTRIFIC          char(32)              \
    TOEGANKELI          char(32)              \
    STATUS              char(32)              \
    HOOGTENIVE          number(11,0)          \
    TDNCODE             number(11,0)

ORACLE8I SPOORBAANDEEL                        \
    oracle_type         oracle_area           \
    OID                 %OID                  \
    BEGINDATUM          %BEGINDATUM           \
    EINDDATUM           %EINDDATUM            \
    BRONTYPE            %BRONTYPE             \
    BRONBESCHRIJVING    %BRONBESCHRIJVING     \
    NAUWKEURIGHEID      %NAUWKEURIGHEID       \
    ACTUALITEIT         %ACTUALITEIT          \
    TYPE                %TYPE                 \
    VERKEERSGEBRUIK     %VERKEERSGEBRUIK      \
    FYSIEK_VOORKOMEN    %FYSIEK_VOORKOMEN     \
    SPOORBREEDTE        %SPOORBREEDTE         \
    AANTAL_SPOREN       %AANTAL_SPOREN        \
    FUNCTIE             %FUNCTIE              \
    ELEKTRIFICATIE      %ELEKTRIFICATIE       \
```

```
    TOEGANKELIJKHEID     %TOEGANKELIJKHEID      \
    STATUS               %STATUS                \
    HOOGTENIVEAU         %HOOGTENIVEAU          \
    TDNCODE              %TDNCODE

SHAPE SPOORBAANDEEL_area                        \
    OID                  %OID                   \
    BEGINDATUM           %BEGINDATUM            \
    EINDDATUM            %EINDDATUM             \
    BRONTYPE             %BRONTYPE              \
    BRONBESCHR           %BRONBESCHRIJVING      \
    NAUWKEURIG           %NAUWKEURIGHEID        \
    ACTUALITEI           %ACTUALITEIT           \
    TYPE                 %TYPE                  \
    VERKEERSGE           %VERKEERSGEBRUIK       \
    VOORKOMEN            %FYSIEK_VOORKOMEN      \
    SPOORBREED           %SPOORBREEDTE          \
    SPOREN               %AANTAL_SPOREN         \
    FUNCTIE              %FUNCTIE               \
    ELEKTRIFIC           %ELEKTRIFICATIE        \
    TOEGANKELI           %TOEGANKELIJKHEID      \
    STATUS               %STATUS                \
    HOOGTENIVE           %HOOGTENIVEAU          \
    TDNCODE              %TDNCODE

# ========================================================================

ORACLE8I_DEF TERREIN                            \
    OID                  number(12)             \
    BEGINDATUM           varchar2(20)           \
    EINDDATUM            varchar2(20)           \
    BRONTYPE             varchar2(32)           \
    BRONBESCHRIJVING     varchar2(32)           \
    NAUWKEURIGHEID       varchar2(32)           \
    ACTUALITEIT          varchar2(20)           \
    LANDGEBRUIK          varchar2(32)           \
    FYSIEK_VOORKOMEN     varchar2(32)           \
    TOEGANKELIJKHEID     varchar2(32)           \
    VOORKOMEN            varchar2(32)           \
    NAAM                 varchar2(32)           \
    HOOGTENIVEAU         number(12)             \
    TDNCODE              number(12)

SHAPE_DEF TERREIN_area                          \
    SHAPE_GEOMETRY       shape_polygon          \
    OID                  number(11,0)           \
    BEGINDATUM           char(20)               \
    EINDDATUM            char(20)               \
    BRONTYPE             char(32)               \
    BRONBESCHR           char(32)               \
    NAUWKEURIG           char(32)               \
    ACTUALITEI           char(20)               \
    LANDGEBRUI           char(32)               \
    VOORKOMEN            char(32)               \
    TOEGANKELI           char(32)               \
    VOORKOME0            char(32)               \
    NAAM                 char(32)               \
    HOOGTENIVE           number(11,0)           \
    TDNCODE              number(11,0)

ORACLE8I TERREIN                                \
    oracle_type          oracle_area            \
    OID                  %OID                   \
    BEGINDATUM           %BEGINDATUM            \
    EINDDATUM            %EINDDATUM             \
    BRONTYPE             %BRONTYPE              \
    BRONBESCHRIJVING     %BRONBESCHRIJVING      \
    NAUWKEURIGHEID       %NAUWKEURIGHEID        \
    ACTUALITEIT          %ACTUALITEIT           \
```

```
    LANDGEBRUIK          %LANDGEBRUIK          \
    FYSIEK_VOORKOMEN     %FYSIEK_VOORKOMEN     \
    TOEGANKELIJKHEID     %TOEGANKELIJKHEID     \
    VOORKOMEN            %VOORKOMEN            \
    NAAM                 %NAAM                 \
    HOOGTENIVEAU         %HOOGTENIVEAU         \
    TDNCODE              %TDNCODE

SHAPE TERREIN_area                             \
    OID                  %OID                  \
    BEGINDATUM           %BEGINDATUM           \
    EINDDATUM            %EINDDATUM            \
    BRONTYPE             %BRONTYPE             \
    BRONBESCHR           %BRONBESCHRIJVING     \
    NAUWKEURIG           %NAUWKEURIGHEID       \
    ACTUALITEI           %ACTUALITEIT          \
    LANDGEBRUI           %LANDGEBRUIK          \
    VOORKOMEN            %FYSIEK_VOORKOMEN     \
    TOEGANKELI           %TOEGANKELIJKHEID     \
    VOORKOMEO            %VOORKOMEN            \
    NAAM                 %NAAM                 \
    HOOGTENIVE           %HOOGTENIVEAU         \
    TDNCODE              %TDNCODE

# ============================================================================

ORACLE8I_DEF WATERDEEL                         \
    OID                  number(12)            \
    BEGINDATUM           varchar2(20)          \
    EINDDATUM            varchar2(20)          \
    BRONTYPE             varchar2(32)          \
    BRONBESCHRIJVING     varchar2(32)          \
    NAUWKEURIGHEID       varchar2(32)          \
    ACTUALITEIT          varchar2(20)          \
    TYPE                 varchar2(32)          \
    WATERTYPE            varchar2(32)          \
    BREEDTEKLASSE        varchar2(32)          \
    BREEDTE              varchar2(32)          \
    HOOFDAFWATERING      varchar2(32)          \
    ZOUTGEHALTE          varchar2(32)          \
    TOEGANKELIJKHEID     varchar2(32)          \
    FYSIEK_VOORKOMEN     varchar2(32)          \
    GEBRUIK              varchar2(32)          \
    STROOMRICHTING       varchar2(32)          \
    STATUS               varchar2(32)          \
    NAAM                 varchar2(32)          \
    HOOGTENIVEAU         number(12)            \
    TDNCODE              number(12)

SHAPE_DEF WATERDEEL_line                       \
    SHAPE_GEOMETRY       shape_polyline        \
    OID                  number(11,0)          \
    BEGINDATUM           char(20)              \
    EINDDATUM            char(20)              \
    BRONTYPE             char(32)              \
    BRONBESCHR           char(32)              \
    NAUWKEURIG           char(32)              \
    ACTUALITEI           char(20)              \
    TYPE                 char(32)              \
    WATERTYPE            char(32)              \
    BREEDTEKLA           char(32)              \
    BREEDTE              char(32)              \
    HOOFDAFWAT           char(32)              \
    ZOUTGEHALT           char(32)              \
    TOEGANKELI           char(32)              \
    VOORKOMEN            char(32)              \
    GEBRUIK              char(32)              \
    STROOMRICH           char(32)              \
    STATUS               char(32)              \
```

```
    NAAM                char(32)            \
    HOOGTENIVE          number(11,0)        \
    TDNCODE             number(11,0)

SHAPE_DEF WATERDEEL_area                    \
    SHAPE_GEOMETRY      shape_polygon       \
    OID                 number(11,0)        \
    BEGINDATUM          char(20)            \
    EINDDATUM           char(20)            \
    BRONTYPE            char(32)            \
    BRONBESCHR          char(32)            \
    NAUWKEURIG          char(32)            \
    ACTUALITEI          char(20)            \
    TYPE                char(32)            \
    WATERTYPE           char(32)            \
    BREEDTEKLA          char(32)            \
    BREEDTE             char(32)            \
    HOOFDAFWAT          char(32)            \
    ZOUTGEHALT          char(32)            \
    TOEGANKELI          char(32)            \
    VOORKOMEN           char(32)            \
    GEBRUIK             char(32)            \
    STROOMRICH          char(32)            \
    STATUS              char(32)            \
    NAAM                char(32)            \
    HOOGTENIVE          number(11,0)        \
    TDNCODE             number(11,0)

ORACLE8I WATERDEEL                          \
    oracle_type         oracle_line         \
    OID                 %OID                \
    BEGINDATUM          %BEGINDATUM         \
    EINDDATUM           %EINDDATUM          \
    BRONTYPE            %BRONTYPE           \
    BRONBESCHRIJVING    %BRONBESCHRIJVING   \
    NAUWKEURIGHEID      %NAUWKEURIGHEID     \
    ACTUALITEIT         %ACTUALITEIT        \
    TYPE                %TYPE               \
    WATERTYPE           %WATERTYPE          \
    BREEDTEKLASSE       %BREEDTEKLASSE      \
    BREEDTE             %BREEDTE            \
    HOOFDAFWATERING     %HOOFDAFWATERING    \
    ZOUTGEHALTE         %ZOUTGEHALTE        \
    TOEGANKELIJKHEID    %TOEGANKELIJKHEID   \
    FYSIEK_VOORKOMEN    %FYSIEK_VOORKOMEN   \
    GEBRUIK             %GEBRUIK            \
    STROOMRICHTING      %STROOMRICHTING     \
    STATUS              %STATUS             \
    NAAM                %NAAM               \
    HOOGTENIVEAU        %HOOGTENIVEAU       \
    TDNCODE             %TDNCODE

SHAPE WATERDEEL_line                        \
    OID                 %OID                \
    BEGINDATUM          %BEGINDATUM         \
    EINDDATUM           %EINDDATUM          \
    BRONTYPE            %BRONTYPE           \
    BRONBESCHR          %BRONBESCHRIJVING   \
    NAUWKEURIG          %NAUWKEURIGHEID     \
    ACTUALITEI          %ACTUALITEIT        \
    TYPE                %TYPE               \
    WATERTYPE           %WATERTYPE          \
    BREEDTEKLA          %BREEDTEKLASSE      \
    BREEDTE             %BREEDTE            \
    HOOFDAFWAT          %HOOFDAFWATERING    \
    ZOUTGEHALT          %ZOUTGEHALTE        \
    TOEGANKELI          %TOEGANKELIJKHEID   \
    VOORKOMEN           %FYSIEK_VOORKOMEN   \
    GEBRUIK             %GEBRUIK            \
```

```
    STROOMRICH          %STROOMRICHTING       \
    STATUS              %STATUS               \
    NAAM                %NAAM                 \
    HOOGTENIVE          %HOOGTENIVEAU         \
    TDNCODE             %TDNCODE

ORACLE8I WATERDEEL                            \
    oracle_type         oracle_area           \
    OID                 %OID                  \
    BEGINDATUM          %BEGINDATUM           \
    EINDDATUM           %EINDDATUM            \
    BRONTYPE            %BRONTYPE             \
    BRONBESCHRIJVING    %BRONBESCHRIJVING     \
    NAUWKEURIGHEID      %NAUWKEURIGHEID       \
    ACTUALITEIT         %ACTUALITEIT          \
    TYPE                %TYPE                 \
    WATERTYPE           %WATERTYPE            \
    BREEDTEKLASSE       %BREEDTEKLASSE        \
    BREEDTE             %BREEDTE              \
    HOOFDAFWATERING     %HOOFDAFWATERING      \
    ZOUTGEHALTE         %ZOUTGEHALTE          \
    TOEGANKELIJKHEID    %TOEGANKELIJKHEID     \
    FYSIEK_VOORKOMEN    %FYSIEK_VOORKOMEN     \
    GEBRUIK             %GEBRUIK              \
    STROOMRICHTING      %STROOMRICHTING       \
    STATUS              %STATUS               \
    NAAM                %NAAM                 \
    HOOGTENIVEAU        %HOOGTENIVEAU         \
    TDNCODE             %TDNCODE

SHAPE WATERDEEL_area                          \
    OID                 %OID                  \
    BEGINDATUM          %BEGINDATUM           \
    EINDDATUM           %EINDDATUM            \
    BRONTYPE            %BRONTYPE             \
    BRONBESCHR          %BRONBESCHRIJVING     \
    NAUWKEURIG          %NAUWKEURIGHEID       \
    ACTUALITEI          %ACTUALITEIT          \
    TYPE                %TYPE                 \
    WATERTYPE           %WATERTYPE            \
    BREEDTEKLA          %BREEDTEKLASSE        \
    BREEDTE             %BREEDTE              \
    HOOFDAFWAT          %HOOFDAFWATERING      \
    ZOUTGEHALT          %ZOUTGEHALTE          \
    TOEGANKELI          %TOEGANKELIJKHEID     \
    VOORKOMEN           %FYSIEK_VOORKOMEN     \
    GEBRUIK             %GEBRUIK              \
    STROOMRICH          %STROOMRICHTING       \
    STATUS              %STATUS               \
    NAAM                %NAAM                 \
    HOOGTENIVE          %HOOGTENIVEAU         \
    TDNCODE             %TDNCODE

# ============================================================================

ORACLE8I_DEF WEGDEEL                          \
    OID                 number(12)            \
    BEGINDATUM          varchar2(20)          \
    EINDDATUM           varchar2(20)          \
    BRONTYPE            varchar2(32)          \
    BRONBESCHRIJVING    varchar2(32)          \
    NAUWKEURIGHEID      varchar2(32)          \
    ACTUALITEIT         varchar2(20)          \
    TYPE                varchar2(32)          \
    WEGTYPE             varchar2(32)          \
    HOOFDVERKEERSGEBRUIK varchar2(32)         \
    FYSIEK_VOORKOMEN    varchar2(32)          \
    KRUISINGSTYPE       varchar2(32)          \
    VERHARDINGSBREEDTEKLASSE varchar2(32)     \
```

```
    VERHARDINGSBREEDTE   varchar2(32)          \
    VERHARDINGSTYPE      varchar2(32)          \
    VERHARDINGSMATERIAAL varchar2(32)          \
    AANTAL_RIJSTROKEN    varchar2(32)          \
    RIJRICHTING          varchar2(32)          \
    TOEGANKELIJKHEID     varchar2(32)          \
    STATUS               varchar2(32)          \
    STRAATNAAM           varchar2(32)          \
    WEGNUMMER            varchar2(32)          \
    HOOGTENIVEAU         number(12)            \
    TDNCODE              number(12)

SHAPE_DEF WEGDEEL_line                         \
    SHAPE_GEOMETRY       shape_polyline        \
    OID                  number(11,0)          \
    BEGINDATUM           char(20)              \
    EINDDATUM            char(20)              \
    BRONTYPE             char(32)              \
    BRONBESCHR           char(32)              \
    NAUWKEURIG           char(32)              \
    ACTUALITEI           char(20)              \
    TYPE                 char(32)              \
    WEGTYPE              char(32)              \
    HOOFDVERKE           char(32)              \
    VOORKOMEN            char(32)              \
    KRUISINGST           char(32)              \
    VERHARDING           char(32)              \
    VERHARDI0            char(32)              \
    VERHARDI1            char(32)              \
    VERHARDI2            char(32)              \
    RIJSTROKEN           char(32)              \
    RIJRICHTIN           char(32)              \
    TOEGANKELI           char(32)              \
    STATUS               char(32)              \
    STRAATNAAM           char(32)              \
    WEGNUMMER            char(32)              \
    HOOGTENIVE           number(11,0)          \
    TDNCODE              number(11,0)

SHAPE_DEF WEGDEEL_area                         \
    SHAPE_GEOMETRY       shape_polygon         \
    OID                  number(11,0)          \
    BEGINDATUM           char(20)              \
    EINDDATUM            char(20)              \
    BRONTYPE             char(32)              \
    BRONBESCHR           char(32)              \
    NAUWKEURIG           char(32)              \
    ACTUALITEI           char(20)              \
    TYPE                 char(32)              \
    WEGTYPE              char(32)              \
    HOOFDVERKE           char(32)              \
    VOORKOMEN            char(32)              \
    KRUISINGST           char(32)              \
    VERHARDING           char(32)              \
    VERHARDI0            char(32)              \
    VERHARDI1            char(32)              \
    VERHARDI2            char(32)              \
    RIJSTROKEN           char(32)              \
    RIJRICHTIN           char(32)              \
    TOEGANKELI           char(32)              \
    STATUS               char(32)              \
    STRAATNAAM           char(32)              \
    WEGNUMMER            char(32)              \
    HOOGTENIVE           number(11,0)          \
    TDNCODE              number(11,0)

ORACLE8I WEGDEEL                               \
    oracle_type          oracle_line           \
    OID                  %OID                  \
```

```
    BEGINDATUM           %BEGINDATUM           \
    EINDDATUM            %EINDDATUM            \
    BRONTYPE             %BRONTYPE             \
    BRONBESCHRIJVING     %BRONBESCHRIJVING     \
    NAUWKEURIGHEID       %NAUWKEURIGHEID       \
    ACTUALITEIT          %ACTUALITEIT          \
    TYPE                 %TYPE                 \
    WEGTYPE              %WEGTYPE              \
    HOOFDVERKEERSGEBRUIK %HOOFDVERKEERSGEBRUIK \
    FYSIEK_VOORKOMEN     %FYSIEK_VOORKOMEN     \
    KRUISINGSTYPE        %KRUISINGSTYPE        \
    VERHARDINGSBREEDTEKLASSE %VERHARDINGSBREEDTEKLASSE \
    VERHARDINGSBREEDTE   %VERHARDINGSBREEDTE   \
    VERHARDINGSTYPE      %VERHARDINGSTYPE      \
    VERHARDINGSMATERIAAL %VERHARDINGSMATERIAAL \
    AANTAL_RIJSTROKEN    %AANTAL_RIJSTROKEN    \
    RIJRICHTING          %RIJRICHTING          \
    TOEGANKELIJKHEID     %TOEGANKELIJKHEID     \
    STATUS               %STATUS               \
    STRAATNAAM           %STRAATNAAM           \
    WEGNUMMER            %WEGNUMMER            \
    HOOGTENIVEAU         %HOOGTENIVEAU         \
    TDNCODE              %TDNCODE

SHAPE WEGDEEL_line                             \
    OID                  %OID                  \
    BEGINDATUM           %BEGINDATUM           \
    EINDDATUM            %EINDDATUM            \
    BRONTYPE             %BRONTYPE             \
    BRONBESCHR           %BRONBESCHRIJVING     \
    NAUWKEURIG           %NAUWKEURIGHEID       \
    ACTUALITEI           %ACTUALITEIT          \
    TYPE                 %TYPE                 \
    WEGTYPE              %WEGTYPE              \
    HOOFDVERKE           %HOOFDVERKEERSGEBRUIK \
    VOORKOMEN            %FYSIEK_VOORKOMEN     \
    KRUISINGST           %KRUISINGSTYPE        \
    VERHARDING           %VERHARDINGSBREEDTEKLASSE \
    VERHARDI0            %VERHARDINGSBREEDTE   \
    VERHARDI1            %VERHARDINGSTYPE      \
    VERHARDI2            %VERHARDINGSMATERIAAL \
    RIJSTROKEN           %AANTAL_RIJSTROKEN    \
    RIJRICHTIN           %RIJRICHTING          \
    TOEGANKELI           %TOEGANKELIJKHEID     \
    STATUS               %STATUS               \
    STRAATNAAM           %STRAATNAAM           \
    WEGNUMMER            %WEGNUMMER            \
    HOOGTENIVE           %HOOGTENIVEAU         \
    TDNCODE              %TDNCODE

ORACLE8I WEGDEEL                               \
    oracle_type          oracle_area           \
    OID                  %OID                  \
    BEGINDATUM           %BEGINDATUM           \
    EINDDATUM            %EINDDATUM            \
    BRONTYPE             %BRONTYPE             \
    BRONBESCHRIJVING     %BRONBESCHRIJVING     \
    NAUWKEURIGHEID       %NAUWKEURIGHEID       \
    ACTUALITEIT          %ACTUALITEIT          \
    TYPE                 %TYPE                 \
    WEGTYPE              %WEGTYPE              \
    HOOFDVERKEERSGEBRUIK %HOOFDVERKEERSGEBRUIK \
    FYSIEK_VOORKOMEN     %FYSIEK_VOORKOMEN     \
    KRUISINGSTYPE        %KRUISINGSTYPE        \
    VERHARDINGSBREEDTEKLASSE %VERHARDINGSBREEDTEKLASSE \
    VERHARDINGSBREEDTE   %VERHARDINGSBREEDTE   \
    VERHARDINGSTYPE      %VERHARDINGSTYPE      \
    VERHARDINGSMATERIAAL %VERHARDINGSMATERIAAL \
    AANTAL_RIJSTROKEN    %AANTAL_RIJSTROKEN    \
```

```
    RIJRICHTING          %RIJRICHTING          \
    TOEGANKELIJKHEID     %TOEGANKELIJKHEID     \
    STATUS               %STATUS               \
    STRAATNAAM           %STRAATNAAM           \
    WEGNUMMER            %WEGNUMMER            \
    HOOGTENIVEAU         %HOOGTENIVEAU         \
    TDNCODE              %TDNCODE

SHAPE WEGDEEL_area                             \
    OID                  %OID                  \
    BEGINDATUM           %BEGINDATUM           \
    EINDDATUM            %EINDDATUM            \
    BRONTYPE             %BRONTYPE             \
    BRONBESCHR           %BRONBESCHRIJVING     \
    NAUWKEURIG           %NAUWKEURIGHEID       \
    ACTUALITEI           %ACTUALITEIT          \
    TYPE                 %TYPE                 \
    WEGTYPE              %WEGTYPE              \
    HOOFDVERKE           %HOOFDVERKEERSGEBRUIK \
    VOORKOMEN            %FYSIEK_VOORKOMEN     \
    KRUISINGST           %KRUISINGSTYPE        \
    VERHARDING           %VERHARDINGSBREEDTEKLASSE \
    VERHARDI0            %VERHARDINGSBREEDTE   \
    VERHARDI1            %VERHARDINGSTYPE      \
    VERHARDI2            %VERHARDINGSMATERIAAL \
    RIJSTROKEN           %AANTAL_RIJSTROKEN    \
    RIJRICHTIN           %RIJRICHTING          \
    TOEGANKELI           %TOEGANKELIJKHEID     \
    STATUS               %STATUS               \
    STRAATNAAM           %STRAATNAAM           \
    WEGNUMMER            %WEGNUMMER            \
    HOOGTENIVE           %HOOGTENIVEAU         \
    TDNCODE              %TDNCODE

# ==============================================================================
# ==============================================================================
```

A.3 Shapefile to Oracle conversion

```
# 18
# shape2ora.fme  03-08-2001  TT
#
# ==============================================================================
# The following line defines the title presented to the user when this
# mapping file is run through the FME GUI.

GUI TITLE TOP10 objects - SHAPE to ORACLE 8i translation

# ==============================================================================
# The following line names the log file to which useful statistics about
# the translation will be written.

LOG_FILENAME shape2ora.log
LOG_APPEND YES
LOG_MAX_FEATURES 20

FME_DEBUG UNGROUPED UNCORRELATED

# ==============================================================================
# The following two lines define the type of reader and writer to be
# used for this translation.

READER_TYPE SHAPE
WRITER_TYPE ORACLE8I

# ==============================================================================
```

```
# The following GUI line prompts for a directory to be used as the
# source of the ESRI SHAPE files.

DEFAULT_MACRO SourceDataset D:\Top10_proef\Data
GUI DIRNAME SourceDataset Source shapefiles directory:
SHAPE_DATASET "$(SourceDataset)"

# ============================================================================

DEFAULT_MACRO admTable ADMINISTRATIEF_GEBIED_area
GUI CHOICE admTable ADMINISTRATIEF_GEBIED_area%No Include Administratief_gebied_area:

DEFAULT_MACRO bebTable BEBOUWING_area
GUI CHOICE bebTable BEBOUWING_area%No Include Bebouwing_area:

DEFAULT_MACRO behTable BEHEERSGEBIED_area
GUI CHOICE behTable BEHEERSGEBIED_area%No Include Beheersgebied_area:

DEFAULT_MACRO funTable FUNCTIONEEL_GEBIED_area
GUI CHOICE funTable FUNCTIONEEL_GEBIED_area%No Include Functioneel_gebied_area:

DEFAULT_MACRO geoTable GEOGRAFISCH_GEBIED_area
GUI CHOICE geoTable GEOGRAFISCH_GEBIED_area%No Include Geografisch_gebied_area:

DEFAULT_MACRO inrPTable INRICHTINGSELEMENT_point
GUI CHOICE inrPTable INRICHTINGSELEMENT_point%No Include Inrichtingselement_point:

DEFAULT_MACRO inrLTable INRICHTINGSELEMENT_line
GUI CHOICE inrLTable INRICHTINGSELEMENT_line%No Include Inrichtingselement_line:

DEFAULT_MACRO spoTable SPOORBAANDEEL_area
GUI CHOICE spoTable SPOORBAANDEEL_area%No Include Spoorbaandeel_area:

DEFAULT_MACRO terTable TERREIN_area
GUI CHOICE terTable TERREIN_area%No Include Terrein_area:

DEFAULT_MACRO watLTable WATERDEEL_line
GUI CHOICE watLTable WATERDEEL_line%No Include Waterdeel_line:

DEFAULT_MACRO watATable WATERDEEL_area
GUI CHOICE watATable WATERDEEL_area%No Include Waterdeel_area:

DEFAULT_MACRO wegLTable WEGDEEL_line
GUI CHOICE wegLTable WEGDEEL_line%No Include Wegdeel_line:

DEFAULT_MACRO wegATable WEGDEEL_area
GUI CHOICE wegATable WEGDEEL_area%No Include Wegdeel_area:

SHAPE_IDs $(admTable)  $(bebTable)  $(behTable)  $(funTable) $(geoTable)  \
          $(inrPTable) $(inrLTable) $(spoTable)  $(terTable) $(watLTable) \
          $(watATable) $(wegLTable) $(wegATable)

# ============================================================================
# Various layer creation parameters.

DEFAULT_MACRO _ORACLE_Dimension 2
GUI CHOICE _ORACLE_Dimension 2%3 Geometric dimension:
ORACLE_DIM $(_ORACLE_Dimension)

DEFAULT_MACRO _ORACLE_Minx -25000
DEFAULT_MACRO _ORACLE_Miny 275000
DEFAULT_MACRO _ORACLE_Minz   -100
DEFAULT_MACRO _ORACLE_Maxx 325000
DEFAULT_MACRO _ORACLE_Maxy 650000
DEFAULT_MACRO _ORACLE_Maxz   1000

# Oracle configuration parameters

MACRO _ORACLE_Config                            \
```

```
      oracle_model          object              \
      oracle_dim            $(_ORACLE_Dimension) \
      oracle_min_x          $(_ORACLE_Minx)     \
      oracle_min_y          $(_ORACLE_Miny)     \
      oracle_min_z          $(_ORACLE_Minz)     \
      oracle_max_x          $(_ORACLE_Maxx)     \
      oracle_max_y          $(_ORACLE_Maxy)     \
      oracle_max_z          $(_ORACLE_Maxz)     \
      oracle_create_indices NO

ORACLE8I_SERVER_TYPE ORACLE8i
ORACLE8I_TRANSACTION 0

# ============================================================================
# The following GUI lines prompt for the user name and password to use for
# accessing Oracle Spatial

DEFAULT_MACRO DestDataset igis
#GUI TEXT DestDataset Destination Oracle service:
ORACLE8I_DATASET "$(DestDataset)"

DEFAULT_MACRO _ORACLE_UserName tdn2
GUI TEXT _ORACLE_UserName Oracle username:
ORACLE8I_USER_NAME "$(_ORACLE_UserName)"

DEFAULT_MACRO _ORACLE_Password tdn2
GUI PASSWORD _ORACLE_Password Oracle password:
ORACLE8I_PASSWORD "$(_ORACLE_Password)"

# ============================================================================

DEFAULT_MACRO _Poly_dissolve NO
#GUI CHOICE _Poly_dissolve NO%YES Dissolve polygons:

# ============================================================================
# ============================================================================
# Factory pipeline to dissolve polygons with identical attribute values
# on ....

FACTORY_DEF * TestFactory                       \
   FACTORY_NAME DissolveSwitch                  \
   INPUT FEATURE_TYPE top10polygons             \
   TEST "$(_Poly_dissolve)" = "YES"             \
   OUTPUT PASSED FEATURE_TYPE top10polys        \
   OUTPUT FAILED FEATURE_TYPE *

# Calculate polygon topology

FACTORY_DEF IGDS TopologyFactory                \
   FACTORY_NAME MakePolyTopology                \
   INPUT FEATURE_TYPE top10polys                \
   GROUP_BY feature_type tdncode                \
   ARC_NUMBER_ATTR arcId                        \
   RIGHT_POLY_ATTR rPolyId                      \
   LEFT_POLY_ATTR lPolyId                       \
   POLYGONS_ATTR polyIds                        \
   POLYGON_NUMBER_ATTR polyNr                   \
   ARCS_ATTR arcList                            \
   OUTPUT POLYGON FEATURE_TYPE topolpolys
#      @Log("TopPolyCreated")

# Dissolve interior lines

FACTORY_DEF IGDS PolygonDissolveFactory         \
   FACTORY_NAME DissolvePolygons                \
   INPUT FEATURE_TYPE topolpolys                \
   GROUP_BY feature_type tdncode                \
   LIST_NAME origPoly                           \
   DISSOLVE_COUNT_ATTRIBUTE polysMerged         \
```

```
   OUTPUT POLYGON FEATURE_TYPE dissolvedpolys
#      @Log("DissolvedPolyCreated")

# ============================================================================
# ============================================================================
# The main body of the mapping file starts here.  Each of the
# _DEF lines describes the data model of the particular feature
# type, and the correlation lines describe how the feature is
# transformed from the source type to the destination type.

SHAPE_DEF ADMINISTRATIEF_GEBIED_area           \
    SHAPE_GEOMETRY       shape_polygon         \
    OID                  number(11,0)          \
    BEGINDATUM           char(20)              \
    EINDDATUM            char(20)              \
    BRONTYPE             char(32)              \
    BRONBESCHR           char(32)              \
    NAUWKEURIG           char(32)              \
    ACTUALITEI           char(20)              \
    TYPE                 char(32)              \
    NAAM                 char(32)              \
    TDNCODE              number(11,0)

ORACLE8I_DEF ADMINISTRATIEF_GEBIED             \
    $(_ORACLE_Config)                          \
    OID                  number(12)            \
    TOP10_ID             number(12)            \
    BEGINDATUM           varchar2(20)          \
    EINDDATUM            varchar2(20)          \
    BRONTYPE             varchar2(32)          \
    BRONBESCHRIJVING     varchar2(32)          \
    NAUWKEURIGHEID       varchar2(32)          \
    ACTUALITEIT          varchar2(20)          \
    TYPE                 varchar2(32)          \
    NAAM                 varchar2(32)          \
    POLYGONPROPERTY      geometry              \
    TDNCODE              number(12)

SHAPE ADMINISTRATIEF_GEBIED_area               \
    OID                  %OID                  \
    BEGINDATUM           %BEGINDATUM           \
    EINDDATUM            %EINDDATUM            \
    BRONTYPE             %BRONTYPE             \
    BRONBESCHR           %BRONBESCHRIJVING     \
    NAUWKEURIG           %NAUWKEURIGHEID       \
    ACTUALITEI           %ACTUALITEIT          \
    TYPE                 %TYPE                 \
    NAAM                 %NAAM                 \
    TDNCODE              %TDNCODE

ORACLE8I ADMINISTRATIEF_GEBIED                 \
    OID                  %OID                  \
    TOP10_ID             %OID                  \
    BEGINDATUM           %BEGINDATUM           \
    EINDDATUM            %EINDDATUM            \
    BRONTYPE             %BRONTYPE             \
    BRONBESCHRIJVING     %BRONBESCHRIJVING     \
    NAUWKEURIGHEID       %NAUWKEURIGHEID       \
    ACTUALITEIT          %ACTUALITEIT          \
    TYPE                 %TYPE                 \
    NAAM                 %NAAM                 \
    TDNCODE              %TDNCODE

# ============================================================================

SHAPE_DEF BEBOUWING_area                       \
    SHAPE_GEOMETRY       shape_polygon         \
    OID                  number(11,0)          \
    BEGINDATUM           char(20)              \
```

```
    EINDDATUM           char(20)            \
    BRONTYPE            char(32)            \
    BRONBESCHR          char(32)            \
    NAUWKEURIG          char(32)            \
    ACTUALITEI          char(20)            \
    TYPE                char(32)            \
    FUNCTIE             char(32)            \
    HOOGTEKLAS          char(32)            \
    HOOGTE              char(32)            \
    STATUS              char(32)            \
    NAAM                char(32)            \
    HOOGTENIVE          number(11,0)        \
    TDNCODE             number(11,0)

ORACLE8I_DEF BEBOUWING                      \
    $(_ORACLE_Config)                       \
    OID                 number(12)          \
    TOP10_ID            number(12)          \
    BEGINDATUM          varchar2(20)        \
    EINDDATUM           varchar2(20)        \
    BRONTYPE            varchar2(32)        \
    BRONBESCHRIJVING    varchar2(32)        \
    NAUWKEURIGHEID      varchar2(32)        \
    ACTUALITEIT         varchar2(20)        \
    TYPE                varchar2(32)        \
    FUNCTIE             varchar2(32)        \
    HOOGTEKLASSE        varchar2(32)        \
    HOOGTE              varchar2(32)        \
    STATUS              varchar2(32)        \
    NAAM                varchar2(32)        \
    HOOGTENIVEAU        number(12)          \
    GEOMETRYPROPERTY    geometry            \
    TDNCODE             number(12)

SHAPE BEBOUWING_area                        \
    OID                 %OID                \
    BEGINDATUM          %BEGINDATUM         \
    EINDDATUM           %EINDDATUM          \
    BRONTYPE            %BRONTYPE           \
    BRONBESCHR          %BRONBESCHRIJVING   \
    NAUWKEURIG          %NAUWKEURIGHEID     \
    ACTUALITEI          %ACTUALITEIT        \
    TYPE                %TYPE               \
    FUNCTIE             %FUNCTIE            \
    HOOGTEKLAS          %HOOGTEKLAS         \
    HOOGTE              %HOOGTE             \
    STATUS              %STATUS             \
    NAAM                %NAAM               \
    HOOGTENIVE          %HOOGTENIVE         \
    TDNCODE             %TDNCODE

ORACLE8I BEBOUWING                          \
    OID                 %OID                \
    TOP10_ID            %OID                \
    BEGINDATUM          %BEGINDATUM         \
    EINDDATUM           %EINDDATUM          \
    BRONTYPE            %BRONTYPE           \
    BRONBESCHRIJVING    %BRONBESCHRIJVING   \
    NAUWKEURIGHEID      %NAUWKEURIGHEID     \
    ACTUALITEIT         %ACTUALITEIT        \
    TYPE                %TYPE               \
    FUNCTIE             %FUNCTIE            \
    HOOGTEKLASSE        %HOOGTEKLAS         \
    HOOGTE              %HOOGTE             \
    STATUS              %STATUS             \
    NAAM                %NAAM               \
    HOOGTENIVEAU        %HOOGTENIVE         \
    TDNCODE             %TDNCODE
```

```
# ===========================================================================

SHAPE_DEF FUNCTIONEEL_GEBIED_area              \
    SHAPE_GEOMETRY       shape_polygon         \
    OID                  number(11,0)          \
    BEGINDATUM           char(20)              \
    EINDDATUM            char(20)              \
    BRONTYPE             char(32)              \
    BRONBESCHR           char(32)              \
    NAUWKEURIG           char(32)              \
    ACTUALITEI           char(20)              \
    TYPE                 char(64)              \
    NAAM                 char(32)              \
    TDNCODE              number(11,0)

ORACLE8I_DEF FUNCTIONEEL_GEBIED                \
    $(_ORACLE_Config)                          \
    OID                  number(12)            \
    TOP10_ID             number(12)            \
    BEGINDATUM           varchar2(20)          \
    EINDDATUM            varchar2(20)          \
    BRONTYPE             varchar2(32)          \
    BRONBESCHRIJVING     varchar2(32)          \
    NAUWKEURIGHEID       varchar2(32)          \
    ACTUALITEIT          varchar2(20)          \
    TYPE                 varchar2(64)          \
    NAAM                 varchar2(32)          \
    POLYGONPROPERTY      geometry              \
    TDNCODE              number(12)

SHAPE FUNCTIONEEL_GEBIED_area                  \
    OID                  %OID                  \
    BEGINDATUM           %BEGINDATUM           \
    EINDDATUM            %EINDDATUM            \
    BRONTYPE             %BRONTYPE             \
    BRONBESCHR           %BRONBESCHRIJVING     \
    NAUWKEURIG           %NAUWKEURIGHEID       \
    ACTUALITEI           %ACTUALITEIT          \
    TYPE                 %TYPE                 \
    NAAM                 %NAAM                 \
    TDNCODE              %TDNCODE

ORACLE8I FUNCTIONEEL_GEBIED                    \
    OID                  %OID                  \
    TOP10_ID             %OID                  \
    BEGINDATUM           %BEGINDATUM           \
    EINDDATUM            %EINDDATUM            \
    BRONTYPE             %BRONTYPE             \
    BRONBESCHRIJVING     %BRONBESCHRIJVING     \
    NAUWKEURIGHEID       %NAUWKEURIGHEID       \
    ACTUALITEIT          %ACTUALITEIT          \
    TYPE                 %TYPE                 \
    NAAM                 %NAAM                 \
    TDNCODE              %TDNCODE

# ===========================================================================

SHAPE_DEF GEOGRAFISCH_GEBIED_area              \
    SHAPE_GEOMETRY       shape_polygon         \
    OID                  number(11,0)          \
    BEGINDATUM           char(20)              \
    EINDDATUM            char(20)              \
    BRONTYPE             char(32)              \
    BRONBESCHR           char(32)              \
    NAUWKEURIG           char(32)              \
    ACTUALITEI           char(20)              \
    TYPE                 char(32)              \
    NAAM                 char(32)              \
    TDNCODE              number(11,0)
```

```
ORACLE8I_DEF GEOGRAFISCH_GEBIED                \
    $(_ORACLE_Config)                          \
    OID                 number(12)             \
    TOP10_ID            number(12)             \
    BEGINDATUM          varchar2(20)           \
    EINDDATUM           varchar2(20)           \
    BRONTYPE            varchar2(32)           \
    BRONBESCHRIJVING    varchar2(32)           \
    NAUWKEURIGHEID      varchar2(32)           \
    ACTUALITEIT         varchar2(20)           \
    TYPE                varchar2(32)           \
    NAAM                varchar2(32)           \
    POLYGONPROPERTY     geometry               \
    TDNCODE             number(12)

SHAPE GEOGRAFISCH_GEBIED_area                  \
    OID                 %OID                   \
    BEGINDATUM          %BEGINDATUM            \
    EINDDATUM           %EINDDATUM             \
    BRONTYPE            %BRONTYPE              \
    BRONBESCHR          %BRONBESCHRIJVING      \
    NAUWKEURIG          %NAUWKEURIGHEID        \
    ACTUALITEI          %ACTUALITEIT           \
    TYPE                %TYPE                  \
    NAAM                %NAAM                  \
    TDNCODE             %TDNCODE

ORACLE8I GEOGRAFISCH_GEBIED                    \
    OID                 %OID                   \
    TOP10_ID            %OID                   \
    BEGINDATUM          %BEGINDATUM            \
    EINDDATUM           %EINDDATUM             \
    BRONTYPE            %BRONTYPE              \
    BRONBESCHRIJVING    %BRONBESCHRIJVING      \
    NAUWKEURIGHEID      %NAUWKEURIGHEID        \
    ACTUALITEIT         %ACTUALITEIT           \
    TYPE                %TYPE                  \
    NAAM                %NAAM                  \
    TDNCODE             %TDNCODE

# ============================================================================

SHAPE_DEF INRICHTINGSELEMENT_point             \
    SHAPE_GEOMETRY      shape_point            \
    OID                 number(11,0)           \
    BEGINDATUM          char(20)               \
    EINDDATUM           char(20)               \
    BRONTYPE            char(32)               \
    BRONBESCHR          char(32)               \
    NAUWKEURIG          char(32)               \
    ACTUALITEI          char(20)               \
    TYPE                char(32)               \
    FUNCTIE             char(32)               \
    HOOGTE              char(32)               \
    NAAM                char(32)               \
    NUMMER              char(32)               \
    STATUS              char(32)               \
    HOOGTENIVE          number(11,0)           \
    TDNCODE             number(11,0)

SHAPE_DEF INRICHTINGSELEMENT_line              \
    SHAPE_GEOMETRY      shape_polyline         \
    OID                 number(11,0)           \
    BEGINDATUM          char(20)               \
    EINDDATUM           char(20)               \
    BRONTYPE            char(32)               \
    BRONBESCHR          char(32)               \
    NAUWKEURIG          char(32)               \
```

```
    ACTUALITEI          char(20)            \
    TYPE                char(32)            \
    FUNCTIE             char(32)            \
    HOOGTE              char(32)            \
    NAAM                char(32)            \
    NUMMER              char(32)            \
    STATUS              char(32)            \
    HOOGTENIVE          number(11,0)        \
    TDNCODE             number(11,0)

ORACLE8I_DEF INRICHTINGSELEMENT             \
    $(_ORACLE_Config)                       \
    OID                 number(12)          \
    TOP10_ID            number(12)          \
    BEGINDATUM          varchar2(20)        \
    EINDDATUM           varchar2(20)        \
    BRONTYPE            varchar2(32)        \
    BRONBESCHRIJVING    varchar2(32)        \
    NAUWKEURIGHEID      varchar2(32)        \
    ACTUALITEIT         varchar2(20)        \
    TYPE                varchar2(32)        \
    FUNCTIE             varchar2(32)        \
    HOOGTE              varchar2(32)        \
    NAAM                varchar2(32)        \
    NUMMER              varchar2(32)        \
    STATUS              varchar2(32)        \
    HOOGTENIVEAU        number(12)          \
    GEOMETRYPROPERTY    geometry            \
    TDNCODE             number(12)

SHAPE INRICHTINGSELEMENT_point              \
    OID                 %OID                \
    BEGINDATUM          %BEGINDATUM         \
    EINDDATUM           %EINDDATUM          \
    BRONTYPE            %BRONTYPE           \
    BRONBESCHR          %BRONBESCHRIJVING   \
    NAUWKEURIG          %NAUWKEURIGHEID     \
    ACTUALITEI          %ACTUALITEIT        \
    TYPE                %TYPE               \
    FUNCTIE             %FUNCTIE            \
    HOOGTE              %HOOGTE             \
    NAAM                %NAAM               \
    NUMMER              %NUMMER             \
    STATUS              %STATUS             \
    HOOGTENIVE          %HOOGTENIVE         \
    TDNCODE             %TDNCODE

ORACLE8I INRICHTINGSELEMENT                 \
    OID                 %OID                \
    TOP10_ID            %OID                \
    BEGINDATUM          %BEGINDATUM         \
    EINDDATUM           %EINDDATUM          \
    BRONTYPE            %BRONTYPE           \
    BRONBESCHRIJVING    %BRONBESCHRIJVING   \
    NAUWKEURIGHEID      %NAUWKEURIGHEID     \
    ACTUALITEIT         %ACTUALITEIT        \
    TYPE                %TYPE               \
    FUNCTIE             %FUNCTIE            \
    HOOGTE              %HOOGTE             \
    NAAM                %NAAM               \
    NUMMER              %NUMMER             \
    STATUS              %STATUS             \
    HOOGTENIVEAU        %HOOGTENIVE         \
    TDNCODE             %TDNCODE

SHAPE INRICHTINGSELEMENT_line               \
    OID                 %OID                \
    BEGINDATUM          %BEGINDATUM         \
    EINDDATUM           %EINDDATUM          \
```

```
    BRONTYPE            %BRONTYPE           \
    BRONBESCHR          %BRONBESCHRIJVING   \
    NAUWKEURIG          %NAUWKEURIGHEID     \
    ACTUALITEI          %ACTUALITEIT        \
    TYPE                %TYPE               \
    FUNCTIE             %FUNCTIE            \
    HOOGTE              %HOOGTE             \
    NAAM                %NAAM               \
    NUMMER              %NUMMER             \
    STATUS              %STATUS             \
    HOOGTENIVE          %HOOGTENIVE         \
    TDNCODE             %TDNCODE

ORACLE8I INRICHTINGSELEMENT                 \
    OID                 %OID                \
    TOP10_ID            %OID                \
    BEGINDATUM          %BEGINDATUM         \
    EINDDATUM           %EINDDATUM          \
    BRONTYPE            %BRONTYPE           \
    BRONBESCHRIJVING    %BRONBESCHRIJVING   \
    NAUWKEURIGHEID      %NAUWKEURIGHEID     \
    ACTUALITEIT         %ACTUALITEIT        \
    TYPE                %TYPE               \
    FUNCTIE             %FUNCTIE            \
    HOOGTE              %HOOGTE             \
    NAAM                %NAAM               \
    NUMMER              %NUMMER             \
    STATUS              %STATUS             \
    HOOGTENIVEAU        %HOOGTENIVE         \
    TDNCODE             %TDNCODE

# ============================================================================

SHAPE_DEF SPOORBAANDEEL_area                \
    SHAPE_GEOMETRY      shape_polygon       \
    OID                 number(11,0)        \
    BEGINDATUM          char(20)            \
    EINDDATUM           char(20)            \
    BRONTYPE            char(32)            \
    BRONBESCHR          char(32)            \
    NAUWKEURIG          char(32)            \
    ACTUALITEI          char(20)            \
    TYPE                char(32)            \
    VERKEERSGE          char(32)            \
    VOORKOMEN           char(32)            \
    SPOORBREED          char(32)            \
    SPOREN              char(32)            \
    FUNCTIE             char(32)            \
    ELEKTRIFIC          char(32)            \
    TOEGANKELI          char(32)            \
    STATUS              char(32)            \
    HOOGTENIVE          number(11,0)        \
    TDNCODE             number(11,0)

ORACLE8I_DEF SPOORBAANDEEL                  \
    $(_ORACLE_Config)                       \
    OID                 number(12)          \
    TOP10_ID            number(12)          \
    BEGINDATUM          varchar2(20)        \
    EINDDATUM           varchar2(20)        \
    BRONTYPE            varchar2(32)        \
    BRONBESCHRIJVING    varchar2(32)        \
    NAUWKEURIGHEID      varchar2(32)        \
    ACTUALITEIT         varchar2(20)        \
    TYPE                varchar2(32)        \
    VERKEERSGEBRUIK     varchar2(32)        \
    FYSIEK_VOORKOMEN    varchar2(32)        \
    SPOORBREEDTE        varchar2(32)        \
    AANTAL_SPOREN       varchar2(32)        \
```

```
    FUNCTIE             varchar2(32)          \
    ELEKTRIFICATIE      varchar2(32)          \
    TOEGANKELIJKHEID    varchar2(32)          \
    STATUS              varchar2(32)          \
    HOOGTENIVEAU        number(12)            \
    GEOMETRYPROPERTY    geometry              \
    TDNCODE             number(12)

SHAPE SPOORBAANDEEL_area                      \
    OID                 %OID                  \
    BEGINDATUM          %BEGINDATUM           \
    EINDDATUM           %EINDDATUM            \
    BRONTYPE            %BRONTYPE             \
    BRONBESCHR          %BRONBESCHRIJVING     \
    NAUWKEURIG          %NAUWKEURIGHEID       \
    ACTUALITEI          %ACTUALITEIT          \
    TYPE                %TYPE                 \
    VERKEERSGE          %VERKEERSGE           \
    VOORKOMEN           %VOORKOMEN            \
    SPOORBREED          %SPOORBREED           \
    SPOREN              %SPOREN               \
    FUNCTIE             %FUNCTIE              \
    ELEKTRIFIC          %ELEKTRIFIC           \
    TOEGANKELI          %TOEGANKELI           \
    STATUS              %STATUS               \
    HOOGTENIVE          %HOOGTENIVE           \
    TDNCODE             %TDNCODE

ORACLE8I SPOORBAANDEEL                        \
    OID                 %OID                  \
    TOP10_ID            %OID                  \
    BEGINDATUM          %BEGINDATUM           \
    EINDDATUM           %EINDDATUM            \
    BRONTYPE            %BRONTYPE             \
    BRONBESCHRIJVING    %BRONBESCHRIJVING     \
    NAUWKEURIGHEID      %NAUWKEURIGHEID       \
    ACTUALITEIT         %ACTUALITEIT          \
    TYPE                %TYPE                 \
    VERKEERSGEBRUIK     %VERKEERSGE           \
    FYSIEK_VOORKOMEN    %VOORKOMEN            \
    SPOORBREEDTE        %SPOORBREED           \
    AANTAL_SPOREN       %SPOREN               \
    FUNCTIE             %FUNCTIE              \
    ELEKTRIFICATIE      %ELEKTRIFIC           \
    TOEGANKELIJKHEID    %TOEGANKELI           \
    STATUS              %STATUS               \
    HOOGTENIVEAU        %HOOGTENIVE           \
    TDNCODE             %TDNCODE

# ============================================================================

SHAPE_DEF TERREIN_area                        \
    SHAPE_GEOMETRY      shape_polygon         \
    OID                 number(11,0)          \
    BEGINDATUM          char(20)              \
    EINDDATUM           char(20)              \
    BRONTYPE            char(32)              \
    BRONBESCHR          char(32)              \
    NAUWKEURIG          char(32)              \
    ACTUALITEI          char(20)              \
    LANDGEBRUI          char(32)              \
    VOORKOMEN           char(32)              \
    TOEGANKELI          char(32)              \
    VOORKOME0           char(32)              \
    NAAM                char(32)              \
    HOOGTENIVE          number(11,0)          \
    TDNCODE             number(11,0)

ORACLE8I_DEF TERREIN                          \
```

```
    $(_ORACLE_Config)                       \
    OID                 number(12)          \
    TOP10_ID            number(12)          \
    BEGINDATUM          varchar2(20)        \
    EINDDATUM           varchar2(20)        \
    BRONTYPE            varchar2(32)        \
    BRONBESCHRIJVING    varchar2(32)        \
    NAUWKEURIGHEID      varchar2(32)        \
    ACTUALITEIT         varchar2(20)        \
    LANDGEBRUIK         varchar2(32)        \
    FYSIEK_VOORKOMEN    varchar2(32)        \
    TOEGANKELIJKHEID    varchar2(32)        \
    VOORKOMEN           varchar2(32)        \
    NAAM                varchar2(32)        \
    HOOGTENIVEAU        number(12)          \
    POLYGONPROPERTY     geometry            \
    TDNCODE             number(12)

SHAPE TERREIN_area                          \
    OID                 %OID                \
    BEGINDATUM          %BEGINDATUM         \
    EINDDATUM           %EINDDATUM          \
    BRONTYPE            %BRONTYPE           \
    BRONBESCHR          %BRONBESCHRIJVING   \
    NAUWKEURIG          %NAUWKEURIGHEID     \
    ACTUALITEI          %ACTUALITEIT        \
    LANDGEBRUI          %LANDGEBRUI         \
    VOORKOMEN           %VOORKOMEN          \
    TOEGANKELI          %TOEGANKELI         \
    VOORKOMEO           %VOORKOMEO          \
    NAAM                %NAAM               \
    HOOGTENIVE          %HOOGTENIVE         \
    TDNCODE             %TDNCODE

ORACLE8I TERREIN                            \
    OID                 %OID                \
    TOP10_ID            %OID                \
    BEGINDATUM          %BEGINDATUM         \
    EINDDATUM           %EINDDATUM          \
    BRONTYPE            %BRONTYPE           \
    BRONBESCHRIJVING    %BRONBESCHRIJVING   \
    NAUWKEURIGHEID      %NAUWKEURIGHEID     \
    ACTUALITEIT         %ACTUALITEIT        \
    LANDGEBRUIK         %LANDGEBRUI         \
    FYSIEK_VOORKOMEN    %VOORKOMEN          \
    TOEGANKELIJKHEID    %TOEGANKELI         \
    VOORKOMEN           %VOORKOMEO          \
    NAAM                %NAAM               \
    HOOGTENIVEAU        %HOOGTENIVE         \
    TDNCODE             %TDNCODE

# ============================================================================

SHAPE_DEF WATERDEEL_line                    \
    SHAPE_GEOMETRY      shape_polyline      \
    OID                 number(11,0)        \
    BEGINDATUM          char(20)            \
    EINDDATUM           char(20)            \
    BRONTYPE            char(32)            \
    BRONBESCHR          char(32)            \
    NAUWKEURIG          char(32)            \
    ACTUALITEI          char(20)            \
    TYPE                char(32)            \
    WATERTYPE           char(32)            \
    BREEDTEKLA          char(32)            \
    BREEDTE             char(32)            \
    HOOFDAFWAT          char(32)            \
    ZOUTGEHALT          char(32)            \
    TOEGANKELI          char(32)            \
```

```
    VOORKOMEN           char(32)            \
    GEBRUIK             char(32)            \
    STROOMRICH          char(32)            \
    STATUS              char(32)            \
    NAAM                char(32)            \
    HOOGTENIVE          number(11,0)        \
    TDNCODE             number(11,0)

SHAPE_DEF WATERDEEL_area                    \
    SHAPE_GEOMETRY      shape_polygon       \
    OID                 number(11,0)        \
    BEGINDATUM          char(20)            \
    EINDDATUM           char(20)            \
    BRONTYPE            char(32)            \
    BRONBESCHR          char(32)            \
    NAUWKEURIG          char(32)            \
    ACTUALITEI          char(20)            \
    TYPE                char(32)            \
    WATERTYPE           char(32)            \
    BREEDTEKLA          char(32)            \
    BREEDTE             char(32)            \
    HOOFDAFWAT          char(32)            \
    ZOUTGEHALT          char(32)            \
    TOEGANKELI          char(32)            \
    VOORKOMEN           char(32)            \
    GEBRUIK             char(32)            \
    STROOMRICH          char(32)            \
    STATUS              char(32)            \
    NAAM                char(32)            \
    HOOGTENIVE          number(11,0)        \
    TDNCODE             number(11,0)

ORACLE8I_DEF WATERDEEL                      \
    $(_ORACLE_Config)                       \
    OID                 number(12)          \
    TOP10_ID            number(12)          \
    BEGINDATUM          varchar2(20)        \
    EINDDATUM           varchar2(20)        \
    BRONTYPE            varchar2(32)        \
    BRONBESCHRIJVING    varchar2(32)        \
    NAUWKEURIGHEID      varchar2(32)        \
    ACTUALITEIT         varchar2(20)        \
    TYPE                varchar2(32)        \
    WATERTYPE           varchar2(32)        \
    BREEDTEKLASSE       varchar2(32)        \
    BREEDTE             varchar2(32)        \
    HOOFDAFWATERING     varchar2(32)        \
    ZOUTGEHALTE         varchar2(32)        \
    TOEGANKELIJKHEID    varchar2(32)        \
    FYSIEK_VOORKOMEN    varchar2(32)        \
    GEBRUIK             varchar2(32)        \
    STROOMRICHTING      varchar2(32)        \
    STATUS              varchar2(32)        \
    NAAM                varchar2(32)        \
    HOOGTENIVEAU        number(12)          \
    GEOMETRYPROPERTY    geometry            \
    TDNCODE             number(12)

SHAPE WATERDEEL_line                        \
    OID                 %OID                \
    BEGINDATUM          %BEGINDATUM         \
    EINDDATUM           %EINDDATUM          \
    BRONTYPE            %BRONTYPE           \
    BRONBESCHR          %BRONBESCHRIJVING   \
    NAUWKEURIG          %NAUWKEURIGHEID     \
    ACTUALITEI          %ACTUALITEIT        \
    TYPE                %TYPE               \
    WATERTYPE           %WATERTYPE          \
    BREEDTEKLA          %BREEDTEKLA         \
```

```
    BREEDTE             %BREEDTE            \
    HOOFDAFWAT          %HOOFDAFWAT         \
    ZOUTGEHALT          %ZOUTGEHALT         \
    TOEGANKELI          %TOEGANKELI         \
    VOORKOMEN           %VOORKOMEN          \
    GEBRUIK             %GEBRUIK            \
    STROOMRICH          %STROOMRICH         \
    STATUS              %STATUS             \
    NAAM                %NAAM               \
    HOOGTENIVE          %HOOGTENIVE         \
    TDNCODE             %TDNCODE

ORACLE8I WATERDEEL                          \
    OID                 %OID                \
    TOP10_ID            %OID                \
    BEGINDATUM          %BEGINDATUM         \
    EINDDATUM           %EINDDATUM          \
    BRONTYPE            %BRONTYPE           \
    BRONBESCHRIJVING    %BRONBESCHRIJVING   \
    NAUWKEURIGHEID      %NAUWKEURIGHEID     \
    ACTUALITEIT         %ACTUALITEIT        \
    TYPE                %TYPE               \
    WATERTYPE           %WATERTYPE          \
    BREEDTEKLASSE       %BREEDTEKLA         \
    BREEDTE             %BREEDTE            \
    HOOFDAFWATERING     %HOOFDAFWAT         \
    ZOUTGEHALTE         %ZOUTGEHALT         \
    TOEGANKELIJKHEID    %TOEGANKELI         \
    FYSIEK_VOORKOMEN    %VOORKOMEN          \
    GEBRUIK             %GEBRUIK            \
    STROOMRICHTING      %STROOMRICH         \
    STATUS              %STATUS             \
    NAAM                %NAAM               \
    HOOGTENIVEAU        %HOOGTENIVE         \
    TDNCODE             %TDNCODE

SHAPE WATERDEEL_area                        \
    OID                 %OID                \
    BEGINDATUM          %BEGINDATUM         \
    EINDDATUM           %EINDDATUM          \
    BRONTYPE            %BRONTYPE           \
    BRONBESCHR          %BRONBESCHRIJVING   \
    NAUWKEURIG          %NAUWKEURIGHEID     \
    ACTUALITEI          %ACTUALITEIT        \
    TYPE                %TYPE               \
    WATERTYPE           %WATERTYPE          \
    BREEDTEKLA          %BREEDTEKLA         \
    BREEDTE             %BREEDTE            \
    HOOFDAFWAT          %HOOFDAFWAT         \
    ZOUTGEHALT          %ZOUTGEHALT         \
    TOEGANKELI          %TOEGANKELI         \
    VOORKOMEN           %VOORKOMEN          \
    GEBRUIK             %GEBRUIK            \
    STROOMRICH          %STROOMRICH         \
    STATUS              %STATUS             \
    NAAM                %NAAM               \
    HOOGTENIVE          %HOOGTENIVE         \
    TDNCODE             %TDNCODE

ORACLE8I WATERDEEL                          \
    OID                 %OID                \
    TOP10_ID            %OID                \
    BEGINDATUM          %BEGINDATUM         \
    EINDDATUM           %EINDDATUM          \
    BRONTYPE            %BRONTYPE           \
    BRONBESCHRIJVING    %BRONBESCHRIJVING   \
    NAUWKEURIGHEID      %NAUWKEURIGHEID     \
    ACTUALITEIT         %ACTUALITEIT        \
    TYPE                %TYPE               \
```

```
    WATERTYPE           %WATERTYPE          \
    BREEDTEKLASSE       %BREEDTEKLA         \
    BREEDTE             %BREEDTE            \
    HOOFDAFWATERING     %HOOFDAFWAT         \
    ZOUTGEHALTE         %ZOUTGEHALT         \
    TOEGANKELIJKHEID    %TOEGANKELI         \
    FYSIEK_VOORKOMEN    %VOORKOMEN          \
    GEBRUIK             %GEBRUIK            \
    STROOMRICHTING      %STROOMRICH         \
    STATUS              %STATUS             \
    NAAM                %NAAM               \
    HOOGTENIVEAU        %HOOGTENIVE         \
    TDNCODE             %TDNCODE

# ========================================================================

SHAPE_DEF WEGDEEL_line                      \
    SHAPE_GEOMETRY      shape_polyline      \
    OID                 number(11,0)        \
    BEGINDATUM          char(20)            \
    EINDDATUM           char(20)            \
    BRONTYPE            char(32)            \
    BRONBESCHR          char(32)            \
    NAUWKEURIG          char(32)            \
    ACTUALITEI          char(20)            \
    TYPE                char(32)            \
    WEGTYPE             char(32)            \
    HOOFDVERKE          char(32)            \
    VOORKOMEN           char(32)            \
    KRUISINGST          char(32)            \
    VERHARDING          char(32)            \
    VERHARDI0           char(32)            \
    VERHARDI1           char(32)            \
    VERHARDI2           char(32)            \
    RIJSTROKEN          char(32)            \
    RIJRICHTIN          char(32)            \
    TOEGANKELI          char(32)            \
    STATUS              char(32)            \
    STRAATNAAM          char(32)            \
    WEGNUMMER           char(32)            \
    HOOGTENIVE          number(11,0)        \
    TDNCODE             number(11,0)

SHAPE_DEF WEGDEEL_area                      \
    SHAPE_GEOMETRY      shape_polygon       \
    OID                 number(11,0)        \
    BEGINDATUM          char(20)            \
    EINDDATUM           char(20)            \
    BRONTYPE            char(32)            \
    BRONBESCHR          char(32)            \
    NAUWKEURIG          char(32)            \
    ACTUALITEI          char(20)            \
    TYPE                char(32)            \
    WEGTYPE             char(32)            \
    HOOFDVERKE          char(32)            \
    VOORKOMEN           char(32)            \
    KRUISINGST          char(32)            \
    VERHARDING          char(32)            \
    VERHARDI0           char(32)            \
    VERHARDI1           char(32)            \
    VERHARDI2           char(32)            \
    RIJSTROKEN          char(32)            \
    RIJRICHTIN          char(32)            \
    TOEGANKELI          char(32)            \
    STATUS              char(32)            \
    STRAATNAAM          char(32)            \
    WEGNUMMER           char(32)            \
    HOOGTENIVE          number(11,0)        \
    TDNCODE             number(11,0)
```

```
ORACLE8I_DEF WEGDEEL                          \
    $(_ORACLE_Config)                         \
    OID                 number(12)            \
    TOP10_ID            number(12)            \
    BEGINDATUM          varchar2(20)          \
    EINDDATUM           varchar2(20)          \
    BRONTYPE            varchar2(32)          \
    BRONBESCHRIJVING    varchar2(32)          \
    NAUWKEURIGHEID      varchar2(32)          \
    ACTUALITEIT         varchar2(20)          \
    TYPE                varchar2(32)          \
    WEGTYPE             varchar2(32)          \
    HOOFDVERKEERSGEBRUIK varchar2(32)         \
    FYSIEK_VOORKOMEN    varchar2(32)          \
    KRUISINGSTYPE       varchar2(32)          \
    VERHARDINGSBREEDTEKLASSE varchar2(32)     \
    VERHARDINGSBREEDTE  varchar2(32)          \
    VERHARDINGSTYPE     varchar2(32)          \
    VERHARDINGSMATERIAAL varchar2(32)         \
    AANTAL_RIJSTROKEN   varchar2(32)          \
    RIJRICHTING         varchar2(32)          \
    TOEGANKELIJKHEID    varchar2(32)          \
    STATUS              varchar2(32)          \
    STRAATNAAM          varchar2(32)          \
    WEGNUMMER           varchar2(32)          \
    HOOGTENIVEAU        number(12)            \
    GEOMETRYPROPERTY    geometry              \
    TDNCODE             number(12)

SHAPE WEGDEEL_line                            \
    OID                 %OID                  \
    BEGINDATUM          %BEGINDATUM           \
    EINDDATUM           %EINDDATUM            \
    BRONTYPE            %BRONTYPE             \
    BRONBESCHR          %BRONBESCHRIJVING     \
    NAUWKEURIG          %NAUWKEURIGHEID       \
    ACTUALITEI          %ACTUALITEIT          \
    TYPE                %TYPE                 \
    WEGTYPE             %WEGTYPE              \
    HOOFDVERKE          %HOOFDVERKE           \
    VOORKOMEN           %VOORKOMEN            \
    KRUISINGST          %KRUISINGST           \
    VERHARDING          %VERHARDING           \
    VERHARDI0           %VERHARDI0            \
    VERHARDI1           %VERHARDI1            \
    VERHARDI2           %VERHARDI2            \
    RIJSTROKEN          %RIJSTROKEN           \
    RIJRICHTIN          %RIJRICHTIN           \
    TOEGANKELI          %TOEGANKELI           \
    STATUS              %STATUS               \
    STRAATNAAM          %STRAATNAAM           \
    WEGNUMMER           %WEGNUMMER            \
    HOOGTENIVE          %HOOGTENIVE           \
    TDNCODE             %TDNCODE

ORACLE8I WEGDEEL                              \
    OID                 %OID                  \
    TOP10_ID            %OID                  \
    BEGINDATUM          %BEGINDATUM           \
    EINDDATUM           %EINDDATUM            \
    BRONTYPE            %BRONTYPE             \
    BRONBESCHRIJVING    %BRONBESCHRIJVING     \
    NAUWKEURIGHEID      %NAUWKEURIGHEID       \
    ACTUALITEIT         %ACTUALITEIT          \
    TYPE                %TYPE                 \
    WEGTYPE             %WEGTYPE              \
    HOOFDVERKEERSGEBRUIK %HOOFDVERKE          \
    FYSIEK_VOORKOMEN    %VOORKOMEN            \
```

```
    KRUISINGSTYPE        %KRUISINGST           \
    VERHARDINGSBREEDTEKLASSE %VERHARDING       \
    VERHARDINGSBREEDTE   %VERHARDI0            \
    VERHARDINGSTYPE      %VERHARDI1            \
    VERHARDINGSMATERIAAL %VERHARDI2            \
    AANTAL_RIJSTROKEN    %RIJSTROKEN           \
    RIJRICHTING          %RIJRICHTIN           \
    TOEGANKELIJKHEID     %TOEGANKELI           \
    STATUS               %STATUS               \
    STRAATNAAM           %STRAATNAAM           \
    WEGNUMMER            %WEGNUMMER            \
    HOOGTENIVEAU         %HOOGTENIVE           \
    TDNCODE              %TDNCODE

SHAPE WEGDEEL_area                             \
    OID                  %OID                  \
    BEGINDATUM           %BEGINDATUM           \
    EINDDATUM            %EINDDATUM            \
    BRONTYPE             %BRONTYPE             \
    BRONBESCHR           %BRONBESCHRIJVING     \
    NAUWKEURIG           %NAUWKEURIGHEID       \
    ACTUALITEI           %ACTUALITEIT          \
    TYPE                 %TYPE                 \
    WEGTYPE              %WEGTYPE              \
    HOOFDVERKE           %HOOFDVERKE           \
    VOORKOMEN            %VOORKOMEN            \
    KRUISINGST           %KRUISINGST           \
    VERHARDING           %VERHARDING           \
    VERHARDI0            %VERHARDI0            \
    VERHARDI1            %VERHARDI1            \
    VERHARDI2            %VERHARDI2            \
    RIJSTROKEN           %RIJSTROKEN           \
    RIJRICHTIN           %RIJRICHTIN           \
    TOEGANKELI           %TOEGANKELI           \
    STATUS               %STATUS               \
    STRAATNAAM           %STRAATNAAM           \
    WEGNUMMER            %WEGNUMMER            \
    HOOGTENIVE           %HOOGTENIVE           \
    TDNCODE              %TDNCODE

ORACLE8I WEGDEEL                               \
    OID                  %OID                  \
    TOP10_ID             %OID                  \
    BEGINDATUM           %BEGINDATUM           \
    EINDDATUM            %EINDDATUM            \
    BRONTYPE             %BRONTYPE             \
    BRONBESCHRIJVING     %BRONBESCHRIJVING     \
    NAUWKEURIGHEID       %NAUWKEURIGHEID       \
    ACTUALITEIT          %ACTUALITEIT          \
    TYPE                 %TYPE                 \
    WEGTYPE              %WEGTYPE              \
    HOOFDVERKEERSGEBRUIK %HOOFDVERKE           \
    FYSIEK_VOORKOMEN     %VOORKOMEN            \
    KRUISINGSTYPE        %KRUISINGST           \
    VERHARDINGSBREEDTEKLASSE %VERHARDING       \
    VERHARDINGSBREEDTE   %VERHARDI0            \
    VERHARDINGSTYPE      %VERHARDI1            \
    VERHARDINGSMATERIAAL %VERHARDI2            \
    AANTAL_RIJSTROKEN    %RIJSTROKEN           \
    RIJRICHTING          %RIJRICHTIN           \
    TOEGANKELIJKHEID     %TOEGANKELI           \
    STATUS               %STATUS               \
    STRAATNAAM           %STRAATNAAM           \
    WEGNUMMER            %WEGNUMMER            \
    HOOGTENIVEAU         %HOOGTENIVE           \
    TDNCODE              %TDNCODE

# ============================================================================
# ============================================================================
```

Appendix B

Oracle scripts

As an example of the many Oracle scripts used in the conversion process the script to cut out buildings from the terrain layer is included in this appendix. As noted before, flexibility is of prime importance for the tools used to develop a prototype. For the GML prototype a complex mixture of shell scripts, Unix utilities (sed, awk, perl), SQL scripts, PL/SQL programs and Java programs was used, all easily adaptable to new needs. After developing the Java application to create GML documents some modules of that application proved to be very handy too for the conversion process (e.g. to create spatial metadata or spatial indices in the database).

Due to changing demands the scripts and programs kept on changing during the whole project with the result that most of them are difficult to read for 'outsiders' (the goal was a prototype, not a production environment). Many of the scripts are created 'on the fly' based on input arguments, executed and deleted immediately afterwards. The script included here is one of the more 'readable' ones, a mixture of shell variables and PL/SQL code. The first part of the script consists of initialization and a number of basic checks. Then the program 'loops' through the features of the spatial layers involved, terrain and buildings. To avoid unnecessary calculations various primary and secondairy filters are applied before the spatial MINUS operation (`sdo_difference`) is executed.

```
#!/bin/sh
# erase.sh  15-07-2001  TT
#
# Script to erase (part of) geometries in a layer
# with geometries from another layer

BASETABLE=${1:-'terreinen'}
CLIPTABLE=${2:-'bebouwingen'}
 DATABASE=${3:-'tdn/tdn'}

GEOM_ATTR='geom'
 OID_ATTR='oid'
TOLERANCE='0.000001'

cat > erase.sql << EOB
--============================================================================
set echo on
set lines 120
set pages 500
col gtype format 9999
set serveroutput on
execute dbms_output.enable (2000000);
alter session set session_cached_cursors=300;
```

```
set trimspool on
spool erase.log

drop table ${BASETABLE}_clipped;
create table ${BASETABLE}_clipped as select * from ${BASETABLE} where rownum < 1;

delete from user_sdo_geom_metadata where table_name = upper('${BASETABLE}_clipped');
insert into user_sdo_geom_metadata values ('${BASETABLE}_clipped','${GEOM_ATTR}',
    mdsys.sdo_dim_array(mdsys.sdo_dim_element('X',-25000,325000,${TOLERANCE}),
                        mdsys.sdo_dim_element('Y',275000,650000,${TOLERANCE})),NULL);
commit;
select count(*) from ${BASETABLE};
select count(*) from ${CLIPTABLE};
set timing on

DECLARE

  new_geom          ${BASETABLE}.${GEOM_ATTR}%TYPE;
  clip_geom         ${BASETABLE}.${GEOM_ATTR}%TYPE;
  ${OID_ATTR}       ${BASETABLE}.${OID_ATTR}%TYPE;
  begindatum        ${BASETABLE}.begindatum%TYPE;
  einddatum         ${BASETABLE}.einddatum%TYPE;
  brontype          ${BASETABLE}.brontype%TYPE;
  bronbeschrijving  ${BASETABLE}.bronbeschrijving%TYPE;
  nauwkeurigheid    ${BASETABLE}.nauwkeurigheid%TYPE;
  actualiteit       ${BASETABLE}.actualiteit%TYPE;
  word_1            ${BASETABLE}.word_1%TYPE;
  tdncode           ${BASETABLE}.tdncode%TYPE;
  word_4            ${BASETABLE}.word_4%TYPE;
  cursor base_table is
                    select * from ${BASETABLE} order by ${OID_ATTR};
  cursor clip_table is
                    select ${GEOM_ATTR} from ${CLIPTABLE};
  type object_list is table of ${BASETABLE}.${OID_ATTR}%TYPE;
  clip_objects      object_list;
  nbase             number(12);
  nclip             number(12);
  ndistinct         number(12);
  nchk              number(12) := 0;
  interact          number(12);
  tot_interact      number(12) := 0;
  logstr            varchar2(255);
  logfile           UTL_FILE.FILE_TYPE;
  oid_not_unique    EXCEPTION;

BEGIN

  logfile := utl_file.fopen('/var/tmp','erase_progress.log','a');
  select count(*) into nbase from ${BASETABLE};
  logstr := 'Base table (${BASETABLE}) rows: '||nbase;
  utl_file.put_line(logfile,logstr);
  select count(distinct ${OID_ATTR}) into ndistinct from ${BASETABLE};
  if nbase <> ndistinct then
      dbms_output.put_line('');
      dbms_output.put_line('ERROR: Base table (${BASETABLE}) ${OID_ATTR} not unique.');
      raise oid_not_unique;
  end if;
  select count(*) into nclip from ${CLIPTABLE};
  logstr := 'Clip table (${CLIPTABLE}) rows: '||nclip;
  utl_file.put_line(logfile,logstr);
  select count(distinct ${OID_ATTR}) into ndistinct from ${CLIPTABLE};
  if nclip <> ndistinct then
      dbms_output.put_line('');
      dbms_output.put_line('ERROR: Clip table (${CLIPTABLE}) ${OID_ATTR} not unique.');
      raise oid_not_unique;
  end if;
  logstr := 'Potential checks: '||nbase*nclip;
  utl_file.put_line(logfile,logstr);
  utl_file.fflush(logfile);
```

```
  for base_object in base_table loop

      new_geom := base_object.${GEOM_ATTR};

      select count(*) into interact from ${CLIPTABLE} where mdsys.sdo_relate
          (${GEOM_ATTR},new_geom,'mask=anyinteract querytype=window') = 'TRUE';
      nchk := nchk + nclip;

      if interact > 0 then

          select ${OID_ATTR} bulk collect into clip_objects from ${CLIPTABLE}
              where mdsys.sdo_relate(${GEOM_ATTR},new_geom,
              'mask=anyinteract querytype=window') = 'TRUE';

          for i in clip_objects.first..clip_objects.last loop

              select ${GEOM_ATTR} into clip_geom from ${CLIPTABLE}
                  where ${OID_ATTR} = clip_objects(i);

              new_geom := sdo_geom.sdo_difference(new_geom,clip_geom,${TOLERANCE});

              if new_geom is NULL then
                  logstr := '${BASETABLE} object '||base_object.${OID_ATTR}||
                      ' NULL after ${CLIPTABLE} object '||clip_objects(i);
                  utl_file.put_line(logfile,logstr);
                  utl_file.fflush(logfile);
                  exit;
              end if;
          end loop;

          tot_interact := tot_interact + interact;
      end if;

      if new_geom is NULL then
          dbms_output.put_line('');
          dbms_output.put_line('Warning: ${BASETABLE} object '||
              base_object.${OID_ATTR}||' completely erased');
      else
          insert into ${BASETABLE}_clipped values (base_object.${OID_ATTR},
              base_object.begindatum, base_object.einddatum,
              base_object.brontype, base_object.bronbeschrijving,
              base_object.nauwkeurigheid, base_object.actualiteit, new_geom,
              base_object.word_1, base_object.tdncode, base_object.word_4);
      end if;
      logstr := '${BASETABLE} object '||base_object.${OID_ATTR}||' processed, '
          ||interact||' interactions with ${CLIPTABLE}';
      utl_file.put_line(logfile,logstr);
      utl_file.fflush(logfile);
  end loop;

  logstr := 'Clipping ready, '||tot_interact||
      ' interactions of potential of '||nchk||'.';
  utl_file.put_line(logfile,logstr);
  utl_file.fclose(logfile);
  dbms_output.put_line('');
  dbms_output.put_line(logstr);

EXCEPTION
  when oid_not_unique then
      return;
END;
/

set timing off
commit;
select count(*) from ${BASETABLE}_clipped;
select count(*),tc.${GEOM_ATTR}.sdo_gtype "GTYPE"
    from ${BASETABLE}_clipped tc group by tc.${GEOM_ATTR}.sdo_gtype;
```

```
spool off
quit
--============================================================================
EOB

sqlplus ${DATABASE} @erase.sql
rm -f erase.sql
exit
```

Appendix C

Java code for generation of GML

This Appendix contains the source code of the Java code to generate the strict version of the GML file.

C.1 TDNtoGMLstrict.java

```
package quak.applications;

import quak.gml.*;
import quak.gis.*;
import java.io.*;
import java.sql.*;
import oracle.sql.STRUCT;
import oracle.jdbc.driver.*;
import oracle.sdoapi.OraSpatialManager;
import oracle.sdoapi.adapter.*;
import oracle.sdoapi.geom.*;
import oracle.sdoapi.util.*;


/**
  * This sample program reads all geometries from a database table and
  * converts them to the GML format.
  *
  * @version $Revision: 1.2 $
  * @author Wilko Quak
  */
public class TDNtoGMLstrict
{
    static String outputBaseName;
    static GeometryAdapter sdoAdapter;

    //
    // Convert SDO objects to GML
    //
    public static void main(String args[]) throws Exception
    {
        //
        // Check command line arguments.
        //
        if (args.length != 3)
        {
          System.out.println("Parameters: basename user pass");
          return;
        }
```

```
String outputBaseName = args[0];
String user = args[1];
String pass = args[2];

//
// Connect to the database
//
Connection conn = DriverManager.getConnection(
        "jdbc:oracle:thin:@www.gdmc.nl:1521:kadtest",user,pass);

//
//
//
sdoAdapter = OraSpatialManager.getGeometryAdapter(
        "SDO",
        "8.1.6",
        STRUCT.class,
        null,
        null,
        conn);
Statement stmt = conn.createStatement();
OracleResultSet resultset;

//
// Open the GML file and write its header
//
GMLStream gml = new GMLStream(outputBaseName + ".gml");

//
// Fill in some parameters.
//
gml.setSrsName("EPSG:7408");
gml.setCoordDigits(3);
gml.setIndentSpaces(2);
gml.setCoordinatesPerLine(3);
gml.useCoordinates();
gml.setDefaultZCoordinate(0.0);
gml.setDefaultNameSpace("tdn");

//
// Calculate envelopes.
//
Envelope spoorbaandeel_envelope  = LoaderOracle.getEnvelope(conn,"spoorbaandeel","geometryproperty");
Envelope wegdeel_envelope  = LoaderOracle.getEnvelope(conn,"wegdeel","geometryproperty");
Envelope waterdeel_envelope  = LoaderOracle.getEnvelope(conn,"waterdeel","geometryproperty");
Envelope terrein_envelope  = LoaderOracle.getEnvelope(conn,"terrein","geometryproperty");
Envelope bebouwing_envelope  = LoaderOracle.getEnvelope(conn,"bebouwing","geometryproperty");
Envelope inrichtingselement_envelope = LoaderOracle.getEnvelope(conn,"inrichtingselement","geometryproperty");
Envelope functioneel_gebied_envelope = LoaderOracle.getEnvelope(conn,"functioneel_gebied","geometryproperty");
Envelope administratief_gebied_envelope = LoaderOracle.getEnvelope(conn,"administratief_gebied","geometryproperty");
Envelope geografisch_gebied_envelope = LoaderOracle.getEnvelope(conn,"geografisch_gebied","geometryproperty");

Envelope ruimtelijke_objecten_envelope = new EnvelopeImpl();
ruimtelijke_objecten_envelope.expand(spoorbaandeel_envelope);
ruimtelijke_objecten_envelope.expand(wegdeel_envelope);
ruimtelijke_objecten_envelope.expand(waterdeel_envelope);
ruimtelijke_objecten_envelope.expand(terrein_envelope);
ruimtelijke_objecten_envelope.expand(bebouwing_envelope);

Envelope all_envelope = new EnvelopeImpl();
all_envelope.expand(ruimtelijke_objecten_envelope);
all_envelope.expand(inrichtingselement_envelope);
all_envelope.expand(functioneel_gebied_envelope);
all_envelope.expand(administratief_gebied_envelope);
all_envelope.expand(geografisch_gebied_envelope);


//
// Write open collection tag.
```

```
//
gml.printHeader("tdn_strict.xsd");
gml.openFirstTag("Top10Themas","tdn_strict.xsd");

gml.printBoundedBy(all_envelope);
gml.println("");

//
// Print the first maplayer consisting of the database tables:
//   spoorbaandeel
//   wegdeel
//   waterdeel
//   terrein
//   bebouwing
//
gml.openTag("top10ThemasMember");
gml.openTag("RuimtelijkeObjecten");
gml.println("");

    gml.printBoundedBy(ruimtelijke_objecten_envelope);
    gml.println("");

    gml.printFeatures(
       stmt,
       "SELECT * FROM spoorbaandeel",
       sdoAdapter,
       "ruimtelijkeObjectenMember",
       "SpoorbaanDeel");

    gml.printFeatures(
       stmt,
       "SELECT * FROM wegdeel",
       sdoAdapter,
       "ruimtelijkeObjectenMember",
       "WegDeel");

    gml.printFeatures(
       stmt,
       "SELECT * FROM waterdeel",
       sdoAdapter,
       "ruimtelijkeObjectenMember",
       "WaterDeel");

    gml.printFeatures(
       stmt,
       "SELECT * FROM terrein",
       sdoAdapter,
       "ruimtelijkeObjectenMember",
       "Terrein");

    gml.printFeatures(
       stmt,
       "SELECT * FROM bebouwing",
       sdoAdapter,
       "ruimtelijkeObjectenMember",
       "Bebouwing");

gml.closeTag("RuimtelijkeObjecten");
gml.closeTag("top10ThemasMember");
gml.println("");


//
// inrichtingselement
//
if (inrichtingselement_envelope != null)
{
    gml.openTag("top10ThemasMember");
    gml.openTag("InrichtingsElementen");
```

```
    gml.println("");
    gml.printBoundedBy(inrichtingselement_envelope);
    gml.println("");
        gml.printFeatures(
           stmt,
           "SELECT * FROM inrichtingselement",
           sdoAdapter,
           "inrichtingsElementenMember",
           "InrichtingsElement");
    gml.closeTag("InrichtingsElementen");
    gml.closeTag("top10ThemasMember");
    gml.println("");
}

//
// functioneel_gebied
//
if (functioneel_gebied_envelope != null)
{
    gml.openTag("top10ThemasMember");
    gml.openTag("FunctioneleGebieden");
    gml.println("");
    gml.printBoundedBy(functioneel_gebied_envelope);
    gml.println("");
        gml.printFeatures(
           stmt,
           "SELECT * FROM functioneel_gebied",
           sdoAdapter,
           "functioneleGebiedenMember",
           "FunctioneelGebied");
    gml.closeTag("FunctioneleGebieden");
    gml.closeTag("top10ThemasMember");
    gml.println("");
}

//
// AdministratieveGebieden
//
if (administratief_gebied_envelope != null)
{
    gml.openTag("top10ThemasMember");
    gml.openTag("AdministratieveGebieden");
    gml.println("");
    gml.printBoundedBy(administratief_gebied_envelope);
    gml.println("");
        gml.printFeatures(
           stmt,
           "SELECT * FROM administratief_gebied",
           sdoAdapter,
           "administratieveGebiedenMember",
           "AdministratiefGebied");
    gml.closeTag("AdministratieveGebieden");
    gml.closeTag("top10ThemasMember");
    gml.println("");
}

//
// GeografischeGebieden
//
if (geografisch_gebied_envelope != null)
{
    gml.openTag("top10ThemasMember");
    gml.openTag("GeografischeGebieden");
    gml.println("");
    gml.printBoundedBy(geografisch_gebied_envelope);
    gml.println("");
        gml.printFeatures(
           stmt,
           "SELECT * FROM geografisch_gebied",
```

```
                    sdoAdapter,
                    "geografischeGebiedenMember",
                    "GeografischGebied");
            gml.closeTag("GeografischeGebieden");
            gml.closeTag("top10ThemasMember");
            gml.println("");
        }

        //
        // Close GML.
        //
        gml.closeTag("Top10Themas");

        gml.close();
        stmt.close();
        conn.close();
    }
}
```

C.2 GMLStream.java

```
package quak.gml;

import java.util.*;
import java.io.*;
import java.text.*;
import java.sql.*;
import oracle.sql.STRUCT;
import oracle.jdbc.driver.*;
import oracle.sdoapi.OraSpatialManager;
import oracle.sdoapi.adapter.*;
import oracle.sdoapi.geom.*;
import oracle.sdoapi.util.*;


/**
  * This package extends an OutputStream to handle GML files. It has
  * functionality for indentation and writing geometries.
  *
  * @version $Revision: 1.15 $
  * @author Wilko Quak
 */
public class GMLStream
   extends PrintStream
{
    /**
      *  Contruct a GMLStream that writes to the given filename.
      */
    public GMLStream(String name)
       throws java.io.FileNotFoundException
    {
        super(new FileOutputStream(name));
        filename = name;

        Integer maxv = Integer.getInteger("java.quak.gml.maxrecords");
        if (maxv != null)
           maxRecords = maxv.intValue();
        else
           maxRecords = -1;

        //
        // Set NumberFormat
        //
        coordinateFormat =  new DecimalFormat();
        coordinateFormat.setGroupingUsed(false);
```

```
        //
        // Set the number of spaces per indentlevel;
        //
        setIndentSpaces(4);

        //
        // Set coordinate format to print.
        //
        useCoordinates();

        //
        //
        //
        setCoordinatesPerLine(3);
    }

    /**
      *  The name of the file that is being written.
      */
    private String filename;

    /**
      *  The current srsName that is used.
      */
    private String srsName = "srs";

    /**
      * Set the name of the Spatial Reference System that is used
      * when printing a geometry.
      */
    public void setSrsName(String newname)
    {
       srsName = newname;
    }

    private int coordinatesPerLine;

    /**
      *  Change the number of coordinates that should be printed per line.
      */
    public void setCoordinatesPerLine(int number)
    {
       coordinatesPerLine = number;
    }

    private static final int COORD_TAG = 0;
    private static final int COORDINATES_TAG = 1;
    private int coordType;

    /**
      *  Write &lt;coordinate&gt; tags from now on when writing coordinates.
      */
    public void useCoordinates()
    {
       coordType = COORDINATES_TAG;
    }

    /**
      *  Write &it;coord&gt; tags from now on when writing coordinates.
      */
    public void useCoord()
    {
       coordType = COORD_TAG;
    }

    private int maxRecords;

    private boolean exceedsLimit(int number)
    {
```

```
   return((maxRecords != -1) && (number >= maxRecords));
}

private DecimalFormat coordinateFormat;

/**
  * Set the number of digits printed for a coordinate.
  */
public void setCoordDigits(int number)
{
   coordinateFormat.setMaximumFractionDigits(number);
}

/**
  *  The number of spaces to print per indentlevel.
  */
private int indentSpaces;

/**
  * Set the number of spaces to print per indentlevel.
  */
public void setIndentSpaces(int number)
{
   indentSpaces = number;
}

/**
  * Set the maximum number of records to be written by printFeatures.
  * Set this to a low value when debugging.
  */
public void setMaxRecords(int m)
{
   maxRecords = m;
}

private int indentLevel = 0;

/**
  *  Increases the indent level of the lines written to this
  *  file by one.
  */
public void increaseIndent()
{
   ++indentLevel;
}

/**
  *  Decreases the indent level of the lines written to this
  *  file by one.
  */
public void decreaseIndent()
{
   --indentLevel;
}

/**
  *  Print the number of spaces needed for the current indentLevel
  *  and indentSpaces.
  */
public void indent()
{
    int spaces = indentLevel * indentSpaces;

    for(int i=spaces/8;i>0;--i)
    {
       super.print("\t");
    }
    for(int i=(spaces%8);i>0;--i)
    {
```

```
       super.print(" ");
    }
}

/**
  *  Print string to the output, preceded by the number of spaces
  *  for the indentation.
  */
public void println(String s)
{
    if (s.length() == 0)
    {
       super.println("");
    }
    else
    {
        indent();
        super.println(s);
    }
}

/**
  *  Write Header for GML file.
  *  @param xsdname The location of the schema definition of this file.
  */
public void printHeader(String xsdname)
{
    println("<?xml version=\"1.0\" encoding=\"iso-8859-1\" standalone=\"no\"?>");
    println("<!-- File: " + filename + "  -->");
}
/**
  *  Write Header for GML file.
  *  @param xsdname The location of the schema definition of this file.
  */
public void openFirstTag(String tagname,String xsdname)
{
    println("<" + getDefaultNameSpace() + ":" + tagname);
    increaseIndent();
          println("xmlns:tdn=\"http://www.gdmc.nl/tdn\"");
          println("xmlns:gml=\"http://www.opengis.net/gml\"");
          println("xmlns:xlink=\"http://www.w3.org/1999/xlink\"");
          println("xmlns:xsi=\"http://www.w3.org/2000/10/XMLSchema-instance\"");
          println("xsi:schemaLocation=\"http://www.gdmc.nl/tdn " + xsdname + "\">");
    decreaseIndent();
    println("");
    increaseIndent();
}

/**
  *  Prints envelope in GML Style.
  */
public void printBoundedBy(Envelope envelope)
{
    if (envelope == null)
    {
        println("<gml:boundedBy />");
    }
    else
    {
        CoordPoint cp[] = new CoordPoint[2];
        cp[0] = new CoordPointImpl(envelope.getMinX(),envelope.getMinY());
        cp[1] = new CoordPointImpl(envelope.getMaxX(),envelope.getMaxY());

        println("<gml:boundedBy>");
        increaseIndent();
            println("<gml:Box srsName=\"" + srsName + "\">");
            increaseIndent();
                printCoordinates(cp);
            decreaseIndent();
```

```
            println("</gml:Box>");
        decreaseIndent();
        println("</gml:boundedBy>");
    }
}

public void printFeatures (
    Statement statement,
    String query,
    GeometryAdapter sdoAdapter,
    String associationTag,
    String featureTag
) throws
   SQLException,
   IOException,
   oracle.sdoapi.geom.InvalidGeometryException,
   oracle.sdoapi.adapter.GeometryInputTypeNotSupportedException,
   oracle.sdoapi.adapter.GeometryOutputTypeNotSupportedException
{
    try
    {
        OracleResultSet resultset = (OracleResultSet)statement.executeQuery(query);
        printFeatures(resultset, sdoAdapter,associationTag,featureTag);
    }
    catch(SQLException e)
    {
       if (e.getErrorCode() == 942)
       {
          System.err.println("Table or view did not exists for query:");
          System.err.println("   " + query);
       }
       else
       {
          throw(e);
       }
    }
}

public void printFeatures (
    OracleResultSet ors,
    GeometryAdapter sdoAdapter,
    String associationTag,
    String featureTag
) throws
   SQLException,
   IOException,
   oracle.sdoapi.geom.InvalidGeometryException,
   oracle.sdoapi.adapter.GeometryInputTypeNotSupportedException,
   oracle.sdoapi.adapter.GeometryOutputTypeNotSupportedException
{
    ResultSetMetaData metadata = ors.getMetaData();
    //
    // Number of columns in table.
    //
    int ncolumns = metadata.getColumnCount();


    //
    // Index of OID attribute. This one gets a special treatment.
    //
    int oidattr = -1;

    //
    // Make an array with all the columnnames.
    //
    String[] columnNames = new String[ncolumns + 1];
    for (int j=1;j<=ncolumns;++j)
    {
         columnNames[j] = new String(metadata.getColumnName(j).toLowerCase());
```

```
      if (columnNames[j].equals("oid"))
      {
         oidattr = j;
      }

//    if (columnNames[j].equals("extentof"))
//    {
//        columnNames[j] = "extentOf";
//    }
}

int localcounter = 0;
while (ors.next())
{
  if (exceedsLimit(localcounter))
  {
     System.err.print(" [truncated]");
     break;
  }
  ++localcounter;
  if ((localcounter % 25) == 0)
  {
     System.err.print(".");
  }
  if ((localcounter % 500) == 0)
  {
     System.err.println(". " + localcounter);
  }

  //
  // If we have an oid attribute we put it up front.
  //
  if (associationTag != "featureMember")
      openTag(associationTag);
  else
      openTag("gml",associationTag);

  if (oidattr != -1)
  {
      println("<" + getDefaultNameSpace() + ":" + featureTag + " fid=\"TOP10." + ors.getString(oidattr) + "\">");
      increaseIndent();
  }
  else
  {
       openTag(featureTag);
  }

  for (int i=1;i<=ncolumns;++i)
  {
       //
       // oid is already printed in front.
       //
       if (i == oidattr)
          continue;

     switch(metadata.getColumnType(i))
     {
        case Types.TIMESTAMP:
           Timestamp t = ors.getTimestamp(i);
            if (t == null)
                   printTag(columnNames[i],null);
            else
                   printTag(columnNames[i],t.toString());
           break;
        case Types.VARCHAR:
        case Types.NUMERIC:
           printTag(columnNames[i],ors.getString(i));
           break;
```

```
            case 2002:
                if (columnNames[i].equals("polygonproperty"))
                    openTag("gml","polygonProperty");
                else
                    openTag("gml","geometryProperty");

                    printGeometry(sdoAdapter.importGeometry((STRUCT) ors.getObject(i)));

                if (columnNames[i].equals("polygonproperty"))
                    closeTag("gml","polygonProperty");
                else
                    closeTag("gml","geometryProperty");
                break;
            default:
                System.err.println("Column " + i + " has type unkn: " +
                metadata.getColumnTypeName(i) + "(" + metadata.getColumnType(i) + ")");
          }
      }
      closeTag(featureTag);
      if (associationTag != "featureMember")
          closeTag(associationTag);
      else
          closeTag("gml",associationTag);
      println("");
    }
    System.out.println(" "  + localcounter + " [" + featureTag + " done]");
}


/**
  * Print an Oracle SDO geometry in GML style.
  */
public void printGeometry(Geometry geom)
{
    if (geom instanceof Point)
        printPoint((Point)geom,"");
    else if (geom instanceof LineString)
        printLineString((LineString)geom,"");
    else if (geom instanceof Polygon)
        printPolygon((Polygon)geom,"");
    else if (geom instanceof MultiPolygon)
        printMultiPolygon((MultiPolygon)geom);
    else if (geom instanceof MultiLineString)
        printMultiLineString((MultiLineString)geom);
    else if (geom instanceof MultiPoint)
        printMultiPoint((MultiPoint)geom);
    else if (geom instanceof GeometryCollection)
        printGeometryCollection((GeometryCollection)geom);
    else
    {
        System.err.println("ERROR: geometry of unknown type: " + geom);
    }
}

/**
  *  Generate a GML coordinate pair.
  */
private String coordToString(double x,double y)
{
    if (defaultZCoordinate == null)
    {
        if (coordType == COORDINATES_TAG)
            return new String(coordinateFormat.format(x) + "," +
                              coordinateFormat.format(y));
        else
            return new String("<x>" + coordinateFormat.format(x) + "</x><y>" +
                                      coordinateFormat.format(y) + "</y>");
    }
    else
```

```
    {
        if (coordType == COORDINATES_TAG)
            return new String(coordinateFormat.format(x) + "," +
                              coordinateFormat.format(y) + "," +
                              defaultZCoordinate);
        else
            return new String("<x>" + coordinateFormat.format(x) + "</x><y>" +
                                      coordinateFormat.format(y) + "</y><z>" +
                                      defaultZCoordinate + "</z>");
    }
}

private void printCoordinates(CoordPoint[] coords)
{
    if (coordType == COORDINATES_TAG)
        println("<gml:coordinates>");
    else
        println("<gml:coord>");

    increaseIndent();
        for(int i=0; i<coords.length; i++)
        {
            if ((i % coordinatesPerLine) == 0)
            {
                if (i != 0)
                   print("\n");
                indent();
            }
            else
               print(" ");
           print(coordToString(coords[i].getX(),coords[i].getY()));
        }
        print("\n");
        decreaseIndent();
    if (coordType == COORDINATES_TAG)
        println("</gml:coordinates>");
    else
        println("</gml:coord>");
}

private void printLinearRing(CoordPoint[] coords)
{
    openTag("gml","LinearRing");
        printCoordinates(coords);
    closeTag("gml","LinearRing");
}

/**
  *  Generates a string representing a DOM node for the given Point.
  */
public void printPoint(Point p,String mtype)
{
    CoordPoint cp[] = new CoordPoint[1];
    cp[0] = new CoordPointImpl(p);

    if (mtype != "multi")
        println("<gml:Point srsName=\"" + srsName + "\">");
    else
        println("<gml:Point>");
    increaseIndent();
        printCoordinates(cp);
    decreaseIndent();
    println("</gml:Point>");
}

/**
  * Generates a string representing a DOM node out of the given line string.
  */
public void printLineString(LineString ls,String mtype)
```

```
{
    if (mtype != "multi")
        println("<gml:LineString srsName=\"" + srsName + "\">");
    else
        println("<gml:LineString>");
    increaseIndent();
        printCoordinates(ls.getPointArray());
    decreaseIndent();
    println("</gml:LineString>");
}

/**
  *  Prints an oracle.sdoapi.geom.Polygon to a GML file.
  */
public void printPolygon(Polygon pg,String mtype)
{
    if (mtype != "multi")
        println("<gml:Polygon srsName=\"" + srsName + "\">");
    else
        println("<gml:Polygon>");
    increaseIndent();
        println("<gml:outerBoundaryIs>");
        increaseIndent();
            printLinearRing(pg.getExteriorRing().getPointArray());
        decreaseIndent();
        println("</gml:outerBoundaryIs>");

        for(int r=1;r<pg.getNumRings();++r)
        {
            println("<gml:innerBoundaryIs>");
            increaseIndent();
                printLinearRing(pg.getRingAt(r).getPointArray());
            decreaseIndent();
            println("</gml:innerBoundaryIs>");
        }
    decreaseIndent();
    println("</gml:Polygon>");
}

/**
  * Generates a string representating a DOM node out of the given multipolygon.
  */
public void printMultiPolygon(MultiPolygon mpg)
{
    println("<gml:MultiPolygon srsName=\"" + srsName + "\">");
    increaseIndent();
        Enumeration pg = mpg.getGeometries();
        while(pg.hasMoreElements())
        {
            println("<gml:polygonMember>");
            increaseIndent();
                printPolygon((Polygon)pg.nextElement(),"multi");
            decreaseIndent();
            println("</gml:polygonMember>");
        }
    closeTag("gml","MultiPolygon");
}

/**
  * Generates a string representating a DOM node out of the given multilinestring.
  */
public void printMultiLineString(MultiLineString mls)
{
    println("<gml:MultiLineString srsName=\"" + srsName + "\">");
    increaseIndent();
        Enumeration ls = mls.getGeometries();
        while(ls.hasMoreElements())
        {
            println("<gml:lineStringMember>");
```

```
            increaseIndent();
                printLineString((LineString)ls.nextElement(),"multi");
            decreaseIndent();
            println("</gml:lineStringMember>");
        }
    closeTag("gml","MultiLineString");
}

/**
* Generates a string representating a DOM node out of the given multipoint.
*/
public void printMultiPoint(MultiPoint mp)
{
    println("<gml:MultiPoint srsName=\"" + srsName + "\">");
    increaseIndent();
        Enumeration p = mp.getGeometries();
        while(p.hasMoreElements())
        {
            println("<gml:pointMember>");
            increaseIndent();
                printPoint((Point)p.nextElement(),"multi");
            decreaseIndent();
            println("</gml:pointMember>");
        }
    closeTag("gml","MultiPoint");
}

/**
  * Generates a string representating a DOM node out of the given
  * geometry collection.
  */
public void printGeometryCollection(GeometryCollection gc)
{
    println("<gml:MultiGeometry srsName=\"" + srsName + "\">");
    increaseIndent();
        Enumeration g = gc.getGeometries();
        while(g.hasMoreElements())
        {
            println("<gml:geometryMember>");
            increaseIndent();
                printGeometry((Geometry)g.nextElement());
            decreaseIndent();
            println("</gml:geometryMember>");
        }
    closeTag("gml","GeometryCollection");
}

public void printTag(String namespace,String tag,String value)
{
    if (value != null)
    {
        println("<" + namespace + ":" + tag + ">" + value +
                "</"  + namespace + ":" + tag + ">");
    }
    else
    {
        println("<" + namespace + ":" + tag + "/>");
    }
}

/**
  * Print an open tag the value and the close tag. The tags are prefixed with
  * the given default namespace.
  */
public void printTag(String tag,String value)
{
   printTag(getDefaultNameSpace(),tag,value);
}
```

```
/**
  * Print an open tag in the give namespace on a separate line.
  */
public void closeTag(String namespace,String tag)
{
    decreaseIndent();
    println("</" + namespace + ":" + tag + ">");
}

/**
  * Print a close tag in the default namespace on a separate line.
  */
public void closeTag(String tag)
{
           closeTag(getDefaultNameSpace(),tag);
}

/**
  * Print an open tag in the given namespace on a separate line.
  */
public void openTag(String namespace,String tag)
{
    println("<" + namespace + ":" + tag + ">");
    increaseIndent();
}

/**
  * Print an open tag in the default namespace on a separate line.
  */
public void openTag(String tag)
{
   openTag(getDefaultNameSpace(),tag);
}

private String nameSpace = "namespace";

/**
  * Return the current default Namespace.
  */
public String getDefaultNameSpace()
{
   return (nameSpace);
}

/**
  * Set the current default Namespace.
  */
public void setDefaultNameSpace(String s)
{
   nameSpace = s;
}

private Double defaultZCoordinate = null;

/**
  *  Set the default Z-Coordinate that is printed with every location.
  */
public void setDefaultZCoordinate(Double value)
{
   defaultZCoordinate = value;
}

/**
  *  Set the default Z-Coordinate that is printed with every location.
  */
public void setDefaultZCoordinate(double value)
{
   defaultZCoordinate = new Double(value);
}
```

```
}
```

Appendix D

Schema definitions and sample GML document

This appendix contains the complete schema definition for the TDN prototype. Both the strict and the free version are given. Also for both versions a valid sample document is given.

D.1 Strict schema definition (tdn_strict.xsd)

```
<?xml version="1.0" encoding="iso-8859-1"?>
<!-- File: tdn_strict.xsd  -->
<schema targetNamespace="http://www.gdmc.nl/tdn"
        xmlns:tdn="http://www.gdmc.nl/tdn"
        xmlns:xlink="http://www.w3.org/1999/xlink"
        xmlns:gml="http://www.opengis.net/gml"
        xmlns="http://www.w3.org/2000/10/XMLSchema"
        elementFormDefault="qualified"
        version="1.0">

  <annotation>
    <appinfo>tdn_strict.xsd v2.0</appinfo>
    <documentation xml:lang="en">
      GML prototype schema for the Dutch Topographic Service 1:10.000 data.
      This 'strict' version has:
      - simple (enumeration) types to restrict the possible values of attribute data
      - feature association types to restrict the membership of feature collections
    </documentation>
  </annotation>

  <!-- import constructs from the GML Feature and Geometry schemas -->
  <import namespace="http://www.opengis.net/gml" schemaLocation="feature.xsd"/>

  <!-- ============================================================
       Declarations for Top10Themas (= root element)
  ============================================================== -->
  <element name="Top10Themas" substitutionGroup="gml:_FeatureCollection">
    <complexType>
      <complexContent>
        <extension base="gml:AbstractFeatureCollectionType">
        </extension>
      </complexContent>
    </complexType>
  </element>

  <element name="top10ThemasMember" type="tdn:Top10ThemasMemberType"
```

```
  substitutionGroup="gml:featureMember"/>
<complexType name="Top10ThemasMemberType">
  <complexContent>
    <restriction base="gml:FeatureAssociationType">
      <sequence minOccurs="0">
        <element ref="tdn:_Top10ThemasFeature"/>
      </sequence>
      <attributeGroup ref="gml:AssociationAttributeGroup"/>
    </restriction>
  </complexContent>
</complexType>

<element name="_Top10ThemasFeature" type="gml:AbstractFeatureType" abstract="true"
  substitutionGroup="gml:_Feature"/>

<!-- ============================================================
     Type definition of Top10ThemaType (= same type for all themes)
============================================================== -->
<complexType name="Top10ThemaType">
  <complexContent>
    <extension base="gml:AbstractFeatureCollectionType">
    </extension>
  </complexContent>
</complexType>

<!-- ============================================================
     Type definition of Top10ObjectType (= inherited and extended by
                                         all Top10 feature types)
============================================================== -->
<group name ="TemporeelObject">
          <sequence>
             <element name="begindatum" type="string"/>
             <element name="einddatum" type="string"/>
          </sequence>
</group>

<group name ="MetadataObject">
          <sequence>
             <element name="brontype" type="string"/>
             <element name="bronbeschrijving" type="string"/>
             <element name="nauwkeurigheid" type="string"/>
             <element name="actualiteit" type="string"/>
             <element name="tdncode" type="integer"/>
          </sequence>
</group>

<complexType name="Top10ObjectType" abstract="true">
  <complexContent>
    <extension base="gml:AbstractFeatureType">
          <sequence>
             <element name="top10_id" type="integer"/>
             <group ref="tdn:TemporeelObject"/>
             <group ref="tdn:MetadataObject"/>
          </sequence>
    </extension>
  </complexContent>
</complexType>

<!-- ============================================================
     Type definition of InfrastructuurType (= inherited and extended by
     SpoorbaanDeelType, WegDeelType and WaterDeelType)
============================================================== -->
<complexType name="InfrastructuurType" abstract="true">
  <complexContent>
    <extension base="tdn:Top10ObjectType">
          <sequence>
             <element name="type" type="tdn:typeInfra"/>
             <element name="toegankelijkheid" type="tdn:toegankelijkheid"/>
             <element name="status" type="tdn:status"/>
```

```
          </sequence>
    </extension>
  </complexContent>
</complexType>

<!-- ============================================================
     Declarations for RuimtelijkeObjecten (= one of the themes)
============================================================== -->
<element name="RuimtelijkeObjecten" type="tdn:Top10ThemaType"
  substitutionGroup="tdn:_Top10ThemasFeature"/>

<element name="ruimtelijkeObjectenMember" type="tdn:RuimtelijkeObjectenMemberType"
  substitutionGroup="gml:featureMember"/>
<complexType name="RuimtelijkeObjectenMemberType">
  <annotation>
  </annotation>
  <complexContent>
    <restriction base="gml:FeatureAssociationType">
      <sequence minOccurs="0">
        <element ref="tdn:_RuimtelijkeObjectenFeature"/>
      </sequence>
      <attributeGroup ref="gml:AssociationAttributeGroup"/>
    </restriction>
  </complexContent>
</complexType>

<element name="_RuimtelijkeObjectenFeature" type="gml:AbstractFeatureType" abstract="true"
  substitutionGroup="gml:_Feature"/>

<element name="SpoorbaanDeel" type="tdn:SpoorbaanDeelType"
  substitutionGroup="tdn:_RuimtelijkeObjectenFeature"/>
<complexType name="SpoorbaanDeelType">
    <complexContent>
       <extension base="tdn:InfrastructuurType">
          <sequence>
             <element name="verkeersgebruik" type="tdn:verkeersgebruik"/>
             <element name="fysiek_voorkomen" type="tdn:fysiek_voorkomenSpoor"/>
             <element name="spoorbreedte" type="tdn:spoorbreedte"/>
             <element name="aantal_sporen" type="string"/>
             <element name="functie" type="tdn:functieSpoor" minOccurs="0"/>
             <element name="elektrificatie" type="tdn:elektrificatie"/>
             <element ref="gml:geometryProperty"/>
             <element name="hoogteniveau" type="integer" minOccurs="0"/>
          </sequence>
       </extension>
    </complexContent>
</complexType>

<element name="WegDeel" type="tdn:WegDeelType"
  substitutionGroup="tdn:_RuimtelijkeObjectenFeature"/>
<complexType name="WegDeelType">
    <complexContent>
       <extension base="tdn:InfrastructuurType">
          <sequence>
             <element name="wegtype" type="tdn:wegtype"/>
             <element name="hoofdverkeersgebruik" type="tdn:hoofdverkeersgebruik"/>
             <element name="fysiek_voorkomen" type="tdn:fysiek_voorkomenWeg"/>
             <element name="kruisingstype" type="tdn:kruisingstype"/>
             <element name="verhardingsbreedteklasse" type="string"/>
             <element name="verhardingsbreedte" type="string"/>
             <element name="verhardingstype" type="tdn:verhardingstype"/>
             <element name="verhardingsmateriaal" type="tdn:verhardingsmateriaal"/>
             <element name="aantal_rijstroken" type="string"/>
             <element name="rijrichting" type="tdn:rijrichting"/>
             <element ref="gml:geometryProperty"/>
             <element name="hoogteniveau" type="integer" minOccurs="0"/>
             <element name="straatnaam" type="string" minOccurs="0"/>
             <element name="wegnummer" type="string" minOccurs="0"/>
          </sequence>
```

```
      </extension>
    </complexContent>
</complexType>

<element name="WaterDeel" type="tdn:WaterDeelType"
  substitutionGroup="tdn:_RuimtelijkeObjectenFeature"/>
 <complexType name="WaterDeelType">
    <complexContent>
       <extension base="tdn:InfrastructuurType">
          <sequence>
             <element name="watertype" type="tdn:watertype"/>
             <element name="breedteklasse" type="string"/>
             <element name="breedte" type="string" minOccurs="0"/>
             <element name="hoofdafwatering" type="tdn:hoofdafwatering"/>
             <element name="zoutgehalte" type="tdn:zoutgehalte"/>
             <element name="fysiek_voorkomen" type="tdn:fysiek_voorkomenWater"/>
             <element name="gebruik" type="tdn:gebruik"/>
             <element name="stroomrichting" type="tdn:stroomrichting"/>
             <element ref="gml:geometryProperty"/>
             <element name="hoogteniveau" type="integer" minOccurs="0"/>
             <element name="naam" type="string" minOccurs="0"/>
          </sequence>
       </extension>
    </complexContent>
</complexType>

<element name="Terrein" type="tdn:TerreinType"
  substitutionGroup="tdn:_RuimtelijkeObjectenFeature"/>
<complexType name="TerreinType">
    <complexContent>
       <extension base="tdn:Top10ObjectType">
          <sequence>
             <element name="landgebruik" type="tdn:landgebruik"/>
             <element name="fysiek_voorkomen" type="tdn:fysiek_voorkomenTerrein"/>
             <element name="toegankelijkheid" type="tdn:toegankelijkheid"/>
             <element name="voorkomen" type="tdn:voorkomen" minOccurs="0"/>
             <element ref="gml:geometryProperty"/>
             <element name="hoogteniveau" type="integer" minOccurs="0"/>
             <element name="naam" type="string" minOccurs="0"/>
          </sequence>
       </extension>
    </complexContent>
</complexType>

<element name="Bebouwing" type="tdn:BebouwingType"
  substitutionGroup="tdn:_RuimtelijkeObjectenFeature"/>
<complexType name="BebouwingType">
    <complexContent>
       <extension base="tdn:Top10ObjectType">
          <sequence>
             <element name="type" type="tdn:typeBebouwing"/>
             <element name="functie" type="tdn:functieBebouwing"/>
             <element name="hoogteklasse" type="tdn:hoogteklasse"/>
             <element name="hoogte" type="string"/>
             <element name="status" type="tdn:status"/>
             <element ref="gml:geometryProperty"/>
             <element name="hoogteniveau" type="integer" minOccurs="0"/>
             <element name="naam" type="string" minOccurs="0"/>
          </sequence>
       </extension>
    </complexContent>
</complexType>

<!-- ============================================================
     Declarations for InrichtingsElementen (= one of the themes)
============================================================== -->
<element name="InrichtingsElementen" type="tdn:Top10ThemaType"
  substitutionGroup="tdn:_Top10ThemasFeature"/>
```

```
<element name="inrichtingsElementenMember" type="tdn:InrichtingsElementenMemberType"
  substitutionGroup="gml:featureMember"/>
<complexType name="InrichtingsElementenMemberType">
  <annotation>
  </annotation>
  <complexContent>
    <restriction base="gml:FeatureAssociationType">
      <sequence minOccurs="0">
        <element ref="tdn:_InrichtingsElementenFeature"/>
      </sequence>
      <attributeGroup ref="gml:AssociationAttributeGroup"/>
    </restriction>
  </complexContent>
</complexType>

<element name="_InrichtingsElementenFeature" type="gml:AbstractFeatureType" abstract="true"
  substitutionGroup="gml:_Feature"/>

<element name="InrichtingsElement" type="tdn:InrichtingsElementType"
  substitutionGroup="tdn:_InrichtingsElementenFeature"/>
<complexType name="InrichtingsElementType">
    <complexContent>
       <extension base="tdn:Top10ObjectType">
          <sequence>
             <element name="type" type="tdn:typeInrichtingsElement"/>
             <element name="functie" type="string" minOccurs="0"/>
             <element name="hoogte" type="string"/>
             <element name="status" type="tdn:status"/>
             <element ref="gml:geometryProperty"/>
             <element name="hoogteniveau" type="integer" minOccurs="0"/>
             <element name="naam" type="string" minOccurs="0"/>
             <element name="nummer" type="string" minOccurs="0"/>
          </sequence>
       </extension>
    </complexContent>
</complexType>

<!-- ============================================================
     Declarations for FunctioneleGebieden (= one of the themes)
============================================================== -->
<element name="FunctioneleGebieden" type="tdn:Top10ThemaType"
  substitutionGroup="tdn:_Top10ThemasFeature"/>

<element name="functioneleGebiedenMember" type="tdn:FunctioneleGebiedenMemberType"
  substitutionGroup="gml:featureMember"/>
<complexType name="FunctioneleGebiedenMemberType">
  <annotation>
  </annotation>
  <complexContent>
    <restriction base="gml:FeatureAssociationType">
      <sequence minOccurs="0">
        <element ref="tdn:_FunctioneleGebiedenFeature"/>
      </sequence>
      <attributeGroup ref="gml:AssociationAttributeGroup"/>
    </restriction>
  </complexContent>
</complexType>

<element name="_FunctioneleGebiedenFeature" type="gml:AbstractFeatureType" abstract="true"
  substitutionGroup="gml:_Feature"/>

<element name="FunctioneelGebied" type="tdn:FunctioneelGebiedType"
  substitutionGroup="tdn:_FunctioneleGebiedenFeature"/>
<complexType name="FunctioneelGebiedType">
    <complexContent>
       <extension base="tdn:Top10ObjectType">
          <sequence>
             <element name="type" type="tdn:typeFuncGebied"/>
             <element ref="gml:geometryProperty"/>
```

```
            <element name="naam" type="string"/>
          </sequence>
        </extension>
    </complexContent>
</complexType>

<!-- ============================================================
     Declarations for Administratieve Gebieden (= one of the themes)
============================================================== -->
<element name="AdministratieveGebieden" type="tdn:Top10ThemaType"
  substitutionGroup="tdn:_Top10ThemasFeature"/>

<element name="administratieveGebiedenMember" type="tdn:AdministratieveGebiedenMemberType"
  substitutionGroup="gml:featureMember"/>
<complexType name="AdministratieveGebiedenMemberType">
  <complexContent>
    <restriction base="gml:FeatureAssociationType">
      <sequence minOccurs="0">
        <element ref="tdn:_AdministratieveGebiedenFeature"/>
      </sequence>
      <attributeGroup ref="gml:AssociationAttributeGroup"/>
    </restriction>
  </complexContent>
</complexType>

<element name="_AdministratieveGebiedenFeature" type="gml:AbstractFeatureType" abstract="true"
  substitutionGroup="gml:_Feature"/>

<element name="AdministratiefGebied" type="tdn:AdministratiefGebiedType"
  substitutionGroup="tdn:_AdministratieveGebiedenFeature"/>
<complexType name="AdministratiefGebiedType">
    <complexContent>
       <extension base="tdn:Top10ObjectType">
          <sequence>
             <element name="type" type="tdn:typeAdminGebied"/>
             <element ref="gml:geometryProperty"/>
             <element name="naam" type="string"/>
          </sequence>
       </extension>
    </complexContent>
</complexType>

<!-- ============================================================
     Declarations for GeografischeGebieden (= one of the themes)
============================================================== -->
<element name="GeografischeGebieden" type="tdn:Top10ThemaType"
  substitutionGroup="tdn:_Top10ThemasFeature"/>

<element name="geografischeGebiedenMember" type="tdn:GeografischeGebiedenMemberType"
  substitutionGroup="gml:featureMember"/>
<complexType name="GeografischeGebiedenMemberType">
  <annotation>
  </annotation>
  <complexContent>
    <restriction base="gml:FeatureAssociationType">
      <sequence minOccurs="0">
        <element ref="tdn:_GeografischeGebiedenFeature"/>
      </sequence>
      <attributeGroup ref="gml:AssociationAttributeGroup"/>
    </restriction>
  </complexContent>
</complexType>

<element name="_GeografischeGebiedenFeature" type="gml:AbstractFeatureType" abstract="true"
  substitutionGroup="gml:_Feature"/>

<element name="GeografischGebied" type="tdn:GeografischGebiedType"
  substitutionGroup="tdn:_GeografischeGebiedenFeature"/>
<complexType name="GeografischGebiedType">
```

```
    <complexContent>
       <extension base="tdn:Top10ObjectType">
          <sequence>
             <element name="type" type="tdn:typeGeografGebied"/>
             <element ref="gml:geometryProperty"/>
             <element name="naam" type="string"/>
          </sequence>
       </extension>
    </complexContent>
</complexType>

<!-- ============================================================
     Attribute type definitions (permitted values)
============================================================== -->
<simpleType name="breedteklasse">
    <restriction base="string">
      <enumeration value="&lt; 1m"/>
      <enumeration value="1-3 m"/>
      <enumeration value="3-6 m"/>
      <enumeration value="6-12 m"/>
      <enumeration value="12-20 m"/>
      <enumeration value="20-50 m"/>
      <enumeration value="50-150 m"/>
      <enumeration value="150-300"/>
      <enumeration value="300-450 m"/>
      <enumeration value="&gt; 450m"/>
   </restriction>
</simpleType>

<simpleType name="elektrificatie">
    <restriction base="string">
      <enumeration value="Gelektrificeerd"/>
      <enumeration value="Niet gelektrificeerd"/>
    </restriction>
</simpleType>

<simpleType name="functieBebouwing">
    <restriction base="string">
      <enumeration value="Gemeentehuis"/>
      <enumeration value="Politiebureau"/>
      <enumeration value="Postkantoor"/>
      <enumeration value="Religieus gebouw"/>
      <enumeration value="Hospitaal"/>
      <enumeration value="Station"/>
      <enumeration value="Watertoren"/>
      <enumeration value="Vuurtoren"/>
      <enumeration value="Lichttoren"/>
      <enumeration value="Zendtoren"/>
      <enumeration value="Windmolen"/>
      <enumeration value="Watermolen"/>
      <enumeration value="Gemaal"/>
      <enumeration value="Dok"/>
      <enumeration value="Kas"/>
      <enumeration value="Opslagtank"/>
      <enumeration value="Overig"/>
      <enumeration value="Crematorium"/>
      <enumeration value="Manege"/>
      <enumeration value="Kapel"/>
    </restriction>
</simpleType>

<simpleType name="functieInrichtingsElement">
    <restriction base="string">
      <enumeration value="Geluidswerend"/>
      <enumeration value="Scheidend"/>
      <enumeration value="Overig"/>
    </restriction>
</simpleType>
```

```
<simpleType name="functieSpoor">
    <restriction base="string">
      <enumeration value="Gemengd gebruik"/>
      <enumeration value="Alleen personenvervoer"/>
      <enumeration value="Alleen goederenvervoer"/>
    </restriction>
</simpleType>

<simpleType name="fysiek_voorkomenSpoor">
    <restriction base="string">
      <enumeration value="Op vast deel van brug"/>
      <enumeration value="Op beweegbaar deel van brug"/>
      <enumeration value="Op verhoogd vlak"/>
      <enumeration value="Op verlaagd vlak"/>
      <enumeration value="Overkluisd"/>
      <enumeration value="In tunnel"/>
      <enumeration value="Op weg"/>
      <enumeration value="Overig"/>
    </restriction>
</simpleType>

<simpleType name="fysiek_voorkomenTerrein">
    <restriction base="string">
      <enumeration value="Op talud"/>
      <enumeration value="Op verhoogd vlak"/>
      <enumeration value="Op verlaagd vlak"/>
      <enumeration value="Overkluisd"/>
      <enumeration value="In tunnel"/>
      <enumeration value="Op brug"/>
      <enumeration value="Overig"/>
    </restriction>
</simpleType>

<simpleType name="fysiek_voorkomenWater">
    <restriction base="string">
      <enumeration value="In sluis"/>
      <enumeration value="Op aquaduct"/>
      <enumeration value="In duiker"/>
      <enumeration value="In grondduiker"/>
      <enumeration value="Overig"/>
    </restriction>
</simpleType>

<simpleType name="fysiek_voorkomenWeg">
    <restriction base="string">
      <enumeration value="Op vast deel van brug"/>
      <enumeration value="Op beweegbaar deel van brug"/>
      <enumeration value="Op talud"/>
      <enumeration value="Op verhoogd vlak"/>
      <enumeration value="Op verlaagd vlak"/>
      <enumeration value="Overkluisd"/>
      <enumeration value="In tunnel"/>
      <enumeration value="Overig"/>
    </restriction>
</simpleType>

<simpleType name="gebruik">
    <restriction base="string">
      <enumeration value="Viskwekerij"/>
      <enumeration value="Waterzuivering"/>
      <enumeration value="Zwembad"/>
      <enumeration value="Overig"/>
    </restriction>
</simpleType>

<simpleType name="hoofdafwatering">
    <restriction base="string">
      <enumeration value="Ja"/>
      <enumeration value="Nee"/>
```

```
    </restriction>
</simpleType>

<simpleType name="hoofdverkeersgebruik">
    <restriction base="string">
      <enumeration value="Snelverkeer"/>
      <enumeration value="Gemengd verkeer"/>
      <enumeration value="Busverkeer"/>
      <enumeration value="Langzaam verkeer"/>
      <enumeration value="Fietsers/bromfietsers"/>
      <enumeration value="Voetgangers"/>
      <enumeration value="Parkeren"/>
      <enumeration value="Overig"/>
    </restriction>
</simpleType>

<simpleType name="hoogteklasse">
    <restriction base="string">
      <enumeration value="Laagbouw"/>
      <enumeration value="Hoogbouw"/>
    </restriction>
</simpleType>

<simpleType name="kruisingstype">
    <restriction base="string">
      <enumeration value="Deel van rotonde"/>
      <enumeration value="Deel van verkeersknooppunt"/>
      <enumeration value="Overig"/>
    </restriction>
</simpleType>

<simpleType name="landgebruik">
    <restriction base="string">
      <enumeration value="Loofbos"/>
      <enumeration value="Naaldbos"/>
      <enumeration value="Gemengd bos"/>
      <enumeration value="Griend"/>
      <enumeration value="Populieren"/>
      <enumeration value="Heide"/>
      <enumeration value="Zand"/>
      <enumeration value="Akkerland"/>
      <enumeration value="Grasland"/>
      <enumeration value="Boomgaard"/>
      <enumeration value="Fruitkwekerij"/>
      <enumeration value="Boomkwekerij"/>
      <enumeration value="Dodenakker"/>
      <enumeration value="Plaveisel, basaltblokken"/>
      <enumeration value="Overig"/>
    </restriction>
</simpleType>

<simpleType name="rijrichting">
    <restriction base="string">
      <enumeration value="Eenrichting"/>
      <enumeration value="Tweerichting"/>
    </restriction>
</simpleType>

<simpleType name="spoorbreedte">
    <restriction base="string">
      <enumeration value="Normaalspoor"/>
      <enumeration value="Smalspoor"/>
    </restriction>
</simpleType>

<simpleType name="status">
    <restriction base="string">
      <enumeration value="In ontwerp"/>
      <enumeration value="In aanleg"/>
```

```
      <enumeration value="In gebruik"/>
      <enumeration value="Niet meer in gebruik"/>
      <enumeration value="Onbekend"/>
    </restriction>
</simpleType>

<simpleType name="stroomrichting">
    <restriction base="string">
      <enumeration value="Eenrichting"/>
      <enumeration value="Twee richtingen (getijde invloed)"/>
      <enumeration value="Stilstaand"/>
    </restriction>
</simpleType>

<simpleType name="toegankelijkheid">
    <restriction base="string">
      <enumeration value="Openbaar"/>
      <enumeration value="Niet-openbaar"/>
      <enumeration value="Onbekend"/>
    </restriction>
</simpleType>

<simpleType name="typeAdminGebied">
    <restriction base="string">
      <enumeration value="Land"/>
      <enumeration value="Provincie"/>
      <enumeration value="Gemeente"/>
      <enumeration value="Bundesland"/>
      <enumeration value="Regierungsbezirk"/>
      <enumeration value="Kreis"/>
    </restriction>
</simpleType>

<simpleType name="typeBebouwing">
    <restriction base="string">
      <enumeration value="Gebouw"/>
      <enumeration value="Huizenblok"/>
      <enumeration value="Toren"/>
      <enumeration value="Installatie"/>
    </restriction>
</simpleType>

<simpleType name="typeBeheersgebied">
    <restriction base="string">
      <enumeration value="Natuurgebied, natuurreservaat"/>
      <enumeration value="Boswachterij"/>
      <enumeration value="Nationaal park"/>
    </restriction>
</simpleType>

<simpleType name="typeFuncGebied">
    <restriction base="string">
      <enumeration value="Industriegebied"/>
      <enumeration value="Militair oefengebied, schietterrein"/>
      <enumeration value="Begraafplaats"/>
      <enumeration value="Sportterrein"/>
      <enumeration value="Vliegveld, luchthaven"/>
      <enumeration value="Bungalowpark"/>
      <enumeration value="Camping"/>
      <enumeration value="Recreatiegebied"/>
      <enumeration value="Zwembad"/>
      <enumeration value="Golfterrein"/>
      <enumeration value="Sluizencomplex"/>
      <enumeration value="Gebouwencomplex"/>
      <enumeration value="Jachthaven"/>
      <enumeration value="Haven"/>
      <enumeration value="Dierentuin, safaripark"/>
    </restriction>
</simpleType>
```

```
<simpleType name="typeGeografGebied">
    <restriction base="string">
      <enumeration value="Streek, veld"/>
      <enumeration value="Heuvel, duin, berg"/>
      <enumeration value="Eiland"/>
      <enumeration value="Polder"/>
      <enumeration value="Bosgebied"/>
      <enumeration value="Heidegebied"/>
      <enumeration value="Kaap, hoek"/>
      <enumeration value="Zee, zeegat, zeearm"/>
      <enumeration value="Meer, plas, vijver"/>
      <enumeration value="Geul, vaargeul"/>
      <enumeration value="Wad"/>
      <enumeration value="Bank, ondiepte, plaat"/>
      <enumeration value="Plaats, bewoond oord"/>
      <enumeration value="Wijk, buurt"/>
      <enumeration value="Overig"/>
    </restriction>
</simpleType>

<simpleType name="typeInfra">
    <restriction base="string">
      <enumeration value="Verbinding"/>
      <enumeration value="Kruising"/>
      <enumeration value="Vlak"/>
    </restriction>
</simpleType>

<simpleType name="typeInrichtingsElement">
    <restriction base="string">
      <enumeration value="Hoogspanningsleiding"/>
      <enumeration value="Kabelbaan"/>
      <enumeration value="Leiding"/>
      <enumeration value="Paalwerk"/>
      <enumeration value="Heg, haag"/>
      <enumeration value="Bomenrij"/>
      <enumeration value="Hoogspanningmast"/>
      <enumeration value="Paal"/>
      <enumeration value="Grenspaal, grenssteen"/>
      <enumeration value="Vlampijp"/>
      <enumeration value="Baak"/>
      <enumeration value="Zendmast"/>
      <enumeration value="Seinmast"/>
      <enumeration value="Peilschaal"/>
      <enumeration value="Oliepompinstallatie"/>
      <enumeration value="Muur"/>
      <enumeration value="Hekwerk"/>
      <enumeration value="Gedenkteken, monument"/>
      <enumeration value="Dukdalf"/>
      <enumeration value="Wegwijzer"/>
      <enumeration value="Boom "/>
      <enumeration value="Hunebed"/>
      <enumeration value="Grafheuvel"/>
      <enumeration value="Stuw"/>
      <enumeration value="Sluis"/>
      <enumeration value="Windmolentje"/>
      <enumeration value="Windmolen"/>
      <enumeration value="Watermolen"/>
      <enumeration value="Kilometerpaal"/>
      <enumeration value="Boom"/>
      <enumeration value="Hoogspanningsmast"/>
      <enumeration value="Heg"/>
      <enumeration value="Wegafsluiting"/>
      <enumeration value="GPS Kernpunt"/>
      <enumeration value="Kruis"/>
      <enumeration value="Toren"/>
      <enumeration value="Grenspaal"/>
      <enumeration value="Kilometerraaibord"/>
```

```
      <enumeration value="Lichtopstand"/>
      <enumeration value="Windturbine"/>
      <enumeration value="Gemaal"/>
      <enumeration value="Opslagtank"/>
      <enumeration value="Aanlegsteiger"/>
      <enumeration value="Wegafsluiter"/>
      <enumeration value="Vuurtoren"/>
      <enumeration value="Veer"/>
   </restriction>
</simpleType>

<simpleType name="verhardingsbreedteklasse">
    <restriction base="string">
      <enumeration value="&gt;7m"/>
      <enumeration value="4-7m"/>
      <enumeration value="2-4m"/>
      <enumeration value="&lt;2m"/>
    </restriction>
</simpleType>

<simpleType name="verhardingsmateriaal">
    <restriction base="string">
      <enumeration value="Asfalt"/>
      <enumeration value="Zeer open asfalt beton"/>
      <enumeration value="Klinkers"/>
      <enumeration value="Grint"/>
      <enumeration value="Zand"/>
      <enumeration value="Overig"/>
      <enumeration value="Onbekend"/>
    </restriction>
</simpleType>

<simpleType name="verhardingstype">
    <restriction base="string">
      <enumeration value="Verhard"/>
      <enumeration value="Half verhard"/>
      <enumeration value="Onverhard"/>
      <enumeration value="Onbekend"/>
    </restriction>
</simpleType>

<simpleType name="verkeersgebruik">
    <restriction base="string">
      <enumeration value="Trein"/>
      <enumeration value="Tram"/>
      <enumeration value="Metro"/>
      <enumeration value="Overig"/>
    </restriction>
</simpleType>

<simpleType name="voorkomen">
    <restriction base="string">
      <enumeration value="Met riet"/>
      <enumeration value="Dras, moerassig"/>
      <enumeration value="Dras, moerassig met riet"/>
      <enumeration value="Riet"/>
      <enumeration value="Overig"/>
   </restriction>
</simpleType>

<simpleType name="watertype">
    <restriction base="string">
      <enumeration value="Waterloop"/>
      <enumeration value="Meer, plas, ven, vijver"/>
      <enumeration value="Sloot, greppel"/>
      <enumeration value="Zee"/>
      <enumeration value="Droogvallend"/>
      <enumeration value="Greppel"/>
    </restriction>
```

```
  </simpleType>

  <simpleType name="wegtype">
      <restriction base="string">
        <enumeration value="Autosnelweg"/>
        <enumeration value="Hoofdweg"/>
        <enumeration value="Regionale weg"/>
        <enumeration value="Lokale weg"/>
        <enumeration value="Straat"/>
        <enumeration value="Overige weg"/>
      </restriction>
  </simpleType>

  <simpleType name="zoutgehalte">
      <restriction base="string">
        <enumeration value="Zoet"/>
        <enumeration value="Zout"/>
        <enumeration value="Brak"/>
      </restriction>
  </simpleType>

</schema>
```

D.2 Non Strict schema definition (tdn.xsd)

```
<?xml version="1.0" encoding="iso-8859-1"?>
<!-- File: tdn.xsd  -->
<schema targetNamespace="http://www.gdmc.nl/tdn"
        xmlns:tdn="http://www.gdmc.nl/tdn"
        xmlns:xlink="http://www.w3.org/1999/xlink"
        xmlns:gml="http://www.opengis.net/gml"
        xmlns="http://www.w3.org/2000/10/XMLSchema"
        elementFormDefault="qualified"
        version="1.0">

  <annotation>
    <appinfo>tdn.xsd v2.0</appinfo>
    <documentation xml:lang="en">
      GML prototype schema for the Dutch Topographic Service 1:10.000 data
    </documentation>
  </annotation>

  <!-- import constructs from the GML Feature and Geometry schemas -->
  <import namespace="http://www.opengis.net/gml" schemaLocation="feature.xsd"/>

  <!-- ============================================================
       Declarations for Top10Themas (= root element)
  ============================================================= -->
  <element name="Top10Themas" substitutionGroup="gml:_FeatureCollection">
    <complexType>
      <complexContent>
        <extension base="gml:AbstractFeatureCollectionType">
        </extension>
      </complexContent>
    </complexType>
  </element>

  <!-- ============================================================
       Type definition of Top10ThemaType (= same type for all themes)
  ============================================================= -->
  <complexType name="Top10ThemaType">
    <complexContent>
      <extension base="gml:AbstractFeatureCollectionType">
      </extension>
    </complexContent>
  </complexType>
```

```
<!-- ================================================================
     Type definition of Top10ObjectType (= inherited and extended by
                                          all Top10 feature types)
================================================================== -->
<group name ="TemporeelObject">
          <sequence>
             <element name="begindatum" type="string"/>
             <element name="einddatum" type="string"/>
          </sequence>
</group>

<group name ="MetadataObject">
          <sequence>
             <element name="brontype" type="string"/>
             <element name="bronbeschrijving" type="string"/>
             <element name="nauwkeurigheid" type="string"/>
             <element name="actualiteit" type="string"/>
             <element name="tdncode" type="integer"/>
          </sequence>
</group>

<complexType name="Top10ObjectType" abstract="true">
  <complexContent>
    <extension base="gml:AbstractFeatureType">
          <sequence>
             <element name="top10_id" type="integer"/>
             <group ref="tdn:TemporeelObject"/>
             <group ref="tdn:MetadataObject"/>
          </sequence>
    </extension>
  </complexContent>
</complexType>

<!-- ================================================================
     Type definition of InfrastructuurType (= inherited and extended by
     SpoorbaanDeelType, WegDeelType and WaterDeelType)
================================================================== -->
<complexType name="InfrastructuurType" abstract="true">
  <complexContent>
    <extension base="tdn:Top10ObjectType">
          <sequence>
             <element name="type" type="string"/>
             <element name="toegankelijkheid" type="string"/>
             <element name="status" type="string"/>
          </sequence>
    </extension>
  </complexContent>
</complexType>

<!-- ================================================================
     Declarations for RuimtelijkeObjecten (= one of the themes)
================================================================== -->
<element name="RuimtelijkeObjecten" type="tdn:Top10ThemaType"
  substitutionGroup="gml:_FeatureCollection"/>

<element name="SpoorbaanDeel" type="tdn:SpoorbaanDeelType"
  substitutionGroup="gml:_Feature"/>
<complexType name="SpoorbaanDeelType">
    <complexContent>
       <extension base="tdn:InfrastructuurType">
          <sequence>
             <element name="verkeersgebruik" type="string"/>
             <element name="fysiek_voorkomen" type="string"/>
             <element name="spoorbreedte" type="string"/>
             <element name="aantal_sporen" type="string"/>
             <element name="functie" type="string" minOccurs="0"/>
             <element name="elektrificatie" type="string"/>
             <element ref="gml:geometryProperty"/>
```

```
            <element name="hoogteniveau" type="integer" minOccurs="0"/>
         </sequence>
      </extension>
   </complexContent>
</complexType>

<element name="WegDeel" type="tdn:WegDeelType"
  substitutionGroup="gml:_Feature"/>
<complexType name="WegDeelType">
   <complexContent>
      <extension base="tdn:InfrastructuurType">
         <sequence>
            <element name="wegtype" type="string"/>
            <element name="hoofdverkeersgebruik" type="string"/>
            <element name="fysiek_voorkomen" type="string"/>
            <element name="kruisingstype" type="string"/>
            <element name="verhardingsbreedteklasse" type="string"/>
            <element name="verhardingsbreedte" type="string"/>
            <element name="verhardingstype" type="string"/>
            <element name="verhardingsmateriaal" type="string"/>
            <element name="aantal_rijstroken" type="string"/>
            <element name="rijrichting" type="string"/>
            <element ref="gml:geometryProperty"/>
            <element name="hoogteniveau" type="integer" minOccurs="0"/>
            <element name="straatnaam" type="string" minOccurs="0"/>
            <element name="wegnummer" type="string" minOccurs="0"/>
         </sequence>
      </extension>
   </complexContent>
</complexType>

<element name="WaterDeel" type="tdn:WaterDeelType"
  substitutionGroup="gml:_Feature"/>
 <complexType name="WaterDeelType">
   <complexContent>
      <extension base="tdn:InfrastructuurType">
         <sequence>
            <element name="watertype" type="string"/>
            <element name="breedteklasse" type="string"/>
            <element name="breedte" type="string" minOccurs="0"/>
            <element name="hoofdafwatering" type="string"/>
            <element name="zoutgehalte" type="string"/>
            <element name="fysiek_voorkomen" type="string"/>
            <element name="gebruik" type="string"/>
            <element name="stroomrichting" type="string"/>
            <element ref="gml:geometryProperty"/>
            <element name="hoogteniveau" type="integer" minOccurs="0"/>
            <element name="naam" type="string" minOccurs="0"/>
         </sequence>
      </extension>
   </complexContent>
</complexType>

<element name="Terrein" type="tdn:TerreinType"
  substitutionGroup="gml:_Feature"/>
<complexType name="TerreinType">
   <complexContent>
      <extension base="tdn:Top10ObjectType">
         <sequence>
            <element name="landgebruik" type="string"/>
            <element name="fysiek_voorkomen" type="string"/>
            <element name="toegankelijkheid" type="string"/>
            <element name="voorkomen" type="string" minOccurs="0"/>
            <element ref="gml:geometryProperty"/>
            <element name="hoogteniveau" type="integer" minOccurs="0"/>
            <element name="naam" type="string" minOccurs="0"/>
         </sequence>
      </extension>
   </complexContent>
```

```
</complexType>

<element name="Bebouwing" type="tdn:BebouwingType"
  substitutionGroup="gml:_Feature"/>
<complexType name="BebouwingType">
    <complexContent>
       <extension base="tdn:Top10ObjectType">
          <sequence>
             <element name="type" type="string"/>
             <element name="functie" type="string"/>
             <element name="hoogteklasse" type="string"/>
             <element name="hoogte" type="string"/>
             <element name="status" type="string"/>
             <element ref="gml:geometryProperty"/>
             <element name="hoogteniveau" type="integer" minOccurs="0"/>
             <element name="naam" type="string" minOccurs="0"/>
          </sequence>
       </extension>
    </complexContent>
</complexType>

<!-- ================================================================
     Declarations for InrichtingsElementen (= one of the themes)
================================================================= -->
<element name="InrichtingsElementen" type="tdn:Top10ThemaType"
  substitutionGroup="gml:_FeatureCollection"/>

<element name="InrichtingsElement" type="tdn:InrichtingsElementType"
  substitutionGroup="gml:_Feature"/>
<complexType name="InrichtingsElementType">
    <complexContent>
       <extension base="tdn:Top10ObjectType">
          <sequence>
             <element name="type" type="string"/>
             <element name="functie" type="string" minOccurs="0"/>
             <element name="hoogte" type="string"/>
             <element name="status" type="string"/>
             <element ref="gml:geometryProperty"/>
             <element name="hoogteniveau" type="integer" minOccurs="0"/>
             <element name="naam" type="string" minOccurs="0"/>
             <element name="nummer" type="string" minOccurs="0"/>
          </sequence>
       </extension>
    </complexContent>
</complexType>

<!-- ================================================================
     Declarations for FunctioneleGebieden (= one of the themes)
================================================================= -->
<element name="FunctioneleGebieden" type="tdn:Top10ThemaType"
  substitutionGroup="gml:_FeatureCollection"/>

<element name="FunctioneelGebied" type="tdn:FunctioneelGebiedType"
  substitutionGroup="gml:_Feature"/>
<complexType name="FunctioneelGebiedType">
    <complexContent>
       <extension base="tdn:Top10ObjectType">
          <sequence>
             <element name="type" type="string"/>
             <element ref="gml:geometryProperty"/>
             <element name="naam" type="string"/>
          </sequence>
       </extension>
    </complexContent>
</complexType>

<!-- ================================================================
     Declarations for Administratieve Gebieden (= one of the themes)
================================================================= -->
```

```
  <element name="AdministratieveGebieden" type="tdn:Top10ThemaType"
    substitutionGroup="gml:_FeatureCollection"/>

  <element name="AdministratiefGebied" type="tdn:AdministratiefGebiedType"
    substitutionGroup="gml:_Feature"/>
  <complexType name="AdministratiefGebiedType">
      <complexContent>
         <extension base="tdn:Top10ObjectType">
            <sequence>
               <element name="type" type="string"/>
               <element ref="gml:geometryProperty"/>
               <element name="naam" type="string"/>
            </sequence>
         </extension>
      </complexContent>
  </complexType>

  <!-- ============================================================
       Declarations for GeografischeGebieden (= one of the themes)
  ============================================================== -->
  <element name="GeografischeGebieden" type="tdn:Top10ThemaType"
    substitutionGroup="gml:_FeatureCollection"/>

  <element name="GeografischGebied" type="tdn:GeografischGebiedType"
    substitutionGroup="gml:_Feature"/>
  <complexType name="GeografischGebiedType">
      <complexContent>
         <extension base="tdn:Top10ObjectType">
            <sequence>
               <element name="type" type="string"/>
               <element ref="gml:geometryProperty"/>
               <element name="naam" type="string"/>
            </sequence>
         </extension>
      </complexContent>
  </complexType>

</schema>
```

D.3 Strict GML document

```
<?xml version="1.0" encoding="iso-8859-1" standalone="no"?>
<!-- File: arnhem_strict.gml  -->
<tdn:Top10Themas
  xmlns:tdn="http://www.gdmc.nl/tdn"
  xmlns:gml="http://www.opengis.net/gml"
  xmlns:xlink="http://www.w3.org/1999/xlink"
  xmlns:xsi="http://www.w3.org/2000/10/XMLSchema-instance"
  xsi:schemaLocation="http://www.gdmc.nl/tdn tdn_strict.xsd">

  <gml:boundedBy>
    <gml:Box srsName="EPSG:7408">
      <gml:coordinates>
        190000,446000,0.0 193000,449000,0.0
      </gml:coordinates>
    </gml:Box>
  </gml:boundedBy>

  <tdn:top10ThemasMember>
    <tdn:RuimtelijkeObjecten>

      <gml:boundedBy>
        <gml:Box srsName="EPSG:7408">
          <gml:coordinates>
            190000,446000,0.0 193000,449000,0.0
          </gml:coordinates>
```

```
  </gml:Box>
</gml:boundedBy>

<tdn:ruimtelijkeObjectenMember>
  <tdn:SpoorbaanDeel fid="TOP10.4200001">
    <tdn:top10_id>4200001</tdn:top10_id>
    <tdn:begindatum>06 Jul 2001 08:08:24</tdn:begindatum>
    <tdn:einddatum/>
    <tdn:brontype/>
    <tdn:bronbeschrijving/>
    <tdn:nauwkeurigheid/>
    <tdn:actualiteit/>
    <tdn:tdncode>4233</tdn:tdncode>
    <tdn:type>Verbinding</tdn:type>
    <tdn:toegankelijkheid>Openbaar</tdn:toegankelijkheid>
    <tdn:status>In gebruik</tdn:status>
    <tdn:verkeersgebruik>Tram</tdn:verkeersgebruik>
    <tdn:fysiek_voorkomen>Overig</tdn:fysiek_voorkomen>
    <tdn:spoorbreedte>Normaalspoor</tdn:spoorbreedte>
    <tdn:aantal_sporen>1</tdn:aantal_sporen>
    <tdn:functie>Alleen personenvervoer</tdn:functie>
    <tdn:elektrificatie>Gelektrificeerd</tdn:elektrificatie>
    <gml:geometryProperty>
      <gml:Polygon srsName="EPSG:7408">
        <gml:outerBoundaryIs>
          <gml:LinearRing>
            <gml:coordinates>
              191008.456,447232.635,0.0 190990.713,447236.938,0.0 190972.849,447239.952,0.0
              190955.904,447235.469,0.0 190940.491,447231.646,0.0 190923.831,447229.355,0.0
              190924.668,447229.093,0.0 190942.211,447223.787,0.0 190944.282,447224.343,0.0
              190957.89,447227.719,0.0 190973.223,447231.776,0.0 190989.103,447229.096,0.0
              191006.57,447224.861,0.0 191008.456,447232.635,0.0
            </gml:coordinates>
          </gml:LinearRing>
        </gml:outerBoundaryIs>
      </gml:Polygon>
    </gml:geometryProperty>
    <tdn:hoogteniveau>0</tdn:hoogteniveau>
  </tdn:SpoorbaanDeel>
</tdn:ruimtelijkeObjectenMember>

<tdn:ruimtelijkeObjectenMember>
  <tdn:WegDeel fid="TOP10.2200689">
    <tdn:top10_id>2200689</tdn:top10_id>
    <tdn:begindatum>06 Jul 2001 08:12:53</tdn:begindatum>
    <tdn:einddatum/>
    <tdn:brontype/>
    <tdn:bronbeschrijving/>
    <tdn:nauwkeurigheid/>
    <tdn:actualiteit/>
    <tdn:tdncode>2003</tdn:tdncode>
    <tdn:type>Verbinding</tdn:type>
    <tdn:toegankelijkheid>Openbaar</tdn:toegankelijkheid>
    <tdn:status>In gebruik</tdn:status>
    <tdn:wegtype>Autosnelweg</tdn:wegtype>
    <tdn:hoofdverkeersgebruik>Snelverkeer</tdn:hoofdverkeersgebruik>
    <tdn:fysiek_voorkomen>Overig</tdn:fysiek_voorkomen>
    <tdn:kruisingstype>Overig</tdn:kruisingstype>
    <tdn:verhardingsbreedteklasse>&gt;7m</tdn:verhardingsbreedteklasse>
    <tdn:verhardingsbreedte>Onbekend</tdn:verhardingsbreedte>
    <tdn:verhardingstype>Verhard</tdn:verhardingstype>
    <tdn:verhardingsmateriaal>Onbekend</tdn:verhardingsmateriaal>
    <tdn:aantal_rijstroken>Onbekend</tdn:aantal_rijstroken>
    <tdn:rijrichting>Eenrichting</tdn:rijrichting>
    <gml:geometryProperty>
      <gml:Polygon srsName="EPSG:7408">
        <gml:outerBoundaryIs>
          <gml:LinearRing>
            <gml:coordinates>
```

```
                191917.328,448486.464,0.0 191923.574,448481.352,0.0 191926.345,448486.996,0.0
                191929.286,448493.52,0.0 191924.399,448495.658,0.0 191889.616,448509.857,0.0
                191887.778,448501.851,0.0 191892.226,448500.256,0.0 191905.661,448493.537,0.0
                191917.328,448486.464,0.0
              </gml:coordinates>
            </gml:LinearRing>
          </gml:outerBoundaryIs>
        </gml:Polygon>
      </gml:geometryProperty>
      <tdn:hoogteniveau>0</tdn:hoogteniveau>
      <tdn:straatnaam>Onbekend</tdn:straatnaam>
      <tdn:wegnummer>A50 # 20</tdn:wegnummer>
    </tdn:WegDeel>
  </tdn:ruimtelijkeObjectenMember>
 </tdn:RuimtelijkeObjecten>
</tdn:top10ThemasMember>

<tdn:top10ThemasMember>
 <tdn:InrichtingsElementen>

  <gml:boundedBy>
    <gml:Box srsName="EPSG:7408">
      <gml:coordinates>
        190000,446000,0.0 193000,449000,0.0
      </gml:coordinates>
    </gml:Box>
  </gml:boundedBy>

  <tdn:inrichtingsElementenMember>
    <tdn:InrichtingsElement fid="TOP10.3200260">
      <tdn:top10_id>3200260</tdn:top10_id>
      <tdn:begindatum>06 Jul 2001 08:06:00</tdn:begindatum>
      <tdn:einddatum/>
      <tdn:brontype/>
      <tdn:bronbeschrijving/>
      <tdn:nauwkeurigheid/>
      <tdn:actualiteit/>
      <tdn:tdncode>3874</tdn:tdncode>
      <tdn:type>Wegwijzer</tdn:type>
      <tdn:functie>Overig</tdn:functie>
      <tdn:hoogte>Onbekend</tdn:hoogte>
      <tdn:status>In gebruik</tdn:status>
      <gml:geometryProperty>
        <gml:Point srsName="EPSG:7408">
          <gml:coordinates>
            192025.722,446915.793,0.0
          </gml:coordinates>
        </gml:Point>
      </gml:geometryProperty>
      <tdn:hoogteniveau>0</tdn:hoogteniveau>
      <tdn:naam>Onbekend</tdn:naam>
      <tdn:nummer>Onbekend</tdn:nummer>
    </tdn:InrichtingsElement>
  </tdn:inrichtingsElementenMember>
 </tdn:InrichtingsElementen>
</tdn:top10ThemasMember>

<tdn:top10ThemasMember>
 <tdn:FunctioneleGebieden>

  <gml:boundedBy>
    <gml:Box srsName="EPSG:7408">
      <gml:coordinates>
        190000,446045.06,0.0 192918.597,448848.067,0.0
      </gml:coordinates>
    </gml:Box>
  </gml:boundedBy>

  <tdn:functioneleGebiedenMember>
```

```
      <tdn:FunctioneelGebied fid="TOP10.7200006">
        <tdn:top10_id>7200006</tdn:top10_id>
        <tdn:begindatum>06 Jul 2001 08:03:04</tdn:begindatum>
        <tdn:einddatum/>
        <tdn:brontype/>
        <tdn:bronbeschrijving/>
        <tdn:nauwkeurigheid/>
        <tdn:actualiteit/>
        <tdn:tdncode>5263</tdn:tdncode>
        <tdn:type>Golfterrein</tdn:type>
        <gml:geometryProperty>
          <gml:Polygon srsName="EPSG:7408">
            <gml:outerBoundaryIs>
              <gml:LinearRing>
                <gml:coordinates>
                  192918.597,448357.376,0.0 192906.417,448428.717,0.0 192902.937,448820.227,0.0
                  192866.396,448848.067,0.0 192798.535,448842.847,0.0 192730.673,448825.447,0.0
                  192662.811,448794.126,0.0 192598.43,448752.365,0.0 192541.009,448712.344,0.0
                  192502.728,448712.344,0.0 192494.027,448752.365,0.0 192474.887,448762.805,0.0
                  192403.545,448747.145,0.0 192330.464,448719.304,0.0 192276.522,448661.883,0.0
                  192194.74,448519.2,0.0 192036.397,448400.877,0.0 191984.196,448327.795,0.0
                  191959.835,448209.472,0.0 191978.975,447978.047,0.0 192024.217,447920.626,0.0
                  192036.397,447922.366,0.0 192126.879,447958.906,0.0 192285.223,448007.628,0.0
                  192593.21,448112.03,0.0 192857.696,448176.412,0.0 192904.677,448212.952,0.0
                  192906.417,448289.514,0.0 192918.597,448357.376,0.0
                </gml:coordinates>
              </gml:LinearRing>
            </gml:outerBoundaryIs>
          </gml:Polygon>
        </gml:geometryProperty>
        <tdn:naam>Onbekend</tdn:naam>
      </tdn:FunctioneelGebied>
    </tdn:functioneleGebiedenMember>
  </tdn:FunctioneleGebieden>
</tdn:top10ThemasMember>

<tdn:top10ThemasMember>
  <tdn:AdministratieveGebieden>

    <gml:boundedBy>
      <gml:Box srsName="EPSG:7408">
        <gml:coordinates>
          190000,446000,0.0 193000,449000,0.0
        </gml:coordinates>
      </gml:Box>
    </gml:boundedBy>

    <tdn:administratieveGebiedenMember>
      <tdn:AdministratiefGebied fid="TOP10.8200002">
        <tdn:top10_id>8200002</tdn:top10_id>
        <tdn:begindatum>06 Jul 2001 07:58:40</tdn:begindatum>
        <tdn:einddatum/>
        <tdn:brontype/>
        <tdn:bronbeschrijving/>
        <tdn:nauwkeurigheid/>
        <tdn:actualiteit/>
        <tdn:tdncode>8013</tdn:tdncode>
        <tdn:type>Gemeente</tdn:type>
        <gml:geometryProperty>
          <gml:Polygon srsName="EPSG:7408">
            <gml:outerBoundaryIs>
              <gml:LinearRing>
                <gml:coordinates>
                  192941.936,448179.52,0.0 193000,447429.872,0.0 193000,449000,0.0
                  192885.822,449000,0.0 192907.168,448681.856,0.0 192920.368,448490.176,0.0
                  192930.944,448376.352,0.0 192938.512,448233.152,0.0 192941.936,448179.52,0.0
                </gml:coordinates>
              </gml:LinearRing>
            </gml:outerBoundaryIs>
```

```
          </gml:Polygon>
        </gml:geometryProperty>
        <tdn:naam>Rozendaal</tdn:naam>
      </tdn:AdministratiefGebied>
    </tdn:administratieveGebiedenMember>
  </tdn:AdministratieveGebieden>
</tdn:top10ThemasMember>

<tdn:top10ThemasMember>
  <tdn:GeografischeGebieden>

    <gml:boundedBy>
      <gml:Box srsName="EPSG:7408">
        <gml:coordinates>
          190000,446000,0.0 193000,449000,0.0
        </gml:coordinates>
      </gml:Box>
    </gml:boundedBy>

    <tdn:geografischeGebiedenMember>
      <tdn:GeografischGebied fid="TOP10.7250005">
        <tdn:top10_id>7250005</tdn:top10_id>
        <tdn:begindatum>06 Jul 2001 08:04:22</tdn:begindatum>
        <tdn:einddatum/>
        <tdn:brontype/>
        <tdn:bronbeschrijving/>
        <tdn:nauwkeurigheid/>
        <tdn:actualiteit/>
        <tdn:tdncode>8803</tdn:tdncode>
        <tdn:type>Streek, veld</tdn:type>
        <gml:geometryProperty>
          <gml:Polygon srsName="EPSG:7408">
            <gml:outerBoundaryIs>
              <gml:LinearRing>
                <gml:coordinates>
                  193000,449000,0.0 190759.601,449000,0.0 190857.351,448094.537,0.0
                  192054.769,448410.186,0.0 192190.695,448539.791,0.0 192320.299,448713.65,0.0
                  192408.809,448685.2,0.0 192484.675,448704.166,0.0 192705.95,448814.804,0.0
                  193000,448885.254,0.0 193000,449000,0.0
                </gml:coordinates>
              </gml:LinearRing>
            </gml:outerBoundaryIs>
          </gml:Polygon>
        </gml:geometryProperty>
        <tdn:naam>Delhuijzen</tdn:naam>
      </tdn:GeografischGebied>
    </tdn:geografischeGebiedenMember>
  </tdn:GeografischeGebieden>
</tdn:top10ThemasMember>
</tdn:Top10Themas>
```

D.4 Non-trict GML document

```
<?xml version="1.0" encoding="iso-8859-1" standalone="no"?>
<!-- File: arnhem.gml  -->
<tdn:Top10Themas
  xmlns:tdn="http://www.gdmc.nl/tdn"
  xmlns:gml="http://www.opengis.net/gml"
  xmlns:xlink="http://www.w3.org/1999/xlink"
  xmlns:xsi="http://www.w3.org/2000/10/XMLSchema-instance"
  xsi:schemaLocation="http://www.gdmc.nl/tdn tdn.xsd">

  <gml:boundedBy>
    <gml:Box srsName="EPSG:7408">
      <gml:coordinates>
        190000,446000,0.0 193000,449000,0.0
```

```
    </gml:coordinates>
  </gml:Box>
</gml:boundedBy>

<gml:featureMember>
  <tdn:RuimtelijkeObjecten>

    <gml:boundedBy>
      <gml:Box srsName="EPSG:7408">
        <gml:coordinates>
          190000,446000,0.0 193000,449000,0.0
        </gml:coordinates>
      </gml:Box>
    </gml:boundedBy>

    <gml:featureMember>
      <tdn:SpoorbaanDeel fid="TOP10.4200001">
        <tdn:top10_id>4200001</tdn:top10_id>
        <tdn:begindatum>06 Jul 2001 08:08:24</tdn:begindatum>
        <tdn:einddatum/>
        <tdn:brontype/>
        <tdn:bronbeschrijving/>
        <tdn:nauwkeurigheid/>
        <tdn:actualiteit/>
        <tdn:tdncode>4233</tdn:tdncode>
        <tdn:type>Verbinding</tdn:type>
        <tdn:toegankelijkheid>Openbaar</tdn:toegankelijkheid>
        <tdn:status>In gebruik</tdn:status>
        <tdn:verkeersgebruik>Tram</tdn:verkeersgebruik>
        <tdn:fysiek_voorkomen>Overig</tdn:fysiek_voorkomen>
        <tdn:spoorbreedte>Normaalspoor</tdn:spoorbreedte>
        <tdn:aantal_sporen>1</tdn:aantal_sporen>
        <tdn:functie>Alleen personenvervoer</tdn:functie>
        <tdn:elektrificatie>Gelektrificeerd</tdn:elektrificatie>
        <gml:geometryProperty>
          <gml:Polygon srsName="EPSG:7408">
            <gml:outerBoundaryIs>
              <gml:LinearRing>
                <gml:coordinates>
                  191008.456,447232.635,0.0 190990.713,447236.938,0.0 190972.849,447239.952,0.0
                  190955.904,447235.469,0.0 190940.491,447231.646,0.0 190923.831,447229.355,0.0
                  190924.668,447229.093,0.0 190942.211,447223.787,0.0 190944.282,447224.343,0.0
                  190957.89,447227.719,0.0 190973.223,447231.776,0.0 190989.103,447229.096,0.0
                  191006.57,447224.861,0.0 191008.456,447232.635,0.0
                </gml:coordinates>
              </gml:LinearRing>
            </gml:outerBoundaryIs>
          </gml:Polygon>
        </gml:geometryProperty>
        <tdn:hoogteniveau>0</tdn:hoogteniveau>
      </tdn:SpoorbaanDeel>
    </gml:featureMember>

    <gml:featureMember>
      <tdn:WegDeel fid="TOP10.2200689">
        <tdn:top10_id>2200689</tdn:top10_id>
        <tdn:begindatum>06 Jul 2001 08:12:53</tdn:begindatum>
        <tdn:einddatum/>
        <tdn:brontype/>
        <tdn:bronbeschrijving/>
        <tdn:nauwkeurigheid/>
        <tdn:actualiteit/>
        <tdn:tdncode>2003</tdn:tdncode>
        <tdn:type>Verbinding</tdn:type>
        <tdn:toegankelijkheid>Openbaar</tdn:toegankelijkheid>
        <tdn:status>In gebruik</tdn:status>
        <tdn:wegtype>Autosnelweg</tdn:wegtype>
        <tdn:hoofdverkeersgebruik>Snelverkeer</tdn:hoofdverkeersgebruik>
        <tdn:fysiek_voorkomen>Overig</tdn:fysiek_voorkomen>
```

```
        <tdn:kruisingstype>Overig</tdn:kruisingstype>
        <tdn:verhardingsbreedteklasse>&gt;7m</tdn:verhardingsbreedteklasse>
        <tdn:verhardingsbreedte>Onbekend</tdn:verhardingsbreedte>
        <tdn:verhardingstype>Verhard</tdn:verhardingstype>
        <tdn:verhardingsmateriaal>Onbekend</tdn:verhardingsmateriaal>
        <tdn:aantal_rijstroken>Onbekend</tdn:aantal_rijstroken>
        <tdn:rijrichting>Eenrichting</tdn:rijrichting>
        <gml:geometryProperty>
          <gml:Polygon srsName="EPSG:7408">
            <gml:outerBoundaryIs>
              <gml:LinearRing>
                <gml:coordinates>
                  191917.328,448486.464,0.0 191923.574,448481.352,0.0 191926.345,448486.996,0.0
                  191929.286,448493.52,0.0 191924.399,448495.658,0.0 191889.616,448509.857,0.0
                  191887.778,448501.851,0.0 191892.226,448500.256,0.0 191905.661,448493.537,0.0
                  191917.328,448486.464,0.0
                </gml:coordinates>
              </gml:LinearRing>
            </gml:outerBoundaryIs>
          </gml:Polygon>
        </gml:geometryProperty>
        <tdn:hoogteniveau>0</tdn:hoogteniveau>
        <tdn:straatnaam>Onbekend</tdn:straatnaam>
        <tdn:wegnummer>A50 # 20</tdn:wegnummer>
      </tdn:WegDeel>
    </gml:featureMember>

  </tdn:RuimtelijkeObjecten>
</gml:featureMember>

<gml:featureMember>
  <tdn:InrichtingsElementen>

    <gml:boundedBy>
      <gml:Box srsName="EPSG:7408">
        <gml:coordinates>
          190000,446000,0.0 193000,449000,0.0
        </gml:coordinates>
      </gml:Box>
    </gml:boundedBy>

    <gml:featureMember>
      <tdn:InrichtingsElement fid="TOP10.3200260">
        <tdn:top10_id>3200260</tdn:top10_id>
        <tdn:begindatum>06 Jul 2001 08:06:00</tdn:begindatum>
        <tdn:einddatum/>
        <tdn:brontype/>
        <tdn:bronbeschrijving/>
        <tdn:nauwkeurigheid/>
        <tdn:actualiteit/>
        <tdn:tdncode>3874</tdn:tdncode>
        <tdn:type>Wegwijzer</tdn:type>
        <tdn:functie>Overig</tdn:functie>
        <tdn:hoogte>Onbekend</tdn:hoogte>
        <tdn:status>In gebruik</tdn:status>
        <gml:geometryProperty>
          <gml:Point srsName="EPSG:7408">
            <gml:coordinates>
              192025.722,446915.793,0.0
            </gml:coordinates>
          </gml:Point>
        </gml:geometryProperty>
        <tdn:hoogteniveau>0</tdn:hoogteniveau>
        <tdn:naam>Onbekend</tdn:naam>
        <tdn:nummer>Onbekend</tdn:nummer>
      </tdn:InrichtingsElement>
    </gml:featureMember>
```

```
    </tdn:InrichtingsElementen>
  </gml:featureMember>

</tdn:Top10Themas>
```

Appendix E

UML model by ITC

This appendix shows one example of a conceptual UML schema as designed by the ITC [20].

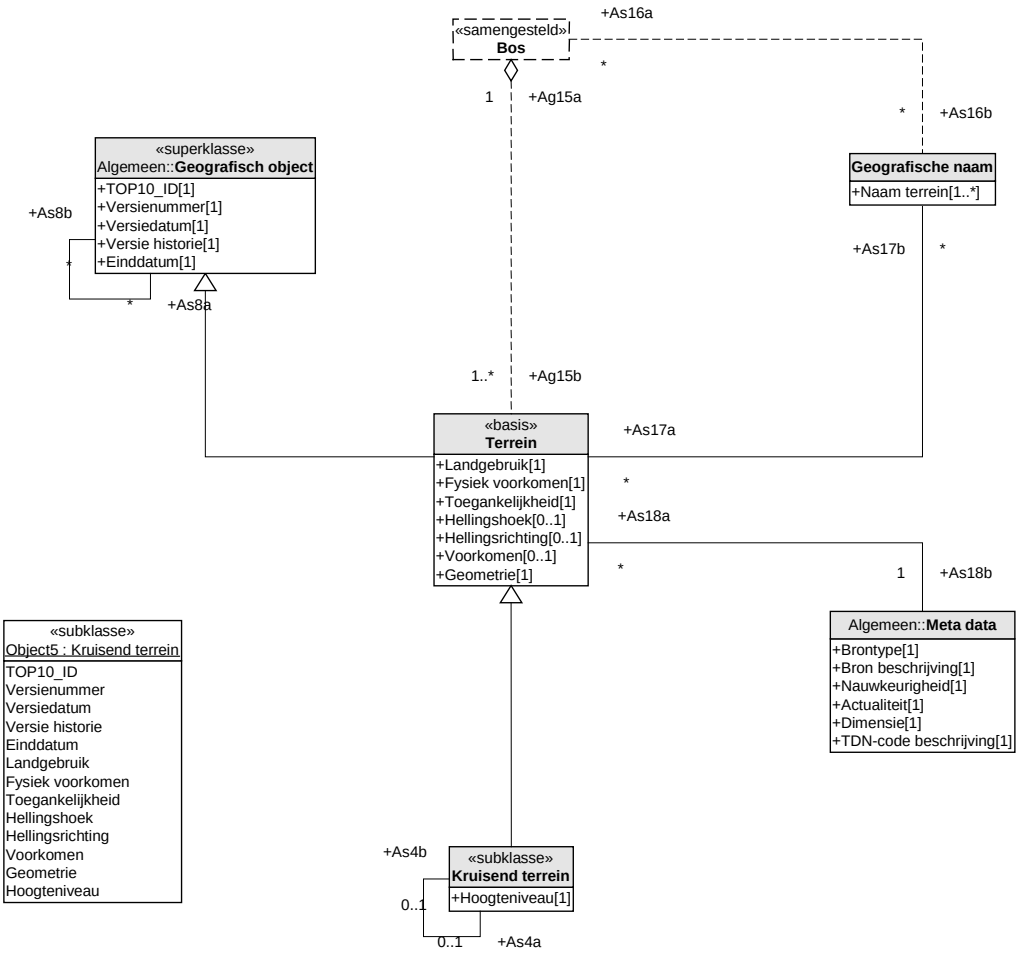

Figure E.1: UML model from ITC document

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